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Going boldly into the future

A series of case studies of co-operative research centres and their relationships with the VET sector

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The summary project report based on these case studies, titled *Going boldly into the future: A VET journey into the national innovation system*, by Fran Ferrier, Clifford Trood and Karen Whittingham, is also available from the NCVER website or in print from NCVER Ltd. A related publication, *Going boldly into the future: Skills and Australian high technology start-up firms* by Karen Whittingham, is available in print or from <http://www.ncver.edu.au>

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Case study 1

Sustainable Rice Production

(Co-operative Research Centre no.43)

Sustainable rice production

Introduction

The Co-operative Research Centre for Sustainable Rice production is supporting the Australian rice industry through its research and education programs. Its work in both the rice production and processing areas is leading to new industry knowledge and practice.

This study begins with a brief overview of the rice industry in Australia, and the issues it faces. This is followed by a discussion of the developments in the industry and the impact these developments are having on industry training. Connections between the centre and the vocational education and training (VET) sector are then identified. Finally the study concludes with concerns raised about the efficacy of current approaches to the introduction of new knowledge into the training process and the need to develop stronger, more formal arrangements between the various participants in order to ensure the timely and effective transfer of relevant knowledge to those working in the industry.

Industry

The Australian rice industry is based in the Riverina region of New South Wales, an area in south-western NSW. This area has a climate and landform well-suited to rice production. The Murray and Murrumbidgee River valleys provide water and extensive floodplains for the pond irrigation of lowland rice. The region also provides an environment relatively free from pests and diseases. This is supported by strong, regional quarantine restrictions since the start of rice production and for the region's fruit industry.

The rice industry began commercial production in the Murrumbidgee area in the early 1920s. Since that time, the industry has developed a strong research base, developing new rice varieties with enhanced cold tolerance, productivity and quality. The Australian rice industry has developed into a global leader in rice productivity, quality and production efficiency.

There have been other attempts in Australia to grow rice commercially, notably in the Adelaide, Ord and Fitzroy River irrigation regions of northern Australia, and on the Burdekin River delta and Mareeba region in northern Queensland. However, they have all proved unsuccessful—mainly due to a high level of disease and pest infestation. Consequently, the Riverina remains the centre of Australian rice production.

At present the Australian rice industry consists of some 2500 rice farms. Most are small family businesses, although there are some larger corporate farms in operation. Approximately 2200 families work the farms with another 3000 employed indirectly in the industry. Over 120 000 hectares are currently under cultivation, producing between 1 and 1.4 million tonnes of rice annually. The farm gate value of the crop of around $300 million, after processing, earns more than $500 million in exports. With over 80% of the harvest sold internationally, the industry provides significant export earnings.

One of the strengths of the Australian rice industry is its single regional location encouraging grower participation into a cohesive, vertically integrated structure that grows, processes and markets its product with a value-adding 'paddock-to-plate' focus. Processing of the rice crop is carried out by the Rice Growers' Co-operative Ltd who also seek, through research, to improve their processes, quality control and the development of new rice-based products to 'value-add' the crop.

Globally, the Australian rice industry is unique in two respects. Firstly, it is one of the most productive and efficient producers in the world, averaging yields of 9.2 tonnes per hectare. Secondly, unlike most other rice producers, it is essentially an unsubsidised industry and yet highly competitive. Its ability to compete against highly subsidised producers is largely a result of the high productivity and efficiency of the farmers and the high quality of the rice produced and quality processing. The necessity to compete, unsubsidised, places high demands on the industry to continue to improve their productivity, rice quality and to maintain efficiencies in production and processing.

At the same time, the industry is being expected to meet increasing national environmental pressures on water use and other environmental concerns. Environmental campaigners such as Stuart Blanch, co-ordinator of the inland rivers network, argues that 'the rice industry should have to show cause why the area sown to rice shouldn't be halved in the next five years. It certainly uses more water than cotton, more water than livestock and much more water than fruit,' ('Drip feed', *Sydney Morning Herald*, 4 May 2000, p.11). The industry is well aware of these concerns and is seeking to increase the efficiency of water use. The research to increase cold tolerance of rice varieties another four degrees, will eliminate the need for paddy flooding and significantly reduce the call on water.

In their Research and Development Plan for the Rice Industry Program 1996–2001, the Rural Industries Research and Development Corporation identified key issues that included the need to:

- further the development of farming systems that use natural resources in a sustainable and beneficial way
- identify, investigate and implement methods for value-adding rice and by-products that enhance grower returns and reduce impact on the environment.

The industry's vulnerability to an increasingly uncertain water supply demands water management, irrigation technologies and cold tolerant rice varieties to increase efficient water use. The need to improve crop yield, salinity tolerance and achieve shorter crop growth cycles are also of high importance in maintaining industry competitiveness. The industry's strong research base continues to address these and other issues to maintain the sustainability of the industry. The need to 'achieve rapid adoption of new and existing technology, both on- and off-farm' is also seen as a key issue for the industry in order to make timely use of research.

Industry developments

Rice industry developments share common themes with other agricultural industries. Research in a mature industry, like agriculture, generally seeks to improve and develop the industry, rather than create new industries. However, often in response to the industry developments, other niche industries will develop to support the major system changes. For example, irrigation specialists are now available to advise on suitable systems, as are specialist agronomists in pest management and plant nutrient needs.

From the development perspective, it is clear that there are two main areas impacting on the development of rice and other agricultural enterprises:

- sustainable practices and their associated support industries
- a quality assurance movement similar to that experienced in manufacturing industries during the past three decades.

These two areas are spawning niche industries or industry developments in the following areas.

Sustainable practice

- irrigation design, monitoring and management
- salinity management
  - irrigation practice
  - land management
  - tree cropping
  - brine shrimp production
- environmental support services and management systems (industry services from the International Food and Agribusiness Management Association?? [IAMA], WesFarmers etc. to encourage purchases of equipment and services)
  - salinity management (services and equipment)
  - land management (services and equipment)

- irrigation (design, installation, sales and manufacture)
- strategic management support (services)
- pest management (products and services)

✧ training: through university and VET, which is short, specific, timed and targetted to deliver the knowledge and skills.

Quality practice and accreditation

✧ accreditation ISO 9000 and ISO 1400 (environmental)

✧ training that will accredit incrementally from short courses culminating in full course completions and national accreditation

✧ marketing
- niche (environmentally friendly, locality awareness)
- value-adding (on-farm)
- creating the market (new products, new markets)
- defining the market (quality assurance, product specifications and new markets).

These developments will require farmers and/or farm employees to learn these skills or engage the support industries that provide the skills. The necessity to engage in or develop these skills foreshadows new training needs and opportunities in the rice and other agricultural sectors.

Developments in skill needs

The agricultural industry, as a mature industry, draws significantly on existing practice. Changes in these practices are incremental and often in niche areas becoming specialised support services. The developing environmental sustainability and quality assurance issues indicate the need for significant development in knowledge and management skills for the farmer. This is leading farmers to become, as one Department of Agriculture manager noted, 'knowledge rich, strategic managers' rather than manager/workers.

Strategic management skills have existed for some time across other industries and business. The CRC recognises this, but is concerned that if training is not contextual, using industry conversant trainers rather than 'generic' management trainers, the outcomes will not be satisfactory. This argues that care must be taken to match trainers to the industry and content. It also argues for professional development of rural educators in strategic management skills.

Forecasting training demands

Forecasting specific demands for training in the emerging skill areas is, to a degree, speculative. However, there are some common drivers and some indicators of emerging demand.

Firstly, market disciplines are increasingly being shaped by public pressure and the awareness of environmental issues. Nationally, governments may respond to these pressures through legislation. Internationally, corporations and nation states respond through the market, seeking or accepting products meeting their particular needs. Clearly at a national level water use and groundwater salinity are two major issues affecting the rice industry despite international market success.

Quality control and accreditation are also drivers of change. Nationally and internationally supermarket chains now seek an assurance on product quality, although they are resistant to paying a premium for quality produce. When public demand grows and leading innovative producers begin to realise a cost benefit, others will follow, raising the demand for training. This is already apparent in export markets such as tuna for the Japanese Sushi market.

Training demand here is closely related to the rate of technology or new practice uptake. Well-implemented diffusion strategies will create that demand and the need for training, while ad hoc arrangements and poor strategies will limit demand.

Using Rogers' (1995) innovation adoption categories, it is considered that in Australian agriculture, approximately 40% of farmers can be placed in the laggards/late majority category (those who reluctantly engage in new practices), while 40% are late/early majority (those who wait to see how the technology pans out before adopting it). In addition, 20% are early adopters (those who are open to new practices), but only a few are innovative, actively seeking out new ideas and prepared to waive the uncertainty associated with new ideas. The paradox for training is that without demand it is difficult to justify, yet it is the training and diffusion of knowledge that can create more demand.

For the rice industry, recognised as being more open to innovation it has actively sought out new ways to improve its performance. For VET the challenge is to keep ahead with technology development and transfer that to industry.

Another paradox applicable to the prediction of training demand is Rogers (1995) innovativeness/needs paradox where those most in need of an innovation often cannot respond, while those less in need are often more likely to respond. This occurs because access to resources, training or skills are often limited for those most needing to adopt new ideas. In the often resource-poor sector such as the rural industry change that requires new equipment, additional resources and more training will result in slow change at best and consequently lower the demands for training.

Government intervention through resource provision such as training, targetted to those who need to adopt new technology, can support change processes.

An awareness of potential government intervention and an awareness of new technologies would enable a level of prediction and targetting for training demand. An example of this is the interest in, and support for, salinity remediation. The government supports this area through funding and program initiatives developing rural awareness and knowledge in various remediation options.

The CRC for Sustainable Rice Production

The CRC for Sustainable Rice Production was first established in July 1997 with a grant period of seven years. The centre is situated within existing networks of industry research and development, and other service structures for rice production and processing. As such, the centre has many co-operative linkages with other research groups, extension and education providers, regulatory authorities, irrigation suppliers and community groups.

Based at Yanco in the Murrumbidgee Irrigation Area of NSW, the CRC for Sustainable Rice Production has 48 full-time equivalent research staff and in 1998–99 had 17 postgraduate research students. Funding for the centre is estimated at $52.2 million over the seven years. Core participants are the Ricegrowers Co-operative Limited, the Rural Industries Research and Development Corporation, the NSW Departments of Land, Water Conservation and Agriculture, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the University of Sydney and Charles Sturt University.

As an agricultural CRC, its focus is to increase the economic contribution of the rice industry to the regional and national economy through 'production efficiency, increased revenue from new value-added products and increased exports, and improvements in the management of soil and water resources'.

Research programs

The CRC for Sustainable Rice Production has four research programs that are interrelated, covering the general areas of natural resources, agronomy, genetic improvement and processing. The four research programs have a common theme—to address the issues that impact on the future of the rice industry.

Sustainability of natural resources

A primary concern of the rice industry is the use of water and its management. This program is evaluating and developing technologies to enable better planning and more efficient water use with less impact on ground and surface water.

The program has three sub-programs: the first, measurement and mapping, is looking at better prediction of groundwater recharge and the measurement of losses from on-farm channels and drains.

The second, net recharge management, is looking at the issue of reducing water flow into the water tables and at the same time increasing water discharge to address soil salinity.

The third is surface drainage management, where understanding and preventing the arrival of algal blooms and the problem of pesticide residues in irrigation drainage waters is being investigated.

The findings from some of this research have also benefitted general agricultural technology. For example, the modelling of crop and water balancing has resulted in more efficient use of water and led to new methods and techniques for crop irrigation.

Sustainable production systems

Within this program, the four sub-programs are:

1 Managing soil, chemical, physical and biological properties to achieve higher yield with environmental quality

2 Crop management in relation to environmental change

3 Mineral nutrition and grain quality

4 Sustainable crop protection.

These programs address strategic issues relating to the long-term sustainability of rice production. As such, its objective is to develop a comprehensive understanding of the mechanisms operating in the soil, plant and biological environment that could be manipulated for higher grain yield and quality.

Genetic improvement for sustainable production

Breeding rice varieties that perform well in a cold climate and with a shorter growing period is a continuing process of development. The research sub-programs include improved yield efficiency, tolerance to abiotic and biotic stress, enhancing the technology base for rice improvement, and breeding for quality attributes.

This work builds on previous genetic work that has seen many advances in productivity and the quality of rice varieties used in Australia.

Product and process development

The Australian rice industry is experiencing increased pressure from aggressive competition in traditional markets. Quality and food safety are becoming important criteria for developing and/or maintaining markets, as is the need to introduce new products to increase market penetration.

To address these issues, five sub-programs are in place. They are:

1 Grain quality in pre-milling phase

2 Development of a rice milling in-line process control

3 Quality assurance systems and post-harvest pest management

4 Novel applications for value-adding rice hulls

5 New rice-based foods.

These research programs reflect the concerns for sustainability and the market orientation of the rice industry. The Research and Development Plan for the Rice Industry Program, 1996–2001, identified seven key issues for the industry. Five of these issues were about market needs, farm profitability and sustainable use of natural resources. The other two key issues were about encouraging a collaborative approach to research development and extension, and the achievement of rapid adoption of new and existing technologies based on and off the farm.

Timely education and training for those in the industry and for the next generation is critical. The rapid adoption of new practices and a quick response to the research findings will maintain the industry's viability.

Commercialisation

The primary focus of the CRC for Sustainable Rice Production in this area is to develop sustainable production technology, then transfer that technology direct to the Australian grower. Many of the changes therefore relate to incremental process improvements rather than systemic change. However, if successful, the genetic work to develop new cold-tolerant rice varieties suited to the climatic conditions of the Murrumbidgee Irrigation Area will bring significant change, and commercially, have a broader application in seed sales or licences to produce seed.

Research into new rice-based foods is developing new products that are consumer-oriented and designed to value-add the rice product. In doing so the new products will build market advantage over other producers. The Ricegrowers' Co-operative, as the core industry participant, will commercialise the food technology.

The CRC has also been involved in the development of a patent for the bioremediation of pesticide residues in irrigation drainage waters. This project is part of the CSIRO's bioremediation program in collaboration with Orica Ltd, who holds the commercial rights to this patent and is indicative of the collaborative nature of the centre's work.

Education, training and knowledge transfer

Knowledge transfer to the industry is fundamental to the CRC's commitment to develop the industry. This is similar to other rural centres working close at the point of application. Their research is usually based on issues of production efficiency, industry and environmental sustainability. In particular, the CRC for Sustainable Rice Production considers itself, through its core partner the Department of Agriculture, a facilitator of rural education for the rice industry.

This transfer of knowledge occurs to various elements of the rural industry through different channels. For example, there is a direct transfer of knowledge into the Ricegrowers' Co-operative Ltd because of their involvement in the CRC's research program. A cross-transfer of knowledge between the centre and various irrigation bodies also occurs through their involvement as advisors or as participants in the research. Agribusiness companies are also involved in research projects as part of their new product development.

The grower, as a primary end user of the new knowledge and practices being developed, is currently kept informed through education programs such as extension services (short courses, field days) and accredited training courses. These programs are supported by the CRC through its education program.

The CRC has recognised that agricultural extension and training programs, while well-developed in some areas due to the work of government departments such as the NSW Department of Agriculture, were not addressing the particular needs of the rice industry such as the processing sector, skills-based training, and undergraduate and postgraduate education. To address these needs, the CRC's education program is acting as an information conduit between the centre and the industry.

Four areas are being targetted in this program. The first is sustainable rice production through farm education and community awareness. The aim of this program is to raise an awareness of the CRC's work in the rice-growing region. The centre works closely with district agronomists to support the flow of information to growers.

Secondly, the extension and information technology methods program is exploring ways to increase the flow of knowledge into the industry. The project is looking at various communications methods and technologies for opportunities to develop and apply new knowledge exchange systems such as the internet.

Skills development in new practices and technologies is important if sustainable rice production is to be achieved. The third program, sustainable rice development through skills development, has established a steering committee to determine industry training needs, both in production and processing, and to develop course outlines to meet those needs. The Murrumbidgee College of Agriculture, as a member of the steering committee and part of the NSW Department of Agriculture, is currently developing short courses in integrated pest management, integrated water management, rice agronomy and rice irrigation. These courses are to be developed and aligned with current industry competencies to enable course accreditation. Another component in this program is to provide information to school students and the general community on the rice industry and the work of the centre. This program is further discussed in relation to vocational education and training.

The fourth and last education program is to provide professional development for sustainable rice production. In order to maintain strong research based in the industry and to continue its sustainable development, the CRC is producing course materials and giving graduate and postgraduate students the opportunity for research experience in the rice industry. In 1998–99 there were 17 postgraduates working on centre projects with another ten expected to join in 2000. In the development of the course materials, the CRC is using a modular design. This will enable their use in the delivery of short courses to growers, extension officers, processes, and other service providers.

Current vocational education and training involvement

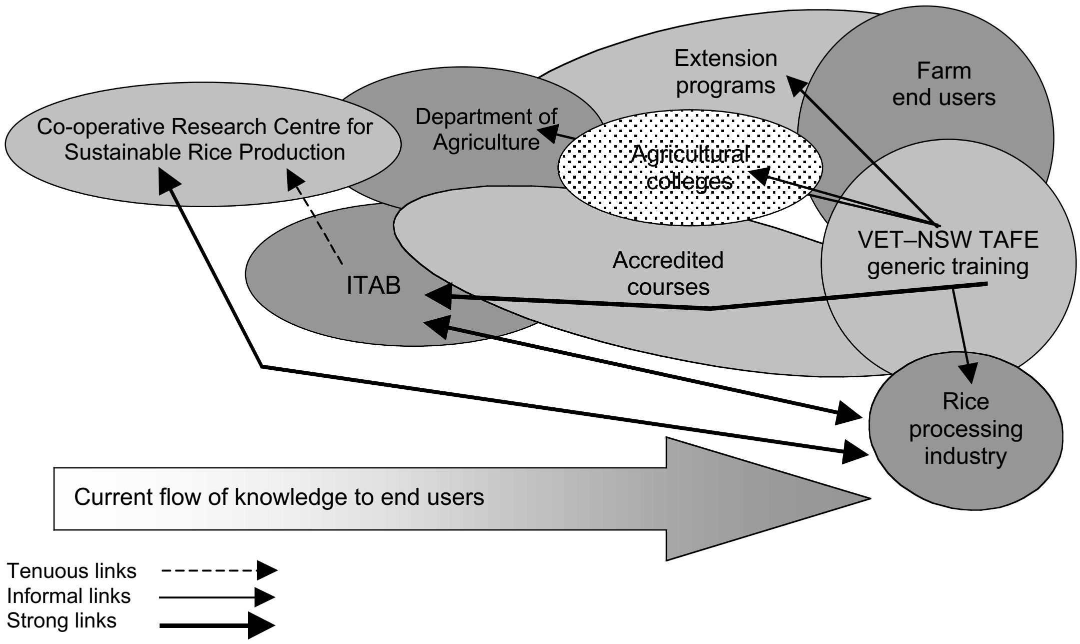
The third education sub-program, mentioned above, is concerned with skills development. This is generally regarded as vocational education and training. As part of its program, the CRC for Sustainable Rice Production has been involved with VET through its core partner the NSW Department of Agriculture and its Murrumbidgee Agricultural College. The department, as part of the CRC, acts as a conduit for the diffusion of new knowledge and practice to the farm, through an extension program of field days and short courses. The Department of Agriculture also produces state (Vocational Education Training Accreditation Board) accredited courses and courses based on the national training packages for delivery at their agricultural colleges.

The CRC's engagement with other VET providers, such as TAFE NSW, is fragmented and negotiated informally at a local level. This engagement may include teacher and student visits to field days, literature or guest lectures. The specific nature and needs of formal training in the rice industry is at present being met through the presence of the Murrumbidgee Agricultural College. The localised nature of the rice industry works against the widespread provision of training. However, as mentioned earlier, some research work has more use on a broader scale. The NSW Department of Agriculture is at present assessing the way this information reaches other agricultural sectors.

Training in the rice processing industry is also highly localised. However, an enterprise training package has been developed in conjunction with the National and NSW Food Industry Training Council. The training can be divided into generic skills such as occupational health, safety and welfare, quality principles and communication skills. These generic skills are being delivered at the Griffith campus of TAFE NSW. A degree of commercial sensitivity has seen the more technical skills that include practices derived from research, are delivered, appropriately, 'in-house'.

Figure 1 presents the current arrangements, described above, for the diffusion of new knowledge and practice from the CRC for Sustainable Rice Production to the industry. As can be seen, there are no formal links direct to VET providers. The centre's link to the State and National Rural Industry Training Advisory Boards (ITABs) is at best tenuous. The ITABs have indicated that this is not a preferred situation. Rather, they would like to see the development of mechanisms for engagement in order to support the transfer of new knowledge and practice into the National Training System.

Figure 1: Current VET–co-operative research centre links

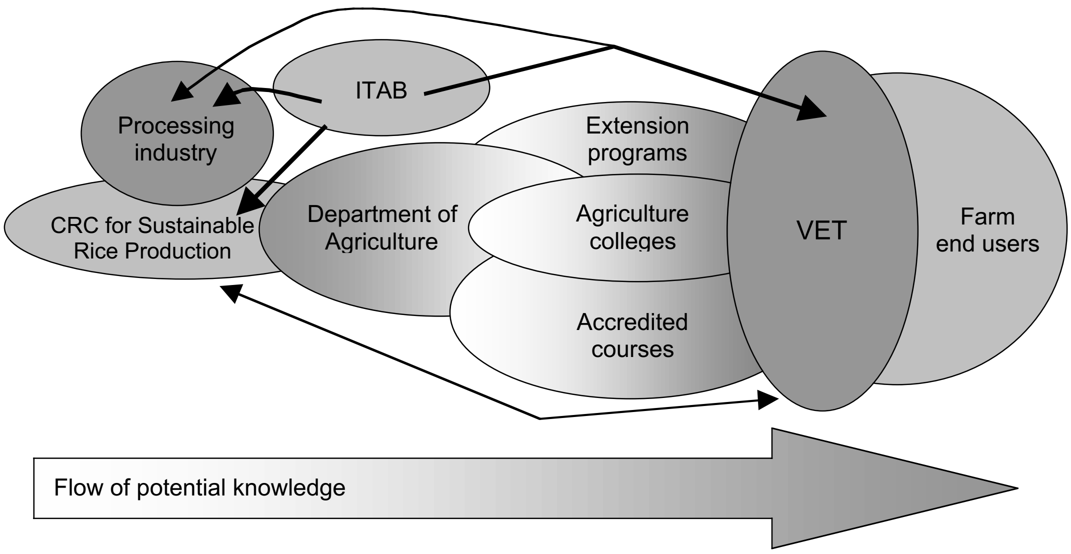


The CRC recognises the importance of vocational skills training and considers that there is much to do in developing stronger links with training providers to develop a co-ordinated approach to training both in rice production and processing. The centre would also like to develop pathways to higher education from within the industry to maintain and develop well-grounded industry management and research capability.

There are, however, barriers that are common to many CRCs. These include a lack of understanding of the VET system, its jargon, organisations and structure, as well as the course development processes. As Laurie Lewin has commented 'the lack of understanding [of VET] by management is a significant barrier to effective planning'.

Figure 2 indicates the role that VET providers and ITABs should play in the diffusion process for agricultural training.

Figure 2: Possible VET–co-operative research centre arrangements



A broader vocational education and training involvement?

While the size, location and nature of the rice industry has seen strong relationships built between research and development, education and the industry, other rural industries do not have easy access to training. In discussions with the NSW Department of Agriculture, it was indicated that there needed to be a development of collaborative and strategic alliances with VET providers, such as NSW TAFE, to enable the department to reach more end users in order to diffuse the knowledge coming out of the research and development sector.

It was envisaged that the Department of Agriculture, as a core participant in many rural industry CRCs, would continue to develop and accredit courses, which could then be either licensed or sold to collaborating VET providers. This would ensure a measure of quality control in delivery and content, and ensure the timely injection of new knowledge into training. As part of this arrangement, those VET personnel delivering courses will receive updates in their knowledge and skills. This arrangement would provide timely and effective delivery to keep the industry abreast of new developments in knowledge and practice, maintaining the cutting edge for a global economy.

From the VET perspective, awareness of changes in practice, new practice and new knowledge would come through the Department of Agriculture, who will have identified the training needs and developed training. Given the traditional role of the Department of Agriculture and its close interaction with rural industry, this would seem a useful arrangement for agricultural CRCs and other registered training organisations (RTOs).

Areas of concern

Those interviewed raised various concerns which could be seen to fall into two areas: 'structural' and 'role'. By this, we mean the way in which training is structured and the roles which entities play within those structures.

Structural concerns

Of concern to both the CRC for Sustainable Rice Production and the National Rural Training Council of Australia is the need for a greater acceptance and take-up of training in rural industries. To this end, the Department of Agriculture is looking to develop more efficient options for the diffusion of research knowledge to the agricultural community. It is currently assessing the feasibility of developing strategic alliances with VET RTOs who already have extensive training infrastructure in place. By using these existing structures and bringing them together, greater efficiencies would be gained.

The Department of Agriculture has made initial enquiries and is concerned that in TAFE NSW the department will have to negotiate the arrangements for delivery of courses with each institute. However, negotiation of these arrangements with a central entity would have been preferable for the department.

Providing cumulative accreditation from the range of training offered, such as extension services, short courses and field days, is a concern of both the CRC and the ITABs. The need is for a system that recognises and provides an incremental accreditation process leading to a course completion. This will require alignment of current competencies to these short courses and the addition of new competencies required to meet the developments in the industry. Structuring such a system will aid in giving recognition for the rural knowledge base held by those in the industry.

With many short courses already developed and more being created to meet niche areas of skills development, the CRC has noted the lack of co-ordination surrounding delivery and content. For the farmer, this provides a confusing maze of courses without clear connections or pathways to accreditation. The centre believes that considerable attention needs to be directed at co-ordinating these courses and developing clear pathways and connections for farmers to determine the best training options.

Of concern to some is the role taken by ITABs as industry training advisors. It is considered that they are not always seen to reflect the industries they represent. Given the resources available to ITABs and the diverse nature of the rural industry, it is understandable but not acceptable. In addition, due to its resource base and ability to respond, the ITABs can be seen as a blockage to the process of rapid development of competency standards. This limits the timely inclusion of new skills in training.

Concerns about organisational roles

The perception of what a CRC is and its role and importance to the national training bodies was raised. It was noted that while strong links exist between the well-established research and development corporations, the CRCs are seen as somewhat tenuous entities that come into existence for a specified period of operation before disappearing, and so they rate low in importance.

It is also clear, from discussions with the NSW Primary ITAB, that it is the National Rural Training Council's responsibility to liaise with research and development bodies as part of the consultation process that develops competency standards. The liaison process is viewed by the NSW Primary Industry Training Advisory Board as a somewhat ad hoc process that could be improved through greater understanding of the various roles and responsibilities of stakeholders.

The National Rural Training Council also believed it had not tapped into the research and development sector as well as it could and that it would like a mechanism to enable access to new knowledge relevant to training package content and new competencies. It is currently involved in a national project to establish a web-based training provider database which gives details of courses available to rural industries. It has been suggested that a similar database containing **research and development developments** could provide a mechanism for awareness of **developments**.

The NSW Primary Industries Training Advisory Board also considers that much new knowledge could be introduced as content rather than as a new competency standard. This places the responsibility for keeping abreast of industry **research and development developments** with the RTO. The National Rural Training Council, however, viewed its relationship to new knowledge and content somewhat differently, arguing that it does have some responsibility in influencing and supporting training package content and certainly identifying new competencies within that content.

Finally, when training is provided by a VET organisation, there is a concern that those who deliver the training may be unfamiliar with the specific context. Many of the skills may appear to be generic having existed and been taught for some time in particular contexts familiar to the trainer. The need will be to contextualise and teach these skills for the specific agricultural industries and their contexts. For example, if an educator is unfamiliar with the rice industry, it would be more difficult for them to contextualise the information thus making the training less effective. Recognition of this, and the professional development of rural educators to meet these needs, will be required.

Conclusion

The future of the rice industry is at present somewhat uncertain. Industry needs of sustainable practice and market advantage demand a strong relevant research program that is supported by timely training. The CRC is meeting these needs through a research education program which is supportive of skills development. In order to better disseminate information coming from the CRC and other agricultural research programs, the NSW Department of Agriculture is looking to other VET providers in order to utilise their infrastructure and increase efficiency of delivery.

There are, however, structural and role concerns that need to be addressed in the national VET system. The VET system needs to be active in approaching CRCs to raise awareness of the VET sector and develop connections. This would enable a more rapid response to the introduction of new technology and support existing technology delivery in a co-ordinated way, thus supporting the sustainability of the rice industry.

To respond to the emerging skill needs of agricultural industries, there is a need to develop and maintain strong links with the research and development sector. It is clear that the VET sector has the infrastructure to support training. Challenges lie in the development of structural ties with the research and development sector to enable the flow of information and its use in courses. There is a grey area in the assessment of new knowledge and whether the development of new competencies is required or it is new content under an existing competency standard. This also raises issues about the quality and depth of the course content, and how new knowledge is included into existing accredited training.

In view of the ITAB's perception of competency standards and content, the onskilling of teachers in new knowledge and practice and the inclusion of that into courses will require a well-developed and effective collaborative approach. This will develop the strong formal and informal networks between VET RTOs and the rural research and development sector.

Predicting the emergence of skill needs and the demands of training in agriculture requires a close reading of the complex interactions of public, environmental and commercial factors that shape the industry. The emergence of knowledge from the research and development sector will often reposition these factors; for example, enabling production with less environmental impact through new sustainable practices that would ameliorate public concern and allow continued operation of the industry.

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Graham Knott, human resources manager, Rice Growers' Co-operative

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Case study 2

Cast Metals Manufacturing

(Co-operative Research Centre no.8)

Cast metals manufacturing

Introduction

Since Ralph Lawrenson's construction of a crude die-casting machine in 1913, the Australian die-casting industry has been engaged in developing world leading die-cast technology. In 1973 a co-operative association, between the cast industry and the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Manufacturing Science and Technology Division led to the development of die-casting equipment that enabled, for the first time, the measurement of important casting process parameters such as metal flow rate, pressure and temperature.

This work led to rapid improvements in machine and die design, placing the Australian industry at the forefront of die-casting technology. However, in the 1970s and 1980s, many manufacturing companies closed or moved offshore. This effectively reduced the number of small die-casting companies, slowing advances in the industry's research and development. In the following decade, a shift from a domestic focus to an export focus stabilised the industry and began a new era for the light metals industry.

Today, the growing international demand for light metal products, particularly in the automobile industry, presents a significant opportunity for the Australian industry that has some local advantages. These advantages include large accessible bodies of aluminium and magnesium ore, relatively low cost of power to process the ores and a die-cast industry that in some companies remains technically advanced and globally competitive.

The introduction of the Co-operative Research Centres (CRC) program in 1990 saw the formation in April 1993 of the CRC for alloy and solidification technology (CAST) and its reconfiguration into the new CRC for cast metals manufacturing in 2000. The CAST CRC has brought together industry, the CSIRO, universities and government participants to support industry-relevant research and innovation in order to meet the needs of an 'internationally competitive and vertically integrated die-casting industry sector'.

This study looks at the work of this CRC and begins by outlining the nature of the die-cast industry, developments in the industry and its current training regime. The research, education and commercialisation programs of the CRC for cast metals manufacturing are then discussed in relation to the particular interest of this study; that is, the relationship between the new knowledge and practice being developed by the CRC research program and its relevance to the vocational education and training occurring in the light metals industry. The study concludes by outlining some of the issues related to industry training and the development and maintenance of a skilled workforce to meet industry's current and future needs.

Industry

The cast metals industry in Australia can be separated into a foundry industry and a die-cast industry. The foundry industry is labour intensive and works with both ferrous and nonferrous metals. The process uses patterns to create a mould cavity, generally in sand, into which molten metal is poured in order to produce the cast product. Ferrous and nonferrous metals can be cast and there is little limit on the size of the castings, with some weighing up to 50 tonnes. Castings made by this method are usually limited to low production numbers. Examples of castings made this way include agricultural pump bodies, cast-iron engine blocks and large bronze ship propellers. Advances in technology have increased efficiency. However, the essential process to produce castings from sand moulds has changed little since the Egyptians began casting their bronze statues over 3500 years ago.

In contrast, the die-cast industry is a relatively modern process beginning around the late 1800s. However, in die-casting, the metals cast are limited to nonferrous metals such as zinc, brass, aluminium, magnesium and various others. The castings are produced from a split steel mould or die, and mounted in a die-casting machine that forces, under gravity or pressure, molten metal into the die cavity. On solidification of the metal, the mould splits, releasing the casting.

This process is especially suited to modem manufacturing, where highly mechanised and low labour content processes are sought. The die-casting process is capable of high production rates and can produce components in complex shapes with narrow wall thicknesses and high accuracy in size and finish. The process has revolutionised the use of cast products in manufacturing and, as such, is now a critical part of the manufacturing process. Some of the products based on die-cast components include electronic equipment, camera bodies, automotive components and household appliances.

The die-cast industry in Australia consists of about 90 companies, of which 12 produce the majority of the castings and account for about 75% of the industry's output. Companies are classified as 'in-house' or 'contract' to identify the nature of their operation. 'In-house' manufacturers produce die-cast components for their own use and include the four automobile manufacturers: Ford, General Motors Holden, Mitsubishi and Toyota. 'Contract' die-casters, who make up the majority of the companies, are often small family businesses who supply other manufacturers with cast components.

In 1996 the industry employed around 3300 skilled workers and provided a significant contribution to the Australian economy through exports. Figures from the Australian Die-Cast Association for 1996 show that at that time 54 000 tonnes of cast aluminium products were being produced, with a value of $420 million. Of this, 23 000 tonnes of vehicle components were being exported. There is a bright future for the light metals industry as indicated in the 'global focus on the use of new materials and light weight metals' (Light metals action agenda, 2001). This interest is evident in the increasing demands for lighter, more efficient vehicle construction and highlights the importance of the die-cast industry as an industry that can value-add to a natural resource and generate significant export earnings.

Industry developments

The genesis of the Australian die-cast industry has been traced to the work of Ralph Lawrenson in 1913. Innovations in equipment, both in Australia and internationally, continue to develop the utility of die-castings in manufacturing efficiencies in production. The post-World War II increase in mass-produced goods, that included household appliances, cars, electronics and hardware, led to a rapid increase between 1950 and 1970 in the use of die-cast components and the number of die-casting companies.

As a result of this rapid industry growth, concerns with product quality and the need to improve both the dissemination of technology and the development of a skilled workforce, the Society of Die-Casting Engineers was formed in 1965. Soon after, the Die-Casting Institute of Australia was formed to represent the zinc and aluminium die-casters. In 1985 these two organisations merged to form the Australian Die-Casting Association (ADCA), which now provides the industry's main forum and support mechanism. The association, as part of its role, is actively engaged in developing and supporting industry training, research and development.

Industry rationalisation

Since the 1980s, global economic shifts and a rationalisation of the manufacturing industry have placed pressure on the die-cast industry to increase its quality, efficiency and competitiveness in a more export-focussed market. Many companies who did not keep pace with advances in technology were left to produce low-value and low-cost products, thus reducing their profits and ability to compete.

These changes have significantly reduced the number of smaller companies in the industry. If the remaining companies are to take advantage of the new demands for light metals products, those who remain need to continuously improve their operations through training and the introduction and application of technology. The new technologies enable the production of high-value, high-return castings and a place in the world market.

While significant advances in technology were made in the 1970s, it is now the continual and incremental development that provides the industry with a competitive edge. Despite the rationalisation of the last few decades, the industry has continued to maintain a strong research and development focus. This has enabled continued development and industry excellence, which has been recognised internationally through awards such as the 1981 Grand Award of the American Die-Casting Institute won by Lawrenson Die-Castings Pty Ltd. More recent industry awards for other companies include those for a 16-port cylinder head casting, a motorcycle laced wheel hub for Harley Davidson and an automotive engine fuel rail. These awards 'demonstrate how the Australian die-casting industry is both embracing and creating new technologies as it succeeds in supplying high integrity products internationally' (ADCA 2001).

Value-adding

Apart from the development of new technology in the casting process, one of the key shifts in the die-cast industry has been to 'value-add' to the cast product by providing additional processing of the casting. This usually includes various machining and finishing operations. Other opportunities to 'value-add' include the 'front-end' services such as design services, rapid prototyping and efficient die production.

It was noted by one interviewee that the Australian industry's tendering capability is limited by its production capacity. The example was given that many international companies have the resources to design, build and test-run a die-set as part of their tender process. They are able to do this because of their capacity to supply very large orders from which the profit margins offset the initial costs of other tenders.

At a national level, there is also a significant opportunity to further value-add to the exports of aluminium through the processing of more raw materials into castings. The production and export of die-cast automotive components is a good example of using the Australian industry's advantages, of accessible raw materials and low-cost power to value-add and to increase exports of these products.

Industry training

The industry's training occurs at three levels: operator, technician and engineer. Engineer training is provided through degree courses at various universities, while the operator and technician courses have been developed and co-ordinated by the Australian Die-Casting Association since 1993.

The take-up of training in the industry is to be seen more in the progressive companies. Here the introduction of new technologies has demanded new skills and a greater understanding of the underlying principles of die-casting processes and equipment. Formal training, both in research and at the operational level, is enabling the industry to use cutting-edge technology.

The basic operator training delivered is not formally recognised outside the industry. Rather, it is recognised within the industry as a qualification that develops a basic operator level of understanding for the casting process and the technologies being used. As such, it is considered entry-level training for the industry. The training covers the basics of plant operation in six modules, each of ten hours' duration and is often carried out 'on the job'.

Technician-level training in the die-cast industry, while relatively recent, is already considered essential given the level of technology now being applied. In fact, technicians are now considered to be the crucial element in the die-casting operation. Through their training, an understanding of the technologies being applied is developed to identify root causes when problems arise and to support the continuous improvement of processes. Their work and skills are a key element in the implementation of new technologies as they participate in the development and commissioning of dies and die-cast equipment.

Training for technicians is at present mainly carried out at the Royal Melbourne Institute of Technology (RMIT). The Engineering Employers Association of South Australia also provides training using, under licence, the RMIT courses.

The arrangement between CSIRO and RMIT is supported by ADCA regarding RMIT's course information, noting that 'the course cost of development and conduct to date is partially funded, sponsored and recognised by the Australian Die-Casting Association'. ADCA also notes its role in negotiating with RMIT and CSIRO, so that CSIRO equipment could be used in the training program.

The course, an Advanced Certificate in Die-Casting Technology, was developed in collaboration with ADCA, RMIT and the CSIRO. With the introduction of the national training packages, the course is presently in the process of being aligned to the national competencies, in order to provide a national accreditation.

The success of this training program has seen over 700 individuals completing operator training since 1993. The advanced certificate has also begun to develop a strong technician base in the industry over the last few years. However, in the last two years, there has been a reduction in operator and technician training. RMIT staff consider this due more to the high levels of unemployment than a reduced industry performance. This occurs because of the reluctance or ability of trained operators to migrate into other employment in a low-demand labour market. This then reduces the turnover in staff and the need to train new employees.

Forecasting training demands

The reduction in numbers being trained is not indicative of the potential need for future training, particularly if the industry is to take advantage of the developing demand for light metals manufacturing and Australia's capability to supply aluminium and magnesium.

As already mentioned, the vehicle industry is looking to light metal castings to reduce vehicle mass and improve efficiencies. The Partnership for a New Generation Vehicle (PNGV) project is a partnership between the US Government and Daimler Chrysler Corp, Ford Motor Co and General Motors Corp that began in 1993.

This project is working towards the development of passenger vehicles with up to 30% increase in fuel efficiency. New manufacturing technologies and lightweight materials will contribute to a projected vehicle weight reduction of 40%. The extensive use of aluminium and magnesium alloys will provide much of this weight reduction and indicates an increasing demand for these metals.

Australia is poised to take advantage of this demand with the development of the Stanwell Magnesium project in Central Queensland. Currently under construction, the project is expected to have an output of 92 000 tonnes of magnesium per annum. Regional developments to value-add this output include die-casting and associated industries at Stanwell and Rockhampton.

The Federal Government's light metals action agenda announced on 18 October 2000 also notes Australia's unique position 'to take advantage of the world's increased interest in lighter metals'. The background paper for the agenda raises the concern that 'the availability of a skilled workforce may also be an issue facing [light metals] industries in the future'. It continues in this vein articulating, in particular, the potential 'skills gap' and a concern with the 'availability of highly skilled design engineers, precision tool makers, and personnel with die-casting expertise'.

Clearly, the growing global demand for light metals and Australia's developing capability to supply that demand will require the availability of a range of skill needs, including the skills of die-casters who are familiar with the latest technology. Against this background, the CRC for CAST metals manufacturing has a significant role to play in supporting industry-based research and education.

The CRC for CAST metals manufacturing

The CRC for CAST metals manufacturing, which began in July 1999, is a continuation of the CRC for alloy and solidification technology, originally established in 1992. The CRC's objective is to 'support the development of the magnesium and aluminium light metals industry through the development of technology and its transfer to the industry' (CRC for CAST Metals Manufacturing 2000).

The CRC, with a grant period of seven years and total funding of $107 million, is headquartered at the University of Queensland. The CRC is comprised of 16 core partners made up of six companies, three industry bodies, four universities, the Queensland and Victorian State Governments, and the CSIRO's Manufacturing Science and Technology division. The CRC began with 65 full-time staff and 25 postgraduate students.

A governing board of 12 members, representing the participants, sets policies and provides direction to the CRC. An industry technical committee provides a forum for industry representatives to have input into the development of research proposals. The research providers committee supports the collaboration between research organisations through recommendations on planning, budgeting and personnel. The CAST Centre Pty Ltd manages the centre and the intellectual property developed as a result of the research, acting as an agent through which commercial opportunities can be achieved.

The CRC is now in its second round of funding with the creation of knowledge, its dissemination and utilisation achieved through the three programs of research, education and commercialisation. These programs are discussed in more detail in the following sections.

Research programs

The research program is divided into four research programs that represent four light metals industry sectors, two each dealing with magnesium and aluminium. The programs detailed below are: magnesium production, magnesium applications, aluminium cast-house products and aluminium die-casting.

Magnesium production

The emerging Australian magnesium industry has the opportunity to develop and include cutting-edge, environmentally friendly technology in its production processes. To support this, the CRC's Magnesium Production program focusses on 'developing processing technology that is competitive in cost and metal quality while satisfying environmental demands'. This program has four subprograms: melt protection, intense refining, magnesium alloy production and life cycle analysis.

Already of significance in this program is the development of a replacement for the toxic greenhouse gas, sulphur hexafluoride, which is used to prevent magnesium from burning in air in its molten state. This has recently been achieved with the CRC patenting a process that uses the hydroflurocarbon gas HFC–134a, commonly used as a refrigerant in car air-conditioners. This process has the potential to reduce greenhouse gas emissions in the production of magnesium by over five million tonnes of carbon dioxide equivalent per annum.

The CRC is also developing methods to improve metal quality through more accurate measurement and the reduction of non-metallic impurities in liquid magnesium. In producing magnesium alloys, research to reduce the associated operating and capital costs will contribute to the industry's efficiency while the 'life cycle analysis' work will develop a tool to assess the efficiency of production and use of magnesium products.

There is little direct impact of this program on vocational education and training. However, its flow-on effects into the development of the light metals industry foreshadows the need for skills training to support the industry's development, as it takes advantage of the growth in magnesium production.

Magnesium applications

This program 'provides a strategic approach to build the capabilities and knowledge required to service the growing demand for magnesium automotive components'. An important research project in this program is the development of a magnesium alloy that will operate at elevated temperatures. This is an important breakthrough if extensive use of magnesium is to be made in the automobile industry. Other programs include 'corrosion performance of protective coatings', 'production and processing of wrought magnesium alloys', 'magnesium casting property database' and 'design and development of magnesium die-castings'. These programs will build an understanding of magnesium properties to enable the design of components that take full advantage of those properties.

With Australia's future as a major supplier of magnesium to the world market, the knowledge and information from this program will assist companies as they build capability in the use of magnesium. The knowledge gained will be particularly useful for design engineers and those studying computer-aided design (CAD).

Aluminium cast-house products

Program three looks at the products of aluminium cast-houses, such as ingots, extrusion billets and rolling slab. The program is looking to provide improvements in the efficiency in production and quality of these products. The six sub-programs will, through the development of models and an indepth understanding of the various processes, extend the industry's knowledge base to maintain existing markets and build Australia's future market share in these products.

Knowledge created in this program will have a bearing on the process parameters for aluminium products. As such, the information is highly technical and of high relevance to metallurgical engineers, rather than operational staff. Its use in the VET sector is highly unlikely, although the essential findings would provide underpinning knowledge for an understanding of cast-house processes.

Aluminium die-casting

The last research program, aluminium die-casting, is working to 'optimise casting technologies to ensure reliable, low-cost production of high-integrity cast components'. In order to achieve these goals, process improvements are being developed through projects that look to reduce 'cycle times' and develop 'automated fault detection systems'.

Research into die operation includes the modelling of fluid flow inside die cavities, die coatings for component release and die design. This research supports the quality production of intricate, structurally complex designs called for in modern castings. This also supports the sub-program to improve the quality of aluminium castings through an understanding of the process variables, providing important technical information for die technicians. Information from this program is important to the VET training of technicians and operators, as they work to train staff and increase the quality, productivity and competitiveness of die-casting operations.

The CRC research program covers four broad areas of the light metals industry focussing directly on industry's needs. While much of the research is highly technical and may seem to have little relationship to vocational training, the very nature of the research is that it informs and directs industry practice. From this viewpoint, there should be an important relationship between research and development and VET. This argues for a mechanism that will support the flow of new information into formal training which could, also, potentially shorten the time to introduce a new technology.

Education and knowledge transfer

A core function of the CRC program is the transfer of knowledge gained to the industry base. The CAST CRC achieves this in several ways.

First, to ensure research relevance, the industry is strongly represented on the CRC board with seven of its 12 members appointed by industry. The industry technical committee further ensures that the research is relevant to industry needs.

Secondly, the transfer of research outcomes to industry is achieved through close collaboration, a quarterly newsletter *Broadcast*, participation in project reviews, and CAST reports on the research.

Thirdly, industry short courses enable small businesses, who are not directly involved with the CRC, to access developments in technology. These support and encourage the small and medium-sized enterprises (SMEs) to develop industry best practice and provide an awareness of evolving technologies. In 1998–99, five short courses were run—three in Melbourne and two in Sydney—with a total of 114 participants. Three of these courses were delivered in collaboration the Australian Die-Casting Association. Technology transfer of this nature is also achieved through visits to industry and the informal contacts made during collaborative research, consultancies and contract research.

Lastly, the education program provides undergraduate and graduate students with industrially grounded research opportunities. This is an important function as, over recent years, the requirements of the light metals cast industry have become more complex. The industry has found it 'difficult to recruit appropriately trained engineers because they require a mix of skills relating to metallurgical processing and materials to cover the diversity of job responsibilities'. In addition, at present there is almost no expertise available for the growing magnesium industry. The training of engineers and researchers in this area is providing a strong, industrially focussed research base that is essential to support the projected growth of this industry.

With these needs in mind, the CRC is committed to all levels of skills development. As part of its commitment to undergraduate and postgraduate training, it has a close involvement in university teaching and supports course development by providing content and advice on relevant topics. In 1999–2000, seven undergraduate students were supervised and 26 postgraduate students were enrolled. Over the previous seven years, the CAST CRC has completed 30 PhDs and 20 Masters degrees, with 92% of these postgraduates remaining in the light metals industry or related research areas.

At the technical and operator training levels, the CRC is faced with an industry where many smaller companies are less willing to train their staff beyond their immediate needs or to introduce new technology. This is in contrast with the larger companies who, being progressive, are prepared to take advantage of industry changes and implement new technology. As yet, the CRC has not developed strategies at this level and is awaiting the results of their industry benchmarking project.

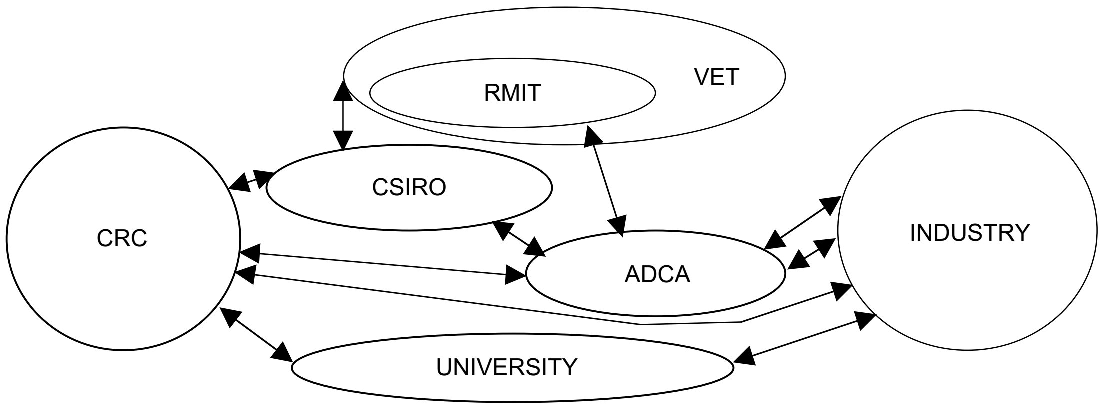
The light metals action agenda makes clear the industry potential and considers the CRC's work with industry training as being an important mechanism 'to improve skills available to the industry at all levels'. Vocational education and training provides industries with a wide, strong skills base and, as such, is a key factor in raising skill levels. The CRC's involvement and approach to this area is discussed in the next section.

Vocational training

Foundry training has a long history and tradition that has its roots in the early industrial revolution. The training has therefore been formalised through apprenticeships and various worker categories. However, the more recently developed die-cast industry does not have a strong training history. Often, those with foundry training previously provided the skilled labour and were supported by unskilled labour, trained on the job as operators for the industry. Large companies such as Comalco have developed and provided, out of necessity, structured in-house training. However they, like others, are now considering options to outsource this training. The replacement of in-house and informal training with accredited formal training has been addressed by the Australian Die-Cast Association's development of operator and technician training courses at RMIT and in conjunction with the CSIRO.

The link between RMIT and CSIRO is provided by the CSIRO's Manufacturing Science and Technology Division, where a member of staff teaches and co-ordinates the program at RMIT. This will also support a level of technology transfer into the training program. Figure 1 maps the links between CRC, its participants and the VET sector.

Figure 1: Links between the CRC, other participants and the VET sector



From discussions with the CRC education manager, RMIT staff and the Australian Die-Cast Association management, it was interesting to find that there is no formal or direct collaboration between RMIT and the CRC, despite the core participant relationship between the ADCA, CSIRO and the CRC. This perhaps can be explained by the fact that the CRC believes the industry's current training needs have been well met by the RMIT training program.

Despite the lack of a strong involvement in the vocational education sector it is clear, from discussions with the CRC, that their intent is to pursue the development of industry training at this level as part of their holistic approach. Part of this approach is their current benchmarking of 18 companies, in order to gauge industry performance against world practice and to determine their needs in a range of the areas, including training. They are also looking to utilise a short training program model, developed by the Intelligent Manufacturing Systems and Technologies CRC, to raise awareness amongst trainers of new casting technologies.

Commercialisation

The commercialisation strategies and program of the CRC include the following:

- the involvement of industry in each research project
- the generation of effective linkages with Australian and overseas research operations to ensure the availability of world competitive technology
- an understanding of the needs and opportunities in light metals for Australian companies
- the focussing for research projects on the technology advances needed by industry
- the development of supply chain synergies for greater efficiency and benefit from technology
- close work with SMEs to meet technical needs and provide commercial opportunities
- the capture and commercialisation of intellectual property from the research
- the integration of global knowledge developments into new and improved technologies.

(CRC CAST Metals and Manufacturing 2000)

To achieve these strategies, a commercialisation manager and the deputy chief executive officer co-ordinate the program.

The CRC's work in supporting and commercialising new products, methods and techniques for the industry is intended to develop an Australian die-casting capability to and beyond world standard. As an example, and increasingly important for the industry, is the development of software for the rapid design of die-cast moulds and software that is user friendly for casting equipment operators. Australia is currently a world leader in this area, due to the work of the ANCA and Moldflow companies.

With a focus on process improvement and new technologies, the commercialisation of the research is achieved mainly through consultancies, with the remainder being collaborative research with the core partners, contract research and project support. In contractual arrangements, the licensing arrangements generally allow the CRC to maintain ownership over the intellectual property generated. In turn, this contributes to the body of available knowledge within the centre.

As yet, no start-up companies have resulted from the research and it is unlikely that this will happen. The CAST CRC, like other CRCs whose work supports an existing industry base, is more concerned with process improvement and incremental development, rather than industry creating technologies. As a result, nine patents, six of which are international, have been taken out over the life of the CRC. They include a mould lubricant, new alloys, the magnesium cover gas, direct chill casting techniques and an automotive seat frame and mounting mechanism.

Areas of concern

Perhaps the most significant concern for the CRC is the potential closure of VET training facilities due to the reduced number of students. The high capital cost of maintaining such training facilities, and their low utilisation, makes them a seemingly rational target for closure. At present, there are two facilities providing public vocational training to the light metals casting industry. One provides the traditional foundry training and is located at the Illawarra Institute of TAFE NSW's Wollongong campus. This facility is training, on average, seven to eight trade students per year and draws them primarily from Queensland, NSW and New Zealand. The second facility, serving the needs of the die-cast industry, is located at RMIT. Both these facilities are under pressure to justify their continued presence.

The superficial views and arguments about cost-efficiencies have made the availability of public training facilities in this area even more tenuous. However, the articulated concerns about skills shortfalls in the light metals industry action agenda would, instead, argue for the enhancement and development of these and other training facilities to prepare a strong skill base for emerging industries.

Another concern is the lack of individuals wanting to enter the industry and its perceived unattractiveness to young people. This is also evident across other engineering trades areas. Engineering in the trade areas is often seen as dirty, manual, labour-intensive work offering poor wages and conditions and is less socially acceptable in comparison to the white-collar computer-related technician and communications worker. There is also little information available about opportunities in the industry. This is in contrast to the North American Die-Casting Association, which provides extensive information regarding careers, wages and fringe benefits of the industry on its website at www.diecasting.org/jobs/careers.htm. The American foundry industry also provides similar online information at www.FoundryOnline.com.

Other concerns relate to the industry's ability to adopt new technology and the need to value-add to the production of light metal castings in Australia in order to increase export returns. There is a need for many industry managers to develop a more innovative approach to equipment, labour, processes and products, and a program of continuous improvement that has a stronger interest in staff training.

Conclusion

The light metals industry has seen periods of development and change since the 1900s. The significant reduction in manufacturing industries led to rationalisation in the industry, despite evidence that it could be innovative and progressive in adopting new technology. Research and development in the Australian context has been world class and primarily undertaken by the CSIRO. The research in the past has often placed Australia at the forefront of technology development.

While training has only been formalised and developed to meet industry's needs in the past decade, the rapid advances in light metals manufacturing technology and demand for light metal products, if realised in Australia, are set to place increasing demands on current training resources.

Clearly the industry and federal and state governments are supportive of major developments in the Australian capacity to produce light metals and their products, in order to increase the export of Australian goods.

To assist this, the CRC for CAST Metals Manufacturing is working to increase knowledge in the industry in order to place Australia in the forefront of light metals technology. Its graduate and postgraduate education program is providing part of the skills spectrum and it appears committed to addressing the needs of the other, more operational training needs, in concert with the industry.

It is recognised that there will be a skills shortage as the light metals industry expands to take advantage of global demands. Encouraging individuals to take up work and training in the industry to support this growth will place demands on currently available training capacity. Equally important will be the flow of relevant new knowledge into the training of technicians and operators, to take full advantage of new technology.

Arguably, the next decade has the potential to see the industry expand rapidly, from extraction to manufacturing, to become a major international supplier of light metals and their manufactured products.

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Case study 3

Landscape Evolution and Mineral Exploration

(Co-operative Research Centre no.25)

Landscape evolution and mineral exploration

Introduction

It is well-recognised that there is a serious salinity problem in rural Australia. We are now facing environmental degradation on a scale that is difficult to comprehend. Research and projects to limit salinisation have been ongoing for over a decade. However, recent reports show the nature of the problem has been underestimated and it will require a much greater effort to stop further decline before beginning to redress the damage already done.

In 1998 over 4.5% or nearly one-twentieth of cultivated land was affected, costing over $130 million annually in lost production. With 5.8% of the workforce linked to the natural resource base and over 50% of our exports being derived from the resource sector, it has had, and will continue to have, even more profound economic, social and ecological impacts. The total cost of this problem now exceeds $2 billion annually and is predicted to rise to $6 billion in 2020 if nothing is done.

Two recent developments include advances in airborne electromagnetic (EM) systems and the promise of $1.4 billion from the state and Commonwealth governments through the national action plan for salinity and water quality in Australia. These promise to have a major impact on the problem of salinisation. It has also been suggested that these two developments will support the emergence of a new industry in the area of salinity management and remediation. This will have implications for vocational education and training (VET) in the provision of operational skills for this industry.

Within this context, the study presented here briefly traces the development and application of airborne electromagnetic technology—in a geological systems context—to salinity mapping through the work of two co-operative research centres (CRCs). The study then looks in more detail at the work of one of these, the CRC for Landscape Evolution and Mineral Exploration (LEME), and its leading work in the area of salinity mapping.

Co-operative Research Centre for Australian Mineral Exploration Technologies (CRC AMET)

The Co-operative Research Centre for Australian Mineral Exploration Technologies (CRC AMET) was established, largely as a result of initiatives by the Australian mineral exploration industry, to develop new mineral exploration techniques suited to the unique Australian landform. CRC AMET began operation on 1 July 1992 for a seven-year period, with a brief to direct its research effort into the area of geophysics and especially electromagnetic geophysics.

Australia, as an old continent, has a highly weathered landscape that has resulted in a relatively deep layer of regolith—the layer of silt and rubble that covers the bedrock. Older electromagnetic (EM) systems, which work successfully in other parts of the world, have difficulty operating in the deep layers of Australian regolith.

CRC AMET's aim, to 'develop and deliver dramatically improved electromagnetic methods (especially airborne electromagnetics) for exploration environments characterised by complex, conductive regolith cover' (CRC AMET 1999), has been successful. The development of a new generation of EM geophysical technology, optimised for Australian conditions, has added significantly improved techniques for mineral exploration.

Core participants

The core participants in the CRC were:

- CSIRO Exploration and Mining
- Macquarie University
- Curtin University of Technology
- World Geoscience Corporation Ltd (now Fugro Airborne Survey Pty Ltd)
- Australian Geological Survey Organisation (AGSO)
- Geological Survey of Western Australia
- Australian Mineral Industries Research Association Ltd.

Research

Necessarily, CRC AMET's research was narrowly focussed on the EM systems and their development to meet Australian conditions.

The research programs were:

Airborne electromagnetic systems

This program developed the TEMPEST airborne EM system, a combination of a wide bandwidth, square-way transmitter with sophisticated noise rejection and continuous data acquisition. The system is fitted to a dedicated aircraft that flies at low altitude over the terrain to collect data on the structure of the regolith. From this data the location of electrically conducting mineral deposits can be ascertained. In addition to mineral exploration, this technology has been found suitable for near-surface environmental mapping that can, through a complex interpretation of subsurface electrical conductivity versus depth and other geological data, identify groundwater flows and the subterranean structures that affect these flows. This system has been commercialised and is currently available from Fugro Airborne Survey Pty Ltd (formerly World Geoscience Corporation Ltd).

Electromagnetic interpretation

The development of software to process and interpret airborne EM data rapidly has been the result of this program. This software provides complex analysis of the data being collected. It has been commercialised through Encom Technology Pty Ltd and is now used around the world in mineral exploration.

Mathematical geophysics

Computerised modelling from EM data, in two and three dimensions, assists in the interpretation of the results. This program has provided the fundamental mathematical work necessary to develop the 'EM Vision' software, which has also been commercialised by Encom Technology Pty Ltd.

Airborne electromagnetic mapping

The application of airborne EM technology, from the data collection hardware to the software programs for analysis, has been developed in this program. A district-scale project was undertaken over an area of 1100 square kilometres to test and develop the applications. It was centred on the Gilmour fault zone in the Temora area of New South Wales. This was a collaborative project, co-ordinated by the Australian Geological Survey Organisation, and included the Bureau of Rural Sciences, CRC AMET and CRC LEME. Importantly, it gave an indication of the exciting potential for recent developments in airborne electromagnetic technologies to assist in the mapping and management of dryland salinity.

Education

Like many CRC education programs, this program has been centred on tertiary education. CRC AMET offered postgraduate scholarships, and a masters and honours program. In the final year of operation, 13 students were undertaking research with CRC AMET. Employment of the graduates, at the completion of their studies, shows that the majority are now working in industry, with around 35% working in universities.

There was no involvement with the vocational education and training sector during the term of this CRC.

Commercialisation

CRC AMET's work has been highly successful, resulting in the commercialisation of a suite of airborne EM technologies. The success of this CRC, in developing new knowledge and technologies, has taken the minerals exploration industry forward. At the same time, a spin-off from the technology has resulted that is set to revolutionise the way in which we address the Australian salinity problem.

Closure

In their seventh year of operation, CRC AMET was granted additional funding to take them into their eighth year as they wound down their operation. Their bid to secure funding for a new CRC in exploration geophysics failed, largely because of a low level of industry support. This lack of support coincided with a downturn in minerals exploration expenditure—a result of the cyclical nature of the minerals exploration industry.

There was considerable disappointment among CRC staff after their unsuccessful bid for a new CRC. Even more disappointing for Australian science is the indication that, because there are few other Australian opportunities for research in this field, many of the staff will be taking their knowledge capital offshore.

Co-operative Research Centre for Landscape Evolution and Mineral Exploration (CRC LEME)

CRC LEME was established in July 1995 for a seven-year period, with 48 full-time equivalent research staff, 21 postgraduate students and a total funding of $70 million. Its task was to generate new knowledge in regolith landscape evolution, identifying implications for mineral exploration and mining and developing new improved geochemical exploration methods.

It has recently been funded for an additional seven years and, using the same acronym CRC LEME, has renamed itself Landscape Environments and Mineral Exploration. The substitution of evolution for environments in its centre name is an indication of new directions for the CRC that are an outcome of work done in its first seven-year period.

Core participants

The core participants for the first CRC were:

- The Australian National University
- The University of Canberra
- Australian Geological Survey Organisation
- CSIRO Exploration and Mining.

Research

CRC LEME's research program has six strategic research themes to address major industry needs in understanding the evolution of the Australian landscape and to translate that into an improved ability to recognise mineral deposits.

An outline of each research area follows, with the first, 'mapping regolith in three dimensions', being more detailed because of its role in developing the new environmental focus.

Mapping the regolith in three dimensions

The objective of this research has been to develop techniques for the preparation of three-dimensional regolith maps, particularly for use in mineral exploration. The program centred on three regions of which the Gilmour project has had the most impact on environmental issues. This project provided the opportunity to take a collaborative and multi-disciplinary approach to data collection that included field mapping, drill hole logging, interpretation of airborne magnetics, radiometrics and electromagnetic surveys. Collaborators in the Gilmour project included the Australian Geological Survey Organisation, Bureau of Rural Sciences, CRC AMET, CRC LEME and World Geoscience Corporation.

The data collected enabled the development of 3-D images that showed various regolith features and their relief. They included the current ground surface, subsurface sedimentary contacts, the saprolite and the surface of the bedrock. The images also provided interpretations of subsurface groundwater, fresh and saline.

CRC LEME's initial interest in the project was to support mining companies around the town of Temora, developing their understanding of the geochemistry and three-dimensional distribution of regolith materials. However, as the data became available from the airborne electromagnetic survey, the resultant data showed that this technology would also be useful in environmental research and ultimately in the management of subterranean saline water flows.

The Gilmour project identified a network of buried basins, buried river sediments and ancient buried water channels, through which both saline and fresh groundwater flowed. This study indicates that with this technology, using a 'geological systems' approach that includes ground and subsurface geology, we can see through the ground and identify from where saline waters are coming and how, and to where, they are going. This provides a new and detailed way to identify those areas most at risk from salinisation, and a level of knowledge, previously unavailable, which will be useful for devising strategies to work against dryland salinity. These same data are both useful for determining the landscape history and in minerals exploration.

This project is expected to have a major impact on the development of significant works to address salinity issues in the rural landscape as well as mineral exploration.

Exploration in areas of basin cover

The objective in this program is to develop procedures to explore and identify mineral deposits concealed within and beneath sedimentary rocks, in shallow sedimentary basins, and basin margins where there is less than 200m of sedimentary cover.

Regolith-landscape evolution

This program is developing a framework of the regolith landscape evolution across Australia. This framework and the extensive regional models developed will aid mineral exploration companies in the selection of appropriate exploration strategies and the interpretation of geochemical data. The same framework is necessary to interpret airborne electromagnetic mapping data for salinity investigations.

The knowledge created here supports and is supported by mapping of the regolith in three dimensions.

Regolith expression ore systems

The objective of the program is to use the airborne electromagnetic system and other geographical methods to recognise mineral deposits within the regolith, thus providing a greater knowledge of the Australian landscape.

Regolith terminology and classification

The production of 'The regolith glossary: Surficial geology, soils and landscapes' has been the main task of this program. Its development will provide a valuable resource to geoscientists in their studies of Australian landscapes.

Synthesis GIS and expert system

As the collection of geological data from the CRC grew, the need was identified to develop a rigorous system to collect, store and manage data for future work. This program is addressing this need through the completion of a data audit and the development of data collection strategies. A program to introduce data standards will enable the ready transfer of this data into national geological and geophysical databases.

Education

CRC LEME's objective in its education and training program is to 'markedly strengthen the teaching in research training in landscape delivery evolution by mineral exploration in Australia' (CRC LEME 2000, p.27). To achieve this, a range of strategies has been developed, including the creation of a National Undergraduate Regolith Geology School (NURGS) that provides an opportunity for university students to gain an appreciation of regolith geology and its applications. This has proved to be a highly successful project, resulting in students pursuing further studies in regolith geology.

The program provides post-doctoral fellowships and in 1999–2000, six of these were taken up. Short courses were also run for industry and LEME staff, including two overseas short courses in Canada and Zimbabwe.

LEME provides comprehensive honours and postgraduate education in regolith geology as well as scholarships.

Of concern to the CRC is the lack of students entering geology. This is causing university numbers to drop and will eventually affect the industry skill base. It has been suggested that factors contributing to the problem include the general trend by school students not to choose science studies at university and the low priority given to geology subjects in secondary schooling.

Involvement with vocational education and training

In discussions with the CRC LEME education and training co-ordinator, it became clear that there has been a strong relationship between the geology faculties at both Canberra University (CU) and the Australian National University (ANU), and the Science and Technology faculty at Canberra Institute of Technology (CIT). The graduates from the Geoscience Diploma at CIT have regularly transferred to, and gained credit for, the first year of university geology courses. This began during the mineral exploration boom in the 1970s.

The quality of the CIT program and the success of CIT students in their university and industry work have led to CIT and ANU targetting them for undergraduate studies. Collaboration between the university and CIT lecturers has also supported the introduction of new knowledge into the CIT courses with this collaboration also extending to course advertising.

The CIT geoscience courses were originally developed in 1974 when it was noted that, in Canada, technician-level workers were successfully supporting professionals in their geological surveys. These technicians performed much of the fieldwork in data collection, leaving the professionals to analyse and interpret the data. CIT's courses were offered at the certificate III and diploma levels and included extensive fieldwork. The rigorous and practical nature of the courses gained immediate support from the industry and also saw the Minerals Council of Australia (MCA) providing some financial support for course maintenance.

The importance of VET paraprofessional training in geophysics is underscored by comments the Minerals Council of Australia made in its discussion paper titled *Back from the Brink: Reshaping the minerals tertiary education* (MCA 1998). In appendix D, it identified that 'there is no doubt that the TAFE sector is a vital part of minerals higher education' (p.116) and that 'TAFE is providing good training for support staff, thus providing the sort of resources that enable professional staff to focus more on the more advanced work rather than routine work. Furthermore, they could play a stronger role in the provision of highly skilled technical assistance to various aspects of the minerals industry'.

The MCA sees VET training in the geosciences as having obvious value. However, a recent downturn in the industry has seen enrolments at CIT—which peaked in 1982 with 40 students—

drop significantly since 1995, making it now difficult to fill a class. At present, the current courses at CIT are accredited until the end of 2001, and it is unclear whether these courses will continue.

Similarly, at the Onkaparinga Institute of TAFE South Australia a reduction in student numbers also occurred but, unlike CIT, has since increased. Their numbers are now approximately 30 in the certificate III course and 15 in the diploma. The relatively stable demand from government and industry, and a lesser demand from mining, has insulated the Onkaparinga institute against the cyclical demand of the minerals exploration industry.

The MCA has identified three characteristics of the minerals industry that determine the supply and demand of professionals and, similarly then, the demand for paraprofessionals from the VET sector:

- ✧ The minerals industry dominates the employment of mining, metallurgy and geoscience graduates.
- ✧ Industry is cyclical in its expenditure and is consequently cyclical in its employment of minerals professionals.
- ✧ In the past, shortages of professionals have been met from a ready overseas supply.

(MCA 1998, p.99)

These factors, combined with an industry that is generally unsupportive of graduate training (MCA 1998, p.6), make it difficult to influence a training agenda in the VET sector. In addition, there is also no national training package and thus no national approach to VET training in geoscience. Where the training has been established, it has been a response to local needs that have predated the national approaches to training.

Despite these difficulties, the relationship between the CRC LEME and the VET sector, embodied in the CIT, has always been one of collaboration and respect. However, it is clear that at this time, industry and economic pressures are limiting the development of the CIT–CRC LEME relationship. It is also clear that the CRC is developing its understanding of the VET sector and, where possible, will encourage the development of this relationship as they move into their second round. The possibilities for this development are discussed in the next section in relationship to the potential emergence of an environmental industry centered on salinity management and remediation.

A new industry: Saltonics[1]?

The potential development of a new industry that focusses on the management and remediation of salinity in rural Australia is an exciting prospect. The factors that indicate the need for such an industry are: firstly, the magnitude of the salinity problem facing Australia and the imperative for action in the face of costly economic, social and environmental consequences. Secondly, the government has responded through the National Action Plan for Salinity and Water Quality and shown its commitment to fund work to address the problem. And, thirdly, advances in knowledge and technologies have the promise to enable the cost-effective mapping of underground bodies of saline water and their movement. These three factors identify the potential demand for people, skills and equipment to meet the management and remediation needs of the vast tracts of land now affected by salinity.

The remediation process is not expected to occur over the short term. Rather, estimates suggest it could take anything from 50 to 100 years to address the degradation that has occurred. This is also strong evidence that there is time to develop a strong grouping of companies and contractors, and create a skill base for an industry.

The following sections briefly outline the three factors driving the emergence of an industry and conclude with a section on the role VET may play with CRC LEME and the industry.

Dryland salinity

Australia is a dry and salty country. Its landscape has a low relief and internal river drainage patterns that, along with high evaporation from the warm to hot, arid to semi-arid weather, concentrates the aerosol salts brought in with rain from the oceans. In addition, it has deposited large concentrations of salts deep in the regolith. The impact of European farming practices, which replaced native vegetation with crops and pastures that have shallow roots and different growth patterns, has resulted in changes to the hydrological cycle in many parts of rural Australia. The effect has been that water now 'leaks' down into the groundwater table, raising the water tables and mobilising the deposits of stored salts. In essence, 'dryland salinity is an expression of a major water imbalance in catchments' (PMSEIC 1999, p.5). This situation brings the salts closer to the surface and, in some cases, onto the surface. This salt inundation has produced widespread land and environmental degradation.

While it is generally understood that salinity is a major agricultural problem, it can also cause problems in populated areas. As an example, Wagga Wagga, a town in southwestern New South Wales, is one of the towns most affected by dryland salinity. It suffers damage to roads, footpaths, parks, sewerage pipes, housing and industry at a cost of over $500 000 per year. Water quality is

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1 The term 'saltonics' arose in a conversation with Dr Ray Smith, of the CRC LEME, about the potential for a new industry to develop based on the management and remedation of the Australian salinity problem. While the term was made in jest as a side reference to the emerging photonics industry, it has stuck in our minds and provided a convenient word to describe the coming together of a range of technologies and skills to address the salinity problem.

also being affected with the increased salinity in the Murray-Darling expected to cost Adelaide between $55 and $65 million per year to deal with the resulting harder water (PMSEIC 1999, p.5).

To address this problem, it is clear that scientists, land-holders and managers, communities, industry and all levels of government will need to work in concerted action.

Government funding

On 10 October, 2000, the federal government's response to this problem was the announcement of the National Action Plan for Salinity and Water Quality in Australia. The federal government has committed $700 million to the first comprehensive national strategy to address salinity and water quality issues. This funding will be matched by the states who will provide $1.4 billion over seven years to enable high priority actions to be undertaken in key catchments and regions across Australia.

This action, along with private and local government initiatives, is set to have a major impact on the implementation of strategies to deal with salinity.

CRC for landscape environments and mineral exploration

The initial CRC LEME played an important role through its work with CRC AMET as well as in its own activities. While significant work to address the problem of salinity has already been done, CRC LEME believes that we now have the technology and funding to begin systematically and more quickly to address Australia's dryland salinity at a regional level using the geological context. In addition to other work for the minerals industry, CRC LEME's role will be to provide the mapping technology which will give new perspectives on the understanding needed to guide remedial action.

The CRC's new focus on environmental issues will utilise the knowledge gained from the previous CRC LEME. Two of its four research programs now address environmental issues.

The first, Environmental applications of regolith geoscience, will address those environmental issues, in which the regolith and its landscape setting play a significant role in the origin and development of risk and its management. In addition, it will also advance the scientific base for this work.

The second, Salinity mapping and hazard recognition, will determine the three-dimensional distribution of salinity in the landscape and determine the pathways through which salt moves. A series of salinity risk maps will be produced to provide basic information, which will guide remedial actions. CRC LEME's role will be to collect, analyse and interpret the data to provide information to guide remediation and management.

Airborne electromagnetic mapping

Following the development of airborne electromagnetic mapping technologies by CRC AMET, collaboration with CRC LEME has developed its application to map and identify bodies of saline water. As this technology is implemented and the process of mapping and analysis occurs, a body of information will become available to those involved in salinity management and remediation that will enable them to locate and make decisions about the management of salinisation. This information will enable strategic management options to target the particular needs of individual landscapes. 'Salt mapping means that tree planting, agronomic and engineering solutions can now be applied where they will work and are appropriate for the terrain' (Craik 2000, p.6).

Skill needs

The implications of these developments for education and training are shown in statements from the Prime Minister's Science and Innovation Council report on *Dryland salinity and its impacts on rural industries and the landscape* (PMSEIC 1999). In the report it is argued that 'we seem to have significant shortages of skilled people to help local communities develop and communicate effective salinity management plans' and also that 'we lack trained professionals who can work in the field, using available information and remote sensing to identify processes … and appropriate remedial action' (PMSEIC 1999, p.16). Further on, PMSEIC suggests that we lack the 'technical skills to progress [their] responses to salinity management' (PMSEIC 1999, p.17). It is clear that as momentum gains in response to funding and new technology, many more skilled workers and professionals will be required to meet the demands of the industry.

Many of the practical skills and training infrastructure required to deal with salinity already exist, albeit marginally, in some areas. They are also spread across a range of disciplines, from information technology to plant equipment use and maintenance. More specific skills in data collection and interpretation will be required to enable management decisions to be made about what actions will be taken. It is these areas that will require the most development.

At the vocational level this would call for more development of courses and skills in remote sensing, geographical information services (GIS), geoscience (particularly regolith geoscience), and surveying with an emphasis on salinity. This would provide a skill base to support the work of the geologists, consultants and researchers in mapping, assessing and developing remediation strategies. The mechanical, electrical and engineering trades, along with civil engineering and construction trades, would support the remediation work.

Vocational education and training

VET, as the provider of education in many of these areas, will have a large role to play in training the industry's skill base. However, VET will need to become more proactive and strategic in its approach to skills development in order to be prepared for changes in demands for skills training.

At present, the VET system is designed primarily to respond to industry demand rather than to lead in skills development. In developing skills for an emerging 'saltonics' industry, VET will have to lead rather than follow, engaging with the CRC LEME as a knowledge base from which to develop focussed training.

The CRC LEME has recognised that there is a need to become more involved in the VET area, to assist in the development of teachers' skills in new technologies and thus to support the development of an industry. They understand that there is a need to work with the vocational education system to ensure the knowledge is used.

Conclusion

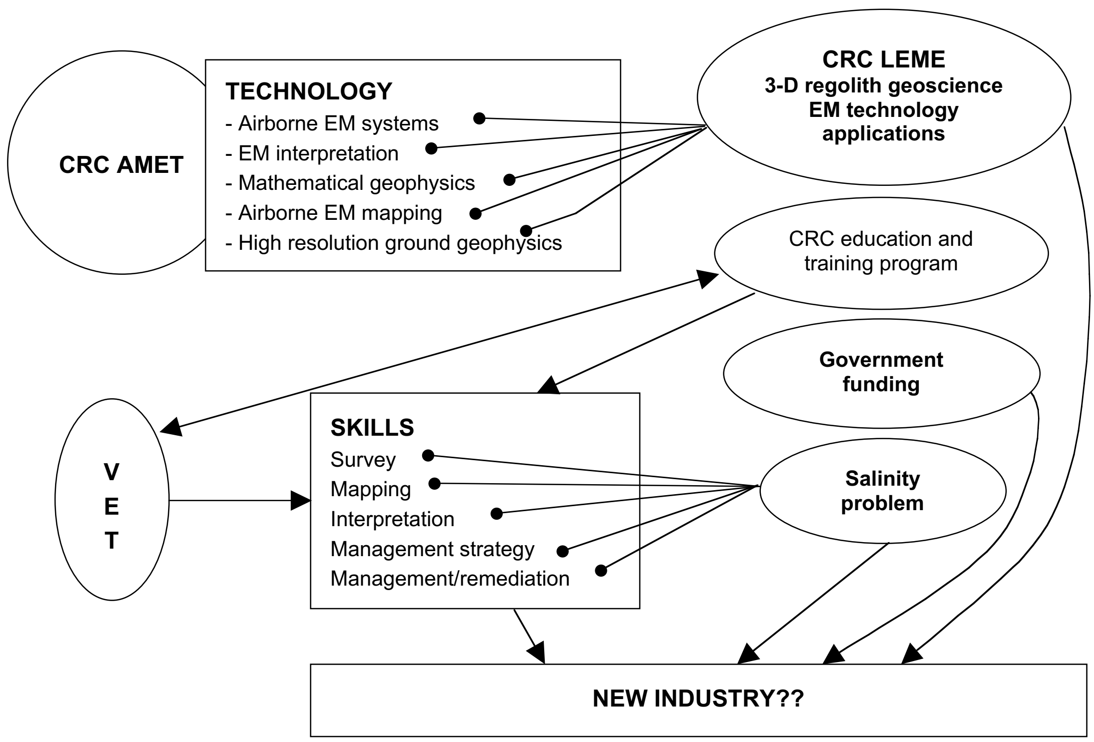
This study has shown that there is the potential for the development of a new industry in salinity management and remediation to address the problems of dryland salinity. The drivers of this new industry are twofold: the new technologies, knowledge and 'know how' that have provided a breakthrough in understanding the problem of salt mobilisation; and the injection of government funding that, like venture capital, provides the needed push to initiate development, production and return.

We have also shown that it is important for a new technology such as EM mapping to go beyond research and development and into the commercial or industry phase. In order to do this, the technology and skills need to be introduced into the national skills development mechanism. The role of the research and development organisation at this stage would be to provide and support the introduction of new knowledge into training by engaging and collaborating with, in this case, the VET system.

The following figure attempts to show the relationships outlined in this study that will lead to the development of a 'saltonics' industry. The four important relationships seem to be between:

- the need for a saltonics industry
- technology development of the industry
- government funding
- the role of VET to develop the industry's skill base.

The interactions between these factors, and particularly between CRC LEME and VET, will be crucial to the flow of knowledge and its utilisation and skills development.



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Case study 4

Australian Photonics

(Co-operative Research Centre no.13)

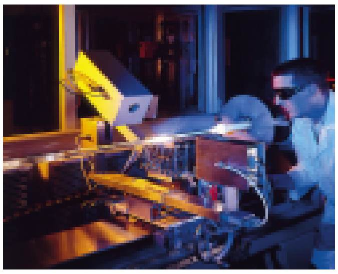
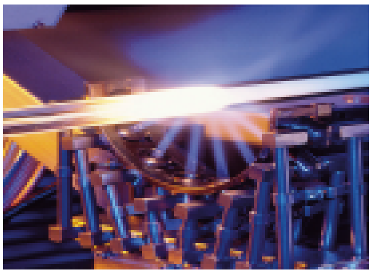
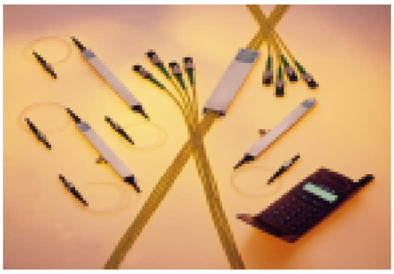
Photonics is the control, manipulation, transfer and storage of information using photons, the fundamental particles of light. This new photonic technology enables, for the first time, sufficient network capacity to meet the forecast demand for fully interactive, multimedia, internet services.

Much of the background material sourced in this document has been derived from documents written for other purposes by the CRC, TAFE Industry Partnership Centre and the Redfern Group of Companies. A significant proportion of the background material is further supported by additional material freely available from the websites listed in the appendix.

Australian photonics

Introduction

Photonics is the control, manipulation, transfer and storage of information using photons, the fundamental particles of light. The goal of photonics research is to utilise the almost limitless capacity of optical fibres to transmit large volumes of information. This new photonic technology enables, for the first time, sufficient capacity to meet the forecast demand for fully interactive, multimedia, internet services.

Photonic technologies are built from the underpinning knowledge and principles of light, lasers and electronics. Photonics technologies are developing in areas of telecommunications, diagnostic equipment and sensing devices. In the telecommunications industry photonic technologies are deployed in the rollout of optical fibre networks. The next generation of photonics technologies in communications will encompass the entire communication food chain; fibre and its production and manufacture; the components and their production manufacture and application in systems; their design, integration and installation in communication networks and their ultimate maintenance.

Photonic technologies have applications in:

- medicine
- telecommunications
- defence, military/aerospace
- consumer products
- laboratory products.

The photonics industry

From research to product: Short history of the development of the photonics industry in Australia

The photonics industry in Australia is emerging. To date it has travelled a short few phases of development. This case study is primarily concerned with the developments post-1992 when the Australian Photonics Co-operative Research Centre was founded and specific commercial focus for the research and development activity in Australian universities was combined with industry investment.

The Co-operative Research Centres (CRC) program was designed and established in 1990 through the then Commonwealth Department of Industry, Science and Tourism (DIST) to help realise the outcomes from public sector research. When the program was established it was widely recognised that many publicly funded research outcomes were not taken up by Australian industry nor by the wider community. The CRC program was then established to foster the commercialisation of Australian public sector research and development. The program has guidelines for the conduct of research, commercialisation and education programs under the scheme.

The Australian Photonics Co-operative Research Centre was established in 1992 following a successful bid to the Commonwealth Government by a consortium of four universities, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and five companies. The amount awarded to the photonics consortium over a seven-year period was $28.8million.

The CRC brought together a number of pre-existing research centres. These included the Optical Fibre Technology Centre (OFTC) at the University of Sydney which had been established in 1989 as an initiative of researchers from the Schools of Physics and Chemistry, and the Department of Electrical Engineering who found they had a common interest in researching fundamental scientific and engineering concepts relating to optical fibre technology. OTC Limited (since joined with Telecom to become Telstra)—which was at the forefront of the roll-out of long distance and terrestrial undersea optical fibre links to neighbouring Asia-Pacific countries—provided sponsorship of $1.6m which funded the installation of the first applications specific optical fibre fabrication facility at the University of Sydney.

This vital infrastructure enabled basic and experimental research to be conducted into novel fibres, and their applications in a number of industries. The Optical Fibre Technology Centre received no recurrent funding from the university, but was supported through in-kind contributions in terms of people and serviced space. The research was funded through two contracts of approximately $300 000 each from OTC; Australian Research Council (ARC) funding ($100 000); and three generic industry research and development (GIRD) grants (from DIST) of approximately $1.2 million each, plus a number of smaller contracts, to a total of $200 000. The GIRD projects variously brought together researchers from the OFTC, the Australian National University (ANU) (Optical Sciences Centre), Royal Melbourne Institute of Technology (RMIT) and the University of New South Wales (UNSW) (Optical Communications Group and the Surface Analysis Facility), with industry, including OTC, BHP, Fibernet, IBM, and Siemens. The GIRD program provided a valuable ‘apprenticeship’ to the CRC program, building research collaborations and developing industry linkages.

At the same time, through the support of Telecom and OTC, the University of Melbourne’s Department of Electrical and Electronic Engineering established the Photonics Research Laboratory (PRL), headed by Professor Rodney Tucker who was attracted back to Australia from AT&T Bell Laboratories in the United States. PRL was also successful in winning GIRD funding of $600 000 for two programs, developing linkages with BHP and NEC.

Both the OFTC and the Photonics Research Laboratory had, separately, indicated their interest in applying for CRC program funding to both the Commonwealth and Telstra. As their research focus was closely related, and in synergistic areas, it was proposed that the two groups join together to bid for CRC funding in the second round. They were successful in attracting the interest of five industry participants and the bid was also supported by the ANU, CSIRO and the University of NSW, all of which had been involved in prior collaborations in photonics research.

By 1996 the CRC moved its Sydney-based facility to the Australian Technology Park. At that time it also became clear that the telecommunications market was strengthening due to the increasing demand for bandwidth driven by internet use. Demand for next generation telecommunications products would most likely be met by optical devices and fibres.

In 1997, Allan Snyder, Rod Tucker and Gottfried Ungerboeck won the Australia prize for achievements in telecommunications. Allan Snyder, then the head of the Optical Sciences Centre at ANU provided new key theoretical concepts to designers which made feasible a range of new components. His early work in the 1960s describing the propagation of light in a single mode optical fibre was used as the basis for many optical Fibre designs and his subsequent work and that of his unit at ANU on temporal solitons led to a whole new class of non-linear devices in photonics. Rod Tucker was then the head of the Photonics Research Laboratory at Melbourne University. Rod’s work focusses on the development of high speed, high efficiency lasers for lightwave communication channels and on the use of photonics devices and systems for high speed switching and routing.

In 1997 the then Commonwealth Department of Industry, Sciences and Tourism awarded funding to the Warren Centre for Advanced Engineering for the ‘Photonics in Australia Project’. The aim of the project was to determine the value of the potential photonics industry to Australia, to determine what impediments and particular opportunities should be supported and to establish a mechanism for the emerging industry to liaise with government.

The project was conducted in three stages:

- Stage 1 was the development of an agreed position on the status of the Australian industry together with a quantified future with a specific emphasis on the Asia-Pacific Region.
- Stage 2 was to educate and motivate all the likely players in the Australian photonics industry to ensure that all impediments to industry development are recognised and overcome with a clear strategic vision of the future.
- Stage 3 was to develop a strong industry body that will ensure an industry synergy for participating companies and provide a platform to enable government support to be martialed and a united industry position presented to countries outside Australia wanting to develop photonics technology applications.

The project team was multidisciplinary and comprised people from industry, university, technical and further education (TAFE) institutes, venture capital organisations and government (group membership is listed in appendix A).

In November 1997 the Warren Centre provided a substantial report to DIST outlining the structural basis of the photonics industry in Australia, the preparation of a market plan for the emerging industry as well as recommendations in relation to training, finance and commercialisation mechanisms.

In 1998, the 'Photonics in Australia' project team commissioned a benchmarking tour of Australia's capability funded by the Macquarie Bank. Tour results were distributed and publicised through a seminar in September 1998 at the Australian Technology Park (ATP), where the photonics industry forum was also launched, with the Australian Electrical and Electronic Manufacturing Association (AEEMA) as the administrator.

By 1998 venture capital companies specialising in photonics had started operations in Sydney and particularly also in the US. In the meantime, the industry had moved into second generation components and was beginning to segment within itself.

In 1999, AEEMA commenced the recruitment of photonics industry forum members but membership was slow to develop. AEEMA and Australian Photonics CRC agreed in 2000 to enhance the development of the industry forum and a funding arrangement was reached which will allow the forum's development to accelerate and for the industry review to be updated. The study will size and scope the industry, examine the photonics industry's manufacturing capability and development in associated industries, and benchmark the international competitiveness of the Australian industry.

As of February 2001, the industry forum still had only a few members. The member organisations are for the most part small companies. A forum board is being convened and a work profile for the forum determined which was due to be in place by July 2001.

AP CRC was refunded by the Commonwealth in 1999 for a further seven years receiving an additional A$27.4 million. The total resources for the centre in the new period including cash and in-kind contributions is A$194.4 million. It now has 18 industry and five university participants with TAFE NSW, AEEMA, the Defence Science and Technology Organisation (DSTO) and other organisations providing support.

November 2000 saw the first industry conference in the ACT where a specific day for education and training issues was held in conjunction with the industry conference.

Beside the nascent photonics forum, there is no industry association which can represent the cluster of new companies at senior government level. While this is envisaged, it is not currently in place.

The establishment of the CRC itself in 1992 was a significant enhancement in the development of research capability and underpinning industry development in this country. As a vehicle for industry participation in research and development, the contributions of industry to the research effort in the centre have been significant. Whether or not a photonics industry would exist in Australia without the establishment of the centre is a debatable point, but it is clear that the CRC model in this case has certainly proven itself as a suitable vehicle for the carriage of industrial research and development into commercial reality.

Current state of illumination of the photonics industry

The global market

The USA Opto-electronic Industry Development Authority (OEIDA) estimated[1] the market for the photonics industry at US$21 billion in 1996. As noted below, forecasts made by RKH incorporated in 2000 have been revised to US$24 billion for 2004.

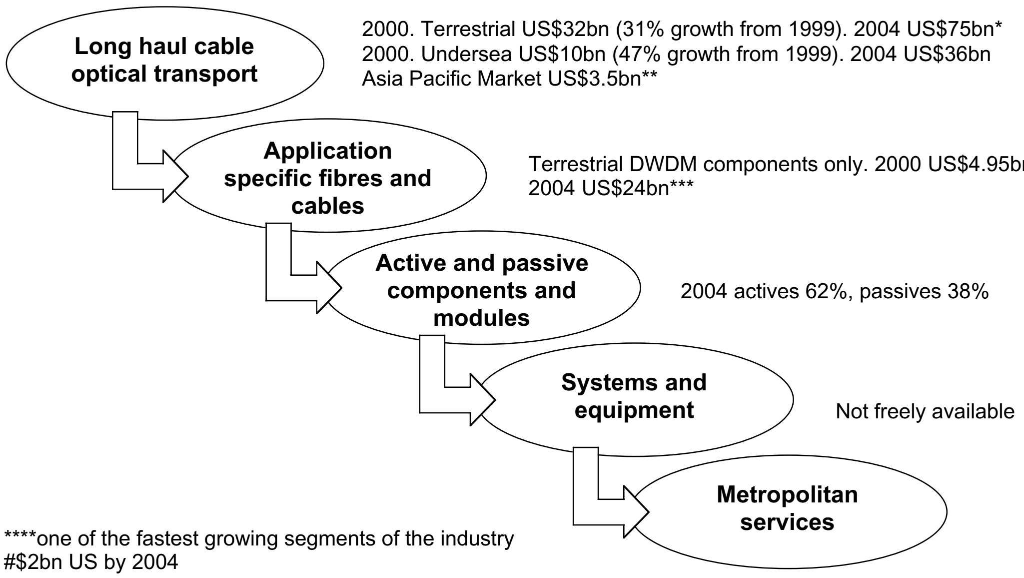
1 OEIDA report

In 2001, only the long haul cable sector of the industry was valued at US$42 billion. The photonics industry could be divided along the 'technology hierarchy' illustrated below which also allows us to describe more precisely the sub-sectors currently evolving in the industry. Current valuations and 2004 forecasts of the global market are given where available.

Most Organisation for Economic Co-operation and Development (OECD) governments are making strategic investments in photonics as a means of boosting their market share and creating jobs for the knowledge economy. In the US, the National Science Foundation, Department of Defense and Defense Advanced Research Projects Agency have boosted investments, and the European Fifth Framework program has significant programs that promote collaboration in photonics. The present-day successes of Canada, Scotland[2] and Israel in optoelectronics point to the economic benefits that can flow to smaller countries that strategically organise their resources and take a long-term view.

By 2010, it is possible to extrapolate that the global photonics industry will be worth $700 billion[3]. The markets are growing very quickly in the US, and it is forecast that Europe and Asia-Pacific will catch up over the next five years. Photonic networks will replace the current ATM frame relay systems and will have reached the consumers' premises. A minimum of 100 megabits per second (instead of the current 64 kilobytes—10 megabyte per second) communications should be the norm.

Currently, clusters of photonics firms appear in Ottawa, Canada; Tucson, Arizona, US; Singapore; Rochester, New York, US and Hartford, Connecticut, US.



* Cooperson, D 2001, RHK Incorporated, Optical Fibre Conference 2001 presentation.

** Walker, M, Vendors seek Asia Pacific rewards, RHK International, www.rhk.com

*** Lively, J 2001, RHK Incorporated, Optical Fibre Conference 2001 presentation.

**** RHK 2001, Analysts report, March.

\# Terrell, G 2000, 'Photonics in telecommunications', *Photonics Spectra*, May 2000.

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[2] In Glasgow alone, the optoelectronics industry now employs around 1000 people and contributes US$160 million to the local economy. Its strengths are its research and development, product development and manufacturing capability built up over the past 15 years (*Optics and Photonics News*, September 1998).

[3] Tekhne 2000, Application for science lectureships initiative.

US labour market facilitation

In 1995, CORD—the Centre for Occupational Research and Development[4]—and the National Photonics Skills Standard project unveiled the National Photonics Skills Standard for Technicians, which outlines what photonics workers should know and be able to do to succeed on the job in the US. Their projections were that an additional 750 000 photonics technicians would be needed by 2000.

The 'Photonics Directory[5]' lists some 33 societies or industry associations outside the US and some 58 within the US which have specified some involvement in the photonics industry.

There are now several international magazines related to photonics where none existed in 1996 and only one, *Optical Spectrum*, is published in Australia. Photonics.com is a US-based 'verticalnet' community website which hosts resources, employment advertisements and technical and market news.

The major international conference for the photonics industry is OFC (Optical Fibre Conference). The last event was held in Anaheim, US in March 2001 and housed over 32 000 attendees. Over 970 companies exhibited at the conference with 10 000 exhibitor staff. Several Australian companies exhibited. Both the number of companies and the individual attendance was twice the value of the year before. OFC hosts short courses, workshops, and commercial technology programs and tradeshow exhibits.

The growth in the conference is a clear indication that the market is beginning to diversify and that leading 'old' component manufacturers are beginning to share the market with an increasing number of new photonics start-up firms. The industry should therefore expect to see some pricing pressures applied in some subcomponent markets where there is increasing competition.

The domestic market and industry

The Photonics in Australia project report (1997) estimated that in 1996 the photonics industry/cluster in Australia could be dimensioned as follows.

Size

Domestic market size	**A$250 million**
Domestic market growth	$5 – 10%
Research and development	A$20–30 million
Export sales	A$60–80 million
Number of companies	70–100
Start-up companies	20–30
Communications and IT share of the market	95%

In the report, figures for the cluster breakdown of the contribution of photonics to the information technology and telecommunications (IT&T) equipment market were given as:

Subsectors

Optic fibre transmission systems	**A$320 million**
Integration of optics fibre/photonics systems	A$50–70 million
Photonic devices and sub-systems	A$30–50 million
Optic fibre and photonic accessories	A$30–50 million
Optic fibre cable	A$90 million
Total	A$520–$580 million

4 www.cord.org
5 www.photonics.com

The 1997 Warren Centre report described the main advantages of photonics over competing technologies as:

- cheap raw materials
- vast information transmission capacity
- immunity from electromagnetic problems
- relative physical simplicity of photonics solutions
- non-corrosive, non-conducting
- rich variety of sensor techniques.

Current size

According to the Warren Centre report, in 1996 the industry in Australia had a turnover of $238 million, 1.2% of the global market and was growing at 8% with 10% export ($80 million). According to the CRC, in 1996 the industry globally was valued at 21 billion and growing at 18% cagr 1996–2010.

The Australian photonics industry was dimensioned in the previously mentioned benchmarking study as comprising of a cluster of about 40 companies. Between 1987 and 1996 the companies in the cluster grew at over five times the rate of the overall Australian economy. In 1996, it was a small segment of the communications industry, with 1800 jobs out of a segment that supports 163 000 jobs.

The global photonics industry is currently valued at over US$50 billion[6]. If Australia has retained its market share at 1.2% of the global market, the current market value of the contributions of Australian firms to the market would be in the vicinity of US$600 million (A$1 billion).

Essentially, photonics is a new industry in Australia and internationally. In 2001, it is marked by one dominant global player—JDS Uniphase Ltd, a US company (with origins in Canada) listed on the NASDAQ stock market—and now has several strategically placed multinational players such as Nortel and Corning Inc. Both JDSU and Nortel have purchased promising Sydney-based small Australian firms in the past two years. Intel and other major companies are represented in Australia through investment in start-up companies of the CRC and other start-up ventures. The presence of multinational organisations in Australia is a reflection of our innovation capability in this area and it provides local enterprises with opportunities for export and collaboration they may not otherwise have access to.

Appendix B lists companies that have an interest or capability in photonics. This list has been drawn from a variety of sources including the attendance lists from various photonics conferences and symposia over the last three years in Australia, the members of the Photonics Industry Forum, the participant list of the CRC, the network list of the Redcentre, contact lists from the TAFE Industry Partnership Centre, the advertising database of *Photonics Spectra* magazine and various supplementary sources. It shows over 400 companies with a capability or interest in photonics. This list is the first of its kind to illustrate the industry and no other has been compiled to date. It is by no means exhaustive and also includes organisations that may only have a secondary or partial interest in photonics. Companies are located in the eastern states predominantly, with NSW having a base three times larger than Victoria. The list includes venture capital companies, industry organisations, and support firms such as contract manufacturers and various technical, financial and policy consultants. It does not include research or education bodies. If they were to be included the

[6] RHK International,2000. www.rkh.com

total number of organisations in Australia with an interest or capability on photonics would increase by a minimum of another 30 organisations.

Current strengths

From the Warren Centre report and our interview with the Australian Electrical and Electronic Manufacturing Association and chief executive officers, we assess the current strengths of the Australian industry are:

- scope and quality of research and development resulting in superior technology
- research and development that is at the cutting edge not at the mainstream
- skill and knowledge level of Australian management and researchers
- speed to market
- presence of overseas multinationals, JDSU, Corning and Nortel, each with research and development and manufacturing capability located in Australia
- capacity of the CRC to generate start-up companies
- ability to attract high-level expertise in ancillary areas—marketing, human resources (HR), start-up ventures
- a strong cluster in Sydney, with emerging clusters in Melbourne and the ACT with potential in Adelaide and Brisbane. A critical mass being reached across the industry.

Perceived current weaknesses in the Australian market

A number of previously identified weaknesses still remain. We asked some industry chief executive officers, the CRC and AEEMA to identify weaknesses in the industry. They identified the current weaknesses of the industry as follows:

- volatile domestic market with major telecommunications companies operating in a small deregulated market with little or no reason to implement a new high-cost disruptive technology
- the Australian market (probably with the exception of mining and agriculture) is not interested in new products if they have a significant impact on business processes, operations, practices, etc. (i.e. if it ain’t broken, why fix it?); in general, change is not welcomed
- Australian executives prefer to sit on the fence and let others, more ‘courageous’ and ‘adventurous’, take the initiative; hence Australia is not a good place for launching a new product
- small size of the domestic market
- absence of major systems developer
- internationally, Australia is not regarded as a supplier (but as a buyer) of high-tech products and as such there is a practical barrier (psychologically generated from the market end) to enter world markets with new products from here
- lack of communication at all levels among the players in the industry, and between the market and its suppliers. Communication is often regarded as a threat through disclosing valuable ‘proprietary’ information
- lack of tax incentives for new start-ups
- low level of investment by Australian venture capitalists
- low level of general government support for developing Australian industries (not research)
- lack of Federal Government support in promoting Australian products and commercial initiatives overseas (one example cited was that Austrade had its budget for supporting national stands at trade-shows cut)

- ✧ low level of market research and market development of the industry
- ✧ low level of investment in the establishment of plant and facilities
- ✧ critical mass has not been reached in any of the subcomponent markets
- ✧ low level of involvement in the nascent industry association
- ✧ low level of education and training programs to support the industry
- ✧ declining enrolments in physics-based science and technology courses in schools, TAFEs and universities
- ✧ overseas loss of leading Australian academics in this field.

Several weaknesses are discussed in the following section.

Critical mass and domestic market

A number of structures define the existence of an industry. The first of these is critical mass. There must be a sufficient number of firms involved in the production of goods or services to warrant collective action or collaborative activity in a given field. Even though the number of start-up firms is increasing, currently the photonics industry lacks this critical mass in each of the subcomponent markets and still lacks a major systems developer. The size of the domestic market is unknown, but without a systems developer or telecommunications carrier with strong market pull actively implementing worlds' best technologies in their home market, it is unlikely that Australia will be able to drive the industry from a strong home base.

Government support

The Commonwealth departments that would have responsibilities for the photonics industry are the Department of Industry, Science and Resources (DISR), the Department of Communication, Information Technology and the Arts (DCITA), the National Office for the Information Economy (NOIE) and the former Department of Education, Training and Youth Affairs (DETYA)/Australian National Training Authority (ANTA). With regard to DISR, the relevant programs for funding support is the CRC program itself, the technology diffusion program and the action agenda area. DISR does have an emerging industries branch but photonics is not an action item in their profile. According to DISR[7]:

> 'In essence the aim of an action agenda is to identify impediments to growth for specific industry sectors and to remove them, to find out where the opportunities lie and to take advantage of them'.

There is no Commonwealth Government action agenda for the photonics industry. The vast majority of the action agendas are in well-defined and established markets such as textile, clothing and footwear (TCF). Funding for the development of the industry (as opposed to the research and development effort) has not been awarded beyond the initial grant to the Warren Centre for the benchmarking study and, indeed, the revision of the industry scoping report described below is being funded by the research organisation, the CRC.

NOIE's Investment Branch began in May 2001 to investigate opportunities for photonics companies but have little external data beyond this study from which to base their analysis or effort.

At least one photonics company chief executive officer reported to us that there was a generally held view that there were poor tax incentives for start-up companies and thus little reason to locate companies in Australia. Often overseas nations and states offer quite lucrative incentives for firms to

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7 www.disr.gov.au/industry

locate their manufacturing and distribution centres there, which also decreases shipping costs in the global market.

The French expression—*Les jeux sont faites, rien ne vas plus!,* 'The games are done, no more play!'—appears to hold for Australian companies entering developing markets as well as those entering mature markets. This factor, when combined with the fact that the market is typically overseas, the cost of transporting export product and a lack of incentives for start-up firms leads Australian chief executives to seek venture capital and supplier and customer partners offshore.

It could therefore be argued that appropriate support for the development of new industries in this country is lacking.

Industry participation, market research and development

In 1999, AEEMA commenced the recruitment of photonics forum members but membership was slow to develop. The association agreed in 2000 with the Australian Photonics CRC to enhance the development of the industry forum and a funding arrangement has been reached which will allow the forums development to accelerate and for the industry review to be updated. The review is necessary as the following questions are not known or understood in Australia as yet:

- ✧ Which firms are public companies? What is the extent of Australian ownership of the remaining firms? What is the contribution of overseas firms investment into Australian companies?
- ✧ Which companies are manufacturing components and systems? What Australian firms are manufacturing overseas?
- ✧ To what extent are Australian firms supporting the development of the international photonics market or the Australian market?
- ✧ Can the key market leaders be identified? Can key players be identified by market segments?
- ✧ What are our capabilities and expertise? Is there a domestic market for photonic components and fibres? What (if any) are our import replacement costs?
- ✧ What size are the major market segments in Australia? What size are the component sub-market segments? How many firms operate in these segments and what do they supply?
- ✧ What are the market trends for this technology? Where is the demand for this technology greatest?
- ✧ What products and services are Australian companies offering? What are the gaps and opportunities in the market that can be serviced by Australian firms?
- ✧ What are the internal company research and development activities and how much do they spend on them?
- ✧ What is our capacity to generate enough skilled labour to ensure these companies have adequate skill supply? How many university and TAFE places can be created in the next three years?

The AEEMA study will size and scope the industry; examine the photonics industry's manufacturing capability, and development in associated industries and benchmark the international competitiveness of the Australian Industry.

Education and training, available courses and declining or lacking enrolments

Schools

One of the key issues to emerge from the 1998 study *Trends in science education*, commissioned by the Australian Council of Deans of Science, is a disturbing picture of declining enrolments in enabling sciences such as physics, chemistry, and mathematics. This decline is profoundly disturbing for the future health of Australia's science base. There is a shortage of quality science teachers which is acute in some regional areas and the current population of science teachers is significantly aging. The increased higher education contribution scheme (HECS) charge on science courses is creating a disincentive for students seeking teaching careers to choose science over other disciplines.

TAFEs

There is no available training package in photonics and only one NSW-accredited and registered short course. There are no official full-time student enrolments in the VET system. Training is on a fee-for-service basis or has been delivered through adapting modules in current diploma courses to study photonics-based projects. Only two colleges, both in NSW, are currently training students for this industry within the VET sector. And while the quality of staff in these colleges is of a high calibre, the 'photonics capital' in terms of equipment is low.

Universities

The decline in staff numbers in physics, chemistry and mathematics departments of Australian universities is of equal concern. Staffing cutbacks in chemistry, physics and mathematics departments over the past 4–6 years have averaged 30%, 17% and 20% respectively[8].

While enrolments in computer science courses have grown, a recent survey by the Australian Information Industry Association suggests that demand for these skills in Australia will significantly outstrip the supply. The photonics industry will need to compete with the broader information technology and telecommunications industry sector worldwide to attract sufficient skilled people to meet its growth projections.

An additional risk that limits the growth of the Australian photonics industry is that it may be unable to meet the demand from component users in Australia resulting in the need for import replacements.

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[8] Techne Pty Ltd 2000, Science Lectureships Initiative

The Australian Photonics CRC

Governance and structure

The centre was established 1 April 1992, in the CRC Round No.2. It is an unincorporated joint venture and has a board of governors which meet yearly. The governing board has appointed Australian Photonics Pty Ltd as centre agent to provide financial, management and administrative services to the centre.

In its first round the CRC received $28.48 million from the Commonwealth and also cash and in-kind contributions from industry. It was established with five university and four industry partners. It was refunded by the Commonwealth as a CRC in 2000 for a further seven years, receiving an additional A$27.4 million. The total resources for the centre in the new period including cash and in-kind contributions is 194.4 million.

Core partners and participants

The Australian Photonics CRC has:

- 18 industry participants
- 5 university participants
- 3 government participants including TAFE NSW
- 2 venture capital companies
- 1 industry representative body.

The full participant listing is given in appendix C.

Management and staff

The CRC is headed by Professor Mark Sceats. Professor Sceats has held this position since the centre's inception. Its corporate structure is as follows:

- governing board
- Australian Photonics Pty Ltd board. Management team with executive directors and directors of research and development, education and training, product development
- industry advisory committee
- defence industry advisory committee
- Redfern Photonics Pty Ltd board and separate boards of directors of the Redfern start-up companies.

Research focus

DISR requires that a CRC's proposed research program:

> … is of high quality and is well defined, with clear outputs that are achievable over the life of the CRC.

The centre has built a strong research base and core competencies and is an acknowledged world leader in photonics research and development. Its research focus is on four major programs built around a set of closely related technologies:

- *photonic integrated circuits* which involves research into the integration of active and passive optical waveguide devices in planar geometry
- *novel photonic components* which capitalises on the centre's special expertise in gratings, optical fibres, laser sources and amplifiers and device design
- *telecommunications technologies* which will develop technologies that will assist in the implementation of future broadband long-haul and local access networks
- *photonic information processing* which will focus on the development of photonics sensors, test and measurement instrumentation and photonics signal processing.

New activities are planned in semiconductor opto-electronics; photonic processing of microwave signals; and broadband optical communications technology, optical fibre and planar waveguide materials characterisation, fibre and planar waveguide fabrication and design, optical fibre amplifiers, novel photonic components, photonic integrated circuits, photonic systems and networks, optical fibre sensing technology, advanced waveguide theory, precision manufacturing, network demonstrations and test beds, photonic signal processing, high-speed wavelength-division multiplexing technologies.

All these research program areas are relevant to the current VET system, particularly in telecommunications and manufacturing.

Industry relevance

Whilst the research remains primarily focussed on the optical communications industry, and wavelength-division multiplexing technologies in particular, emphasis is also placed on the development of technologies with defence industry applications.

Optical fibre and photonic technologies can also be used in other industrial applications. Theoretically, almost any physical or environmental parameter can be measured using light, including temperature, strain, electric current, vibration, chemical and biological pollution, or sound. The Australian Photonics CRC is developing a number of photonic measurement systems for use in the electric power, steel and automotive industries.

Researchers

By 30 June 2000, the personnel involved in the centre numbered:

- 121 full-time equivalent research staff
- 63 postgraduate students.

These figures do not include staff of the centre's start-up companies. The total number of staff within the CRC is difficult to determine at any one time as centre staff are being transferred into the start-up companies and some staff are completing their research or development work in a start-up company and returning to the CRC.

At 30 June 2000 the centre had 55 PhD students, eight Masters students, and nine staff in Australian Photonics Pty Ltd, its contracts, licensing and patent portfolio company.

A full listing of the research projects of the CRC is given in appendix D.

Commercialisation

DISR specifies the strategy for utilisation and commercialisation of research outputs as:

> The proposed CRC has a well structured, feasible and practicable strategy for the utilisation and commercialisation of the research outputs to achieve the proposed outcomes[9].

DISR recommends several strategies for commercialisation.[10]

Generally speaking, the commercialisation strategy for a particular product or service or process is not controlled by DISR, but it does have the right to review the sale of intellectual property developed in a CRC.

A number of strategies for commercialisation utilisation are available to the CRC. These include:

- contract research and development
- licensing/technology packaging
- collaborative research
- transfer of CRC researchers to industry
- consultancies
- education and training
- patents and publications
- sale of intellectual property (IP)
- company establishment.

The Australian photonics centre, like some other co-operative research centres, has, in the first instance, formed one main company as its main marketing and licensing company, but it is unique in utilising nearly all these strategies. It is also unique as the only CRC to develop and house a set of start-up companies from its research.

Australian Photonics Pty Ltd

Australian Photonics Pty Ltd is the technology marketing and licensing company of the Australian Photonics Co-operative Research Centre. The company is beneficially owned by the participants of the first CRC. The company's board of directors is appointed by the centre's governing board. The company's premises are at the National Innovation Centre, Australian Technology Park, Eveleigh, NSW. Australian Photonics Pty Ltd has maintained a level of nine full-time management staff.

The company's major assets are its rights to exploit and sub-license the intellectual property developed by the centre and its participants. The company has intellectual property licence agreements with the members of the centre, including the universities of Sydney and Melbourne, ANU, and University of NSW (Unisearch), Telstra, and TransGrid (Electricity Transmission Authority), and is progressing similar licences with the new research providers. The company sub-licenses this intellectual property to CRC participants and other companies, receiving revenues in the form of sub-licence, royalty and other fees, or taking equity in start-ups and joint ventures.

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[9] DISR guidelines, *Establishment of CRCs*, 2001

[10] www.isr.gov.au/industry/crc

Patents

In 1999–2000, Australian Photonics Pty Ltd filed 13 provisional patents. Additionally, 37 patents are in various stages of 'full specification' prosecution in Australia and internationally. Most of these patents are centre intellectual property, and some of them are owned by the research participants, but nevertheless administered and/or funded by the company because they are germane to the commercialisation activities of the centre. Patent costs are paid in first priority from the outcome of any commercialisation activity associated with the respective patents.

Licences

During 1999–2000 the company also issued eight licences, the majority to the Redfern Group of Companies but also to ABB and British Telecom/Corning.

Start-up companies

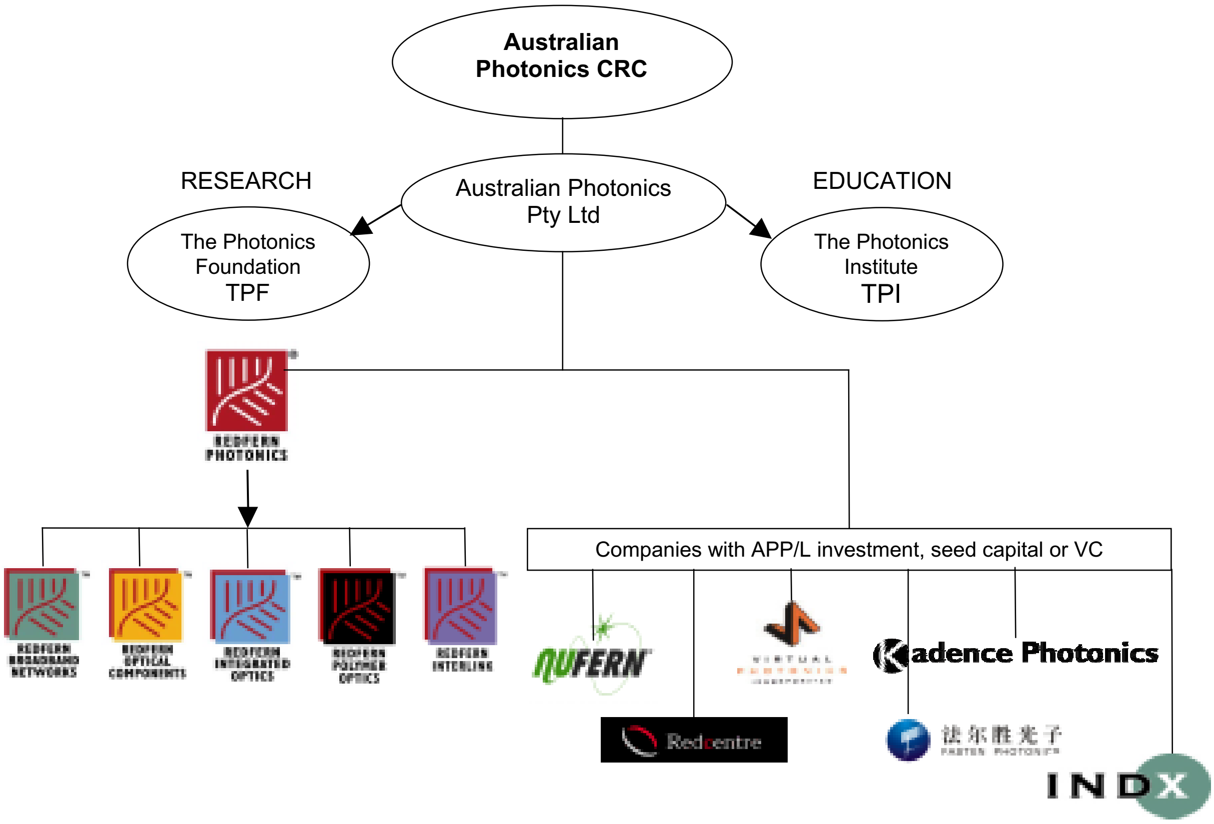
In the last four years the CRC has established a number of start-up companies with plans for several more in the immediate future. These companies are growing rapidly and are at various stages of development. A full report on the CRC start-up companies, their training needs and staff profiles is given separately. Several start-up companies of the CRC have been sold down and are no longer under the controlling influence of the CRC. For example INDX was acquired by Uniphase Fibre Corp. It started operations in 1996 with five employees and now has over 300 and the company is growing at over 200% per annum. Another, Virtual Photonics, was merged with BnED and is partially owned by Australian Photonics Pty Ltd. It has 25 employees in Australia and expects to have 40 by 2002. The third start-up company Redfern Fibres is now Nufern International and is partially owned by Australian Photonics Pty Ltd. It has a head office in the US, and is locating a manufacturing facility there. The remainder are a series of start-up companies under its 'Redfern' brand as well as venture investments in another start-up photonics manufacturing organisation including a joint venture in China. The total value of these companies is in excess of $200 million as at May 2001.

The Photonics Foundation

The Photonics Foundation was established on 2 May 2000 to support long-term, high quality, scientific and technological research in photonics; to capture the benefits of research by strengthening links between photonics research and its commercial and other applications; to stimulate a broad education and training experience; and to promote co-operation in photonics research by building centres of photonics research concentration. It will be the centre's main funding source after Commonwealth CRC funding ceases.

It is proposed that the foundation receives shares arising from the commercial operations of the CRC's start-ups, attract bequests, and manage funds in order to achieve the centre's objectives in the longer term. The foundation was not operational in 1999–2000 but was expected to be operational by December 2001.

The following diagram illustrated the commercial interests of the CRC and Australian Photonics Pty Ltd. The main object of interest in the chart below is the Redfern Group.



Australian Photonics Co-operative Research Centre: The AP CRC is described under the Commonwealth agreement for the purposes of conducting research and development, commercialisation and education in photonics.

Australian Photonics Pty Ltd: APP/L is the technology marketing and licensing company of the Australian Photonics Co-operative Research Centre.

The Photonics Institute: TPI is a newly established division of Australian Photonics, which would provide a one-stop shop for the management of photonics educational material, services and marketing.

The Photonics Foundation: TPF is a newly established division of APP/L to support long-term, high-quality, scientific and technological research in photonics after the CRC funding from the Commonwealth ceases.

The Redfern Group of Companies: This is the commercial incubator company and its incubator/start-up companies for Australian Photonics Pty Ltd.

Redfern Broadband Networks (RBN) is manufacturer of broadband photonic networking products. The company delivers world-class, high-performance equipment that underpins communications systems.

Redfern Optical Components (ROC) was established in January, 1999 to manufacture and market optical components based on advanced grating devices, dense WDM filters with high band utilisation, high performance dispersion compensations and DFB fibre lasers. ROC's proprietary direct UV writing technology 'ROC Rite™ provides.

Redfern Integrated Optics (RIO) specialises in the fabrication of silica-on-silicon-based planar waveguide structures and devices for a variety of research and commercial applications. The company employs a proprietary fabrication method that allows the integration of photonics and electronics into a single monolithic device.

Redfern Polymer Optics (RPO) specialises in the development of polymer-based planar lightwave circuits and integrated devices for advanced optical communication systems.

Redfern Interlink (RI) is in the early stages of being established and plans to install, commission and operate Gigabit Photonic Networks together with demonstrating photonic systems and equipment.

Nufern was initially established as Redfern Fibres Pty Ltd but its ownership has been sold. It is now Nufern International and its head office is in Connecticut, US.

Redcentre is in the business of 'networking commercial opportunities' in photonics, opto-electronics, electronics and microtechnologies. Redcentre was initially owned by the CRC but now operates independently.

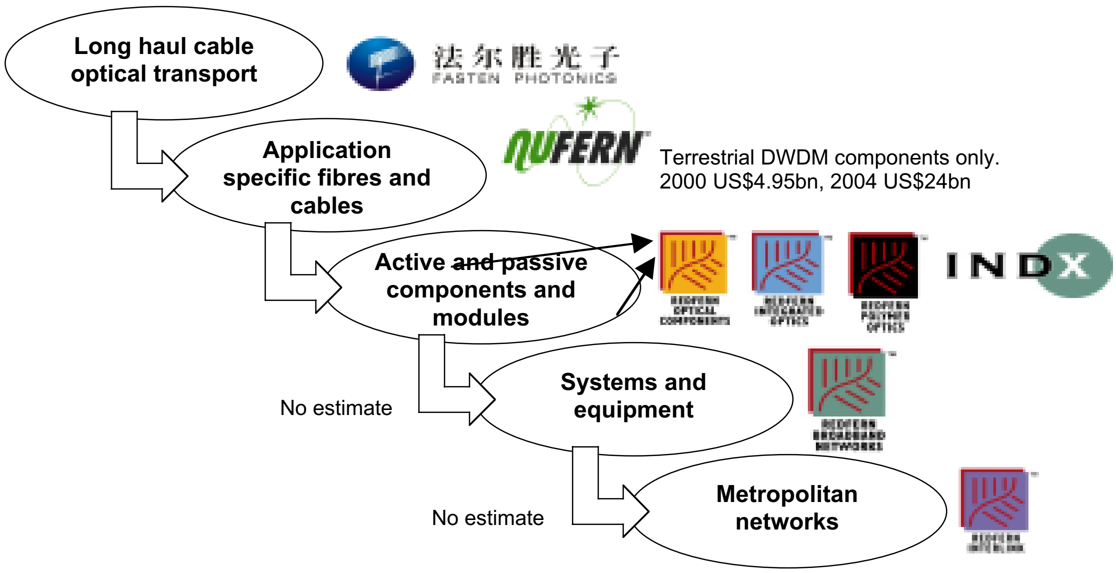
Kadence Photonics is developing a packaging and manufacturing capability for the Australian photonics industry. Australian Photonics Pty Ltd has invested start-up funding.

Visual Photonics Incorporated (VPI) manufactures, and markets globally, photonic computer-aided design (CAD) software design tools. It is only partially owned by Australian Photonics Pty Ltd.

INDX was sold outright by the CRC to JDS Unipahse in 1998 for approximately A$10 million. These funds have been used to bankroll the development of the other companies.

The Jiangsu Fasten Photonics joint venture is partially owned by the CRC and located in China. Its major products are Optical Fibre Preform, and Optical Fibre. About 60% of production will be for the Chinese domestic market and 40% for the overseas market.

The nature of the company's spread across the global market is as follows:



Company growth

The projected staffing levels in Australia for each of these companies is as follows:

Company name	Number of staff as at April 2001	Projected staff as at December 2002
Australian Photonics	9	10
Redfern Photonics	16	16
Redfern Fibres/Nufern	15	20
Redfern Optical Components	15	119
Redfern Integrated Optics	28	130
Redfern Broadband Networks	73	162 (Dec 2001 only)
Redfern Polymer Optics	6	30
Redfern Interlink	1	1
Redcentre	9	11
Kadence	3	22
VPI	25	40
JDSU	305	499
Total number	**505**	**1060**

As can be seen from the above table the growth rate for these firms is staggeringly high. It would be more than reasonable to state that the CRC was most successful in its commercialisation strategies. Taken together it could be argued that to date the public sector investment in photonics research and development has generated 11 new firms (not including APP/L) and about 500 direct new jobs. This figure is likely to be double that by the end of 2002.

Knowledge transfer/education and training

The CRC program defines the education program in the context of technical, undergraduate, postgraduate and professional development programs. In order to be successful in their funding applications, CRCs must show that they have:

> … a well developed graduate education and training program oriented to research user and industry needs. The education and training program will demonstrably enhance the employment prospects and the value of the graduates of the program in the industry and user environment.

Education program guidelines for CRCs in 2000 are listed in appendix E:

As shown above, the major education and training focus for most CRCs lies in their postgraduate research program. However, the photonics CRC has quite a rounded program with involvement in:

- postgraduate education and training both by research and coursework
- undergraduate training
- international education
- schools and community outreach program
- in-house professional development training for researchers
- photonics education enhancement and management
- vocational and technical training.

It is arguably one of the most comprehensive and varied education and training programs of all the CRCs.

The most recent development in the CRC's ability to support education and training activities was winning $1.5 million under the science lectureships initiative (SLI). Funded by DETYA, the SLI funding will be allocated to the development of a comprehensive suite of photonics-based training modules, innovative flexible delivery modes, and a strong educational outreach program. The funding is for distribution within the university sector. No such funding from within the VET system is available for emerging industries. The SLI funding will establish a separate division of the CRC—the Photonics Institute. This is described later in this section.

Postgraduate education

Postgraduate studies in photonics are available at five major universities, ANU, Sydney, University of New South Wales (UNSW), Melbourne and RMIT. Postgraduate coursework degrees will become available at Macquarie and Newcastle in the near future and have been launched at UNSW in 2001.

At 30 June 2000 the centre had 55 PhD students and eight Masters students as members.

The distribution of the postgraduate students across the relevant universities is as follows:

University	PhD	Masters
ANU	6	
Latrobe/ANU	4	
Melbourne	14	3
RMIT	6	2
Sydney	10	1
UNSW	15	2

There has been an increase in the number of honours-level students undertaking photonics research projects. Honours students numbered ten in 2000.

Postgraduate coursework students can enrol in courses at RMIT, University of Melbourne, UNSW. A total of 116 students were enrolled in these courses in 2000.

Undergraduate education

This activity is funded by the Commonwealth as part of the recurrent grants to the universities, and the involvement of co-operative research centre members in this activity does not form part of the universities' contribution to the CRC.

The centre's policy is to enhance the resources for, and encourage participation of, qualified members in undergraduate teaching.

In 1999–2000 the University of Melbourne provided tuition and project supervision to 1026 students, offering seven courses at first, third and fourth-year levels. The University of Sydney's Department of Electrical and Information Engineering provided 226 hours of undergraduate lectures, laboratory tuition and project supervision to 544 students in the BE Electrical and BE Telecommunications degrees. The University's School of Physics provided ten hours of lectures to 150 students in optics and photonics. Australian National University presented one undergraduate course to 25 third and fourth-year students. RMIT University's Department of Communication and Electronic Engineering provided tuition to 744 students at first, third and fourth-year undergraduate level.

New initiatives at the undergraduate level include the closer involvement of Macquarie University, (formally an education associate member of the centre), and the University of Newcastle. The University of Newcastle launched a new Bachelor of Photonics degree in 2001.

The Australian National University has also approved a $1 million business plan for new science and engineering degrees in photonics to be introduced in 2002. The proposal was supported by the centre and a number of centre member companies, and will involve the teaching of the majority of final year units by CRC researchers. Undergraduate scholarships at Macquarie University are supported by the CRC and, more recently, at JDS Uniphase.

Professional development

Professional development activities in 1999–2000 included workshops, short courses and seminars sponsored or organised by the centre, and involvement of centre members in tutorials.

International education

The CRC undertakes educational activities in other countries. Researchers have presented to many prestigious organisations including the Los Alamos National Laboratories, USA; Technical University of Darmstadt, Karlsruhe University, University of Erlangen-Neurberg, Friedrich-Schiller-Universitaet, in Germany; University of Technology, Wroclaw, Poland; CEA-LETI (Technologies Avancees), CE Saclay, France; Centre de Recherche Paul Pascal, Bordeaux, France; the Department of Chemistry, Stereochimie et Internations Moleculaires Ecole Normale Superieure de Lyon, France; Institut fur Organische Chemie und Makromolekulare Chemie, Freidrich-Schiller-Universitaet Jena, Germany. Overseas students also undertake placements in the participating universities and within the CRC.

Education outreach

The CRC conducts educational outreach programs to encourage more students to undertake post-secondary education and training appropriate for a career in photonics. These activities raise awareness of the career opportunities in science and technology generally, but more specifically in disciplines that underpin such careers. In any given year over 2000 school students are exposed to the new industry through travelling science shows, visits to the CRC at the Australian Technology Park and summer science schools conducted in the participating universities. Work experience placements are also available. The CRC now has a contract with Questacon to promote photonics as a career opportunity around Australia.

Educational enhancement and management—The Photonics Institute

A major new initiative was the successful bid for science lectureship initiative (SLI) funding from the Department of Education, Training and Youth Affairs.

In parallel with the planning for the SLI funding bid, the centre had been developing plans for the establishment of the Photonics Institute, as a Division of Australian Photonics, which would provide a one-stop-shop for the management of photonics educational material, services and marketing.

The Photonics Institute will play three integrated roles:

1 outreach
- encouraging students to undertake photonics-related education and training
- encouraging the development of the photonics profession in Australia

2 education and training
- enhancing the quality of photonics-related programs offered by Australian tertiary education institutions
- expanding the size and range of photonics-related programs offered by Australian tertiary education institutions
- providing specialist photonics education and training to fee-paying Australian and international students

3 research
- undertaking high quality research, including fundamental research, in areas of relevance to the Australian photonics industry.

The SLI funding comes from the Higher Education Division of DETYA. No similar funding from the VET system is available. The business plan for the Photonics Institute is not yet in place and it is not known whether it will become a registered training organisation (RTO).

The CEO of the CRC, Professor Sceats, on the announcement of the funding said: 'The existing teaching programs within Australian educational institutions are systemically inelastic with respect to industry demand and therefore incapable of expanding to meet the photonic industry's growing needs. The existing culture is such that institutions align with established industries that have established demands on teaching programs'.

Establishment of the TPI is the way the photonics industry can have substantial input into the education agenda and ensure that the education system meets the needs of the new photonics companies being formed.

The ACT government announced its support for the institute by donating $600 000 to its establishment in the ACT.

VET and the CRC

VET sector involvement with the CRC was established at the Australian Technology Park through the TAFE Industry Partnership Centre. The TAFE IPC's role is to anticipate training needs of emerging technologies and industries. The CRC is also located at the ATP.

Through the work of the TAFE IPC in the Photonics in Australia project, a strong working relationship between the two organisations was cemented. A memorandum of co-operation (MOC) was developed in 1998. This was a first for co-operative research centres who do not have VET links as a performance indicator and a first for TAFE who has never had a formal relationship with a co-operative research centre before. It provided a framework for the development of vocational education and training in the new technology.

The intent of the MOC was to assist in the transfer of knowledge into the VET system—which had no intellectual capital, products or services in this area. It was hypothesised that if one could transfer the knowledge of photonics into VET one could accelerate the process of curriculum development and ensure that there was no gap between the supply and provision of appropriately trained TAFE graduates and the creation of jobs in this emerging industry.

The CRC perceived that its start-up companies would need staff with appropriate training and qualifications in photonics and optical fibre technology at the technical, graduate and postgraduate level. They saw TAFE NSW providing training both through the addition of new modules in its existing diploma programs, and through short courses where science and engineering graduates could gain specialist training in photonic and optical fibre technology.

Co-operative activities outlined in the memorandum include:

- provision of technical and vocational training in Australia or offshore
- provision of training materials, curriculum and training equipment
- development of collaborative training
- joint research and development
- provision of work experience and scholarships or prizes to TAFE students
- other joint ventures.

To date TAFE NSW is the only VET participant in the CRC (indeed in any CRC), but recently effort has begun to facilitate the entry of the Canberra Institute of Technology (CIT) into the CRC.

TAFE NSW—through Lidcombe College initially and Mt Druitt College recently—is the only RTO provider of training for the photonics industry. Lidcombe College has the only VET-based photonics laboratory in the country. The course developed by TAFE NSW has ten modules available for delivery on a fee-for-service basis. These modules were developed with assistance from staff of the CRC. This is the only nationally accredited and registered course in photonics: TAFE NSW no.3678, NSIT code 90039. There are no photonics competencies in the telecommunications training package. The modules are:

- Photonics industry overview

- Introduction to photonics and devices
- Photonics and devices and applications 1
- Introduction to optical communications
- Optical fibre transmission
- Photonics and devices and applications 2
- Optical communications and networks theory
- Photonics analysis and design principals
- Wavelength division multiplexing devices
- Wavelength division multiplexing networks.

The take-up of these modules by the CRC itself and also by its participants has been quite high. Given that the CRC is located across three states and that the industry is growing in five states (predominantly in NSW but substantially in the ACT and Victoria), it is imperative that the VET sector and the CRC develop relationships in these states.

In short, the CRC is currently involved with VET in the following ways:

- VET RTO delivery of training
- lobby ITABS and the Board of Vocational Education and Training (BVET), ANTA
- assistance in the delivery of courses
- facility tours for RTO students and staff
- use of facilities by TAFE for training
- guest lectures at TAFE
- provide information to TAFE/colleges etc.
- host student visits
- host teachers on projects
- recruit TAFE students
- teacher professional development
- donate plant and equipment to colleges.

This is a considerable effort by the CRC in relation to the VET system. No other CRC has such a substantial program of activities.

Developments in skill needs

Implications of the CRC's commercialisation program and global market growth for demand of education and training qualifications.

For the purposes of this research project we undertook to examine the set of CRC start-up companies in relation to issues of training, training provision and labour supply. We sought to find answers to the following questions:

- How many workers would be required to support the companies formed from the outputs of public sector research and development in this area?
- What level of training for workers would be required?

- ✧ What forms of training would ensure that the supply of skilled workers would be sufficient to meet the need of new companies which would be formed as an outcome of this research conducted in the CRC?
- ✧ What skills would be required?
- ✧ Would workers need to be university qualified?
- ✧ What attitudes to training did new companies have?
- ✧ Could new companies articulate their needs?
- ✧ Do the people who start new companies know anything about VET?

Our study showed that for the CRC start-up companies the total number of staff across the companies in early 2001 was 505 with an expectation of growth to 1060 between the end of 2001 and mid-2002.

CRC start-up companies staffing by qualification

Qualification	April 2001	Projected 2001–2	% increase	% of total workforce
PhD	79	106	34.18	10
Postgraduate	149	285	91.28	27
Undergraduate	86	184+	113.95	17
VET/TAFE	81	283+	249.38	27
Experience—no Australian qualifications	109	189	73.39	18
Unspecified	1	0		00
USA**	0	13		1
Total	**505**	**1060**	**109.90**	

** where the company specified either category of qualification the figures were given to the higher award. Some jobs may in fact be filled by persons with a lower level of qualification.

The table shows that the TAFE/VET qualified jobs projected to be created by 2002 will number at least 283 and the number of university qualified positions will be 575. Of these 391 are postgraduate qualifications. The proportion of VET jobs in the cluster now is 16% but will rise by 249% to a minimum of 27% of the total workforce and could be higher by 2002.

Companies participating in the study were quick to point out that they were seeking experienced workers and that it was unlikely that they would recruit new graduates. In many instances companies asserted that entry-level employees for them were workers with post-trade or diploma-level qualifications and experience.

According to an unpublished survey of 12 Australian photonics firms conducted by Tekhne Pty Ltd for the Australian Photonics CRC, if Australia maintains its market share at 1.2% of the global market, the consequent predicted skill demand is for 24 700 workers specific to the industry and 32 000 in associated industries/areas by 2010.

Data from the same study show that a total of 2750 jobs would be created by the 12 firms by 2010 of which 1200 would require VET/TAFE qualifications. This would represent 43.6% of the total demand at that time. Our findings closely align with the Tekhne Pty Ltd survey for the Australian Photonics CRC and show the following.

TEKHNE sample

Qualification	Forecast 2001	Forecast 2010	% increase
PhDs	65	140	115
Postgraduates	70	300	329
Undergraduates	300	920	207
TAFE	190	1200	532
	(29.4% of the total)	(44% of total)	
Non-graduates	20	190	
Total	**645**	**2750**	**326**

Data supplied by Tekhne Pty Ltd for the Australian Photonics CRC

There are two notable points of difference between the studies. In the first instance it shows that the number of VET-qualified workers in the firms surveyed is higher than in the firms we sampled. This could be explained by the fact that our companies are in much earlier stages of development than the ones in the Tekhne study, as some of the companies in the Tekhne sample were large multinationals and quite mature. Secondly, our study did not identify the need for entry-level workers with no formal qualifications while the Tekhne study showed a small number of workers for this industry (14% of the total required by 2010). The same reason could account for this difference also, but the Tekhne study did not seek to clarify what was meant by the term entry level.

A disturbing feature of industry responses in both the Tekhne study and ours was that firms expressed concern about the possible lack of skilled workers to meet company growth plans. If the Australian photonics industry is to grow, there is now an urgent need to provide some assurance to companies that programs are in place to generate adequate numbers of skilled workers to support their investment in growth.

In our study, it was particularly interesting to note that specific training requirements in relation to technical staff were not identified as a major need as it was assumed that the required personnel would be found through TAFE or in the marketplace without too much difficulty. There was a reasonable level of awareness that classes were available through NSW TAFE and other colleges throughout Australia in manufacturing and production, automation and electronics but no knowledge about the level of provision.

The Tekhne study forecast that the entire Australian photonics industry would, by 2010, create approximately 24 700 new jobs. On the basis of its proportional division above, the number of VET-qualified jobs they predict is 10 560. Our study predicts slightly lower numbers and on the basis of current expectations would forecast a minimum of 6916 jobs requiring VET qualifications by 2010. Given the fact that we do not know the size or earnings of the Australian companies in the industry, it would be wise to exercise caution in this study in relation to forecasting future demand. Early industry development is cyclic; it is filled with uncertainty and very extreme highs and lows. To a large extent, industry growth is assured in Australia and so both highs and lows should be kept in perspective.

Chief executive of APPL Mark Sceats notes that if the growth of companies over the last few years was recalculated—accounting for the heady growth of the late 1990s and the downturn in 2000–2001—employment would still be tracking at 20% each year. Thus the hypothesis of rapid industry growth has been substantiated by the growth of individual companies in this study and the industry globally. It is reasonable to argue that significant numbers of workers will be required and demand for VET qualifications will be strong regardless of where one is in the cycle.

A number of companies are concerned that there will be a shortage of workers and if they are assuming the VET and university sectors will provide trained people in sufficient numbers, the lack of efficiency in the supply of trained workers bodes poorly for the development of the industry.

Factors affecting demand and type of qualification

It is clear after collecting data from CRC companies that the qualifications profile and skill requirements of the company change as the company develops. This could be understood in terms of a shift in the dominant activity of photonics components firms from research and development to manufacturing. The following table illustrates this in terms of the companies profiled as well as a function of their stage of development.

Development stage[11]	**Research and development**	**Prototype development or support**	**Single product or niche product**	**Mass production global export**
Essential ingredients	Idea, R&D Equipment and skill	Skill Materials know-how Basic packaging Basic testing Prototyping equipment	Skill and labour Detailed materials Specific packaging Standard testing Basic process Production equipment	Skill, labour and automation Advanced packaging Appropriate testing – functional – statistical – define standards Advanced process Manufacturing equipment
Qualification composition and skills required	PhDs 80–100% of Co. Postgraduates 0–20% of Co. *Minimum skills and knowledge* Analytical and research skills High-level scientific knowledge in photonics and materials Problem-solving Communication	PhDs 70–100% of Co. Postgraduates 0–30% of Co. *Minimum skills and knowledge* Analytical and research skills High-level scientific knowledge in photonics and materials Problem-solving Communication Teamwork	PhDs 30–60% of Co. Postgraduates 20–40% of Co. Undergraduates 30–60% of Co. Technicians Up to 10% of Co. *Basic skills and knowledge* Analytical skills Problem-solving Teamwork Communication Production and automation knowledge Applied technical knowledge in photonics and materials	PhDs Up to 10% of Co. Postgraduates 10–40% of Co. Undergraduates 20–60% of Co. Technicians Up to 70% of Co. *Basic skills and knowledge* Analytical skills Problem-solving Teamwork Communication Production and automation knowledge Appreciation of cultural diversity and change management Applied technical knowledge in photonics, polymers and manufacturing

[11] This table was adapted from a powerpoint slide developed by Dr Simon Fleming, researcher Australian Photonics CRC.

The CRC start-up companies, their phase of development and the qualifications profile are given below.

By company

Company name	Phase	Number of staff at April 2001	VET qualifications now	Projected staff as at December 2002	VET qualifications projected to 2002	VET 2002 %
Australian Photonics	A	9	0	10	1	10.0
Redfern Photonics	A	16	4 all admin.	16	4	25.0
Redcentre	A	9	3	11	3	27.3
Redfern Polymer Optics	R	6	0	30	16	53.3
Redfern Interlink	R	1	0	1	Unknown	
Redfern Optical Components	D	15	1	119	Up to 95	79.8
Redfern Fibres/ Nufern	S	15	5	20	6	30.0
Redfern Integrated Optics	S	28	2	130	Up to 56	43.1
Redfern Broadband Networks	S	73	7	162 (Dec 2001 only)	30 (Dec 2001 only)	18.5
Kadence	S	3	0	22	2	9.0
VPI	M	25	3	40	4	10.0
JDSU	M	305	56	499	Over 80	16.0
Total number		**505**	**81** **(16.03%)**	**1060**	**297** **(28.01%)**	

A = assisting company; R = research phase; D= product development; S = specific product production and sale; M = mature and mass production

High rates of growth were also a factor affecting training demand. The USA Opto-electronic Industry Development Authority dimensioned[12] the photonics industry as having a market of US$21 billion in 1996. In February 1997, *Optics and Photonics News*[13] reported that the US market research firm Electronics, in its 'Dense Wavelength Division Multiplex Products global market forecast', predicts the DWDM component of the market alone at US$12.1 billion by 2005, a huge increase over the US$101 million market in 1995. The most recent forecast made by RKH Incorporated has revised the prospective value of the photonics industry to 24 billion by 2004.

US investment was a major influence affecting demand for training. Without investment a company cannot grow, recruit staff, purchase plant and equipment or implement manufacturing operations. Along with this investment came some cultural expectations which were also felt by management and could be addressed by training in cultural diversity and so on. Sale down (full or partial) of the company could also cause the manufacturing operations to shift overseas. In the case of Nufern, over 200 manufacturing jobs will be located in the US. Is it possible that these jobs could have been located in Australia if sufficient Australian venture capital could have been found?

Recruitment and ramping-up to full-scale manufacturing and automation was another critical determinant for training. As these companies recruit new staff they need to ensure that their core processes are in place and that staff can undertake their roles successfully. It was assumed that once staff were recruited, the customised courses available to the companies currently would fill the need

[12] Opto-electronic Industry Development Authority report, cited by Tekhne, SLI application
[13] *Optics and Photonics News*, February 1997

for any additional training required. Many of the staff from non-photonics backgrounds would need to be aware of the theoretical constructs underpinning photonics technologies.

Paradoxically, the recent downturn in the growth estimates (from 100% to 60%) of the industry globally also meant that anticipated training demand would be, in fact, lower than previously expected. The companies in this study have not revised their recruitment forecasts downward. However, it is apparent that as a consequence of the global economic downturn these companies will slow their rates of growth. This will mean that the urgency of the training need is lessened. Further, these companies are employing staff from US organisations which have shed staff (such as Lucent, Nortel etc.).

Attitudes to training

While demand for training may be high, the need is often poorly articulated and riddled with misconceptions about the training system as it is not well-understood. We found in general that the attitudes to training and providers were fairly good with all respondents keen to assist in the development of such training as it was good for the industry.

Our research shares the following findings with the Tekhne study:

- The majority of the respondents reported a commitment to training of their staff. Companies actively encourage skills enhancement, allow part-time study and support such study, except in the case of small and relatively new firms.
- Many companies provide workplace training and are interested in flexible modes of teaching and learning for staff, including instructors visiting the workplace. Companies emphasise the importance of quality in training and the relevance to competitive performance.
- Most companies are concerned that the availability of skills may be insufficient for growth plans. Companies are strongly in favour of government initiatives to address this issue. Except for small and relatively new companies, they are also prepared to invest in their training needs.

In our discussions with the CEOs, HR managers and in some cases the chief training officers (CTOs), we found different attitudes to training as well as a number of common themes. Many of the utterances were similar to those made by their more mature industry counterparts. We also found some issues that were unique. Themes that emerged in relation to training were:

- Unique findings:
  - the need to take PhD and Masters 'virtuosos' (who were often found to be unemployable, because of their single-person-project focus) and teach teamwork, leadership and communication skills
  - the attraction to foreign investment and the links to established markets in photonics could create a possibility that manufacturing jobs will be located offshore. Training demand will suffer as a consequence
  - a perceived greater difficulty to find the time or resources to free staff up for training activities, that larger or more fully developed companies could afford to do
- Similar findings
  - the reliance on recruitment as a form of intellectual capital building
  - the need for in-house company-specific training in relation to procedures
  - the need for frontline management training
  - the need for environmental health and safety (EHS)/occupational health and safety (OHS) training
  - the multicultural nature of the workplace.

Current impediments to training

The impediments to training in these companies are fairly traditional and many can be found in the literature on investment in training. Reasons given for not investing in training can be conceived as:

- internal to company factors
- external to company factors.

Internal to company factors were:

- state of development of the company. If manufacturing or development processes weren't in place, a person's skill level could not be evaluated nor their training requirement
- perceived time constraints within production line deadlines
- high-level knowledge workers who could self-manage and learn on the job
- knowledge is transferred outside the organisation
- perceived value to the company at its point in development
- cultural bias against VET provision

External company factors were:

- lack of available courses
- lack of available trainers/instructors
- cash cost of training and lack of government support
- lack of a cohesive industry to support co-operation amongst companies on training issues
- structural weaknesses in the education system in identifying and anticipating needs
- lack of knowledge transfer between the higher education and VET system
- lack of VET accreditation.

Impediments identified were significant enough to cause a change in the level of productivity or success of firms in the longer term. Attitudes to training could be better and certainly companies could be better informed about VET. Government support for companies in early start-up phases would assist them in their growth and subsequent profitability and also with the export competitiveness of the company.

While these findings are not entirely unexpected the context in which they occur is quite different from those impediments mature firms experience.

In the first instance these companies are undergoing rapid growth. All skill needs are dealt with in the first instance through recruitment solutions. Any cash the company has is expended on plant, equipment, staff and marketing/sales.

The level of knowledge of existing workers is already high and it is perceived as unlikely that these workers would need high levels of external training as much could be 'picked up' on the job. Much of the work being conducted falls neatly into the description of work Reich provides for technical symbolic analysts.

Specific training needs of the industry

In our study, specific training requirements in relation to technical staff were not identified as a major need as it was assumed that the required personnel would be found through TAFE or in the marketplace without too much difficulty. There was a reasonable level of awareness of classes available through NSW TAFE and other colleges throughout Australia in manufacturing and production, automation and electronics. However, many senior managers could not hypothesise in relation to staff and training beyond 2002. The types of VET qualifications being sought were across a number of areas and not just specific to photonics. These were:

- photonics technicians
- software development, IT and networking
- electrical and mechanical engineering
- manufacturing production (perhaps even ex-fitters and turners)
- sales and marketing management
- office administration
- accounting and human resources management.

On-the-job or in-house training provided by the VET system is implicated in:

- technical skills in photonics
- project, financial and team-based management
- recruitment and HR
- production and manufacturing
- quality assurance
- sales and marketing
- occupational, environmental health and safety.

It was difficult to collect data in relation to this issue. One of the other main reasons why CRC researchers/company managers couldn't articulate their needs clearly or precisely was that it was too early in the research, development, commercialisation cycle. At a more fundamental level, a company with a product specification and a CEO/entrepreneur but without investment is also usually a company without a business plan. More simply put, it is a business proposition, not a company. A company without a business plan is one that has not determined its development, manufacturing or production systems and therefore does not have an HR plan. One without an HR plan does not know what type of workers it needs, the qualifications it wants, or the essential skills its culture requires. It is only through a maturing process that these companies can understand their VET needs.

Despite the fact that the current involvement of these companies with the VET sector is quite broad, it is in indirect ways and little is known by these companies about the VET system, its funding sources, funding which may be available to them and the mechanisms in place for them to articulate their needs (i.e. ITABS).

VET and the photonics industry

Photonics training providers and courses

Technical training in NSW has been funded, initially, by the NSW Government.

NSW TAFE—through Lidcombe College primarily and Mt Druitt College recently—are the only RTO providers of training for the photonics industry.

TAFE NSW has the only VET products available to photonics firms, their suppliers and customers. TAFE NSW has ten modules available for delivery on a fee-for-service basis. Currently, there are no photonics competencies in the telecommunications training package.

Approvals are being sought through the IT&T Industry Training Advisory Board to include photonics in training packages funded by the Commonwealth through the Australian National Training Authority.

To date, many attempts have been made to include photonics in the telecommunications training package but all have failed as there has not been a review of the telecommunications training package since its implementation in 1997.

Both Lidcombe College and Mt Druitt College are using their discretion to increase skills and awareness (by existing telecommunications students) in photonics.

TAFE NSW Telecommunications and Electrical Engineering Diploma students are undertaking photonics-based research projects where there are opportunities in their existing courses.

Staff development and capability

In 1999 and again in February 2000 the CRC at the Australian Technology Park hosted a Return to Industry program for Michael Moulten of Lidcome College and then Doug Fraser of Mt Druitt TAFE, who subsequently prepared a new photonics course for offering in the second semester of 2000. To date TAFE NSW has trained four teachers in this new technology.

Plant and equipment

Lidcombe College has acquired two fibre lasers for its portable lab, as well as some in-fibre gratings. They are positioning to have the next generation technology rather than the last technology. They are counting on local companies to solve the stability problems and develop real-time tuning for DWDM. The college has acquired a DWDM capable optical spectrum analyser that will be the backbone of most of the workshops they conduct. Essentially Lidcombe College now has a photonics lab. It is the only VET institution which has this facility.

VET sector investment

To date the investment by TAFE NSW in training for the photonics industry would be in the vicinity of A$1 million over a five-year period (cash and in kind). This includes staff professional development time, costs of training materials development as well as capital costs of plant and equipment.

VET sector networks—sharing the intellectual capital

Other states

Lidcombe College has hosted staff from Canberra Institute of Technology and assisted them in the development of relationships with the CRC and its start-up companies. CIT has only one member of staff with an optical physics background and no facilities in photonics.

RMIT has expressed an interest in delivery of photonics training as have institutes in Victoria. There has been no activity on this front to date.

With a view to raising interest in photonics by the VET system a number of TAFE NSW–CRC awareness-raising activities have been undertaken. For example:

- In Victoria, Mark Sceats, CEO AP CRC and Karen Whittingham, director TAFE IPC addressed 90 delegates who were board members and senior management from each of the Victorian TAFE institutes as well as industry training boards at the annual conference of the Victorian TAFE Association in 2000.
- Karen Whittingham, and Elizabeth Elenius presented a paper 'Growing a new Australian industry: Meeting the demand for training for emerging industries' at the International Vocational Education and Training Association (IVETA) conference in Sydney.
- A number of other audiences have received the photonics message: SA school principals conference and NSW school principals. The TAFE IPC in collaboration with the CRC hosts school student visits to the Australian Technology Park and all visiting students are briefed on the nature of photonics. Over 200 students have been introduced to the photonics industry this way.

Training delivery by the VET system to date

In 1999 and in 2000 Lidcombe TAFE College provided over 1900 hours of tuition to over 350 students.

To date 53 industry participants from five companies have taken photonics modules provided by Lidcombe TAFE College. Each was approximately 36 hours in length.

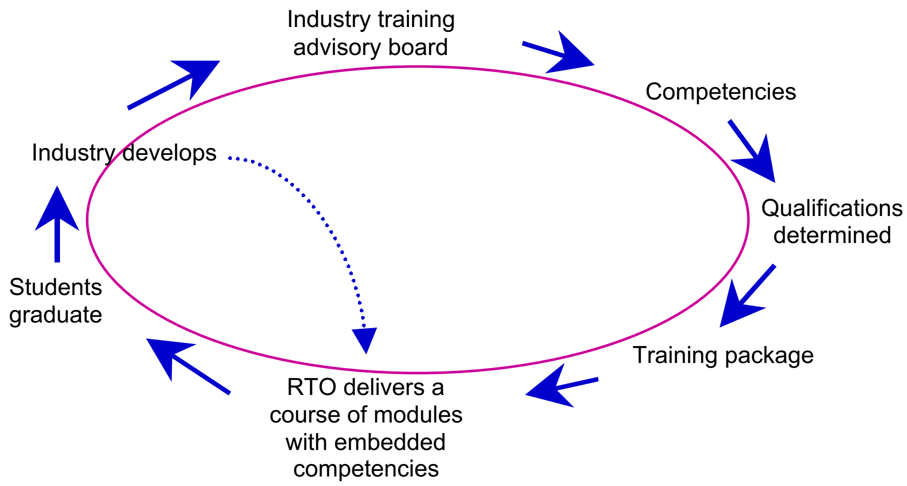
Generally speaking, companies choose topics that suit their specific needs. Much of the training is conducted in house and some is conducted at the ATP.

It is important to note that the majority of the Redfern companies have not tried to recruit VET-level workers as yet. When they do they will find that there are no such graduates with specific photonics qualifications. Further, there will be no diploma graduates in photonics until at least 2004, assuming success for the TAFE NSW course in 2002. There will be no VET graduates until 2004 if training providers wait for the training package.

There has been no other formal TAFE or RTO training delivery conducted for the industry to date.

Telecommunications training package and photonics

A number of pre-existing circumstances and activities have to be in place before any training package qualification is available. The life cycle of the development of training packages along with the development of an industry is illustrated below.



If one looks at the cycle, it can be seen that training package development is dependent upon:

- the existence of companies so that competencies can be determined from underpinning technology knowledge, company processes and production methods
- the ITAB needs to be aware that a new cluster is forming
- the ability of the industry to articulate its needs to the ITAB
- RTO being in a position to be able to deliver training—it must have the intellectual capital of the technology.

Clearly in the case of photonics, structural impediments exist which inhibit the responsiveness of the national system.

Our interviews with staff of the CRC indicated that they viewed the present system for the development of training packages as:

> 'unresponsive, unwieldy and dense'
>
> (National communications manager, Australian Photonics CRC)

However, they found the state board system appropriately responsive and proactive. Given the circular and backward-looking nature of the training package and its reliance on a mature industry base—and in the absence of a nationally modified development system—there is a need to ensure that state training systems can respond in a timely manner to the needs of emerging industries. This will ensure that courses are developed and technical training is undertaken to assure the supply of new workers in a pre-emptive manner.

Conclusion: Comments and observations

Disruptive technologies, such as photonics, start with small student demand even when their economic impact is considerable. If one waits for large student demand to appear before developing educational resources one creates the likelihood, caused by the time lag between development and delivery, that the demand will be met some other way; that is, by moving the technology development and manufacturing offshore to a country which already has the education resources.

There appear to be a number of major impediments to the full engagement and involvement of the CRC with the broader VET system. This impedes the flow of knowledge created by the CRC into VET and reduces the likelihood that Australia will be able to produce or develop a highly skilled and competitive industry in photonics.

Recommended actions

1 Government could address the challenges facing the industry and support its development.

2 Funding to conduct a SWOT analysis on the competitiveness of the Australian firms could be found by DISR.

3 An industry database which identifies and defines markets, companies, products and services by Australian firms could be established by AEEMA.

4 Photonics competencies should be included in the training package when the latter is reviewed by the IT&T ITAB.

5 A Victorian training college could develop an interest and capability in photonics delivery.

6 Special funding for developing training materials and equipment could be made available without the usual waiting and planning periods. A special fund to support emerging high tech—disruptive—industries could be established by ANTA.

7 Activities to support the transfer of knowledge from the CRC program to the VET system could be encouraged and funded—either through the CRC program or through being identified for allocation in ANTA's budget.

References

Interviews

CRC and its start-up companies

Mark Sceats, CEO, Australian Photonics CRC, CEO Redfern Photonics Pty Ltd

Elisabeth Elenius, national communications manager, Australian Photonics CRC

Karen Emmanuel, national mamketing Manager, Redfern Photonics Pty Ltd

Glen Jelfs, human resources manager, Redfern Photonics Pty Ltd and Redfern Optical Components Pty Ltd

Tod Campbell, human resources manager, Redfern Integrated Optics Pty Ltd

Kyle McGinty, human resources manager, Redfern Optical Components Pty Ltd

Maggie Alexander, director, Kadence Photonics

Peter Hill, director, Kadence Photonics

Ian Maxwell, Redfern Polymer Optics

Mr Terry Polkinghorn, Phonics RED Centre

David O'Connor, general manager, Nufern

Melina Scardilli, HR manager, JDSU

Arthur Lowry, director, Virtual Photonics Incorporated

Source documents

Australian Photonics CRC annual reports (1998–1999; 1999–2000)

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Benchmarking study on the Australian photonics industry

Websites

www.photonics.com.au

www.photonics.com

www.photonicsnet.com

www.photonicsonline.com

Industry association

Angus Robinson, general manager, AEEMA

Rod Galloway, project manager, Warren Centre for Advanced Engineering

National ITAB

Leo Van Neuren, CEO, National Telecommunications and IT Industry Training Advisory Board

TAFE NSW

Branko Kulevski, curriculum co-ordinator, ITAM Division, TAFE NSW

Nick Westley, program manager, Telecommunications and IT, ITAM Division, TAFE NSW

Agnes Vukovic, program manager, Telecommunications and IT, ITAM Division, TAFE NSW

Micheal Moulten, teacher, Lidcombe College of TAFE

Doug Fraser, teacher, Mt Druitt College of TAFE

Ian Fraser, assistant director, Southern Sydney Institute of TAFE

Karen Whittingham, director TAFE NSW Industry Partnership Centre, ATP

Appendices

Appendix A

Steering committee: Photonics in Australia project

The Hon Tony Staley, chair

Professor Mark Sceats, Australian Photonics CRC

Professor Trevor Cole, Sydney University

Mr Greg Gurr, project officer, DISR

Mr Daniel Phillips, Macquarie Bank

Mr Terry Polkinghorn, Phonics RED Centre

Mr Peter Moore, National Office for the Information Economy

Mr Ed Tepanes, Future Fibre Technologies Pty Ltd

Ms Karen Whittingham, centre director, TAFE NSW

Mr Leo Tyrrell, Leo Tyrrell Consulting

Mr Angus Robinson, general manager, Warren Centre

Mr Rod Galloway, project manager

Appendix B

Companies listing—A separate document listing these companies in an MS Excel spreadsheet is included.

Appendix C

CRC participants

Industry: ABB Transmission and Distribution Ltd; AOFR Pty Limited; Allen and Buckeridge Pty Ltd; Australian Photonics Pty Ltd; CEOS Pty Ltd; Coherent Australia Scientific Pty Ltd; Ericsson Australia Pty Ltd; Filtronic Components Pty Ltd; Future Fibre Technologies Pty Ltd; Macquarie Photonics Pty Ltd; Nextrom OY; Photonic Technologies Pty Ltd; Redfern Photonics Pty Ltd; Telstra Corporation Limited; JDS Uniphase Pty Ltd; Virtual Photonics Incorporated; Vision Abell Pty Ltd; Bishop Innovations.

University: The University of Sydney; The University of Melbourne; The Australian National University; The University of New South Wales; Royal Melbourne Institute of Technology.

Commonwealth: Defence Science and Technology Organisation (DSTO).

State: Electricity Transmission Authority (TransGrid); NSW Technical and Further Education Commission of New South Wales.

Other: Australian Electrical and Electronics Manufacturers Association.

Appendix D

CRC research programs 2000

Program/projects	Type	Years	Industry collaborations	Linkages
PECVD waveguide technology	Centre	3–8	Ericsson Australia, Redfern Integrated Optics	Royal Institute of Technology KTH (Sweden), British Telecom Laboratories (UK), Universitat Jena (Germany)
Organic and organic/ inorganic hybrid materials and waveguide technologies	Centre	5–8		Ecole Normale Superieur de Lyon (France)
Helicon activated reactive emission technology	Centre	7–8		
Indigenous development of RF photonic links	Applications	8		
Specialised lithium niobate integrated optics modulators	Centre	8		
Laser ablation technology	Centre	8		Southampton University (UK) and University of Central Florida (USA)
Photosensitivity of fibres and waveguides	Associated (ARC)	4–8		
Waveguide theory and design	Centre	3–8		Ericsson Australia, Siemens, ADC Australia
Switchable planar devices	Collaborative	6–8	Ericsson Australia, Ericsson Components (Sweden)	
Direct writing of waveguides	Centre	6–8		
Novel UV processed waveguide devices	Collaborative	8	DSTO	
Pigtailing and packaging technology	Centre	6–8	Newport Corp, Coherent Communications, Redfern Integrated Optics	University of Melbourne–Chemistry
High-speed optoelectronic prototyping and packaging	Centre	8	Filtonic Components, Tenix Defence Systems	US Army CECOM (USA)
Applications-specific fibres	Centre	1–8		
Development of high precision fibres	Associated (ARC Spirt)	8	Nextrom Oy, Redfern Fibres, Hoffman and Co	
Non-zero dispersion shifted fibre	Applications	7–8	Korea Telecom	University of Auckland (NZ)
Fibres for in fibre optical filters	Associated (ARC Spirt)	8	JDSUniphase	
Glass materials for electro-optic modulators	Centre (NEDO)	6–8	Mitsubishi Cable Industries	Toyota Technological Institute (Japan), Catholic University of Rio de Janeiro (Brazil)
Perovskite films for acousto-optic and electro-optic modulators	Centre	8	-	SONY Research Centre (Japan) Max Planck Institute for Microstructure Physics (Germany) Research Centre Julich (Germany)
Fibre bragg gratings	Centre	2–8		
Gratings design application*	Applications	8	ADC Australia	
Fibre lasers	Centre	4–8		KETI (Korea), St Mary's University (Canada), Manchester University (UK)

Program/projects	Type	Years	Industry collaborations	Linkages
Future technologies	Centre	1–8	-	See international linkages
Fibre handling and packaging technology	Centre	8	Bishop Innovation	
Optical add/drop multiplexers	Centre	8		
Optical amplifiers for robust WDM systems	Centre	7–8		
Components and subsystems for fibre radio access	Centre	3–8		
DWDM millimetre-wave fibre-radio networks for data transmission	Collaborative	8	Redfern Broadband Networks	
R&D studies in WDM and broadband access	Applications	1–8	Telstra Corp	
High-speed optical TDM	Centre	2–8		
Remote fibre testing for WDM networks	Applications	7–8	Korea Telecom, Daewoo Telecom	Seoul National University (Korea)
Novel sensing concepts	Centre	8	ABB	
High-voltage optical fibre sensing	Collaborative	6–8	ABB T&D, TransGrid	
Fibre optic current sensor	Applications	1–8	ABB T&D, TransGrid	
Optical hydrophones	Centre	8		
Photonic signal processing	Centre	7–8		UCLA (USA), Drexel University (USA)
WDM techniques for RF signal processing	Collaborative	8		
Holographic memory technology	Centre	8		
Sidearm specification	Collaborative	8	Tennix Defence, BAe, Filtronic Components	Dept of Defence—DMO

Appendix E

Education program guidelines for 2000 are as follows (DISR 2000)

- It is expected that research training will be the main component of the CRC's education program.
- Applicants should give detailed consideration to developing innovative approaches to graduate education and training. Education and training programs should be designed to meet the needs of the user sector. In designing education activities, applicants should ensure that students in the CRC receive a broad range of experiences and skills development. These programs should be aimed at enhancing their acceptance by the user sector, and consequently their employment prospects.
- CRCs should ensure that students benefit from direct contact with researchers in multi-disciplinary and multi-organisational research teams. Students should be involved in areas of research utilisation and commercialisation.
- Students should have access to outstanding researchers not presently involved in the educational system. It is expected that students have a co-supervisor from outside the higher education system.

- It is expected that researchers from organisations other than higher education institutions, who contribute to a CRC's education and training program, will be accorded appropriate status in a participating higher education institution, to allow them to participate in the supervision of students.
- The program for students should include appropriate induction courses in such areas as occupational health and safety, research utilisation and commercialisation, intellectual property rights (including their own), and project management.
- It is also important that students engaged in the CRC have a good understanding of the CRC program and the way it is bringing about a change in Australia's research culture. This includes changes in the attitudes of research providers collaborating with industry and users, and willingness of industry and users to become more involved in long-term research. Emphasis is on multi-disciplinary and multi-institutional research programs, user linkages with participation from concept to completion, effective co-operation and responsible management.
- CRCs should ensure that changes to the research programs do not disadvantage students by disrupting their study and funding.
- Where appropriate, CRCs may provide professional training for people already in the workforce to update technical skills and to facilitate technology transfer.
- Education and training activities are likely to produce some of a CRC's most enduring achievements. Graduates carry with them detailed knowledge of the CRC's field of research and are in an excellent position to encourage its application through their future employment.

Case study 5

Renewable Energy

(Co-operative Research Centre no.27)

Renewable energy

Introduction

Renewable energy is the term used to describe a source of energy that can be used without depleting its reserves. This contrasts with non-renewable energy sources, which are finite and are depleted when they are used.

The Australian Greenhouse Office lists the sources of renewable energy as sunlight or solar energy, wind, wave, biomass and hydro energy. Biomass is derived from organic matter produced in a sustainable manner (e.g. sugar cane crop waste used to produce bagasse). Tidal power is also a source of renewable energy.

Fossil fuels such as coal, oil and gas are formed from biomass transformed by geological activity over a lengthy period, but are not renewable energy sources. World reserves of fossil fuels are finite and being depleted through use. Uranium used to generate nuclear energy is also a non-renewable energy source.

Renewable energy is used for three main purposes:

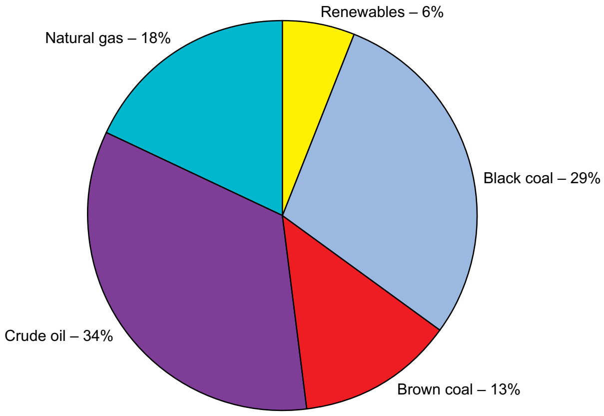
- transport and industrial use
- electricity generation
- domestic appliances (e.g. solar hot water).

Of these, the generation of electricity is now the primary use of most renewable energy technologies.

The 'new' renewable energy industry

The renewable energy industry has, until recently, been considered a small sub-sector of the broader utilities industry which includes the production, generation and supply of electricity, gas and water. Progress in developing new technologies (both in Australia and overseas) has now led to new products and processes for generating and delivering energy and has promoted growth in the industry. Nevertheless, the use of renewable energy remains small in comparison with more traditional (non-renewable) energy sources. As figure 1 shows, renewables were only 6% of all energy used in Australia in 1997–98.

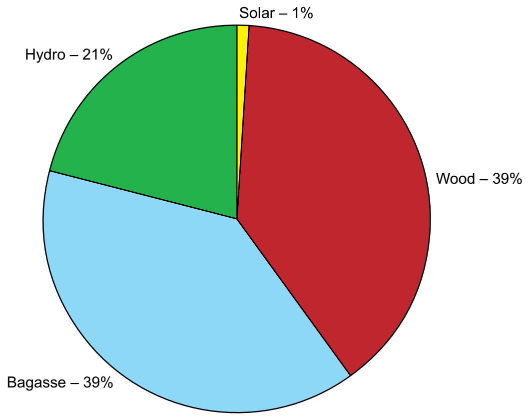
Figure 1: Australian energy use 1997–98



Source: ABARE

Figure 2 shows the types of renewable energy used. These were bagasse, used to generate electricity and steam, and wood used mainly for home heating. Hydro power was also used to generate electricity and contributed about 11 per cent of all electricity generated. The low use of solar power is a surprise in a country that enjoys considerable sunlight.

Figure 2: Australian renewable energy use



Source: ABARE

Worldwide, about 80% of energy comes from non-renewable fossil fuels. In 1996 oil was the most used (36%), followed by coal (24%) and gas (20%). Use of fossil fuels is now under pressure for two reasons, the contribution to pollution, particularly greenhouse gases, and because reserves are being run down. By comparison, use of renewable energy creates only a small amount of greenhouse gas and, as noted above, sources can be replenished.

The Australian renewable energy industry is both highly fragmented and diverse. Most firms are small or medium-sized enterprises (SMEs), producing only one or two products—there are only a few large well-resourced enterprises. Different parts of the industry are at very different stages of development. Some are mature and produce and supply commercial products to developed markets (e.g. solar hot water). Some are in the process of becoming commercial, making the transition from research and development. Others are still in the pre-commercialisation stage, improving and testing the technologies, or setting up demonstrations or pilot plants. Some examples of each type are given below:

- *Fully commercial:* solar hot water, solar dryers, wind turbine/generator, wood heater, bagasse boiler (co-generation), wastes—boiler co-generation, hydro turbine/generator.
- *Commercialising/in transition:* photovoltaics, wastes—gasification/gas engine or fuel cell.
- *Pre-commercial (research and development/pilot or demonstration):* solar thermal electric, bagasse gasification, wave power (other than shoreline), organic wet waste biogas digestor.

In addition, some technologies have been developed that have not been commercialised (e.g. geothermal hot dry rock heat exchanger/turbine).

These differences in the stage of development of various parts of the industry make it difficult to classify the industry generally as *mature*, *new* or *emerging*. Though it is not yet entirely mature or established, the description 'new' does not fit entirely, either, for parts of the industry (e.g. solar hot water) have been around for some time. Also, new technologies continue to emerge and may lead to new sectors (or at least new products or processes) in the industry in the future.

Considering this complexity, and the fact that new opportunities are now opening up for the industry to expand substantially, we have for the moment classified it as a 'new industry'. This label really illustrates that renewable energy has begun to move out from the umbrella of the broader utilities industry to form a new industry in its own right—a fact that is reinforced by the recent creation of an industry association.

Strengths, weaknesses and prospects

The renewable energy industry is now described as 'at the crossroads'. New opportunities are developing for expansion in both domestic and export markets, but rapid action and some change in the industry are necessary to grasp them. On the one hand, Australia is well-positioned to take advantage of these opportunities. It has abundant renewable energy resources and proven skills in developing the technologies to harness them. It is considered to be competitive in many areas and to have a competitive advantage in some areas (e.g. remote area power supply). In addition, government support to develop the industry has strengthened in recent years as a response to international and local concerns about greenhouse emissions.

On the other hand, the industry has been criticised for a focus on the development of the technology at the expense of attention to the demands and needs of markets and customers. Some adjustment is considered necessary to win commercial success against competition—including from overseas. The industry also suffers from a poor reputation for the quality and reliability of products which is often attributed to a lack of uniform standards and inadequate training. In addition, the costs associated with renewable energy are still generally higher than non-renewables (particularly capital costs), although the differential is declining. Access to venture capital can also be difficult in the industry, as it lacks a history of strong market growth.

Globally, growth in renewable energy is anticipated as countries respond to an international agreement to reduce greenhouse emissions by reducing their use of fossil fuels (the Kyoto Protocol). In Australia a National Greenhouse Strategy has been created as a joint initiative of national and state governments in consultation with local government and industry and community groups, and the recently passed *Renewable Energy (Electricity) Act 2000* mandates that by 2010 an additional 2% of Australia's electricity supply must be provided from renewable sources. This target seeks to increase the contribution of renewable energy sources in Australia's electricity mix by 9500 GWh per year by 2010—enough to power four million households.

The greenhouse strategy includes a variety of programs and financial incentives at state/territory and national levels to increase renewable energy use. One is a program to support remote area power services (RAPS) using renewable energy. At the state/territory level, governments are promoting renewable energy use through information and advisory services, financial rebates and program support. For instance, through its Office of Sustainable Energy, the Queensland Government offers information about energy-smart home design and solar power. It also offers rebates for installation of solar hot water services and photovoltaics (power derived from sunlight). Support for renewable energy use also occurs at some local levels with councils encouraging or mandating the installation of solar hot water in new houses.

The Kyoto Protocol opens up opportunities for Australian exports in what could be a very substantial and lucrative market (e.g. electricity generation from wind turbines is growing faster than the information technology industry). However, Australia faces some stiff competition from overseas. Some renewable energy technologies are further advanced in Australia than elsewhere, while others are behind.

Export potential for renewable energy technologies has also emerged in developing countries, particularly for local power generation. This is an area in which Australia has world-leading skills and experience and could build a market and reputation, but opportunities will rely on local government support and the availability of international aid.

Domestic opportunities for expansion of the renewable energy industry are also increasing, primarily in electricity generation and supply. In part, this is occurring in response to changing consumer views, but it is also a result of the opening of former state monopolies to competition. This situation presents some challenges.

- It puts the industry into competition with some long-established and well-resourced fossil fuel producers and distributors able to keep costs down and influence consumers. The renewable energy industry has in the past relied on a small market of committed 'political consumers', but this is unsustainable in the longer term. It needs to convince more consumers to make the switch. However, it faces a consumer awareness problem and misinformation spread by competitors.
- It will need to tackle the problem of costs, particularly high capital costs (installing renewable energy systems), which have proved a problem in expanding the industry in the past. This will be helped on a number of fronts. Renewable energy is proving to be cheaper where generation and consumption are co-located and where there are no costs of distribution. It is thus particularly efficient for remote and rural communities. High capital costs (installation) are being addressed by the provision of government subsidies. In addition, ongoing costs are anticipated to fall for most forms of renewable energy (not hydro). Efficiencies are expected to increase through economies of scale and further refinement of products and services.
- The lack of standards and warranties that has characterised the industry needs to be tackled. This will be helped by the formation of an industry association and by improved training in renewable energy technologies and processes. (Skill needs are discussed further below.)

The ability of the industry to take advantage of emerging global and domestic opportunities will be assisted by the *Renewable Energy Action Agenda* (DISR 2000)—recently released by the Commonwealth's Department of Industry, Science and Resources (DISR), but developed in conjunction with industry representatives.

The agenda sets an ambitious target of growth for the industry:

> To achieve a sustainable and internationally competitive renewable energy industry which has annual sales of $4 billion by 2010

which requires an annual compound growth rate of about 25%—and a very substantial increase in the level of exports.

The agenda notes that responsibility for achieving the target rests largely on individual businesses. But it also proposes a five-pronged strategy by government and the industry as a whole to help them. The agenda's five strategies are depicted in figure 3.

Figure 3: Five key strategies of the Renewable Energy Action Agenda

Source: DISR 2000

Of these, the strategy for building industry capability has particular resonance for the vocational education and training (VET) sector as it is concerned with ensuring the availability of the skills required to develop the industry (this is discussed further in the next section).

Table 1 indicates in brief some examples of action to be taken under each strategy.

Table 1: **Key strategies of the Renewable Energy Action Agenda and examples of actions for each strategy**

Strategy	Examples of action
Encouraging a culture of innovation	Encourage greater co-operation between industry and the research community
	Increase market pull research and development
Market development	Act to leverage the effect of the mandated renewable electricity requirement into business opportunities for Australian companies
	Implement an integrated export strategy
	Promote the development of the renewable transport fuels industry
Building community commitment	Provide more accurate information on the economic, environmental and other characteristics and benefits of the renewable energy industry
	Implement a community awareness and education strategy
Building industry capability	Improve the reliability and quality of renewable energy products and services
	Work to address skill shortages
	Implement a strategy to improve access to investment capital
Setting the policy framework	Accelerate electricity market reform
	Develop a comprehensive energy policy framework

Source: DISR 2000

Employment and skills

The Renewable Energy Action Agenda foreshadows 'significant opportunities in terms of economic and employment growth', particularly for regional areas.

This will mark a shift, for in recent years the utilities industries (gas, electricity, water) have experienced a decline in employment. Australian Bureau of Statistics (ABS) statistics show that, in 1995–96, 80 800 people (annual average) were employed in utilities but in August 2000 there were 65 400. This decline flows from a shift from state control to privatisation and the opening up of competition leading to new cost controls.

Although still very few, job vacancies in utilities already show a small rise in 2000 and the number of people employed in the industry grew from 62 000 in February 2000 to more than 65 000 in August 2000.

While employment growth in renewable energy is expected, it must also be remembered that if the renewable energy industry is able to capture some of the market now dominated by non-renewables, then a shift in employment from one to the other might also occur—with no nett growth in total employment. A shift of this kind would also have skill implications, for while some skills will be transferable, some new ones will also be required by those who move from work in traditional energy generation, for instance, to energy production from renewable sources.

A further consideration for training is that the decline in employment in utilities over the past five years might have created a pool of workers who have some skills in energy production, generation and supply, but who are now no longer employed in these fields. To help meet an emerging skills gap in the renewable energy industry, it may be effective to offer re-training to these workers so that they can add competencies in renewables to the skills they already have.

Forecasts of employment growth in the renewable energy industry are supported by forecasts of increases in some relevant occupations. In electrical and electrotechnology trade occupations, for instance, a shortage of skilled workers is already being experienced and has been the subject of a joint government–industry working group. The electrotechnology industry includes the installation, servicing, repair and maintenance of electrical and electronic equipment for industrial, commercial and domestic purposes and thus some applications of renewable energy. As the industry is challenged and altered by changes in technology (it no longer considers itself to be a 'smokestack industry') it is seeking more sophisticated technical skills and problem-solving abilities in its workers.

Apprenticeships have provided the traditional form of training for these occupations, but while apprentice and trainee commencements have increased since 1996, completions have not kept pace and the gap between completions and commencements has widened—pointing to a significant retention problem.

Table 2: Apprentices and trainees by occupation (electrical and electronic), Australia, commencements and completions 1996–1999

Year	Commencements '000	Completions '000
1996	2.99	1.86
1997	2.86	1.91
1998	3.06	1.81
1999	3.37	1.89

Source: *NCVER Australian apprentice and trainee statistics*, vol.6, quarter 1, January to March 2000, NCVER, Adelaide.

New renewable energy units of competence are currently being developed for inclusion in the electrotechnology training package. These will cover the use of renewable energy technologies such as solar water heating systems and wind generation. These will help to meet some of the skill needs of the renewable energy industry, but given the range of renewable energy technologies, there is considerable room for further competencies to be developed[1].

Inclusion of renewable energy competencies in the electrotechnology training package reflects the absence of a separate industry training advisory body (ITAB) for this rapidly growing industry. While they see the integration of renewable energy and electrotechnology as having some positive aspects, staff from the Renewable Energy Centre at Brisbane Institute of TAFE indicate that it also has resulted in some problems:

- It is inappropriate to have a multidisciplinary field of study with a tightly defined industry sector such as electrotechnology because optimal training in renewable energy systems requires integration of knowledge from a number of different fields.
- It restricts access to a qualification in renewable energy to non-electricians as certificate IV qualifications in the training package are accessible only to certificate III electrotechnology graduates.
- The electrical underpinning knowledge required for understanding renewable energy systems is dispersed through different qualifications and requires non-electricians to 'pick and mix' to gather that knowledge.
- It means there are confusing alternative pathways through the qualifications and units of competency to gain renewable energy industry accreditation (e.g. accreditation from the Sustainable Energy Industry Association, which gives businesses and their customers access to government rebates on renewable energy technologies).

[1] The National Utilities ITAB advises (March 2001) that they are currently part-way through the endorsement process, i.e. the states and territories evaluation of the renewable energy competencies and qualifications. The next phase is approval from the National Training Quality Council (NTQC). The ITABs involved in this process are the National Utilities ITAB and the Queensland Utilities ITAB (QUISITAB). Also contributing is a national industry reference group comprising representatives from the Australian Greenhouse Office, the Sustainable Energy Industries Association, National Electrical Contractors Association and the Communications, Electrical and Plumbing Union.

Skill and training needs

The considerable progress in developing renewable energy technologies in Australia demonstrates the wealth of research and development skills in this field. The discussion paper for the Renewable Energy Action Agenda notes that Australia has capabilities in the majority of renewable energy technologies and markets and there are a few technologies where Australia is a world leader, such as research and development of photovoltaic (PV) modules and fuel cells, and remote area power systems.

As the industry moves into its next phase, where the emphasis will be less on research and development and more on meeting the needs of an expanded market, research and development skills will remain important for further development of the technologies and products/processes, but the stronger need will be for applied technical skills.

Already problems arising from a lack of uniform standards in the industry, particularly problems with product quality and reliability, have been linked to a need for greater skills in product installation and service. Demand for these skills is also likely to rise as the renewable energy market expands.

The Renewable Energy Action Agenda flags a skills deficit in the medium to long term and thus one of its initiatives is 'ensuring skilled people are available to support industry growth'. Responsibility for meeting this objective is ascribed to 'government and industry working together with education and training bodies such as ANTA [Australian National Training Authority] and various ITABs'. Some of the specific actions required to meet the objective are noted as:

- A gaps analysis of present training and education programs against forecast needs.
- Development and accreditation of training programs for persons or companies working with renewable energy products as required. This should include installers and repairers of equipment. It could also extend to companies providing other services such as consulting advice.
- Integration into national TAFE [technical and further education] and university programs to fill identified gaps.
- Development of industry strategies to attract, retain and educate people to appropriate skill levels.
- Facilitating greater industry access to existing skill support mechanisms.

As noted above, development of some renewable energy competencies for the electrotechnology training package should help to meet some needs—at least in the short term. However, further competencies may be required and strong market growth may create a skills gap that cannot be met by the small number of new entrants (apprentices and trainees) to employment.

The task of providing some of the required technical skills training has been taken on by the Australian Co-operative Research Centre in Renewable Energy (ACRE) in conjunction with Brisbane Institute of TAFE (this connection is discussed more fully below). Brisbane Institute of TAFE offers a certificate IV-level course in renewable energy technologies through its Renewable Energy Centre. The course was offered originally on campus, but funding provided by ACRE enabled the production of distance learning materials, so that the course is now also available off campus and thus to a wider clientele. The course provides training in the design, installation and maintenance of renewable energy systems and energy efficient building design[2].

[2] Recent information advises that Goulburn–Ovens TAFE in Victoria is also marketing training materials in renewable energy.

ACRE also provides a range of short courses and programs to industry and government and is currently seeking registered training organisation status in order to expand this work and provide accredited training. However, although ACRE's role has so far been critical in meeting many current training needs, it is not primarily a training organisation. Its capacity to meet increasing future needs will be limited and will be insufficient if there is strong market growth in the renewable energy industry. In the medium–longer term, increasing technical skill needs in renewable energy may require further provision of training through other channels—including registered training organisations (RTOs) that do not already offer modules.

In addition to technical skills, the new focus in renewable energy on the market may require additional management skills. However, this has not yet received attention and it is possible that skills will be transferable from other industries.

The Renewable Energy CRC (ACRE)

The critical role of ACRE in the production of technical training materials with Brisbane Institute of TAFE illustrates the benefits of closer co-operation between VET sector organisations and the national research and development system. The connection with VET secures a conduit by which the new knowledge created in the co-operative research centre (CRC) can be speedily transferred into the VET system, helping to ensure that training remains current and that VET is aware of potential new skill needs as they arise.

The Renewable Energy Action Agenda discussion paper (DISR 1999) notes that ACRE is one of only five renewable energy technology development programs of significant scale in Australia—the others being the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Pacific Solar, ANU Photovoltaics and Ceramic Fuel Cells Limited. Given the fragmented nature of the renewable energy industry and the small size of most firms, there are few industry resources for research and development. Thus ACRE has a significant role in the industry and this may increase as industry shifts from a focus on the development of technology to market needs.

While ACRE has many good features, there is one area in which it illustrates best practice within the CRC program. ACRE has taken on a significant education and training responsibility beyond that of many other CRCs. Its innovative and far-reaching program of activities goes beyond standard university links and industry demonstrations or short programs to include schools, VET, and public education. Education and training thus plays an important part in the transfer of technology to industry and in market development (e.g. increasing consumer knowledge and awareness of the industry).

Structure and objectives

ACRE was established in 1996 and has annual funding of about $10 million. Its mission is defined as 'leadership in sustainable energy solutions' and its objectives centre on developing the renewable energy industry, which includes implementing 'education and training to develop the competencies for commercialisation and technology transfer'.

The centre has a large number of core participants—21 are listed on its website—including 11 industry partners, eight universities, CSIRO and the Centre of Appropriate Technology. Building a 'growing business for the benefit of members' and improving the 'market access' of members are two of the centre's listed objectives. ACRE notes that, reflecting the renewable energy industry generally, the eight companies that are centre members are all SMEs, but the power utilities that are members are large organisations and fulfil a role as 'leading-edge' customers for many of the products of ACRE's projects.

Like other CRCs there is no VET sector core participant in the centre but, unlike most other CRCs, a TAFE institute (Brisbane Institute of TAFE) has formal status as an associate. ACRE's associate scheme aims to allow 'small and large organisations to participate in a low-cost way that is easily accessible' (ACRE 1999).

ACRE has also developed international links with universities, research institutes and energy firms to assist its research and commercialisation programs.

Research program

Our review of the 1998–99 annual report for ACRE indicated that the research was organised into four programs, each centred on a different aspect of the renewable energy market. Within each of these programs were several different projects. A fifth program aimed to assess and develop the market for renewable energy and to provide management support to ACRE. Table 3 lists these five program areas and their main objectives.

Table 3: ACRE research programs

Program	Main objective
Generation	The development of renewable energy systems for areas currently served by diesel generation.
Energy efficiency	Major improvements in the efficiency of mechanical/electrical energy conversion.
Energy storage	Providing means of storing renewable energy from various sources.
Power conditioning	To improve converters to connect renewable energy sources with conventional power generators, rural distribution lines, battery storage and power in buildings.
Systems integration	To integrate systems by combining components into reliable, cost-effective renewable energy systems.
Strategic planning and market assessment	Assessment of markets; creation of opportunities for the renewable energy industry; support of strategic planning in ACRE.

Several new products were indicated as likely to emerge from these programs and almost all were becoming closer to commercialisation. As they move to market, all would require some form of industry training/retraining. Table 4 below gives an example of a potential product from each program.

Table 4: Potential products from ACRE's research

Program	Product
Generation	Small high-efficiency wind turbines.
Energy efficiency	A small motor and power controller for appliances—a tropical ceiling fan.
Energy storage	A zinc/bromine battery module for application in remote area power systems.
Power conditioning	A low cost photovoltaic inverter with solar controller.
Systems integration	A methodology to facilitate decision-making with regard to power supply options.
Strategic planning and market assessment	Recommendations for the application of renewable energy power systems to meet the needs of remote communities.

More recent information from ACRE indicates that as a result of the centre's second-year review, the research program was re-organised into three 'products', each with its own product executive, and each consisting of several projects:

- remote area power systems (RAPS)—five projects
- grid connected systems—four projects
- education and training—three projects.

It is intended that although the projects will change from time to time the products will remain for the duration of the CTC.

Commercialisation and knowledge transfer

Before they can receive internal approval and funding, all ACRE's projects are required to demonstrate market awareness and identify a 'clear and credible route to market' (ACRE 1999). Potentially, then, each project can take a different commercialisation route. However, in practice, commercialisation generally occurs through one of the centre's core participants. Most projects in the research program identify research partners and at least one end user. Some projects identify both a 'commercialiser' and one or more end users.

This structure strengthens the commercial focus of each project by facilitating participation of end users and commercialisers in the research and identifying potential markets from the start of the work. By closing or eliminating a gap between the completion of the research and the identification of markets and commercialisation routes it may have the added effect of accelerating time to market—thus improving the competitive position of Australia's renewable energy industry. It may also increase the speed at which new skill requirements emerge.

The transfer of new knowledge or technology created within the centre to industry and others outside the centre—including people and organisations in the VET system—occurs through a number of different routes. The commercialisation of the research products through the centre's partners is the most significant of these routes, but the centre's education and training program also plays a very important role in this task. This occurs through its links with three education sectors, its provision of short courses, its production and distribution of courseware and professional development materials for teachers and its public education activities. (The features of this program are discussed further below.) ACRE also operates a demonstration program that aims to showcase research products in practical situations in order to improve their marketability and to raise public awareness and has developed a range of strategic links with external organisations and people. (For instance, ACRE claims some credit for influencing the direction of the renewable energy programs of the International Energy Agency through its representation on a sub-group.)

Education and training program

ACRE's education and training program is an *outward-focussed* program that is among the best practice in the 1999 CRCs for two reasons. Firstly, the program is unusual in the scope and scale of its activities and, secondly, the program includes the VET sector—something that the majority of CRCs neglect.

Following the centre's second-year review, the program was re-designated as one of the centre's three 'products' and contains three projects:

- E1: university education
- E2: TAFE education
- E3: information and training services.

As is the case for most other CRCs, postgraduate education is a strong feature of ACRE's program, with many students participating in and learning from the centre's work. In addition, however, ACRE's program includes a range of other activities that reflect the centre's objectives of developing the market for renewable energy and opening up new opportunities. Education and training is considered to be an important contributor to capacity building in the renewable energy industry by helping to rapidly expand the skills pool that the industry now lacks and will require in the future. Two main aims:

- to provide information and training to industry and the community on renewables, energy efficiency and greenhouse issues

- ✧ to address the need for education in renewable energy at all levels

are operationalised in projects around:

- ✧ short courses and workshops for government and industry
- ✧ community education and information
- ✧ school education
- ✧ VET programs.

Many of these projects aim to reach as wide an audience as possible and often use the internet as a tool to do this. As part of its community education program, ACRE has prepared information for the website of the Australian Greenhouse Office. ACRE's school-level program has included the provision of learning materials (including through the internet) and the delivery of professional development workshops for teachers and workshops for students. The VET program has supported the flexible delivery of a Certificate IV in Renewable Energy Technologies program through Brisbane Institute of TAFE.

ACRE has now developed its own interactive training facilities and these are being used for on-site training to support its RAPS and grid-connected products. As noted earlier, the CRC is seeking to become a registered training organisation, which will allow it to deliver accredited and funded training. This will support further use of ACRE's on-site facilities—which are a valuable resource for training.

The inclusion of a VET project and VET activities in the education and training program was not a feature of the CRC from its start in 1996, but came about several years later as a result of an approach from a VET provider (Brisbane Institute of TAFE). Once this connection was made, ACRE became aware that it had missed the 'technical training sector' and that there was a 'gaping hole' in its endeavours to build capability in the industry.

ACRE's VET connection

The connection between ACRE and the VET sector is an important and unusual one. That it came about at all has little to do with the structure of the CRC program or ACRE. Nor did it arise through links between educational institutions in the higher education and VET sectors. The connection can best be explained as arising from common interests between people working in the same field—in this case renewable energy—and meeting through professional networks.

From a practical perspective, the connection has provided the funding for an existing VET course to be redeveloped and packaged for flexible delivery and thus has opened it up to many people unable to attend on campus. The course materials are also being licensed to other TAFE/university institutes, such as the Northern Territory University and Swinburne, so that the CIV can be offered in each state (flexibly or face to face) allowing better student access to equipment and practical assessment opportunities for large and small class sizes. For an industry with a technical skills gap, this is an important development in itself that will have longer term benefits.

The connection has also brought some financial rewards for both sides. The work was not funded outright but on a return-on-investment basis, with TAFE paying royalties to the CRC for sales of training materials. This arrangement provides both parties with an income stream and has enabled the TAFE personnel in particular to take up some new professional opportunities.

For the CRC, the link has allowed a 'more holistic approach' to education and training. It highlighted a gap in what was already being done and provided a way for it to be addressed. The result is a 'more complete picture', in which no one can say 'What about TAFE?'. Making the link work was helped by knowledge of the reputation of the individuals through the industry network, which provided a basis on which collaborative activities could be built.

For TAFE, the CRC connection has provided access to a 'prestigious network', to sources of information and to financial assistance. It has opened up new opportunities for dissemination of information about the course and for marketing the training materials.

The success of the link—and the benefits that have been gained out of it by both sides—point to the potential for gains to arise from similar connections and collaboration between other CRCs and VET organisations, particularly in industries where there is a technical training need in existence or developing. The link also suggests that one way of establishing such useful collaborative activities is for VET organisations to approach the CRCs directly, perhaps (but not necessarily) with a proposal. This direct approach may help to overcome the neglect of the VET sector that marks the education and training programs of most CRCs. The approach is more likely to be successful if the VET staff have been able to establish professional and personal networks with others working in the same field in different settings and organisations.

While the connection has been successful, it has not been achieved without some risks—and some misgivings—within TAFE. Where funding is tight and staff resources are small, the willingness and capacity to take on new things can be limited. However, the resounding success of this venture shows both that it can be done—and that it can be done in a way that leads to rewards on both sides.

Conclusion

There is substantial potential for growth in the renewable energy industry in the next decade. If the industry can overcome some barriers and weaknesses that might affect its ability to fulfil this potential then there is likely to be a skill shortage in the industry in the medium to long term.

Already the industry is experiencing a shortage of workers with technical skills for the installation, service and repair of products. This shortage has hampered product quality and fed a poor reputation for quality and standards in the industry.

Government support for the industry has grown and augurs well for its future development. A newly formed industry association should also be able to contribute to growth. Both recognise the market potential for renewable energy solutions in Australia and overseas. They also recognise the depth of expertise and experience in Australia's renewable energy industry and the abundance of renewable energy resources in this country.

The renewable energy CRC has an important role in the industry, for it is largely comprised of small- to medium-sized companies which have few resources for research and development. The CRC takes a broad view of its role. It is concerned not only with research for the development of new products and processes, but it has also taken on a responsibility for expanding the capability in the renewable energy industry and for developing market opportunities for renewable energy solutions. This broad view is reflected in the many activities of its education and training program which is best practice among the 1999 CRCs.

As part of its education and training program, the CRC has developed strong links to the VET sector through a TAFE college. Both the CRC and its VET partner benefit substantially from the collaborative work they perform. The model of co-operation this relationship presents points to the potential for benefits to arise from similar connections between other CRCs and VET organisations, particularly in industries where a technical training need exists or is developing.

The experience of the two organisations in establishing this connection suggests that it is important for VET organisations to provide opportunities for staff to develop professional networks and to take some risks. There may be a significant payoff.

An interesting development is the CRC's decision to seek RTO status. This underscores the CRC's determination to expand its training activities in the VET sector and suggests fruitful ground for further co-operation between the CRC and other VET organisations, beyond that which has already been accomplished with Brisbane Institute of TAFE.

The inclusion of some renewable energy competencies in a relevant training package (electrotechnology) has been a slow process but is nearing completion. Continuing development of new products and processes in the industry may require further amendment to training packages in the future.

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Case study 6

Satellite Systems

(Co-operative Research Centre no.17)

Satellite systems

Introduction

Arthur C Clarke, the English science fiction writer, is credited with conceiving the idea of a communications satellite system in 1945. It was to be a remarkable piece of foresight, for 12 years later on 4 October 1957 the USSR launched the first artificial earth satellite, Sputnik 1. Four months later, in February 1958, the United States of America launched its first satellite, Explorer 1. So began the aptly named 'space race' between the Eastern Bloc and Western democracies, especially the USA.

This 'space race' led to rapid advances in space technologies and the use of satellites as an integral component on communications systems. Satellites, initially utilised by military and government agencies for research and defence purposes, are now increasingly important in the provision of national and global information services such as navigation, emergency services, mapping, crop monitoring and weather and climate observation. Commercialisation of the satellite industry has also increased the range of services provided through satellites with television, distance education, business communications services and the internet now available to many remote communities.

The Asia-Pacific is a region with many remote communities which can benefit from the satellite services. It is timely, then, that as part of this region Australia should enter the space industry and work towards the self-supply and export of space-related goods and services.

Australia has long had an interest in space-related projects and had a significant role in some of the early satellite work in the 1960s. Despite this early involvement, an Australian space industry has never been realised. The last substantially Australian-designed satellite, an amateur science project, was completed and launched in 1970. Since then, despite the strong utilisation of satellite services, the Australian experience has been one of missed opportunities for the development of an Australian space industry.

The advent of the Co-operative Research Centre for Satellite Systems (CRCSS) is, however, set to change Australia's satellite history. The CRCSS has the vision 'to become an internationally competitive manager of space missions that benefit Australian society'. The following case study is about this vision and the role the vocational education and training (VET) sector may play in the development of a skilled satellite workforce.

The study begins with an overview of the global satellite industry, its developmental history and the Australian contribution. The industry's economic impact and the skills demands are then discussed. The final section is about the role of the CRC for Satellite Systems in developing industry skills and the implications for the VET sector.

The space industry

The space industry has seen rapid developments in its short 44-year history. Continued communication developments, particularly with the commercial application of satellite technology and services, are rapidly shrinking the globe. The technology is opening up new opportunities and finding new applications as the potential of satellite services develops and is understood. This, in turn, has created a growing consumer demand for satellite services, and the rapid growth of the industry.

The phenomenal growth of this industry is seen in the worldwide market for satellite products and services that topped US$66 billion in 1997 and has a 15% annual growth. According to the Satellite Industry Guide published by Futron Corporation and the Satellite Industry Association of America (SIA), the industry is currently in a transition period where 'increasing demand for high-growth, high-revenue satellite consumer services is changing hardware, manufacturing, and launch systems'. The growth in communications services, especially those delivered direct to consumers, is one of the major drivers of demand for satellites and their services. In 1997, these services accounted for over US$20 billion in earnings and is presently growing at 30% per year.

The history of satellite development is relatively short. Understanding the growth of this industry and the drivers of its success provides an interesting exploration into the relationships between new technology, government interests and commercial interests. While these relationships are outside the scope of this study, a brief history of the industry is provided to give the Australian story context to the work and role of the CRCSS.

History

The space industry had its genesis, as previously mentioned, in the late 1950s with the USSR's launch of Sputnik 1. The potential for satellites—orbiting high above the earth—to support communication networks, was quickly recognised by western democracies. Locked in a 'cold war' with Russia, the Western powers, which were separated by vast distances, quickly recognised the potential of satellites to provide more secure communication services than subterranean cables or terrestrial radio.

In December 1958, soon after its first satellite launch, the United States began experiments in communications technology using satellites. The first project sent the satellite SCORE (signal communication by orbiting relay equipment) into orbit carrying a pre-recorded message from President Eisenhower, which was broadcast automatically from the satellite, giving Christmas greetings to the American people from space. This showed that messages could be received from space and was followed in 1960 by the satellite Echo 1. Orbiting 1600 kilometres above the earth, the satellite was inflated to become a large spherical balloon 30m in diameter. Being made from aluminium-coated mylar, its purpose was to bounce back radio signals beamed from earth. The Echo 1 experiment successfully transmitted signals carrying voice, music and pictures from the United States to Europe. On 4 October 1960, Courier 1B, launched by the US Army, became the first communications satellite to carry an amplifier in order to improve the signal strength and quality.

Governments and their agencies funded and carried out the early space and satellite research work. However, the commercial sector quickly realised the potential for the technology and on

10 July 1962, the Telstar satellite, built and operated by the American Telephone and Telegraph Co (AT&T), became the first commercial communications satellite. It had the capacity to transmit 60 telephone calls simultaneously or one television channel. This began the rapid development of communications satellite technology and satellite deployment.

Governments continued to fund much of the satellite industry's work. Their needs and priorities included land mapping, surveillance, meteorological data collection, military communications and navigation systems. The high costs involved in construction and launch, and the high risk of failure, slowed the entry of the commercial sector. This began to change as costs reduced and systems reliability rose. By 1980, private satellite systems were being launched to provide global network facilities for anyone wishing to lease a private system.

The global value in development and launch of satellites for commercial communication and information services overtook the government sector's expenditure on satellites in 1998, with a record 82 commercial satellites being launched. While government spending is predicted to remain static, according to Futron Corp's Satellites Industry Statistics Survey in 1997, commercial spending is predicted to rise rapidly in the next decade.

Industry development

With the rapid development of the industry, an industry body was formed on 2 December 1986, some 20 years after the first commercial satellite launch, to represent all segments of the satellite industry. The Satellite Broadcasting and Communications Association of America (SBCA) is committed to expanding the utilisation of satellite technology for the broadcast delivery of video, data and voice services. The industry it represents includes digital broadband service (DBS) platform providers, programmers, equipment manufacturers, retailers, encryption vendors, software technology providers and national and regional distribution companies.

In April 1995, a further industry association, the Satellite Industry Association (SIA), was formed from the SBCA and the Satellite Superskyway Coalition, to represent the satellite industry. It comprised US satellite service providers, satellite manufacturers, launch services companies and ground equipment suppliers. These associations support the industry's interests in the area of government policy development. For example the 'satellite spectrum' auctions have seen considerable lobbying for their removal by the industry associations.

The development of industry associations is generally indicative of the growth of an industry. In Australia, despite the relatively small number of companies involved in the space industry, there already exists an Australian Space Industry Chamber of Commerce which meets four times a year and forms a central point of contact and lobbying for industry members.

Industry growth

Futron's 1998 'Space transportation and the global space commerce market: Issues and indicators' paper suggested that in the four industry sectors—ground equipment, satellite manufacturing, satellite services and the launch industry—the projected increases in global revenue range from US$51.2 billion in 1997 to US$200 billion in 2007.

In the Satellite Industry Association's (SIA) latest annual survey, a 17% increase in revenues occurred for 2000—the commercial satellite industry is now generating over US$80 billion in total revenue annually. According to the study, satellite services are the largest and fastest growing segment of the industry, generating a total of US$39.5 billion in revenue, a 29% increase over 1999, with US$8.4 billion in revenue from transponder leasing by satellite operators, and US$31.1 billion from subscription satellite services.

It is clear that the take-up of satellite technology is yet to plateau, and growth in demand for services is expected to continue for some time. In addition to the take up of services, the satellite infrastructure that services the physical needs of these services has a finite life span. Advances in satellite technology, and satellite life cycles of approximately 15 years, call for a program of continuous replacement to meet service demand. Ground equipment also becomes redundant, generating further work. The computer industry is a good example of technology advances rapidly making serviceable products redundant. Even if growth in services were to cease, the servicing of the industry is becoming a significant industry in itself.

Economic impact

Figures for the US indicate the substantial benefit of the satellite industry. The US industry uses a ratio to determine the number of employees from the industry's sales. In 1996 the industry employed 4.56 employees for every million dollars in sales. This equated to 26 000 jobs in 1994 for the US$5.7 billion in revenue earned.

Other factors that produce an economic effect are the increased productivity from facilitating business communications in all sectors of the economy and the industries developed from satellite technology, such as the satellite television industry. Remote sensing, mapping and monitoring require new skills to process the data collected. These skills are developing new niche user services and in the application of the knowledge gained, there is a further contribution to economic growth.

Australian involvement

Australia's involvement in the space industry began shortly after World War II at Woomera in South Australia. The site was chosen to provide a facility for the testing of long-range missiles in a joint program of research between Australia and the United Kingdom. Experiments in geophysics, atmosphere physics and astronomy were also carried out at this site.

Australia's first satellite, WRESAT I, was developed for research purposes and launched on a United States Redstone rocket from Woomera on 19 November 1967. The satellite collected data on high altitude molecular oxygen densities and measured ultraviolet and Xrays from the sun. Soon after, rocket and satellite launches ceased, and Australia's short foray into rocket launches stopped. Continued interest in space science saw the design and construction by members of the Melbourne University Astronautical Society (MUAS) of the Australis–Oscar V, an amateur radio satellite carrying radio beacons. This was to be the last substantially Australian-built satellite for some time. It was launched in January 1970, piggy-backed onto a National Aeronautics and Space Administration (NASA) rocket deploying a US satellite.

While Australia's history in the launch and construction of satellites is thin, there has been a strong involvement in space exploration and satellite support through the construction and manning of space tracking stations. These stations have played a major role in supporting many United States space programs. This work dates back to 1957, when the Department of Supply, through the Weapons Research Establishment, established a tracking station at Woomera as part of the first worldwide space tracking network built to support the United States Vanguard project. Several other tracking stations across Australia have also been built to assist NASA in tracking space vehicles. A highlight of Australia's involvement in space exploration occurred in 1969, when these tracking stations relayed television pictures of the first manned lunar landing by the crew of Apollo 11.

Commercial satellite communications services began in Australia in 1967 with an involvement in the Intelsat global satellite communication network. This provided the Australian telecommunications network with a shared facility for communication services. The Intelsat project, an international co-operative effort to provide a single global communication system, had begun in 1964 with the launch of Intelsat 1. This satellite only provided a partial service, although by 1966 the launch of the Intelsat 2, a series of three satellites, provided a fully global communication system. Australia continues to be served internationally by the Intelsat and Inmarsat systems and domestically by the Optus system, which is now in its second generation.

Although little specific progress has been achieved, the Australian Government has continued to show some interest in a space industry. The Australian Space Office, in operation for 12 years, was one government response to supporting the space industry development. However, this project saw little in the way of industry development. The advent in 1997 of the Co-operative Research Centre for Satellite Systems, a research and development project funded by government and industry, heralds another opportunity to initiate a space industry. However, as noted by the CRC's executive director, 'the development of a space industry has never been achieved without special support from the government and at present Australia is the only country where research and development is attempting to establish a new industry without government support'.

Problematic to the development of a space industry, and normally associated with satellite construction and launch, are the factors of high initial costs, uncertainty and volatility. The cost of launch vehicles and their generally one-off use is driving work to develop reusable vehicles—the space shuttle is a result of this concern. However, as seen in the 'Challenger' shuttle disaster, there is an ever-present potential for the rapid loss of equipment and resources. These high risk factors make the industry unattractive to private investment, although increasing reliability is reducing these risks. As a consequence, the space industry has been heavily dependent on government support and public funding for its development and maintenance.

Recently there have been moves to re-establish a satellite launch capability in Australia. Notably, in 1998 the US-based Kistler Aerospace Corporation was to begin development of the Woomera satellite launch facility in preparation for regular satellite launches, although it is not clear whether this will go ahead. Another attempt has been the recent SpaceLift Australia Ltd project to utilise proven Russian launch vehicles at the Woomera site. There has also been the Asia-Pacific Space Centre's project to establish a launch facility on Christmas Island that will utilise Russian launch capability.

In preparation, the Federal Government has drawn up and passed the Space Activities Act 1998 to cover commercial space activities. It has also created a Space Policy Unit and Space Licensing and Safety Office within the Department of Industry Science and Resources to implement a regulatory and safety regime for commercial space activities in Australia.

Regional needs

Drawing on the report from the Second Ministerial Conference on Space Applications for Sustainable Development In Asia and the Pacific, held in New Delhi, 15–20 November 1999, it is argued that the Asia-Pacific region could benefit substantially from the development of satellite services.

> … the major challenge facing the region is in generating sustainable economic growth sufficient to feed and employ the increasing population without endangering the ecology and environment. Any framework for sustainable development at national and regional levels should take an integrated view, making effective use of frontier technologies such as space technology. Space technology, in particular, has special advantages in that it offers a vantage point from which environmental conditions can be continuously and objectively monitored. The 'high ground' of space permits communication services and information to be distributed quickly and over wide areas. The information capacity of modern space satellites is very high and can be simultaneously shared among many users. Thus, satellite systems can fill the role of an information infrastructure.

Developing a regional capacity in the construction, launch and management of satellite systems would provide a significant benefit to the region and the Australian economy.

Skill needs

The satellite industry's skill needs are met from the basic disciplines of electronic, electrical, mechanical and systems engineering. As such, many of the generic skills already exist in education systems for the construction, launch and management of satellite systems. However, it is in the application of these skills that the difference occurs and the need arises for specialist training. Developing these skills requires the contextualisation of the training into a satellite engineering environment. A recent advertisement for space engineers called for the applicants to have 'at least a degree in engineering or a science-related field' and that they 'may be recent graduates or highly experienced, but all will be disciplined, self motivated and willing to work in a team environment'. This is indicative of the environment in which space engineers work and of the specific requirements needed in training personnel to work in that environment.

Other necessary skills are emerging as the technologies needed for satellite services are developed and made more available, such as remote sensing, digital image processing, satellite communications and satellite meteorology.

The demand for individuals with computerised mapping skills and spacial information processing skills is particularly high (*Sydney Morning Herald*, 14 Feb. 2001). This has also been noted by the CRC for Landscape Environment and Mining Exploration, where satellite imagery and other remote sensing technologies require the manipulation of spatial data to extract relevant information. Continuous developments in information collection and processing will no doubt call for new skills to make use of the data.

The Second Ministerial Conference on Space Applications for Sustainable Development in Asia and the Pacific (1999) recognised the importance of education and training to develop space-related skills and called for 'the sharing of expertise and facilities among centres of excellence—to address the continuous need for skilled and trained personnel in various space-related fields'. The conference also recommended that:

> … more universities should offer space technology and applications-related subjects such as remote sensing, digital image processing, satellite communications, satellite meteorology, and computers and software development. Fellowships and travel allowances should be available to facilitate the effective use of regional centres of excellence in space education and training.

An indication of the United States commitment to developing its society's capability in new space-related technology is the US National Workforce Training and Development, Education and Training's initiative. This initiative, in conjunction with the NASA Stennis Space Centre in Mississippi and the University of Mississippi is conducting a five-year educational program in Mississippi (1998–2003), focussed on remote sensing (geographic satellite imagery). The ultimate objective of this project is that every child in the USA will be introduced to the concept of remote sensing at primary school level.

At the local level, Property Services Training Australia (PSTA), the national industry training advisory board for a range of industries including local government, has developed a set of competency standards in spatial information systems for the following fields: mapping science, remote sensing, surveying, cartography, town planning and geographic information services. The qualifications will be at certificate III, diploma and advanced diploma levels. It is as yet uncertain as to the level of demand that these qualifications will attract, particularly in relation to satellite services. It has been suggested that to make full use of satellite-provided services, higher qualifications, at least at the tertiary level, will still be needed for some time.

Co-operative Research Centre for Satellite Systems

In January 1998, the Co-operative Research Centre for Satellite Systems (CRCSS) was established to deliver sustainable advantage for Australian industry and government agencies based on the applications of micro-satellites. With the demand for space services dramatically increasing in recent years, the establishment of the CRC for Satellite Systems presents a timely response to this demand. The development of an Australian satellite industry will not only provide Australia with affordable access to the products and services provided by satellite services, but also develop an industry base to supply the satellite service needs of the Asia-Pacific region.

The centre is based at the Australian National University in Canberra and has a grant period of seven years, taking its operation to 2004, with funding of $58 million. There are 42 full-time equivalent research staff and 56 research students working on the centre's research projects.

The core participants in the CRC reflect the substantial government involvement at this stage of development. The core participants, providing the academic and research base, are the CSIRO and the universities: Queensland University of Technology, University of Technology Sydney, University of South Australia and University of Newcastle, while the industry participation is provided by Auspace Ltd and Vipac Engineers and Scientists Ltd. The CRC also has the following supporting participants: La Trobe University, Curtin University, the Defence Science and Technology Organisation (DSTO), Dspace Pty Ltd and Codan Ltd.

The industry partners such as Auspace, an Australian company but now owned 75% by Astrium and 25% British Aerospace, provides the CRC with practical engineering, research and development expertise in space hardware and satellite-related systems. Auspace also delivers specific training to CRC staff on industrial aspects of satellite technology. Vipac provides the CRC with satellite platform expertise, construction and testing and has overall responsibility for the CRC's satellite platform for its FedSat project.

With the satellite industry in Australia still very much in a developmental stage, the CRC's work to place the FedSat satellite in orbit is an important part of the CRC's agenda. The design construction, launch and management of the satellite will develop the industry's skill base and showcase the Australian space industry's capability in micro-satellites to potential purchasers and users of satellite services. It is also hoped that the Australian Government will be encouraged to provide financial support for the development of the industry.

The launch of the satellite, expected to occur in 2000, has been delayed until early 2002. The launch set-back is a result of problems being faced by the Japanese launch rocket H-IIA. The use of Japanese launch facilities is an indication of the international collaboration the CRCSS is achieving. The launch will provide an opportunity for Japan and Australia to assist each other in their respective space industries. The problems experienced here are also indicative of those that can face the satellite industry such as getting satellites into orbit and meeting customer expectations.

For the Australian satellite industry, the developing Asia-Pacific communications and satellite services market is a primary target for sales. To determine the needs of this market and refine the CRCSS's technology focus, a survey is being undertaken of users and potential users in this region.

The results will provide for the CRC an understanding of regional services demand and a focus for the future direction of commercial operations.

Research program

The research work of the CRC is centred on developing the technologies to provide smaller, faster 'design to delivery' and cheaper micro-satellite turnkey systems. The research programs cover four areas and are outlined below.

Space science

Space science is basic research on the structure and dynamics of the ionosphere using magnetic field observations and propagation delays of global positioning system (GPS) signals. The results of this research will be applied to space weather and communications prediction models and will support the mapping of the geomagnetic field over Australia.

Several research projects are embedded in each program. The first is the research that is working to improve the accuracy of GPS applications. The research will deliver benefits for navigation and position service industries, including geomagnetic mapping.

The propagation of satellite signals through the ionised part of the atmosphere results in distorting effects on the information received. Another project is developing improved models to counter this distortion. These models will improve error correction and enable greater data integrity. The demand for this technology is growing as the communications industry increasingly utilises satellites to deliver large quantities of information.

The outcome of the development of solar cells for space use will be the world's most efficient silicon solar cells. These are being developed at the University of New South Wales. Their performance on FedSat will be measured in the hostile space environment. As the first Australian solar cells to go into space, this research will demonstrate the competency of local Australian research to support a new internationally competitive industry in space photovoltaics.

Satellite communications

This research is developing new techniques for Low Earth Orbit (LEO) satellite communications and earth observation. Research being undertaken will develop innovative solutions for network management and satellite tracking and control.

The project is also looking to find new solutions for the design of the LEO satellite communications systems and networks that are robust against the interference and fading which are common in some satellite communication frequencies. The design and development of modems for satellite systems has resulted in the creation of a 'super modem' that is twice as fast as the competition.

Satellite systems

This program consists of two sub-programs. The first is to develop new improved techniques based on the use of GPS receivers for real-time satellite tracking and precision orbit determination. The second is to improve the capability of onboard computers by developing a re-configurable high performance onboard computer to process more efficiently the information which satellites are designed to acquire and return to ground stations.

Satellite engineering

This research program supports the design, development and manufacture of the satellite and its ground support. With the FedSat platform now being developed in Australia, this research is developing platform capability at the local level. The increased knowledge and understanding of the construction of satellite platforms will benefit the long-term sustainability of a satellite industry. Auspace staff with experience in satellite platforms are working as part of the CRCSS to define the project, its system and the quality documentation required. Expertise from Auspace is also helping the universities to define the way in which their projects can be effectively incorporated into a space mission.

Education and training

The CRC's aim, to develop a satellite industry, will enable Australia to develop and maintain a pool of expertise in the design and production of satellite systems and thus to raise our capacity and competence in this area. Building Australia's knowledge capacity in satellite systems, to create a skill base to meet the needs of the local industry, is a core function of the education and training program.

To achieve this, the CRC now has 56 postgraduate students enrolled in the CRC's partner universities. Of these, six students are in Masters in Engineering programs, five are in Masters in Science and the remaining 45 are PhD students.

The education program has also been involved in a foreign exchange student program, allowing students to gain first-hand experience in appreciation of the variety of applications of space science and technology. The CRC also supports science programs such as Questacon and has been involved in the Australian Science Festival held in Canberra, providing an opportunity for several thousand schoolchildren to learn about satellites and space.

The education program also supports the delivery of specialised short courses to meet the industry needs. One of the CRC's participants, Auspace, has developed a course for CRCSS research personnel to enable them to become familiar with industry processes and practices. These were needed to ensure that the proposed FedSat-1 micro-satellite would be designed, built and tested on time and with a reliable chance of operating as intended until the completion of the research.

Communication

CRC believes that Australians are interested in space technology and the potential for an Australian space industry. To support this, the *Space Industry Newsletter (Spin)* is available both in hard copy and on their website.

The centre also provides many media releases, both in the print and the electronic media. The CRC's 'space grams' program, launched in April 1999, gives the opportunity for Australians to record messages that will be included on a CD-ROM and included on the payload of FedSat.

Commercialisation

After two years of operation, the research outputs are now providing an opportunity to commercialise some of the products and services developed.

Currently there are two potential commercial results from the research. One is a baseband processor that can be used with unattended sensors, for example in environmental monitoring, messaging, data acquisition terminals, or on marine buoys. The second is a personal communications pack using Ka band communication technologies. The pack will provide defence forces with a platform that can be adapted for a range of communication applications.

There is currently a move to incorporate the CRC in order to operate as a parent company for spin-off companies, and to present a commercial front for the technologies being developed and the services offered.

Initial investigations to explore appropriate corporate structures for the centre have led to the call for the provision of contract services to support the commercial activities of the centre. The services required will be to create and maintain an intellectual property register, prepare a detailed plan for incorporation of part of the centre in order to manage the intellectual property resulting from the research, and prepare a plan for the commercialisation of products resulting from the research.

Vocational education and training

With the satellite industry in Australia still very much in the developmental stage, there is at present no demand for vocational training or involvement with the CRC. However, the CRC clearly has articulated that there will be a need for VET involvement in the future at a variety of levels and in a range of disciplines. The anticipation of the skills required and the level of demand to support the industry is unknown because they will be dependent on the speed of the industry's transition from research and development to production. This transition is reliant on many factors. Not the least is the substantial financial demand in this industry. This is not unlike other start-up companies where the injection of funding occurs to accelerate the transition to the production stage.

With regard to the problem of identifying and anticipating skills demand, the CRC believes that the responsibility has to be shared between the providers of skills, in the tertiary and VET sectors, the industry and the research and development sector. A continuing dialogue—to enable the onset of skills demand to be anticipated—would be achieved from regular contact between these parties. Importantly, in view of the time required to develop VET competencies, courses and appropriate training structures, the earlier that needs can be identified, the better. The following figure represents the current relationships between the industry, the CRC, industry training advisory bodies (ITABs) and VET, indicating the lack of interaction that exists to support skills development.

Figure 1: Current relationships between the satellite industry, the CRC, ITABs and VET

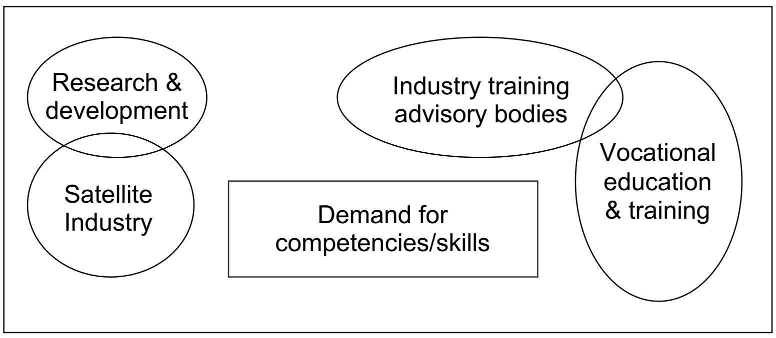
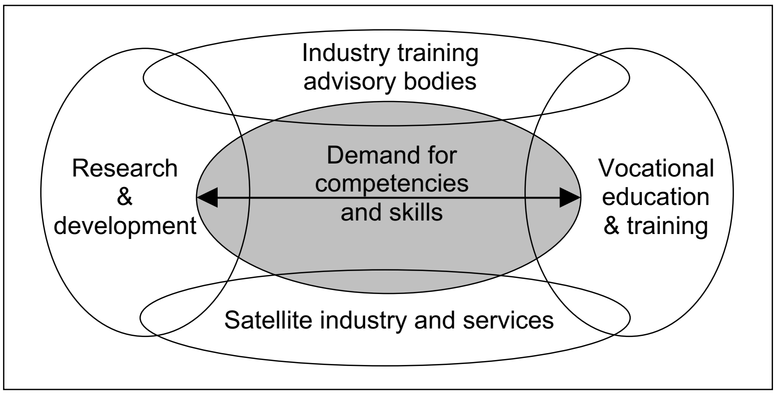


Figure 2 shows the potential links between the various players that would support dialogue and collaboration. The actual mechanisms for dialogue would be the subject of negotiation.

Figure 2: Potential links between the various players



One of the key points also raised by the CRC was the need to train individuals to work in an environment which required them to be autonomous and self-directed, but also able to work as part of a team. The emerging industry will require workers to see the whole picture; that is, the way in which what they do fits into the overall project. The multi-tasking team approach is an increasingly important workplace model for the production of satellites more quickly and more cheaply. This approach is not traditional and can be related to the nature of the industry and those it attracts. That is, the industry is still very much a research and development area, attracting highly skilled but specialised research people, unfamiliar with a production context where time demands are critical. It is in this sense that 'entrenched ideas must go' to develop a commercial production focus. VET, as an industry trainer, can provide that production ethos.

Areas of concern

A primary concern for the CRC is the lack of government financial support to accelerate the industry development. Without this support, it will be difficult to realise a vibrant and competitive industry.

Other concerns raised in the research relate to the need to predict, in a timely fashion, the necessary skills and the ability to identify the point and level of entry for VET involvement. This also raised questions about the nature and structure of a relationship between the VET sector and the CRC. While it is still too early to determine answers to these questions or to explore more fully the issues, there is a need for VET and the CRC to maintain some connection.

Conclusion

It is clear that this CRC is at the forefront of a potential new Australian industry. The entry into the satellite/space industry will reap substantial benefits to the economy and place Australia in an important position in the Asia-Pacific community. There is also social, economic and environmental value in being self-reliant in satellite services. Whether this can be realised is too early to determine. The technical and scientific skills are available to build, deliver and manage satellite systems. Converting this capability into a commercial reality will require the involvement and commitment of others.

The role of VET in supporting the industry development is also too early to determine. What is clear, however, is the need to develop a mechanism: firstly, to identify the role VET can play; secondly, to determine, if necessary, a point of entry for the VET sector; and, thirdly, to identify the particular skill demands and training required for an industry determined to shake entrenched concepts about satellite production.

The need to introduce space technology and related concepts into all levels of education, in order to maximise the development and use of space-related services, has been clearly articulated at a regional level. The VET response to this call is yet to be determined.

The current structure of the national training framework is an industry demand-driven process of skills development. In this role, its mechanisms are unwieldy for skills prediction, identification and introduction into the national framework. The inclusion of the research and development sector, as a component or contributor to the national skills framework, would better position a response to future skill needs.

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Case study 7

Sustainable Tourism

(Co-operative Research Centre no.57)

What is 'sustainable tourism'?

'Sustainable tourism' describes the application of the principles of 'sustainable development' to the tourism industry. Sustainable development takes a long-term view of industry. It seeks to meet the needs of the present, without compromising the future, by taking concerted action to minimise the negative environmental and social impacts of an industry—so that the industry can be sustained in the long term. Thus the sustainable tourism industry would, for instance, seek to protect tourist destinations from the kind of developments that yield economic results in the short term, but which ultimately degrade the environment and lead to long-term economic failure.

Sustainable tourism is sometimes confused with 'eco-tourism', but they are not the same. Both are based on social and environmental awareness and so we could expect that eco-tourism would be conducted in a sustainable fashion. However, the goals of eco-tourism, cited below, focus on educating tourism consumers, while those of sustainable tourism address the way in which the industry operates:

- to interpret ecological phenomena
- to educate diverse audiences
- to create critical awareness of, and responsible attitudes toward, environmental issues.

(Muhlhausier & Peace 1999)

Sustainable tourism is one of a number of new 'green' industries that are arising as mainstream industries are re-shaped by the adoption of more economically, socially and environmentally sustainable practices. The development of these green industries has been a gradual process since the 1970s but has gained pace in recent years in the context of international concerns about global warming and growing environmental awareness and apprehension among communities, consumers, enterprises and industries.

Consumers in Australia and other western nations are showing a growing preference for products and services produced and delivered in a sustainable fashion—even if this means paying a higher price. This means there is an expanding market for 'green' products—and 'greenness' is increasingly being used as a marketing tool. Investors also are favouring enterprises that operate in a socially responsible manner, seeking out 'ethical investments' that meet 'green' principles.

Enterprises and industries are responding to these changes by re-inventing themselves as good corporate citizens, aware of and responsive to the needs of the societies and environments in which they operate. This can mean adopting a 'triple bottom line' accounting model that includes their social and environmental performance alongside their economic performance. It can also entail taking a more active public role in supporting protection of the environment and countering social disadvantage.

The growth of 'green' industries has also accelerated and strengthened in response to many domestic and international regulations, standards, treaties and agreements that have come into force to protect the environment. Most states and territories in Australia have Environmental Protection Acts (or their equivalent) and Australia is a signatory to several international agreements, for example, to control pollution through the reduction of greenhouse gas emissions. Existing industries are changing the ways in which they operate so that they can meet their obligations under these laws and agreements while also seeking to gain by providing some new 'green' products and services and adopting sustainable practices. In addition, whole new industries are developing based on the products and services that enterprises and communities need to help them meet their legal obligations and new standards (Astolfi et al. 2000).

The tourism industry

The Australian tourism industry consists mainly of numerous small enterprises, offering a great diversity of products and services and distributed throughout all the states, territories and regions of Australia. For this reason, the industry is often characterised as fragmented and dispersed. About 85% of firms are 'micro businesses', many of them family businesses (interview with Peter O'Clery). However, the industry also has a small number of very large enterprises, such as the major hotel chains, which can have a substantial share of the market.

The fragmented and dispersed nature of much of the industry, together with the relatively small size of many of its enterprises, creates difficulties in co-ordinating the industry and collecting accurate and comprehensive industry data. Innovation in the industry is slowed and training inhibited. Many tourism operators work in very small or niche markets. Economic returns can be insufficient to support the allocation of funds to activities regarded as discretionary, such as research, development, innovation or training. Further, access to the facilities and information necessary for these types of activities may be difficult for operators located in remote or regional areas. Consequently, many firms may be unable to keep up with the latest trends and developments in the industry. They may lack information about the scope of the market and the opportunities on offer. There is also limited product and process innovation at the local level.

Despite its fragmentation, the Australian tourism industry has been proven to have a substantial economic impact. The Australian Bureau of Statistics (ABS) figures indicate that in 1997–1998:

- Tourism contributed 4.5% of Australia's gross domestic product.
- Expenditure by international visitors on Australian-produced goods and services (tourism-related exports) accounted for 11% of all exports.
- In fact, 4.2 million international visitors had an average consumption per head of $3031 on Australian supplied goods and services; 75 million domestic overnight visitors had an average consumption per head of $465; 155 million domestic day trips accounted for an average consumption of $69 per head.
- Over 500 000 persons were employed in tourism-related activities, representing 6% of all employed persons.

Industry developments and prospects

The Australian tourism industry has experienced substantial growth for most of the past two decades, with only short periods of downturn or low growth. However, in an increasingly global market it is facing strong competition from overseas, from both developed and developing countries.

Much of the gross domestic product (GDP) contributed by tourism derives from domestic tourism (79% in 1997–1998). However, the number of international tourists has grown strongly from a low base and is forecast to grow strongly in the future. ABS data indicate that growth in the tourism flow to Australia in the late 1980s was almost twice the international growth rate in tourism flows to all countries. The number of international visitors to Australia increased at an average of 25% per year from 1984 to 1988. Following a short downturn, growth continued again in the 1990s. The number of inbound visitors in 1991 was 2.3 million and this almost doubled to 4.4 million in 1999. Based on data collected by the Department of Multicultural Affairs, the Australian Tourism Commission found that 4.65 million international visitors arrived in Australia in the year ended June 2000, up 8.5% on the previous year. The Tourism Forecasting Council has forecast average annual growth in the number of overseas visitors of 7.8% from 1999–2010, but higher growth for visitors from Asia and North America (Australian Tourism Commission website).

In spite of substantial growth in the number of international visitors, Australia's share of world tourism is still small, accounting for only around 0.5% of total international arrivals in all countries. This leaves a considerable potential for growth. However, Australia's distance from much of the rest of the world means that this potential is limited (ABS—Tourism Economic Importance). On the other hand, as a 'long-haul' destination, Australia benefits from the tendency of international visitors to stay for a relatively lengthy period. ABS data (*Overseas arrivals and departures*, cat. no. 3401.0) show that in 1999, 41% of international visitors stayed for more than two weeks and 21% stayed for more than a month. Most visitors arrive for 'holiday' purposes (56% in 1999) with another fifth 'visiting friends/relatives'. The ABS comments on the 'relative lack of seasonality' in overseas visitor arrivals, which it attributes to 'the attractive climate experienced in different parts of Australia throughout the whole year and the wide diversity of source countries' (Tourism—inbound tourism—characteristics).

An important consideration for the industry is that the demand for tourism product is driven by value, fashion and reputation. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) suggests that as a result, setbacks in the industry are likely to be more rapid and irreversible than in other industries (CSIRO website—sustainable tourism). However, CSIRO also suggests that research can play an important role in providing understanding to the industry so that these setbacks can be avoided.

The recent history of the industry confirms that tourism is affected by external forces or events, which may be unpredictable. For instance, the ABS notes the adverse impact on tourism of the disruption to domestic airline services caused by the airline pilots' dispute in late 1989. It notes also that major events (such as the Bicentennial celebrations and the Brisbane International Expo of the late 1980s) can cause temporary upsurges in both domestic and international tourism followed by downturns (current data are not available on the post-Olympics period in 2000–2001). However, data indicate that recovery from downturns has generally occurred within a short period, with new periods of growth following. Thus, the industry appears to have a fair degree of resiliency that allows it to weather some temporary storms without sustaining long-term damage.

Changing economic conditions in some visitor source countries have affected the industry in recent years by altering the mix of visitors entering Australia. While falls in the number of visitors from some countries tend to have been made up by increases in visitors from others, the shifts can have some economic effects and can impact on employment, because visitors from different parts of the world spend their money in Australia on different things. ABS data show that the highest spenders tend to be visitors from mainland China, the United States of America and Canada. Visitors from Asian countries tend to spend more on shopping, while visitors from China and Europe spend more on food, drink and accommodation.

The number of people employed in the industry is growing and Tourism Training Australia (TTA), the national industry training board, projects that about 300 000 new jobs will be created in the next three years. Table 1 shows ABS data on employment in the industry 'accommodation, cafes and restaurants'. Though there have been some changes in the data collections so that the figures are not directly comparable over the time period indicated, substantial growth is still clearly evident.

Table 1: Employed persons, Australia—accommodation, cafes and restaurants

Date	Persons ’000
1995–95 (annual average)	380.6
February 2000 (seasonally adjusted)	439.4
August 2000 (seasonally adjusted)	463.5

Source: ABS *Labour Force Australia* (cat. no. 6203.0)

ABS data presented in table 2 also indicate that there are a growing number of job vacancies in the industry, reflecting growing demand and spending.

Table 2: Job vacancies 1995–2000—accommodation, cafes and restaurants

Date	Job vacancies ’000
May 1995	4.6
May 1997	6.0
May 1999	8.9
May 2000	8.5

Source: ABS *Job Vacancies Survey* (cat. no. 6354.0)

Industry data show that some regions in Australia receive many more visitors than others. For instance, many more international visitors travel to New South Wales and Queensland than other states. As a consequence, employment opportunities in the industry are also unevenly spread and there are variations in the levels of demand for tourism training in different states and territories. Mobility of the skilled workforce is also an important issue, particularly if an oversupply of labour in one state is matched by an undersupply in another.

Skill needs and training

The application of the principles of sustainable development to tourism raises a number of skill needs, because it entails a substantial shift from the ways in which the industry has interacted in the past with its social and economic environments. Moving the industry to a more sustainable footing requires, for instance, enhanced knowledge in the industry of the principles of sustainable development, environmental management and environmentally sensitive design. It also requires knowledge of methods for assessing their social and environmental, as well as economic, performance. Adopting ‘sustainability’ also means that resources need to be used differently—and also that different types of resources are drawn on. These changes pose a challenge, particularly for those in the industry whose knowledge and experience are based on a different set of principles.

Something of the extent of the changes and their implications is illustrated by the fact that training of eco-tour guides has taken on a new urgency, in that they:

> … are not just pathfinders, group managers, or showers and tells … they are strategic communicators who are capable of creating meaningful bonds between their clients and the places they take them …

and the potential for a huge demand for training for this type of tour guiding within the industry is noted:

> … it is timely, industry relevant and very connected to the bottom line of profit and revenue.
>
> (Dr Sam Ham, quoted in the CRC for Sustainable Tourism 1999, p.45)

In addition to the challenges posed by the adoption of sustainable practices, the industry is also facing new training needs as a result of ongoing technological change and the growth of e-commerce. In recent years, new technologies have enabled many more of the industry’s functions to be undertaken online and at high speed. For instance, some functions formerly undertaken by tourism operators (e.g. travel agents) have moved online and become directly accessible by consumers. The result has been growth in business to consumer services at the expense of business to business. Flowing from these changes, those working in the industry are increasingly required to have skills that will enable them to take advantage of new opportunities being offered. These include advanced skills in information and communication technologies, and skills in analysing the market and the performance of their own business.

According to Tourism Training Australia (TTA), the industry training advisory body, there is a change of culture occurring in the industry that is placing a stronger focus on turnover, profit and margins. Re-training of existing workers is now as important as training for entry-level workers. For the industry to grow, it will also require graduates in law and financial management who have the skills to deal with an increasingly complex and sophisticated industry.

While the industry employs both higher education and vocational education and training (VET) graduates, TTA suggests VET graduates are preferred because of their direct industry experience and applied skills. Technical and further education (TAFE) institutes are the primary VET providers in the industry, but there are also some private providers offering training. Two relevant training packages in hospitality and tourism have been developed for VET-level training by TTA and are being widely used throughout Australia. There is also a plan to market them internationally. The competencies currently in the package are:

Hospitality training package	Tourism training package
Commercial cookery	Tour guiding
Food and beverage	Tour operations
Gaming	Tourist attractions and theme parks
Commercial catering	Wholesale operations
Housekeeping	Visitor information services
Patisserie	Retail travel
Kitchen attending	Meetings and events
Hospitality security	General units
Hospitality management	
Asian cookery	
General units	

In 2001 the training packages underwent a stage 2 review, which included consideration of the ‘sustainable development’ of the industry. TTA notes that the industry is ‘warming to’ the packages and likes their flexibility. Free TAFE training is also ‘a big drawcard’ (TTA comments from interview with CEO Bill Galvin).

While a substantial training need is indicated, many of the dispersed small businesses in the tourism industry currently experience difficulty in gaining access to appropriate training and information resources about new developments. This is particularly so for those operating in remote areas. TTA has a strengthening role in assisting these enterprises, by developing information technology (IT) ‘smart products’ for small businesses using the training packages. However, the tourism industry also has a small number of very large employers who currently undertake substantial levels of training and who may have registered training organisation (RTO) status, e.g. the hotel chain ACCOR.

TTA has adopted the slogan ‘improving profit through training and training packages’ to promote training in the industry and uses stories illustrating the benefits of training to support its promotional campaign. For instance, in one TTA brochure the staff development manager from the Wrest Point Casino (WPC) Hobart, explains that:

> The true effectiveness of training is linked to the business plan in terms of higher productivity of staff, high staff satisfaction and improved bottom line results …
>
> Our future challenges are to attain RTO status in our own right and to continue to refine and tailor the way we use the training packages to meet our business objectives.

National Centre for Vocational Education Research (NCVER) data on the number of students in each VET discipline group for 1999 indicate 238 600 in the field of hospitality, tourism, and personal services. This compares with 474 538 in 1996 and thus indicates a considerable reduction. In 1999, Queensland had the largest number of students (70 900) with NSW (65 200) and Victoria (64 000) following closely behind. From 1996–99 there were considerable reductions in the number of students in this discipline group in all three states, with the largest drop in NSW.

Table 3: Number of students in the discipline group hospitality, tourism and personal services, by state, 1996 and 1999

	NSW	VIC	QLD	WA	SA	TAS	NT	ACT	AUS
1996	160.6	113.8	115.1	34.6	26.3	14.1	2.8	6.8	474.5
1999	65.2	64.0	70.9	12.6	16.0	5.0	2.0	2.9	238.6

Source: NCVER statistics

However, module enrolments (see table 4) show a significantly different picture, with the number growing by over 46% during the three-year period. As students can be enrolled in modules in more than one discipline group, this may indicate that an increasing number of students in other disciplines are taking modules in hospitality, tourism and personal services and/or that each client is taking a greater number of modules.

TTA estimates that there is a significant amount of 'reverse articulation' in the tourism industry (interview with CEO Bill Galvin). That is, there are many university graduates entering VET. No data are available on prior education qualifications completed by this discipline group and thus no conclusion can be drawn. However, data on module enrolments indicate that incidences of credit transfer and recognition of prior learning (RPL) (which indicate relevant prior study and work experience) have both grown from 1996 to 1999. In 1999, credit transfers of 31 800 represented 3% of all module enrolments, up from 2% in 1996. RPL was granted for 1.6% of module enrolments in 1999, up from 1.3% in 1996.

Table 4: Module enrolments in hospitality, tourism and personal services, all clients, Australia, 1996 and 1999

	Total	Credit transfer	RPL	Pass
1996	743.5	15.5	9.8	517.6
1999	1083.5	31.8	17.9	677.9
Increase (%)	46.0	105.0	82.0	40.0

Source: NCVER statistics

Research into reverse articulation has shown that university graduates enter VET for a number of reasons but often to gain some specific work skills in a new field or in the same field. It might be that the high degree of reverse articulation in the tourism industry reflects differences in the types of programs offered in the two education sectors, with university tourism graduates seeking some practical skills to top up the more theoretical work they have already undertaken. Or it could be that graduates from other fields are participating in VET to gain the skills to enter the tourism industry. Or it could be a combination of these things.

The CRC for Sustainable Tourism

The highly fragmented and dispersed nature of the tourism industry limits the industry's capacity to undertake research and development and related activities. The CRC for Sustainable Tourism thus has an important part to play in promoting innovation in the industry. It fills a gap where little other research and development would occur if it did not exist.

This does not mean that it is the only organisation performing research in tourism. Others include research centres within universities, which also provide postgraduate-level training for the industry. However, CRC CEO Terry De Lacey indicates that the CRC takes up a 'new research area' where previously there was only 'market research'. Notably, two government-funded tourism research bodies continue to provide the industry with much-needed basic data about the tourism market: the Tourism Forecasting Council and the Bureau of Tourism Research.

Structure, mission and goals

The CRC was established in 1997, and in 2001 is thus approaching its fifth year. Statements published in the CRC's 1998–99 annual report (CRC for Sustainable Tourism 1999) indicate that its mission is to deliver innovation and strategic knowledge to business, community and government to enhance the environmental, economic and social sustainability of tourism'. Its 'vision' is a dynamic, internationally competitive and sustainable tourism industry.

A goal of the CRC to change the culture of the tourism industry:

> Toward high interaction in a widening research agenda, active participation in setting priorities, positive contribution to outcomes and development of capacities to reap benefits.
>
> (CRC for Sustainable Tourism 1999)

Much of the work that the CRC undertakes falls into the category of 'public good' and therefore is not always expected to lead to viable, commercial products or services as is the case in more commercially focussed CRCs. However, it does not preclude them, for the CRC maintains an 'end-user' focus and the outputs of the CRC's research are expected to be diverse (e.g. tools, information, best practice, processes, policy principles and strategies).

The CRC has a larger number of partners than many other CRCs, with 23. This includes 12 universities across all but one state, the peak industry body (the Tourism Council of Australia), state-level major tourism agencies from Queensland, New South Wales, Victoria, Tasmania and Western Australia, the City of Melbourne, and the Australian Federation of Travel Agents (AFTA). An additional university is an associate member. The CRC has developed memoranda of understanding with the Australian Tourism Commission, the Australian Tourism Research Institute, the World Travel and Tourism Council and Green Globe 21. It also has linkages with more than 20 other organisations, including major players in the industry such as Qantas, the Australian Heritage Commission, the Australian Football League and American Express International. These are listed in the *Researchers' compendium 2000* (CRC for Sustainable Tourism 2000).

Available published documents indicate that the CRC has no VET partners or associate members. However, a memorandum of understanding with the industry training advisory body (ITAB) Tourism Training Australia has since been developed. This relationship, which is seen by both sides to have benefits, will be further discussed in the section of this report on VET linkages.

The CRC has developed a commercial arm to offer research and professional consultancy services. The National Centre for Tourism aims to provide clients with 'authoritative industry intelligence and policy analysis on tourism and travel-related issues' and also has a role in commercialising the CRC's research output. It has four programs:

- Business—commercial tourism research and development assisting with the marketing, commercialisation, information dissemination, and export of CRC research outcomes and services.
- Professional development—delivering management and practical industry extension and training programs.
- Industry—fostering strategic alliances between the CRC and industry.
- Research applications—providing a commercial research and management resource to support the policy needs of the Australian travel and tourism industry and the CRC.

(CRC for Sustainable Tourism 2000)

The CRC has also developed a joint venture with Green Globe 21, a global environmental certification program that enables consumers to identify 'green' products. This is aimed to deliver certification in the Asia-Pacific region. In conjunction with the Tourism Council of Australia and Southern Cross University, it also supports a Centre for Regional Tourism Research as a joint initiative. The centre has a strong focus on regional needs and issues.

Given the many partners in the CRC, the centre's governing board is also large. For this reason, there is also a smaller executive board to deal with more day-to-day decision-making. Collaboration and communication between the partners is also facilitated through the establishment of a 'node' in each state or territory, managed by a 'node co-ordinator', with responsibility for fostering communication and industry links, co-ordinating research proposals, providing advice to the board and facilitating the participation of PhD students. Node co-ordinators also sit on the CRC's Research Committee, which meets twice annually to consider research project proposals and progress.

The main functions of the CRC are split into two program groups: Developing intellectual property—the research program, and Managing intellectual property—the program of activities and strategies to deliver research outputs to end-users. Each program group is the responsibility of a manager reporting directly to the chief executive officer (CEO). There is no discrete education and training program, as there is in many other CRCs. Within the CRC, education and training is primarily inward focussed, with an emphasis on postgraduate education. Some additional training is offered through the National Centre for Tourism and as part of the Managing intellectual property program—largely in response to external requests. However, as more research outputs become available, there are indications that a stronger emphasis on training will be required to support them. This is not seen as something that the CRC can do itself and so is driving the development of further connections with external organisations able to assist—such as VET providers.

Developing intellectual property—the CRC research program

The research work of the CRC is multi-disciplinary in nature, drawing on skills in science, information technology, engineering, design, policy and management. Four main research programs each have their own aims and expected outputs, with postgraduate training and the production of PhD graduates common to all.

Table 5: Research programs of the sustainable tourism CRC

Tourism environmental management research	**Tourism engineering, eco-technology and design research**
Aims:	*Aims:*
Innovation and improvement in environmental management practices, environmental policies and environmental tourism products	Technological innovation and postgraduate training
Outputs:	*Outputs:*
Best practice environmental management	Tools to predict and manage impacts of tourism facilities in coastal and marine environments
Environmental management policy principles, strategies and tools	Tools and knowledge to manage impacts of tourism on coastal ecosystems
New environmental tourism products	Waste management and other environmental impact technology
PhD graduates	Benchmarks, design and construction strategies for resorts
	PhD graduates
Tourism policy, product and business research	**Travel and tourism information technology research**
Aims:	**Aims:**
Management innovation, product innovation, process innovations, policy innovation and postgraduate training	Information technology innovation and postgraduate training
Outputs:	**Outputs:**
New products	Technology tools to assist digitising travel agents' businesses
Best tourism management and planning principles, strategies and practices	Technological tools to assist travel decision-making and planning
Tourism policy principles and recommendations	Best practice online marketing models
PhD graduates	Online tools to assist digitising small and medium travel and tourism enterprises
	Best practice and online tools to digitise rural and regional tourism product
	Software and expert systems to support continuous environmental improvement in the world's travel and tourism businesses and destinations
	PhD graduates

Source: CRC for Sustainable Tourism 2000, *Researchers' compendium 2000*.

A quick survey of the outputs listed for each research program (table 5) indicates potential for a number of commercial outputs in all areas, including tools, processes and systems. This potential seems particularly strong in the program centred on information technology.

Within each of these program areas the CRC supports a variety of projects within three categories:

- commissioned projects initiated and funded mainly by industry (approved by the CEO and tabled at board meetings)
- small projects for less than one year and under $30 000 called for each year from core partners, ranked by industry panel, recommended by the research committee and approved by the board
- large projects for over one year and $30 000 usually involving more than one core partner and in response to an invitation to submit from a program co-ordinator, the deputy CEO or CEO. Ranked by industry panel, peer review, recommended by the research committee and approved by the board.

An industry panel is convened to examine projects in each program area. The research committee includes the deputy CEO, and program and node co-ordinators. Each project application is assessed against the mission and goals of the CRC. Given the diverse nature of the projects, and the tourism industry, each project has its own dissemination strategy.

Managing Intellectual Property—the commercialisation/utilisation/ dissemination program

The CRC's industry extension manager is responsible for the centre's Managing Intellectual Property program, which encompasses seven groups of activities, listed in the following table.

Table 6: Activities in the Managing IP program

Activity and aim	Description
The maintenance of an intellectual property register Capture and record all CRC and background IP.	Register intellectual property. Assess potential and appropriate opportunities and treatments. Develop tools for handling different kinds of products.
Technology transfer and green leaders initiative Maximise the transfer and uptake of CRC research outputs, deliver environmental management tools and strategic knowledge to stakeholders.	Gather and transfer environmental best-practice tourism to stakeholders through seminars, website, newsletters, fact sheets, direct canvassing, etc.
Executive training Develop and deliver targetted training for executives, particularly in SMEs (small and medium enterprises).	Develop courses for tourism business linked to CRC research outcomes. Facilitate delivery by partners. Develop opportunities with industry sectors and regions. Develop opportunities to deliver through international bodies.
Commercialisation Through joint ventures and licences, deliver research products to industry and to planners, consultants and regulators.	Raise awareness of commercial product and find partners, joint ventures and licensees. Develop strategic relationships to help identify potential partners for product. Establish alliances with venture capital and commercial product development companies. Build links with commercialisation arms of partner universities.
Destination management products Deliver destination management products to destinations globally through collaboration with industry and agencies.	Work with state tourist commissions to drive development and delivery. Establish working alliances with overseas and international organisations to deliver products. Develop destination management expert systems as web-based tools and market through National Centre for Tourism.
Spin-off companies Build commercial enterprises from CRC outcomes that have the capacity to be developed as viable independent businesses and underpin ongoing re-investment in CRC research.	Foster strategic partnerships for products with major commercialisation capability. Build business planning and assessment capacities and tools toward maximising CRC performance. Establish alliances with financial institutions and venture capital companies.
Delivering international services Deliver CRC services into the international market.	Market the CRC's intellectual property internationally. Deliver specialist training programs internationally. Undertake contract research and development work for overseas and international agencies and companies. Provide postgraduate training for international students on a fee-for-service basis. Collaborate with international tourism organisations on applied research, policy development, consulting and capacity building.

Source: CRC for Sustainable Tourism 2000, *Researchers' compendium 2000*

From this multi-faceted program, a particular strategy will be developed for each project, depending on the nature of its outcomes. Doing this requires a thorough understanding of the nature of the project and its outcomes, costs involved, and what industry will pay for a product (interview with Peter O'Clery). While some potential outcomes are identified when a project is initially developed, there is an awareness that these may change as the project progresses. Thus, an annual review of project outcomes forms part of the reporting cycle. Overall, the CRC identifies outcomes as:

> … practical, understandable 'tools' for industry that can improve its performance, sustainability or provide community benefit. These can be in the form of articles, reports, or other material that industry accesses free-to-air through websites, direct contact, seminars,

newsletters, or it may mean commercial products that they buy through publications, designs or services. (CRC for Sustainable Tourism 2000)

The CRC is currently developing a spin-off company to manage, but not hold, the CRC's intellectual property.

The challenges of ensuring that the CRC's research outcomes reach the many small and dispersed businesses that dominate the Australian tourism industry are significant. They have provided an impetus for the CRC to develop closer links with the VET system to develop strategies to meet these challenges.

VET involvement

The CRC has a current link to VET through a memorandum of understanding which it is developing with the industry training advisory body Tourism Training Australia (TTA). Both within the CRC and TTA there are expectations that this relationship will strengthen and that TTA will take an increasingly important role in the centre's research program, as well as its program for disseminating and commercialising its research outputs. In addition, the CRC is seeking other connections that will help it to reach the many small and dispersed businesses in the tourism industry. This contains the potential for further VET partnerships.

CRC CEO Professor Terry De Lacey sees the TTA primarily as able to provide avenues for reaching parts of the tourism industry that are otherwise disconnected from the CRC. He favours the development of the CRC–TTA relationship on a commercial basis, for the delivery of CRC products and related training and support.

Professor De Lacey notes that TTA has a 'sophisticated network of contacts', developed through the personal contacts of 'high profile' TTA staff and through the ITAB having done a 'good job' in 'training at the service level across Australia'. Distribution of CRC products, such as a recently produced CD-ROM on 'digitising your business' is difficult, but can be assisted by TTA, who are able to give the product 'a polish' and market it globally.

He is currently looking to TTA to assist the CRC with the commercialisation of a web-based business plan template designed for small businesses. To use the template effectively, businesses will require some additional training and support that the CRC is unable to deliver to the extent required.

Professor De Lacey notes a need for the CRC to connect in a better way to regional and rural areas to assist them to develop their assets in tourism. For this purpose, he is seeking to make further connections with VET providers, and possibly also adult and community education providers, with links to small tourism businesses. TTA may also be able to assist with identifying and introducing some new partners, given limited knowledge in the CRC about the VET system and its many players.

CEO of TTA, Mr Bill Galvin, also sees some substantial benefits in the relationship his organisation has with the CRC—and a potential for more as the connection develops further. He notes the need for a stronger research base in tourism to sustain the industry and is keen for TTA to be involved in, and to influence, research. Opportunities may be provided through its links with the CRC.

The relationship works, he believes, because the CRC has strong links with the universities, but weaker links with industry, and TTA is able to fill these gaps through its extensive network of contacts. In general, he believes CRCs have limited knowledge of VET and, in some cases, of industry. In the case of sustainable tourism, the CRC–TTA relationship has led to a better understanding in the CRC of VET and TAFE and of industry's needs and has enabled the CRC to have some input into the current review of the tourism training package.

CRC industry extension manager, Mr Peter O'Clery, played an important role in bringing together the CRC and TTA, through personal and longstanding links with Mr Bill Galvin. He also sees some possibilities for the relationship to be extended—perhaps even with TTA becoming a full partner and signatory to the Commonwealth agreement. However, he notes that as an external organisation, TTA was able to provide support for the bid for CRC funding that would not have been possible had it been a participant.

Mr O'Clery also believes the CRC faces a challenge in getting its research products into the many small and dispersed businesses that comprise the majority of enterprises in tourism—and that the TTA connection will be useful in addressing the problems. But he is also aware that, for the relationship to be successful, TTA also needs to gain benefits from it.

Another challenge he identifies is a need for the CRC to find ways to get VET students and teachers to access the material produced by the CRC. He notes the CRC's website as a preferred source and that this contains resources and tools that could be useful for VET courses and projects. However, further work is needed to bring it to their attention.

Conclusion

The tourism industry is forecast to grow substantially over the next five years and will require many additional skilled workers if it is to operate efficiently and take advantage of opportunities. The skills required by workers in the industry are changing as the industry becomes more complex, new technologies are adopted and e-commerce grows. Consequently, there is an increasing demand for initial training and re-training for existing workers in market and business analysis and information and communication technologies.

The CRC aims to change the culture of the industry by encouraging and assisting businesses to adopt sustainable practices and governments to create appropriate policy frameworks for sustainable development. Its research is aimed largely at the production of tools to assist businesses to move to sustainable practices. A shift in the industry toward sustainability will also create a need for training for new and existing workers in understanding and applying the principles of sustainable development and using the 'tools' created by the CRC effectively.

The CRC faces some substantial difficulties in reaching many of the small businesses that make up the tourism industry in Australia because they are geographically dispersed and many have limited access to the information, training and facilities that they need to keep up with the latest developments. The tourism industry has already developed a connection with the VET sector that it believes is helpful in assisting it to overcome some of these difficulties. However, as the problem is significant, further VET connections are becoming viewed as necessary and are beginning to be sought.

The experience of the Tourism ITAB (TTA) in being involved with the CRC has shown that there are benefits to be gained from these types of links, particularly if the VET organisation wants to influence the course of research in the industry, or participate in it. For the CRC, the VET organisation is also able to provide some of the 'missing links' in their connections with industry. However, there is considerable scope and potential for the relationship to be developed further, to the advantage of both parties.

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Case study 8

Viticulture

(Co-operative Research Centre no.34)

Viticulture

Introduction

The wine and grape industry of Australia has seen rapid growth in its wine exports in the past decade. Its success has become the envy of other wine-producing countries. In 1985, bulk wine was the major component of the wine exported. Bottled wine now represents over 90% of the exported wine and has added considerable value to the product and export revenues. A compounding growth of 15% by volume and 20% in value for wine exports has seen the market accelerate from $98 million in 1987–88 to $1373.8 million in 1999–2000 (Hardie 2000). In 1999–2000 the industry experienced record levels in the production and export of grapes and wine. The growth can be seen in a comparison between the 1998–99 and 1999–2000 industry figures. These included a 19% increase in the area under grape cultivation, a 6% increase in the grape harvest and record exports of wine that increased 32% to 284.9 million litres at a value of $1372.8 million (ABS 2000a).

While the favourable Australian dollar has supported export growth, the success of the Australian wine industry has primarily been achieved through strong industry leadership and a focussed cohesive industry that has developed a strong market focus, a passion for value-adding, the rapid adoption of innovations in viticulture and wine-processing technology, and a drive to increase the industry skill base at all levels. The wine industry provides an example of what can be achieved when research, innovation and education combine to meet industry's needs.

This case study investigates the success of the wine industry, with particular emphasis on the role of the second Co-operative Research Centre for Viticulture (CRCV2) and its relationship to industry development and education. To give context to the role of the CRCV, the study begins with a brief outline of the grape and wine industry, its history, structure, development and training, before the CRCV's role in industry-based research and education is discussed. The study concludes by arguing that the CRCV's education model, that is inclusive of all levels of industry education and training, is to be applauded and can be considered a model of best practice within the Co-operative Research Centre program.

Industry

Grapes are a temperate crop and in Australia are now grown primarily for winemaking although, prior to the Second World War, dried grapes accounted for about 70% of grape production. While there continues to be a dried fruit industry and a small table-grape market, the 1998–99 harvest statistics indicate the dominance of the wine industry on the Australian grape growing industry. Of the 1 266 000 tonnes harvested, 1 076 000 or 85% were used in winemaking (ABS 2000b).

History

The history of the grape and wine industry began with the planting of vines soon after settlement began. These vines were brought from South Africa in 1788 for domestic use. The increasing settlement of New South Wales, Victoria and South Australia saw the beginnings of an industry, as plantings of substantial vineyards began in the more temperate regions that bore similarities in climate and soils to the European wine regions. Today, grapes are grown primarily in the southern half of Australia, where the climate is drier and supports a more pest-free environment. Notably, the states of New South Wales, Victoria, South Australia and Western Australia contain the prime grape-growing regions in Australia. These regions include the Hunter Valley and Riverina regions of New South Wales, the Coonawarra, Clare, Riverland, Southern Districts and Barossa of South Australia, Sunraysia, North Eastern and Great Western regions of Victoria and the Swan Valley and the Margaret River region in Western Australia (ABS 2000c).

One of these areas, and perhaps the best known of all the Australian wine regions, is the Barossa, located in South Australia and named by William Light, the South Australian Surveyor General in the 1830s, after the Barossa Ridge on the Napoleonic Peninsular. The history of the Barossa region encapsulates many of the challenges and achievements of the wine industry in Australia.

Originally a cottage industry in the late 1800s, the Barossa sold wines to the Melbourne market and to England. In 1877, the tightening of distillery licences saw the many small growers and winemakers cease wine production and begin to sell their grapes to the larger winemakers. This period divided the industry into grape-growers and winemakers. This distinction remains and is in sharp contrast to the European model where grape growers often also make the wine. It is argued that this separation of the disciplines and the resulting specialisation has contributed to Australia's ability and reputation to produce some of the best wines in the world.

Australian wine production grew steadily and, prior to the outbreak of the Second World War, the United Kingdom had been the main market for Australian wines. These wines were generally fortified wines and shipped in bulk. After the war, Australian winemakers faced strong competition from South Africa on the English market, leading to a reduction in exports and some difficult times for the wine industry.

This was not helped by Australians who generally did not appreciate or use wine, preferring beer. However, in 1955, Colin Gramp of Orlando Wines developed Barossa Pearl, which became an instant success. Dubbed the 'wine for the masses', its sales were so strong that a program to ration its supply was introduced. The 1960s saw the Barossa lead the wine industry in winemaking, producing wines such as Sparkling Rhinegold, Chalambar Burgundy and Lindemans Bin 23 Riesling.

This was also a period when many of the old family-owned holdings were sold to multi-nationals, ushering in what is considered to have been a period of ignorance where little thought was given to the quality or varieties required for specialist wine production. During the 1970s, the wine industry in general was suffering poor returns, fluctuating consumer demand and preferences and, with poor long-term planning by the large wine companies, was struggling to survive.

The red wine boom of the 1970s had swung to the white wine boom of the 1980s and many growers in the Barossa ripped out and burned their vines and subdivided their land for housing. At the same time, in NSW the industry was beginning to develop regions which grew grapes more specifically suited to the prevailing tastes of the public. Other regions also began to develop particular characteristics in their wines.

Despite the difficulties faced by an industry fragmented by distance, products and the dominance of a few large companies, the Australian wine industry has, since the 1980s, become more strategic and market oriented. The regional differences are now a marketing tool with bottle labelling reflecting the distinctive regions and their wines. Wine is now produced to meet the varying demands of the consumer. In the 1990s, this market orientation has seen a remarkable growth in exports and worldwide demand for Australian wines. This is a significant change from the mid-1980s when Australia was a net importer of wine.

National wine and grape industry bodies

The wine industry now has a strong foundation of industry forums to represent it at national and international levels. It is interesting to note that all, except the Winegrape Growers' Council of Australia, were formed mainly towards the end of the 1980s or in the early 1990s, at a time when unity of purpose was developing. Now, as a result, so much has been achieved. Prior to the 1990s, the industry was fragmented and unable to act collectively. The functions of these bodies therefore provide an insight into key areas such as policy and program development, marketing, information dissemination, research and education that are supporting the industry's growth. The following list, most of which is taken from the *Winetitles* website listed in the appendix, outlines the ten bodies and their roles in the wine and grape industry.

- Winegrape Growers' Council of Australia, 1932—represents the independent winegrape growers and is made up of state and regional organisations from NSW, Victoria and South Australia. It is concerned with information for its members and development, promotion and implementation of policy.
- Australian Society of Wine Education, 1990—is involved in the training of wine educators, disseminating information to them.
- Australian Wine and Brandy Corporation, 1980—as a statutory body, it administers statutory requirements and is involved in export administration. The corporation reports both to the federal parliament and to industry.
- Australian Wine Export Council, 1992—promotes wine exports, with offices in London and San Francisco.
- Grape and Wine Research and Development Corporation, 1991—a statutory body involved in assessing and disbursing funds for research and development in the grape and wine industry. The corporation reports to the federal parliament and to industry.
- Australian Wine Foundation, 1988—promotes and researches the beneficial links between wine and health.
- Co-operative Research Centre for Viticulture, 1991–2006—undertakes research and introduces the findings and their applications through an education program that supports industry training providers.

- ✧ Wine Industry Information Service, 1998—provides a first point of contact for wine industry enquiries and collects information, which is disseminated through the wine industry, media, government, and community.
- ✧ Winemakers' Federation of Australia Inc. 1990—represents the interests of Australia's winemakers in the wine industry and at the political level. It develops policies and programs to increase financial returns to the winemakers, and has also supported and has driven the industry education agenda. In 1995, developed the industry action plan, *Strategy 2025.*
- ✧ Wine Industry National Education and Training Council Inc. 1995—ensures the industry's skill requirements are met for vocational education and training.

As already noted, the key areas of policy and program development, marketing, information dissemination, research and education are prominent in this list. The collective and strategic management of these key areas has rapidly placed the industry in a commanding position.

Industry developments

The success of the wine industry in recent times has been built on a technical ability to respond to consumer demands. That is, the industry's knowledge and skill base allows it to adjust wine characteristics to meet changing tastes and deliver high-quality wine at a reasonable cost. Listening to the consumer and meeting his/her needs through innovative means has placed Australia as a world leader in technology and sophistication, reaping the benefits of innovation in marketing, grape production and winemaking.

As part of this market-oriented and strategic approach, the industry developed in 1995 a 30-year industry plan, Strategy 2025. This plan was based on an analysis of the industry carried out by the Australian Wine Foundation. Strategy 2025 now provides a national industry blueprint that is working towards the achievement of $4.5 billion in annual sales by 2025.

A key element in this strategy has been the foresight to understand that innovations drive competitive advantage, but only when the innovation is put into practice without delay. This philosophy, combined with the ability to be focussed and cohesive, has led to an industry that is integrating research, education, and technology diffusion with its business and marketing strategies (PMSEIC 1999). This has transformed the wine industry into a knowledge-based, innovative industry that has effectively closed the nexus between science, innovation and commercial practice and is reaping rewards from this synergy.

New practice new skills

The latest industry figures from 1996 show that almost 16 000 people were directly employed full time in the wine industry, with another 3500 full-time equivalent jobs in casual labour. This labour force has since undoubtedly grown with the increases in production in the late 1990s. Historically the wine and grape labour force has been unskilled or semi-skilled.

The introduction of new ideas or innovations in recent times have inevitably changed the way grapes are grown and processed, with a resultant impact on the skill needs of those in the industry. For example, the introduction of mechanisation to the harvesting and pruning of vines may have replaced manual labour, but now demands new skills of the operator. Changes in irrigation practice such as the dry root zone irrigation technique and drip irrigation are critical in an environment of scarce water supplies and an increasing demand. These practices require close specifications and careful monitoring to maximise efficiencies. Soil analysis, sampling, and harvest timing are also important in the production of just the right crop to produce specific market-demand wine characteristics.

Training

Change, training and farm profitability, a study funded by the National Farmers' Federation and researched by Sue Kilpatrick, found that farm businesses utilising training are more likely to embrace changes to their practice which improve, or can be expected to improve, long-term profitability. Training is increasingly recognised as an enabling factor in the take-up of new ideas and their use.

The traditional handing down of skills from generation to generation, and a lack of formal training, is not effective industry education practice in an industry increasingly reliant on the findings from research that is quantifying cause and effect in grape production and winemaking. The ability of workers to understand the importance of specific practice, and the technology that underpins that practice, is increasingly important. To address this need, the industry is developing and adopting an industry-wide formal training program.

The formation of the Wine Industry National Education and Training Advisory Council (WINETAC) in 1995 has seen its involvement in the development of national wine industry competency standards for the food processing industry training package (wine sector). This has been a significant achievement, which has enabled the introduction of nationally accredited training and portability of qualifications across the wine regions. The introduction of the training package and WINETAC's involvement in the CRC for Viticulture has also provided mechanisms for new practices, based on research, to be introduced into formal vocational training. One such mechanism has been the Research to Practice workshops widely regarded in the industry as an important source of information about research findings directly applicable to the industry's production base.

WINETAC has also been active in supporting registered training organisations (RTOs), such as state-based technical and further education (TAFE) institutes, in their delivery of industry training. While WINETAC is not involved in the delivery of training, it does develop, produce and disseminate up-to-date training materials for use by RTOs in industry training. It also provides industry newsletters and invites industry trainers to the Research to Practice workshops in order to keep them up to date with industry developments and research. They have also developed an educational practitioner network to support the industry's aim to develop a well-educated workforce at all levels. This active supportive role of industry education providers is increasing the quality and consistency of training in the industry.

An indication of the level and demand for vocational training in grape production is seen in the training of 82 employees from Taylors Wines, in the South Australian Clare Valley, in a range of industry-related certificate II courses. This has resulted in Taylors Wines winning the South Australian Employer Award of the Year. Similar training efforts have occurred throughout the industry. Statistics by the Wine Industry National Education and Training Advisory Council, collected and presented in their *October Quarterly*, show that in August 2000 there were over 2100 individuals enrolled in certificate I through to diploma and advanced diploma courses. Of these, just over half were from South Australia, still the major producer of wine. There were also over 1310 graduate diploma or degree students, with the majority coming from NSW, the second largest wine producer. In the research field, 62 of the 78 postgraduate students were studying in South Australia and of all those enrolled, 85% are currently employed in the industry. These figures point to the strong training culture that is developing across all levels of knowledge and skill in the industry.

Co-operative Research Centre for Viticulture

The Co-operative Research Centre for Viticulture was initially established in 1992 and began the development of a strong research and postgraduate education program. The centre's philosophy 'of encouraging adoption rather than income generation' resulted in an estimated return to industry of $350 million during the first seven years of operation. While there were no patents taken out, two CRCV products were to be commercialised, the AustVit™ training packages and the Research to Practice™ training workshops. To support further commercialisation, the CRCV Technologies Pty Ltd was set up in 1997. In June 1999 the first CRCV(1) closed and CRCV(2) began operations. The rest of this section describes the CRCV(2) and its research and education programs.

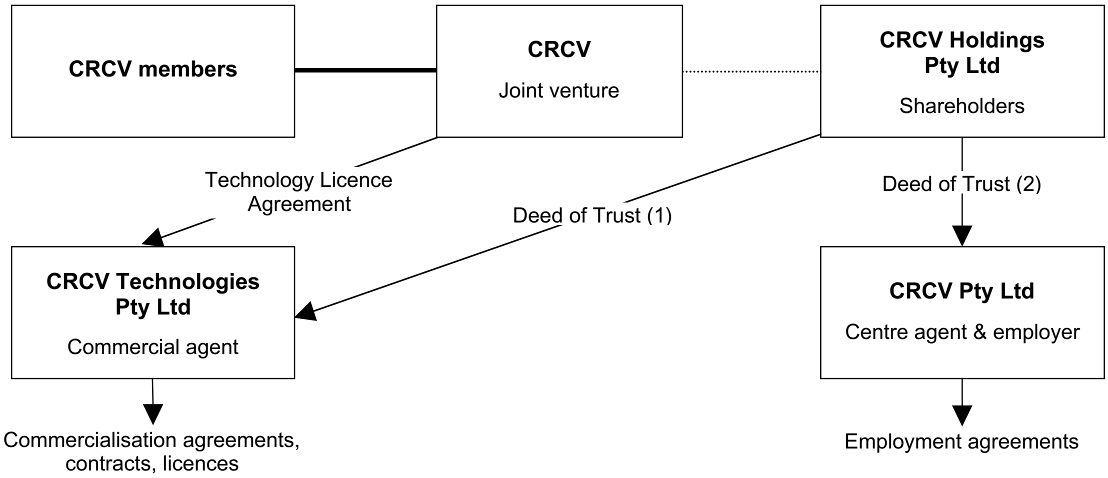
The second CRCV is somewhat different from the first. As an industry-led bid, the second CRCV has a strong focus on research priorities that address commercial issues. The CRCV has become 'a national, industry-driven research, development and education program' (Hardie 2000). Another significant difference occurs in the educational program, where the focus has turned to developing and supporting education and training at all levels in the industry, rather than graduates or postgraduates. In this program, unlike many other CRC programs, vocational education is recognised as a critical factor for industry advancement.

The CRCV(2) began in July 2000 for a second seven-year period and intends to be self-funded after that. The current total funding for this period is $63.8 million and is made up of government and industry contributions. The centre has begun with 22 professional staff, with a further 14 PhD students joining the research programs.

The 12 core participants in this co-operative venture come from industry, government, and research organisations and are listed below:

- Industry
  - Winemakers' Federation of Australia Inc.
  - Australian Dried Fruits Association Inc.
  - Winegrape Growers' Council of Australia Inc.
  - The Australian Wine Research Institute
- Industry education
  - Wine Industry National Education and Training Advisory Council (WINETAC)
- Government
  - Department of Primary Industries and Resources (South Australia) (incorporating the South Australian Research and Development Institute [SARDI])
  - Department of Natural Resources and Environment (Victoria)
  - Grape and Wine Research and Development Corporation
  - Rural Industries and Development Corporation (Dried Fruits Research and Development Council)
- Research
  - The National Wine and Grape Industry Centre (Charles Sturt University, NSW Agriculture)
  - Commonwealth Scientific and Industrial Research Organisation (CSIRO)
  - The University of Adelaide.

The CRCV structure, shown below, indicates the relationships between the various entities. Each one is governed by the CRCV Board, which is made up of 11 members, the majority being drawn from the industry or user participants. Highlighting the industry focus of the CRCV, one of the principles for board membership is that 'the majority of the board must be persons who are not "research providers"'.



CRCV industry reference groups

In order to maintain a strong industry focus in the CRCV, industry reference groups, comprised of 8–10 industry representatives, provide strong direction to the research and education programs. The wine industry believes that researchers need to focus on supporting the aims of the industry, with their research output being the tangible and practical application of their work, rather than just the presentation of academic papers.

Research

The CRCV research is divided into three program areas. The first two include the development of practical technologies and practices for the improved operation of vineyards to achieve more consistent quality outcomes. These first two programs at this time have the most relevance to vocational education. The third project involves gene research, which will have a significant impact on the industry in the near future.

These descriptions are necessarily brief but more detail can be found at the CRCV website listed in the appendix.

Program 1—Vineyard management processes to meet grape quality specifications

Current methods and measurements to ascertain quality are inadequate in an increasingly sophisticated industry. The program objectives are to improve these measurements and determine other parameters for grape quality. The result will be better tools to determine quality. The program is addressing ways in which to minimise or overcome variations in vineyard yield and quality.

Program 2—Sustainable vineyard systems

Sustainable practice of agriculture is a key driver of research. If the future of viticulture is to be secured, sustainable practices must be developed. This program is focussed on:

- ✧ developing sustainable production systems that can operate within defined water volume and quality regimes, drainage and regional soil regimes
- ✧ developing sustainable approaches to the management of pests and diseases
- ✧ devising sustainable production systems to accommodate regional variations and the demands of the industry's diverse production and marketing goals.

Program 3—Molecular improvement of grapevines

The application of molecular biology to grapevines has the potential to improve grapevine management and to produce improved vines and yeasts through genetic modification. Using these techniques will provide opportunities to address grape quality, cost of production, sustainability and competitiveness, without changing the essential characteristics of established cultivars. This program is collaborating with French researchers to identify and introduce a gene that will provide resistance to powdery mildew.

Application of research, commercialisation

Two projects initiated in the first CRCV continue to provide a mechanism for the application of research and an opportunity for commercialisation of an essentially educational product. They are the 'Viticare' project and 'Research to Practice' workshops. As yet, however, there is no indication that these 'products' have been sold or licensed in the new round of the CRC.

The success of the two projects grows as the CRC continues to develop and apply them to the Australian industry. The Research to Practice workshops are now included in the education program and will be discussed there. The Viticare initiative is described below.

Viticare™

Viticare™ is designed to facilitate the application of research outcomes through the support of local adaptations and applications of specific practices, such as water use efficiency, pest management, system sustainability, and the achievement of quality outcomes. The project is designed to achieve three objectives:

- ✧ facilitate communication between regional groups
- ✧ assist in the implementation of environmental management systems (EMS)
- ✧ assist in the conduct of meaningful trials of emerging technologies.

Continued development of the 'Viticare communication network' will provide a support framework and a service to growers, sharing technical information from grower trials and other events across the regions. The communications from this sharing will build into a database, to enable growers to search for the experiences of others on a wide range of topics, supporting their own knowledge and development.

Education, training and professional development for a sustainable industry

At a more formal level, the CRCV's education program is working to achieve the development of a sustainable industry-driven education and training capability that will cover all levels of education and training required in the wine and grape industry. The needs range from entry-level training at the vineyard or winery, through para-professional levels for industry management and to graduate and postgraduate levels for research. The rationale for this broad education focus comes from the industry perspective, that to improve industry performance, the skill levels across the industry have to be raised.

WINETAC

To achieve this approach, the Wine Industry National Education and Training Advisory Council proposed that it become a core participant and assume the role of managing the CRCV's education program. With the support of the Winemakers' Federation of Australia, and against the wishes of some, WINETAC was given responsibility for the CRCV's education program.

In its bid to manage the education program, barriers faced by WINETAC, included a lack of understanding of what vocational education and training actually was. Many from university viewed VET as blue-collar trade training and low skilled rather than as a broad spectrum of training, ranging across disciplines and up to the para-professional level. Some have interpreted these barriers in other CRCs as an indication of social elitism. However, it is preferable to argue that it is simply a lack of understanding of the value and importance of new knowledge flowing to vocational training and so to industry. Others, while recognising value in an education program working at all levels, were concerned that it would reduce the funding pool for research.

WINETAC, established in 1995 to oversee and develop industry training, had already achieved credibility and recognition for its work in developing the wine industry's training standards through its involvement with the National Food Industry Training Council. It now represents the wine industry in the National Food Industry Training Council, and is currently negotiating a contract to continue the development of the wine sector components of the food processing industry training package. Through the CRCV and industry funding, WINETAC also continues in its work of revising, identifying and adding units of competency to the training package.

Its industry work, and the networks it has forged, have placed WINETAC in a strong position to address the industry training needs. Its access to the developments from research enables it to rapidly introduce changes into industry training at the various levels. Discussions with a viticulture head teacher from NSW indicate how strongly WINETAC is supporting the development of industry training through regional workshops, assessor training, resource materials, and visits to training centres. The WINETAC staff are becoming familiar faces to the industry trainers and training providers.

The work of WINETAC staff has also seen them involved in secondary schools as the introduction of the VET in Schools program gains momentum. The success of the Willunga High School's viticulture program, based on industry competency standards, has recently led them to receive the School VET Award at the National Training Awards. This across-the-board involvement in education is developing a strong base for the industry's future.

Education program

The CRCV education program for 2000–2001 aims to consolidate the work begun by WINETAC in the vocational sector. The industry reference group for this program, while considering tertiary education as an important contribution to industry development, identified vocational training as providing at this time 'maximum leverage' from the CRCV's education funds. Consequently at this time, tertiary education, while still important in the overall program, will receive less attention for development. In the strategic plan for the CRCV education and training program, developed from the industry reference group deliberations, the development of vocational education and training includes:

- changes to the entry-level training standards through to the senior operator levels
- research to quantify the economic returns on training to support the promotion of training

✧ development of a training pathway for those at advanced certificate or diploma level to articulate directly into a degree program

To achieve the broad educational objectives of the CRCV, its education program is divided into four project areas:

1 *Enhancing the ability of PhD researchers*

This project addresses the development of researchers for the industry. In fact, 14 PhD students have been recruited, with a total of 42 expected over the life of the centre.

2 *Industry education and training policy, curriculum development, and standards maintenance*

This project represents the main thrust of the education program and has various objectives:

- ✧ raising awareness among employers and employees of the purpose, availability and benefits of industry education, training and research applications
- ✧ increasing the relevance, quality and accessibility of industry education and training at all levels
- ✧ increase the uptake and application of research and technologies
- ✧ increase the national consistency and quality of assessments
- ✧ increase the investment in industry education by employers at all levels.

These objectives are being achieved through surveys and communication strategies such as newsletters and visits to wine regions to meet with employers, industry associations, government departments, industry training advisory bodies (ITABs) and education and training providers. It is considered that face-to-face contact will support the development of strong training relationships.

The assessor development network has also been established to increase the quality and consistency of assessments. The network is providing a mechanism through newsletters, workshops, seminars and online facilities to deliver updated information on assessment, resources for assessments and provide networking opportunities for remote assessors.

3 *Wine and grape industry personnel education, training, and assessment need analysis*

In order to maintain relevant training standards in an industry that is continuously developing through innovation, there is a constant need to review and define the knowledge and skills needed, and then to address those needs as they are recognised. This project has explored and identified the knowledge and skill needs in current education programs through a range of mechanisms and is in the process of determining strategies to address these needs.

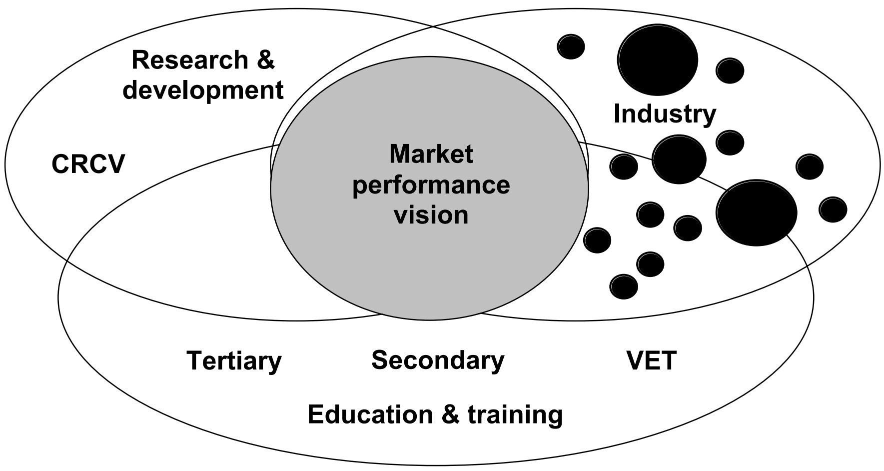
4 *Research to Practice™*

The Research to Practice program is one of the success stories of the education and training program from the previous CRCV. These programs are designed 'to provide participants with the skills and knowledge to manage their vineyards more effectively through the application of new research-generated science and technology'. Researchers travel to all grape-growing regions throughout the year to present the one and two-day interactive workshops.

Conclusion

The wine and grape industry has had remarkable growth in the past decade. The various factors that have influenced this growth are clear from policy and program development to research, education, information dissemination and marketing. In research, the CRCV is playing an important role in the research that supports the market focus of a quality product. The industry's perspective, that calls for the timely introduction of knowledge gained from research in order to maintain market advantage, is now being achieved through the CRC's education program. Despite the cultural challenges of introducing a vocational component into a tertiary-dominated area, the benefits to industry are real. The PMSEIC report commented on the ability of the wine industry to adopt new technology such as drip or sub-surface irrigation 'extraordinarily fast', and considered it a manifestation of the 'learning culture which is now a way of life in the industry and a cornerstone of its success' (1999, p.15). WINETAC, who has been at the forefront of developing this learning culture, is now able to include new knowledge into industry training more easily. The involvement of WINETAC, while initially resisted, has been justified through the rapid uptake of new cutting-edge practices.

The general unity, collective vision and purpose of the industry have flowed into the industry's research and education sector, supporting its remarkable success. The following figure is an attempt to display this integration of industry, research and all levels of education with the industry purpose.



The CRCV and the wine and grape industry have provided us with what we consider to be a case of 'best practice' in the involvement of VET, to ensure that new knowledge flows to the point of application. While it is recognised that all industries and CRC research efforts are unique, there is no doubt that lessons can be drawn from this case and applied in other CRCs.

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Mr Peter Mansfield, project leader, CRCV and project manager WINETAC

Ms Penny Dunstan, head teacher, Horticulture, TAFE NSW

Mr Lee Cummings, program manager, Food & Pharmaceutical ESD, TAFE NSW

Ms Fiona Woodward, chair, National Food Industry Training Council

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Winetitles www.winetitles.com.au

Case study 9

Waste Management and Pollution Control

(Co-operative Research Centre no.44)

Waste management and pollution control

Introduction

Globally, the management and disposal of waste—those products and materials unwanted and discarded in society—have become an issue for the ecological sustainability of the global environment. Environmental sustainability and the demands of consumers are challenging society to reduce and manage this waste. By the mid-1990s Australia was the second-largest producer of solid waste per capita among the Organisation for Economic Co-operation and Development (OECD) countries. In 1997, it was generating 15.7 kg of garbage each week from the average Australian household and, along with industry, produced over 26.7 million tonnes of solid sludge and liquid waste. The cost of collecting and disposing of this waste amounted to over $2.2 billion.

Our management of this waste has significant implications for the environmental sustainability of our lands and has raised considerable debate and concern at many levels, from individuals to government and industry. These concerns called for a rethinking of how waste is viewed. That is, from being a disposal problem needing to be buried, to its use and value as a resource. The intervention of governments through legislation and monitoring has provided much of the impetus to address waste issues and, with the support of research, society has begun to manage its waste in a more resourceful way.

The development of new uses and innovative ways to deal with and recycle our waste has further encouraged change and, in recent times, we have begun to accept waste as a resource from which benefits can be gained. New products, processes and management tools from research work have also added to our ability to deal with and make use of waste. As such, research plays a significant role in developing and adding to the knowledge and understanding of waste and its reuse.

One of these research efforts is through the Department of Industry, Science and Resources (DISR) co-operative research centre program. The Co-operative Research Centre for Waste Management and Pollution Control (CRCWMPC) is a research centre that is working closely with major industries to bring the results of research and development into commercial application. The following study is about this centre and the role it plays in the waste industry

To give context to this role, this study begins with an overview of the waste industry in Australia, discussing its development in recent times and outlining some of its challenges, achievements and future possibilities. Education, and the role it plays in this industry, is also discussed before turning, in the next section, to the CRCWMPC and its work. In this section, the CRC's commercial strategies, research, education and technology transfer programs are outlined and discussed in relation to the industry and vocational education and training (VET). Finally, concerns that have been identified through this study are articulated and discussed before the concluding remarks.

Industry

The way that we, as people, have dealt with material for which we have no perceived use has changed over time. Many may still remember the backyard incinerator as the common practice of dealing with combustible waste, or the pile of rubbish at the bottom of the garden which, when it became too large, was carted off to the local tip to reclaim a gully or fill a disused quarry. These practices are considered no longer acceptable, particularly in heavily populated areas. Here the scarcity of land, together with the air, water, and land pollution associated with open landfill sites, has restricted such sites to more remote regional areas. However, even in these areas, landfill practices are being reviewed in favour of more ecologically sustainable practices.

As landfill sites close, they are being replaced with waste management centres. Here the waste is sorted and, as much as possible, is recycled. Similarly, more liquid wastes are now being treated to remove contaminants and reused as nutrient sources. Trade waste legislation has also seen an emphasis on recycling industrial waste. The processes and equipment required to decontaminate and process waste efficiently and effectively for recycling are areas of considerable development and, increasingly, are the target of research and development.

These changes have not come easily and it has taken a developing social awareness of environmental issues to influence consumer preferences, which in turn has influenced government policy and industry changes. It has been recognised that these demands for 'cleaner production and products, are powerful catalysts of change' (DISR 2000, p.31). The broadening acceptance of environmental sustainability, and a recognition of diminishing global resources, have driven demands for eco-friendly waste management and the strategic re-entry of processed waste into the ecology.

The government response to these demands has had 'implications for both the mainstream and environment industries', (DISR 2000, p.34). Developing and implementing new ways of dealing with waste is costly, and the government has had to take action through legislation to encourage these approaches. As DISR clearly states 'regulations have been the traditional driving forces for the environment industry' (2000, p.33).

Legislation

An early federal response to waste management was the decision of the 1992 Australia and New Zealand Environment and Conservation Council (ANZECC) to set a national goal for a 50% reduction in waste going to landfill by 2000 (based on 1990 levels). Subsequently it has been considered that this goal was unrealistic, as recent figures indicate there has been little reduction in landfill activity.

As a result, the waste management awareness program (WMAP), a five-year Federal Government plan, was initiated in 1996–97 to promote the benefits and practicalities of effective waste management and recycling to industry and the community. This plan indicated a shift in waste management thinking where now 'increasingly there is more focus on balancing minimisation and reuse, and the diversion of waste from landfills and strategies for re-use' (Environment Australia 2000).

Other responses at the state level have seen over 63 pieces of environment and planning legislation (DISR 2000) developed across regional Australia, and is indicative of the variety in specific regional waste management needs. The need to have regional focus in environmental legislation led the Federal Government to develop the *Environment Protection and Biodiversity Conservation Act 1999,* which replaced several other acts and clarified the Federal Government's regulatory role, now restricting its powers to matters of national environmental significance.

The legislative and policy arrangements are now primarily the responsibility of state and territory governments with local government as the principal regulator. There are various mechanisms that provide for the regulation and management of waste. A general framework can be seen in the following outline of New South Wales' arrangements.

- Legislation—the *Waste Minimisation and Management Act 1995* enables the funding of regional waste boards and the State Waste Advisory Council.
- Environmental Protection Authority (EPA)—has the role to develop waste management policy and co-ordinate the implementation of the Waste Minimisation and Management Act 1995.
- State Waste Advisory Council—is a council made up of industry, local government, waste industry, environmental and consumer groups, and the NSW EPA. The council provides advice on waste management to the Minister for the Environment.
- Regional waste planning and management boards—there are eight boards across NSW that develop strategic regional solutions to waste management needs.
- Local governments—they are responsible for residential waste planning policies and practices that are to be consistent with the Regional Waste Planning and Management Board policy.

While regulatory frameworks are in place there is, as yet, no uniform national standards for waste management. However, there are voluntary codes that have been developed through Standards Australia and some state and local guidelines. As a result, there is a level of inconsistency in the various policies, making it difficult to develop consistent waste management strategies. At an international level, the International Standards Organisation has developed the voluntary ISO 14000 standards. However, these standards are more concerned to ensure action is taken through the development of environmental management systems rather than what the actions are.

Structure

The waste industry continues to be fragmented; indeed, some suggest that as an industry it does not exist. Rather, it is a loose grouping of companies, organisations and bodies involved in many aspects of dealing with waste products and identifying themselves as working in areas related to the environment. An indication of this diversity is that there is no waste management industry association, although there is an Environment Industry Association of Australia that is concerned with the broader environment industry of which waste management is a part. While there is no representative industry association, there is an association of professionals—the Waste Management Association of Australia—that brings together those professionals and others interested in waste management, in order to support the dissemination of knowledge and information about waste management.

The 'industry' and how this study interprets 'waste industry' is that it is made up of a variety of players and includes public and private companies, government organisations and utilities. These players may be involved in one or more operations that would include the transport, collection and processing of solid, liquid, organic and contaminated industrial, domestic or commercial wastes. Statistics reported by the Australian Bureau of Statistics (ABS) in 1998 (not including sewerage figures), show that the industry is made up of 1727 businesses and organisations, of which 1023 were private and public businesses and 704 were general government organisations.

The high capital and infrastructure costs of waste management have traditionally been borne by local government, who generally provide for the collection and disposal of domestic solid waste and the sewage and wastewater services. The change to a market-driven economy, with diminishing government intervention in service supply, has led to the opportunity for private enterprise to be involved in the supply of these services.

The waste management industry in its infancy was essentially a transport industry. The outsourcing for much of this work saw transport contractors becoming involved in the transport of waste to landfill sites. The transition from landfill to recycling and the new processes developed to deal with waste, as well as the evolution of waste companies such as Cleanaway, Richards, Rethman Australian Environmental Services and Thiess Environmental Services, has seen the range of work performed by contractors also increase. Waste contractors continue to provide an important role in the industry. The Australian Bureau of Statistics data for 1996–97 show that at that time there were 608 owner-drivers working for waste businesses on a contract basis. Other contract work in the industry shows a dominance of consultancy services with Environment Business Australia—formerly Environment Management Industry Association of Australia (EMIAA) noting that 'consultant services from auditing to engineering design and environmental science make up the largest single component' (EMIAA 1995).

Other ABS statistics show that 71% of all businesses employed less than five people. Of the remaining 29%, 11 businesses employed 100 or more workers and accounted for 44% of industry employment and 56% of the total industry income. The result has been intense competition and a high level of secrecy among companies in some segments of the market. This secrecy has hindered a collaborative approach to the sharing of information and the benefits from that sharing, such as technological advancement. This secrecy also has implications for industry training where new information is not readily passed on.

The long life-cycle for waste treatment works inhibits the rapid introduction of new technology and limits the competition for new, improved products. This may explain why there are only a few manufacturers of waste equipment, nationally and internationally, and why there is a small range of technologies being used in waste treatment. It may also explain why rapid change and the will to introduce new practice and knowledge is not characteristic of the waste industry.

Economic contribution

The size of Australia's domestic waste industry is indicated in the 1996–97 expenditure of $1672 million on waste management. Of this, $1493 million went to private and public businesses with the two major sources of income from the collection and transport of waste (59%) and its treatment, processing and disposal (25%). These figures are part of a total expenditure of $8622 billion on environment protection that included waste management, wastewater, water protection, air and climate, biodiversity and soil and groundwater. Households are the largest final consumers of waste services, with their expenditure on rates, sewage, storm water drains etc. at over $2.6 billion in 1996–97, representing just less than 1% of total household expenditure. Predictions show that the Australian environment market will continue to grow at 3% per annum (DISR 2000, p.15). In contrast, the global market is estimated at $US513 billion and is growing faster than the global economy (DISR 2000, p.15).

The waste industry is a significant employer with statistics showing that in 1997 the industry employed 9956 people in private and public waste businesses, with a further 4891 people employed by various government organisations.

Australia's geographical position and its waste management skills provides a developing opportunity to market Australian expertise to Asia-Pacific countries. Many of these countries are in the process of developing waste management and treatment infrastructure and several mechanisms are being developed to support Australia's entry into this and other world markets. For example, the Environment Industry Association of Australia, the Australian Industry Group and the CRC for Waste Management and Pollution Control are all promoting and marketing Australian capability in environment management.

It is clear that if Australia takes a lead in developing waste treatment technology, there are opportunities in product sales, infrastructure development, consultancy and education and training. Historically the Australian waste industry has been somewhat slow to develop technology and to improve practice unless government legislation has placed limits on waste and pollution production and disposal. As one interviewee argued, if the waste industry is to develop new technologies, environmental legislation will need to be even more restrictive.

Industry development

The development of the waste industry is being driven by global demands for more sustainable practices that have arisen out of changing social attitudes toward the environment and its maintenance. In identifying more specific industry drivers, the OECD has found that there are four main factors affecting the demand for waste industry goods and services:

- social pressures and changes in lifestyles
- government regulations coupled with a move towards incentives and economic instruments
- public expenditure on infrastructure
- technological development.

These drivers are clearly evident in the Australian context and it is the fourth factor, technological development, which is changing the skill demands in the industry. The shift in emphasis, from the collection and dumping of wastes to waste minimisation and the processing of waste to produce useful products, has already begun to deliver environmental and economic benefits. Research is providing new processes and improvements to current practice, driving industry sophistication and growth to meet public and legislative demands. These changes have implications for industry training with a key shift from low-skill operations to more demanding and complex processes and operations.

Skill needs

The waste industry has not had a well-structured training regime. The AWAA has noted the poor industry training culture where many operators consider formal training as an unnecessary expense. While there are some courses available, such as the waste management traineeship, an entry-level course in TAFE NSW, they have only been recently introduced, as has the waste management training package discussed further on.

Historically, those employed at the operational level in the waste industry have had little formal training and have usually progressed or developed their learning informally, on the job. For example, the early landfill operations required, at best, plant operators and labourers to process the waste while in the sewage treatment plants, skilled trades labour maintained and installed equipment, and operators monitored the processing.

The developments in sewage, wastewater and solid waste processing and recycling have seen a need for staff with higher skill levels and understanding. The developments in monitoring technology and advanced management systems along with a narrowing of quality limits and performance boundaries require staff with higher levels of understanding as well as the operational knowledge and skills. The reuse of waste also calls for more care and higher levels of control to ensure pathogens are removed and standards are reached.

In vermiculture—the use of worm bio-mass to reduce organic waste to a product useful in soil conditioning—the careful mixing of organic wastes that do not contain anything harmful to the worms requires a grasp of the vermiculture process when making decisions about what wastes are to be used.

The necessity to stabilise and monitor landfill sites, and the composting of organic material, also requires an understanding of the processes involved. The variety of processes and the skills needed have come a long way from the early days of the industry.

The development of the 'Waste not' training program began from concerns among municipal councils about inconsistencies in waste management practices and a lack of training available to address this need. The program was developed through the University of Technology, Sydney, and delivered by council staff to provide a base level of waste management practice in councils.

Waste boards have also been concerned about the lack of training in waste management and have made attempts to address the issue by talking to the Vocational Education and Training Advisory Board (VETAB) and the Australian National Training Authority (ANTA). The result has been the development of the asset maintenance (waste management) training package through Property Services Training Australia, which was released late in 1998 after six years of development. The package is to be reviewed again late in 2001. Qualifications for this package range from the entry-level certificate II through certificate III (tradesman level) and certificate IV level (technician/ management skills). Courses from the training package are currently being developed and while some were available in 2001, it was planned that they become more widely available from VET providers in 2002.

The six years taken to develop competency standards is a reflection of the fragmented industry and the diverse nature of the work undertaken. Developing a training package to suit all facets of the industry has been very difficult.

The AWAA has also noted the poor training culture and believes that the development of a qualified industry skill base will be slow. The industry culture then is an impediment to the development of its skill base.

Despite this, sectors within the industry recognise the need for new skills. For example, in the Environment Australia Organics Market Development Strategy (November 1999), it was noted how new processes are making organic waste a valuable commodity and that it has been 'identified that there may be insufficient technically experienced personnel with processing skills to manage the significant volumes of recycled organics'. While the report did not identify the level of education required, it is clear that a skills gap has emerged because of advances in technology.

In its report *Investing in sustainability* (2000), DISR noted the skills gap analysis survey of co-operative research centres. It also indicated, not surprisingly, that gaps exist at the professional level, where a clear demand for consulting and management services is emerging in the environment industry. The CRC's focus on its areas of expertise—the professional, graduate and postgraduate areas—does not appear to recognise skills demands at other levels. The development of new processes, products and services will need professionals, but will also require a labour force capable of operating and managing equipment and resources in order to be productive using these new processes and services.

The DISR report nominated reasons for the emerging skills gaps that are also relevant to the vocational education and training sector. They indicate the industry's poor position to develop quickly and a lack of well-structured involvement with the education sector in order to drive an industry training agenda. The reasons follow:

- poor industry involvement with research, education and training
- increasing demand for techno-commercial skills, entrepreneurship and intellectual property management skills
- inadequate responsiveness of education and training systems to curriculum development and inflexibility to meet industry needs. (DISR 2000)

There is also a lack of industry career paths, low salaries and poor working conditions that generate poor perceptions in potential employees, creating little motivation to enter the industry. Research and education organisations, such as the Co-operative Research Centre for Waste Management and Pollution Control, can play an important role in the industry's development through a strong involvement in industry training.

CRC for Waste Management and Pollution Control

The CRC for Waste Management and Pollution Control began its work in 1992. It is now in its second round of funding, having been given a grant in 1997 for another seven years to take its operation into 2004. Its total funding over the second seven-year period is $51.3 million, and is inclusive of Commonwealth and industry funding. The centre began its second grant period with 54 full-time equivalent research staff and 15 postgraduate students.

The CRC is based at Kensington in New South Wales and has a vision to be recognised internationally as a national centre for research and development in waste management and pollution control. To achieve this, the CRC has drawn together participants from the waste industry to support its research.

Some of the key objectives of the CRC are to:

- provide appropriate returns to its members
- capture the outcomes of research through commercialisation and technology transfer for the benefit of Australia
- become financially self-sustaining by 2004
- provide education and training to practitioners in the industry.

The first three objectives make clear the commercial focus of this CRC, as does its incorporation and strong commercially focussed structure.

The core participants come from four areas, representing industry, research and government regulators. They are:

- Private/public industry—BHP Ltd, Orica Australia Pty Ltd, Brambles Australia Ltd (Cleanaway), USF Filtration Ltd (now Vivendi), Australian Water Services Pty Ltd
- Universities—University of New South Wales, University of Western Sydney, University of Queensland
- Commonwealth—CSIRO Energy and Technology, ANSTO (Australian Nuclear Science and Technology Organisation)
- State utilities and regulatory authorities—Environmental Protection Authority of NSW, NSW Department of Public Works and Services, NSW Department of Land and Water Conservation, Sydney Water Corporation Ltd, Waste Service NSW.

The CRC has three main program areas: commercialisation, research and development and education, and technology transfer. This program structure was introduced in 1999–2000 to give a more efficient and focussed operation. The main change was to separate commercialisation from the research program to give greater focus to this activity. This has enabled a greater control over the commercialisation process. At the same time, the research program was restructured into a single program consisting of four research areas. This change has led to a more focussed approach to the output of commercially viable products.

Commercialisation

The incorporation of the CRC set its commercial focus early in its work. The CRC's objective, to become financially self-sustaining by 2004 and provide appropriate returns to members, has underpinned its work. The CRC's initial policy was to commercialise its output mainly through licence agreements. The establishment of Waste Technologies of Australia Pty Ltd (WTA) wholly owned by the CRC now provides the mechanism through which the CRC's intellectual property can be transferred or held.

As a company, WTA sources technology primarily from the CRC, but may also source complementary waste management technologies from other providers. In this way, the WTA can provide a suite of complementary technologies to a customer.

After the initial development of a product, the technology is transferred to WTA where it is first offered to the core participants to enable them to benefit from its commercial potential. If there is no interest, the technology is offered to others. This process is a commercial transaction through WTA that keeps the CRC distant from transactions and preserves its research and education operations.

The WTA also has three subsidiaries: the Environment Industry Development Network (EIDN Pty Ltd), which undertakes, with some success, development activities for the environment industry, particularly in Asia. Other subsidiaries are Australian Wetlands, which has now been sold as a going concern, and Australian Wetlands Services. The CRC, through the WTA, also has a small interest in four other companies in which CRC technology is being developed or trialled.

The products being developed by the CRC include software models, risk assessments, life-cycle assessments, process control systems, process design tools, instrumentation, chemical processes and treatment technologies and are developed through the CRC's research or in collaboration with other researchers or companies.

The success of this program is yet to be realised. While 13 patents have already been taken out for new products and processes, none have been taken up by industry. The nature of the industry, as capital intensive, tends only to introduce major new technology changes at 'greenfield' sites. Consequently this may see a gestation period of 10 to 15 years for new technology implementation.

To encourage the uptake of its technology, much of the CRC's research is now focussed on the trialling, at various pilot plants, of mature research considered to be commercially viable. In order to focus on viable projects, the research program was rationalised in 1999–2000 to cull non-viable projects.

Research

At the beginning of its second round, the CRCWMPC determined to undertake research characterised by:

- process intensification—more efficient processes in less space, with fewer resources and less energy
- obtaining value from waste products
- technologies and processes that can be retro-fitted to existing waste infrastructure.

The research characteristics reflect the industry's needs, where waste infrastructure such as waste water treatment works or solid waste management plants are capital intensive and built to last many years. To improve outputs from these and other waste processing sites calls for technologies that can be integrated into the existing frameworks. Researching in these areas will also see earlier commercial returns.

In determining the research projects, the CRC assessed them for the development potential of the research and the potential use of technology by their partners. The projects also needed to align with the research capability of the CRC partners. The following range of areas within which to focus the research were then selected:

- ✧ enhancement of biological treatment processes using biotechnology as a basis
- ✧ advanced control systems for biological treatment systems and membrane systems
- ✧ rapid separation of solids, including dewatering and processing
- ✧ advanced membrane processes
- ✧ advanced oxidation processes
- ✧ monitoring and detection of contaminants
- ✧ life cycle assessment and cleaner production.

The CRCWMPC classifies its research into the following areas: early, mid-range, mature, commercialisation, and adopted by industry. In 1998–99, it was recognised that many of the CRC's projects were in the early to mid-range area. This led to a revision of its targets to concentrate on projects nearer to commercialisation. This shift in research focus to commercial outcomes can be seen in table 1, compiled from the CRCWMPC annual reports 1998–99, 1999–2000.

Table 1: Summary of the status of research projects June 1999–2000

Status	**Program 1**		**Program 2**		**Program 3**		**Program 4**		**Total**	
Year	'99	'00	'99	'00	'99	'00	'99	'00	'99	'00
Early	3	2	1		1		2		7	2
Mid-range	4	1	2	1	2		2	1	10	3
Mature	8	6		2	1	3	2	3	11	14
Commercialisation	2	2				1		1	2	4
Adopted by industry	1								1	
Total	**18**	**11**	**3**	**3**	**4**	**4**	**6**	**5**	**31**	**23**
Completed	7	8		2		4	1	4	8	18

The table shows the effect of the revision with a reduction in early and mid-range projects and an increase in the mature projects. The focus is now on achieving commercial outcomes through increased project completions, and the increase in the projects entering the commercialisation stage in 2000.

Research programs

Following is an outline of the CRC's research program, divided into four program areas that reflect the various industry sectors:

- ✧ wastewater treatment and water reuse
- ✧ solid waste management
- ✧ contaminated site remediation and hazardous waste treatment
- ✧ waste minimisation and cleaner production.

Program 1: Wastewater treatment and water reuse

Global industry and research trends in the fields of wastewater treatment and water reuse are being driven by lower capital and the need for lower operating costs, reduced energy demand, a preference for distributed treatment systems, the increasing reuse of treated wastewater, adding value to waste products and achieving higher environmental standards.

In addressing these trends, the program is divided into two sections, with 60% of the research effort in 'advanced biological processes' and the remaining 40% in 'physico-chemical treatment processes'.

Advanced biological processes

It is now accepted that biological processes are the most appropriate treatment technology for wastewater treatment. As biological and chemical technologies are developed, the shift from the traditional civil engineering and hydraulic design will become more evident. These processes utilise biochemical reactions to remove the nutrients in wastewater. Several full-scale projects to test the processes and treatments have begun, including a retrofit project at Bathurst.

Physico-chemical treatment processes

Solids separation: In the separation of solid from wastewater, traditional methods have used sedimentation tanks or clarifiers. These systems are large and slow in comparison to the newer developments of tangential flow and tangential flocculation processes, which are more efficient separators, require less energy and take up less space.

Membrane separation: The filtering of wastewaters to remove fine solids is achieved through membranes. One of the problems facing this technology is obstruction in the membrane from solids. The research is developing the use of electrical fields to enhance the performance of these membranes for their more efficient operation. Collaborative work with Korea has been completed on one project, leading to the licensing of the technology.

Program 2: Solid waste management

Landfill has been a traditional method of dealing with solid waste. Sustainability of this method is being called into question, with concerns about the resulting leachates and their impact on water quality and environmental health. The rapidly diminishing landfill space is also a major problem currently facing Australia, particularly in highly urbanised areas. There is also a need to reduce organic waste in landfill sites and to deal with it in a way that is commercially and environmentally productive. The research into the way within which this waste is dealt is centred in two projects.

Domestic vermicompost filtration

This is a process for treating organic household sewerage, grey water and organic solid wastes. The use of worms to process this organic material is a natural process that recovers the organic material, processes it and returns it to the soil. In this process, the worms convert the waste into vermicast and worm biomass. Both these products have commercial markets. The vermicast is valuable as a soil conditioner in agriculture and the worm biomass is rich in protein and used in animal feed. The worms are also used to supply domestic and small vermiculture composting systems.

Fundamentals of bioreactor landfill design

This project looks at understanding the chemical and biological factors of municipal solid waste degradation and the development of bioreactive processes to provide the rapid degradation of municipal solid waste. Accelerating the decomposition rate in landfills will lead to landfill site stabilisation in years, rather than in decades. This will limit the environmental and socio-economic impacts such as the post-closure management of landfill sites, the cost of developing new landfill sites and the lowering of waste disposal costs. The CRC is now looking at options for commercialisation of this technology.

Program 3: Contaminated site remediation and hazardous waste treatment

This program is concerned with the development of instrumentation for environmental monitoring and assessment and technologies to deal with intractable or hazardous materials in a clean and more efficient way. Of the four projects, two have been completed, with no further activities planned, and one has ceased when the project objectives no longer met the participant's needs. One project is proceeding to commercial development. The four projects are briefly described below.

Development and demonstration of sludge dewatering control device

This project was aimed at producing a device to optimise the level of polymer dosing in sludge dewatering to reduce polymer use and the associated costs. The project has ceased, with no further activity planned.

Specification development for a biosolids centrifugal dewatering control

This project has reached the stage where a device to validate the application of floc structure determination in centrifugal dewatering processes is being bench and then pilot tested. However, commercialisation is not proceeding as the project does not meet the CRC's current goals.

Microbiological site assessment technologies

This research is being driven by growing concerns about contaminated sites and the leaching of contaminates into ground waters, and the need to treat this soil and water contamination in a reliable and cost-effective manner. With the breakdown of pollution highly dependent on microbial activity, this project is developing kits for the comprehensive microbiological assessment of contaminated sites. These kits will utilise biosensors to increase the ease of assessments and reduce the associated costs of site monitoring. The development of these kits has resulted in patent applications being filed, with the commercial development of bio-sensors for specific contaminants being explored.

Chlorinated hydrocarbon decontamination

This project was initially developing an advanced oxidation technology to remove chlorine-based air emissions. Once developed, the technology has commercial potential for the reduction of chlorine pollution at chemical manufacturing plants. However, the project ceased, as it no longer met the CRC research participant's needs.

Program 4: Waste minimisation and cleaner production management

This program is developing a life cycle assessment tool in order to meet the environmental challenges facing industry. The development of a waste database, and data sets on a range of commodity materials, will provide reliable and detailed information on environmental emissions. These data will also be useful for making decisions concerning materials and energy use and will support the 'environmental certification' of Australian goods and services. The following four projects are currently part of the development of the life cycle assessment tool.

Life cycle impact assessment

This project is encouraging a systematic and scientific approach to environmental impact assessment, selecting and developing localised models for the comprehensive assessment of chemical stressors on the environment. This type of assessment is an essential part of the International Environmental Standard ISO14042. The project has been completed, with further activities to be planned in this area.

Advanced oxidation technology

This deals with the development of a patented process for the removal of dissolved arsenic and manganese. The research has been working to make the photo-oxidation processes more economical than conventional chemical oxidants. The project has been successfully completed and commercialisation opportunities are being assessed.

The status of cleaner production adoption by industry

This project, now complete, investigated the extent of industry adoption of best practice in cleaner production. It utilised a literature review, interviews with industry personnel and expert evaluation. This project has provided details of industry adoption of cleaner production, barriers to that adoption and has identified the opportunities for products and services to promote cleaner production in Australian industry. The findings have shown that the market is presently underdeveloped with opportunities for tools to assist in developing cleaner production.

A decision support service for sustainable waste management and cleaner production strategies

The outcome of this project was to develop a process and a set of tools to identify options and to assess alternatives in decision-making about waste management. The project has ceased, as it no longer meets the strategic goals of the CRC.

Education and technology transfer

Education and training is considered a key function of the CRC and has been placed within the research program to 'provide closer alignment between research strategies and educational objectives'. The education program is involved in the presentation of in-house courses, seminars and external workshops for students and researchers.

Postgraduate education

As part of the education and training program, the CRC provides postgraduate scholarships for students to undertake relevant research. In 1998–99, there were 23 postgraduate student scholarships, with seven more to begin. The CRC also provides funding for students, as part of their development, to attend conferences and present papers. Three students have also been funded to engage in study overseas as part of the CRC's international collaboration work.

Student links with industry have also been considered important and an industrial experience and mentoring program was established in 1998–99 to provide students with an industrial context for their studies. However in 1999–2000, only one student was placed in the program and, as a result, the program is to be reviewed in 2000–01. The education and training program has also provided in-house courses and seminars for students and other research and external workshops.

The CRC's involvement with other CRCs in the 'Water forum' has also led to its involvement in organising the 'Young Water Scientist of the Year Award'.

Involvement with vocational education and training

From discussions with the CRC, Waste Management Association of Australia, TAFE NSW, Property Services Training Council and several waste boards, it is clear that there is neither formal involvement with the VET sector nor informal contact. The CRC also has no knowledge of the waste management training package developed by Property Services Training Australia. This is not surprising, given the current limited waste industry training available in VET.

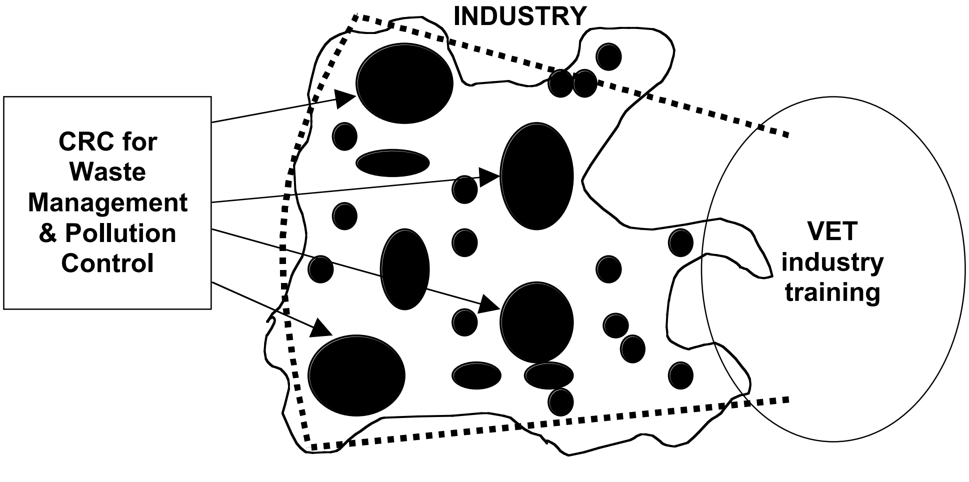
The Waste Management Association of Australia, which has been involved in the development of the competency standards and is involved with TAFE NSW in developing courses, does not consider that VET should have an involvement with CRCWMPC. However, given the nature of the CRC's work—which is to develop devices, processes and technologies for waste treatment and the new practices for these technologies—it would seem that the development of a skills base through VET involvement would support these new operations and be fundamental to the success of the technology. It could be argued here that CRCWMPC involvement in supporting skills development into the VET sector would in fact support the commercial aspects of its work, where the provision of a technology could also include skills development as part of the technology package.

Despite the current lack of interchange between VET and the CRC, the CRC has acknowledged the potential for dialogue about the issues and will be happy to share appropriate knowledge that is not commercially sensitive. However, the VET organisations would have to make the initial approaches and, in keeping with the nature of CRC operations, determine some useful contributions to the work of the CRC, for example 'in kind' contributions of staff and/or facilities. This is a positive approach and one that should be investigated. The development of mechanisms to ensure early introduction of new information into training at the VET level will support a strong and relevant training culture in waste management.

Conclusion

The waste industry is undergoing considerable change as new ways of dealing with waste are developed and implemented. The CRCWMPC is supporting the development of these changes through its research program and the focus on the commercialisation of the products and processes it pioneers.

The changes are introducing new practices and skills that require higher levels of understanding and technical competence in employees. The implications for the VET sector are that it will need to develop and maintain a position that allows for the timely introduction of these skills and technologies into its industry training. However, the relationship between the CRCWMPC, industry and VET shows that the CRC, rather than taking a whole-of-industry approach, has aligned itself with particular industry partners that does not provide ease of access to commercial rights for new technology or the knowledge and practice associated with that technology. While this is certainly not a criticism, it helps to explain the lack of a broad approach to technology transfer in the industry and the lack of involvement in the VET sector. The following figure provides a graphical representation of these relationships.



The potential to develop links between the CRCWMPC and the VET sector would both support the introduction of non-commercially sensitive but relevant new knowledge into the broader training in waste management and support the knowledge base and implementation of generic new technologies and new products. It is timely then to investigate further the opportunities to develop a relationship between the CRCWMPC and the VET sector.

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Clean Up Australia www.cleanup.com.au

Case study 10

Water Quality and Treatment

(Co-operative Research Centre no.55)

Water quality and treatment

Introduction

The work and role of the CRC for Water Quality and Treatment, as it relates to water industry training, is the focus of this study. To contextualise the work of the CRC, the study first presents a brief overview of the nature of water resources in Australia before outlining the Australian water industry, its operation, and the nature and extent of industry training. Within this context, the work of the CRC for Water Quality and Treatment is analysed for its relationship to industry development and workforce training. The relationship between the CRC and the vocational education and training (VET) sector is identified through the nature of various links, before concluding with arguments for developing strategic alliances between the CRC research community and the VET sector to ensure the timely and effective transfer of relevant knowledge to those working in the industry.

Water: A resource under pressure

Australia is the driest inhabited continent in the world. Its rainfall averages only 455mm per year. Usable water from this rainfall is further reduced by 88% through evaporation and transpiration, particularly in the hot and dry interior of the continent. With much of the Australian continent arid or semi-arid, water reserves are of significant and vital importance for agriculture and its associated communities. Long periods of drought characterise this region. The inland river systems and subterranean water supplies, such as the Great Artesian Basin, provide much of the inland with water for irrigation, livestock production and the community.

The importance of water for sustainable agriculture is highlighted in the water use figures from the National Land and Water Resources Audit (NLWRA) (2000), which determined that 75% of water is currently being used for irrigation, 5% is used in other agricultural pursuits and the remaining 20% for urban and commercial use. Continued expansion of land under cultivation and irrigation is increasing the pressure on water resources in rural areas, leading to reduced irrigation allocations to maintain resource sustainability.

Pressure on Australian water resources is also increasing in the more populated regions. Since the early 1980s, an increase of 65% in water use has occurred in the states of Queensland and New South Wales which relate to the rapid population increases in the eastern coastal areas of Australia. Despite a much higher and more consistent rainfall, these areas are facing increasing pressures on the quality and quantity of water resources and the delivery infrastructure.

With water resources under increasing pressure, a series of government studies, reports and management plans have been made to better understand the issues and develop management strategies. One such report is the Great Artesian Basin Strategic Management Plan, launched in November 1998. This plan set out to identify actions to minimise waste and manage the resource for a sustainable future 'to achieve a balance between productive and environmental demands for water' (NLWRA *Fast Facts 22*, 2001).

Several years after the launch of this plan, the Australian Water Resources Assessment (2000) identified the precarious state of water quality and availability in the various regions and the need for more efficient and sustainable practice. The study reported that 26% of Australia's surface water and 34% of Australia's groundwater is subject to a high level of development and approaching, or beyond, sustainable extraction limits.

With 55% of Australia's water being supplied by 34 water management areas that are now considered overdeveloped, only their careful management will achieve a balance between productive and environmental demands. With 23% of water being lost to seepage or evaporation, the development opportunities in these areas are limited to reducing that loss through improved water use efficiency and water trading (NLWRA 2000).

The need for industry and governments to address the economic and ecological needs through the sustainable management of water is being echoed globally. Recently, Australia hosted the Xth World Water Congress of the International Water Resources Association (IWRA), a triennial event that draws scientists, policymakers, and water experts from more than 50 countries together to address the wide range of global and regional water concerns facing humanity. In recognition of the increasing scarcity of water, the discussions at the congress, 'served as a powerful reminder of the urgency of balancing competing claims to limited water resources in an increasingly thirsty world' (International Water Resources Association 2001).

Water quality

In addition to concerns about water as a sustainable resource, water quality from stretched resources is an issue that impacts on the health of communities. Research to determine the cause and effect of contaminants and ways to minimise the contamination of water or provide for the effective removal of contaminants is an important area of work. The development of new products and processes will enable the three main variables that affect the quality of water—salinity, nutrients and turbidity—to be addressed.

Salinity is a significant water quality issue, particularly in the temperate southern regions of Australia, and is a measure of the salt concentration in the ground water. It affects agricultural capability and domestic use. Nutrients such as phosphorus and nitrogen are contaminants that cause oxygen depletion through algal growth, ecological problems for surface water resources and health concerns. Turbidity is the visual clarity or 'dirtiness' of water. High turbidity results from particles entering the water supply from irrigation and/or cultivated land runoff and from other disturbances such as European carp infestation. Other variables include the pH alkalimetry, faecal coliforms (bacteria from human and animal waste), toxic chemicals, algal blooms and heavy metals. Research to address these issues will provide new products and processes to deliver water that is free from contaminants harmful to users.

Industry

The water industry in Australia is a diverse mix of over 300 entities operating more than 750 wastewater treatment plants and over 200 water treatment plants. The role and responsibility of the individual bodies vary but in general they manage water catchment areas, reservoirs and reticulation systems in order to provide clean quality water to their customers.

From the 1970s through to the mid-1990s, there was considerable construction and expansion in the water supply infrastructure in order to meet the reticulation needs of an expanding population. While developments in infrastructure have now slowed, there continues to be pressure on existing infrastructure, particularly in the expanding coastal regions.

While not coded into statistical collections as an industry, it has been estimated by the Australian Water Association that the industry annually generates over $5 billion in revenue, with a capital outlay of $347 million for water treatment plants and $565 million for wastewater treatment plants.

As a well-developed and mature industry that addresses a wide variety of customers there is, understandably, considerable diversity among the industry players. This diversity arises from the predominantly public nature of natural resource utilities, their regional responsibilities and the attendant regulatory authorities that arise from three tiers of government—local, state and federal. While the water industry has been traditionally a combination of state authorities, water boards and local councils, in more recent times there has been a shift to corporatise the industry. As a result, private companies now provide many of the water services, particularly in the more densely populated areas. Theiss Pty Ltd, for example, provides Victoria with about one-third of its water.

The industry is regionally dispersed with industry operators who may cater for large urban systems with over a million users, mostly household, or may be servicing small regional areas with just a few thousand users. The large operators are generally more technically advanced in their equipment and suffer different operational problems from the smaller and more remote operations.

With between 80 000 and 100 000 employees (there is considerable debate on these figures, given that there are several ways of arriving at the figures, due to industry and worker classifications), the industry has a significant need for initial and ongoing training. The diversity in operations, noted above, creates a diversity in the skills required. In explaining this diversity, an industry trainer from the Open Learning Institute in Brisbane commented that the staff from the smaller country centres needed a greater range of skills to address their wider responsibilities when compared to their city counterparts. The variation in operations, resources and training needs creates a horizontal segmentation of the industry that presents challenges for a collective standardised approach to industry training.

Industry developments

Technology, reduced public funding and workforce rationalisation have all impacted on the industry. Like many other essentially public utilities, funding is becoming a critical issue for the maintenance and development of water supply infrastructure. Within these constraints, the water industry has continued to respond to the public health concerns articulated by both government and consumers. Events, such as the 1998 giardia and cryptosporidium parvum contamination of Sydney's water supplies, indicate the fragility of quality systems and the need for more robust systems in order to provide safe, high-quality water.

With the potential for environmental contamination ever present, quality assurance and accountability provide greater impetus for a strong and continued response from the water industry to address water quality issues. The developments in the water industry can be seen to focus on improved processing, contamination management and the ecological sustainability of the water resource. From this perspective, research plays a crucial role in industry development and cannot be understated.

Developments in skill needs

The water industry, and its skill needs, have experienced significant changes: most prominently, the development from a tradition where many employees were likely to begin in the industry as unskilled labourers and then often worked their way through the various skill levels by learning on the job as opportunities arose. Changes in the industry, including developments in the knowledge base for water supply systems and quality accreditation, now require more highly skilled and accredited employees.

Industry trainers, from public and private providers, have all noted how the industry now needs its employees to have a greater contextual knowledge of its work and the ability to use sophisticated monitoring equipment. Prior to developments in technology, water operations staff commonly made physical observations of water quality and, along with basic gauge readings and manual adjustments to valves, would manage the systems output. However, changes in technology have introduced remote monitoring including telemetry and sensitive measuring equipment to assist in systems management and quality control. Centralised operations now monitor much of a system's operation. This calls on operators to have a more strategic focus in their work and higher levels of system understanding, especially in the relationships between the various sub-systems and operations.

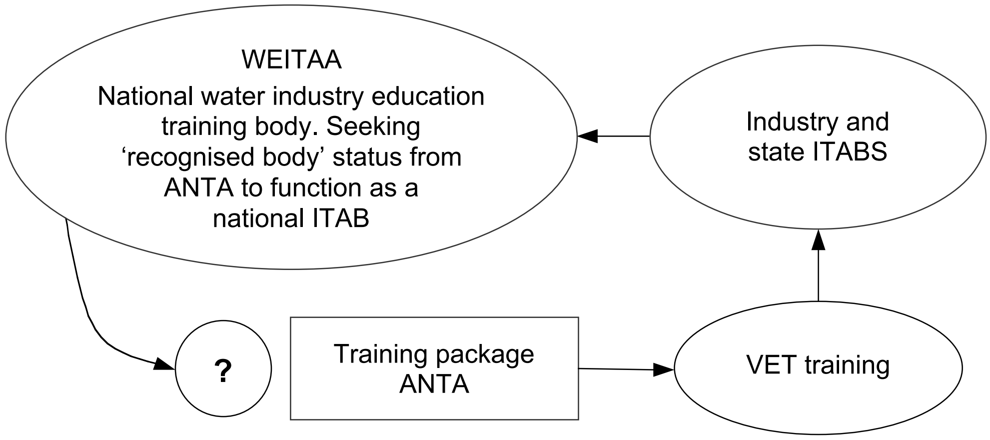
Industry training advisory boards (ITABs)

There are considerable changes occurring in the way the water industry is represented in the national training system. Originally the National Utilities and Electrotechnology Industry Training Advisory Board (NUEITAB), as a national ITAB, represented all water, gas, and electrical industries in the national training system. In this capacity NUEITAB had the responsibility to develop the industry training packages and work through the accreditation system for their eventual endorsement by the Australian National Training Authority (ANTA).

The NUEITAB is no longer the national ITAB for the water industry. The Water Industry Education and Training Association of Australia (WEITAA) now represents the industry in training issues and has sought 'recognised body' status from ANTA to act as the industry's ITAB. The outcome of this request is pending ANTA's review of ITABs, due in July 2001.

A recognition of WIETAA as the water industry training body is seen in ANTA's funding of two projects by WIETAA. The first is to review the water industry training package competency standards to ensure they address the industry skill needs; the second, to produce training package resources, currently in conjunction with the Metals Engineering and Related Services ITAB (MERSITAB). As can be seen, 'ownership' of the water industry training package is currently a grey area. However, the WEITAA continues to act as the intermediary between the water industry, government agencies and other related bodies, organisations, enterprises and authorities in relation to vocational education and training issues in the water industry (see figure 1).

Figure 1: Relationship between WEITAA, government and other bodies



In 1995 the national water industry training package was introduced by the NUEITAB to provide a national platform of qualifications ranging from certificate I to the advanced diploma. The training package is designed to enable the development of a skill base across the qualifications and ranges from operator to supervisor, technician and management levels. The package has been subsequently reviewed in 1997, and again in 2000, to meet developing industry needs.

While significant industry training has always been available, the introduction of the training package has been seen as a significant step forward that ‘will provide the catalyst for the development of structured accredited training’ (Water industry training package, part C 1998, p.2, ANTA). The package, and the competencies defined within it, is an indication of the range of skill levels needed in the industry. The VET system develops training courses from these competencies to meet industry needs.

Training demand

Since the introduction of the water industry training package, increasing numbers of operators are receiving training. This is an indication that the industry is in the process of developing a well-trained and accredited workforce. Various public and private registered training organisations (RTOs) deliver the training. The nature of the industry, and its current training needs, are both reflected in the training delivered. For example, Australian Water Technologies, part of Sydney Water is, through its training arm, providing much of NSW’s water industry training. Beginning with the certificate II training as the base level, training is now being done up to certificate IV. However, there is yet little demand for the higher diploma and advanced diploma courses.

Of interest is the mix where approximately 60% of those trained are current employees who access training to recognise and develop their existing skills, while the remaining 40% are new employees in entry-level training. The greater percentage of those already in the industry who are receiving training is at present a common industry phenomenon. It highlights the industry move to an accredited workforce. The majority of those training with the Water Training Centre, located at the Waurn Ponds campus of Deakin University, are also in the industry, with many doing specific competencies in order to address their specific work training needs. The training ranges from full courses to niche training in specific competencies that will eventually build to a course completion. TAFE Tasmania predicts a surge of training in 2001, again from within the industry, as acceptance of the national training standards grow.

The elements of base-level training, specific competency training building to course completion and predictions of increases in training, are common across industry trainers. Current numbers in training are hard to gauge, with the National Centre for Vocational Education Research (NCVER) noting that, under the ASCO code 2129-21, (Water and Waste Water Plant Operator), there are currently only 25 enrolments being reported. However, a quick phone survey indicated that there were probably 900 to 1200 individuals engaged in operator training across Australia. With most trainees at the entry-level of certificate II, this indicates a strong move to accredit the industry's operational staff. The industry trainers also indicated that from this certificate II base will come further training to certificate III, IV and possibly some diploma training. With the uptake of the training package, enrolment statistics are also expected to better reflect the level of industry training in the near future.

Technology developments and the introduction of nationally accredited industry training to meet the skill demands have seen a significant shift in the role of education in this industry. In this context, the diffusion of cutting-edge technology into a developing skill base can only enhance the industry's skills, capability and development.

Co-operative Research Centre for Water Quality and Treatment

The Australian experience of strong competition for a tenuous water resource, and difficulties in addressing its sustainable management, has led to increased research in this area. To support this research, the Federal Government's co-operative research centre (CRC) program currently funds five centres engaged in various aspects of water research. One of these, the CRC for Water Quality and Treatment, is focussed on helping 'the Australian water industry produce high quality water at an affordable price'. Its work is closely tied to specific industry needs and, as such, its research programs directly impact on the operational aspects in the water industry.

The Co-operative Research Centre for Water Quality and Treatment, with its headquarters in Adelaide, was initially established in July 1995 with total funding of $55 million for the seven-year term to 2001. The CRC has recently received funding for a further seven-year period, taking its operation up to 2008. The CRC currently has 164 staff drawn from the core partners. As an unincorporated joint venture, the CRC has 27 core participants and six associates. Of the 27 core participants, six are universities from South Australia, Queensland, Victoria, NSW and Western Australia. Six private companies are core partners with the remainder made up of various public water utilities from around Australia. The objective of the CRC is to support the Australian water industry with a research capacity that will enable a greater understanding of water quality issues and the development of new technologies and practices for the assessment, monitoring and management of water.

Research

Much of the CRC's work to date has been to assess the quality of water as it travels from source to consumer. This has been done to develop a greater understanding of the extent and nature of water treatment needed to provide consistent high-quality water supplies. For example, major surveys, also supported by the CRC's participants, are being carried out to determine the levels of pathogens in water catchments. This work has led to the development of analysis techniques for rapid diagnosis of toxic algal blooms. In assessing the public health risk associated with water supplies, the CRC has also made it possible to better understand and benchmark the relationship between public health and water quality.

The CRC's current research work is divided into four principal areas (although this aimed to change in July 2001 when the CRC entered its second round):

- **Public health risk assessment—**to develop preventative, rather than reactive, approaches to water quality management through a risk-based framework. The end product/tool will provide industry with an assessment methodology that will better inform management decisions in the production of quality water.
- **Catchment and source water management—**is looking to understand the way catchments and sources of water affect its quality. This research is enabling management strategies to be identified that can be applied early in the process of providing quality water.
- **Water treatment technology—**cost-effective water treatment with minimal risk is the focus of this research. The development of more effective membrane filters and novel treatments to

destroy pathogens will significantly improve the safety of water. The research has developed an in-depth understanding of the mechanisms leading to more effective removal of some contaminants and detailed information about why other contaminants continue to pass through the filters. Development of processes and techniques to remove more of the contaminants continues as the focus of this research.

- **Maintaining water quality in distribution systems**—this research aims to understand the 'mechanisms by which water flows, its quality, biofilms and pathogens interact in pipes and service reservoirs, to affect health and aesthetic quality aspects at consumers taps' (CRC for Water Quality and Treatment 2000, p.29). The development of flow models for improved prediction of pathogen prevention, and the development of improved tests for water quality assessment in reticulation systems, will enable more accurate, efficient and timely use of disinfectants to control pathogenic contaminants.

The outcomes of these research programs have a direct bearing on the operational work and training in the water industry. A teacher at the Open Learning Institute, TAFE Queensland—a university-trained chemist teaching competencies to industry operators—noted the use he made of research findings from the CRC to underpin the reasons for current practice and changes in practice. He considered the use of this information developed in the operators a greater understanding of their role and their work context that gave them greater capability across operational areas—of particular importance in smaller operations. This highlights the need to diffuse research findings, albeit in a condensed and practical form, into the VET sector, a point addressed in more detail later.

Education and training

The CRC for Water Quality and Treatment has developed a strong education and training program that aims 'to provide specialist undergraduate and postgraduate experience in water science and technology' (CRC for Water Quality and Treatment 2000). This focus on both undergraduate and postgraduate education is common to the CRC program, which aims to provide graduates with industrial understanding and commercial skills to support industry at the research and development level.

The CRC contributes to this skills development through its undergraduate, postgraduate, Masters and PhD programs in water science and technology. Currently 40 postgraduate students are working on CRC research. The CRC also co-ordinates summer research scholarships for students involved in, or wanting to proceed to, honours work in water research. Internal training to develop time and project management skills, technical writing expertise and career development capabilities in postgraduates, is intended to better prepare them for research in the commercial arena.

Despite links to the Water Industry Education and Training Association of Australia (WIETAA), NUEITAB and the South Australia Water Industry Council (WIC) through attendance at meetings and membership of boards, there are no formal links between the CRC and training organisations, nor is there a direct input into the development or revision of competency standards.

Commercialisation

The CRC is primarily publicly funded and works mostly with public utilities. As a consequence, the research outcomes of new or improved processes and/or products are not commercialised through spin-off companies or licences. Rather, they are subsumed into the public domain as improvements to practice. As a result, the CRC's commercialisation strategy is primarily committed to ensuring that research is relevant and the outcomes diffused into the utilities sector. This is achieved through a small committee that works closely with the research co-ordinators in developing and assessing the research programs.

The CRC has developed improved processes and devices such as probes for the monitoring and testing of water. These processes and devices are the main 'commercial' products of the research. New detection methods have been developed for toxic forms of cyanobacteria that have led to a provisional patent being taken out. The second round of the CRC will enable more patents to be taken out as the early research develops into new processes and products for the industry. The international links of the CRC will support the sale of these patented products and processes in international markets.

Knowledge transfer

The transfer of CRC-developed technology is achieved in various ways. The presentation of conference papers and journal publications in refereed and trade publications, along with the CRC's *Health Stream* and *Water Quality News* publications and web-based information, provides a strong text-based transfer mechanism targetted to industry and the public. In addition, the growing participation of industry in the various research programs provides a short path and strong link with industry for the transfer of knowledge from the research.

Workshops are also used to present the research outcomes across the industry base, including operational staff. Working relationships with industry, linkages with government regulatory bodies and international groups, communication strategies for public and private small and medium-sized enterprises (SMEs) and regional water authorities and staff exchange programs, all assist in the diffusion of CRC technology.

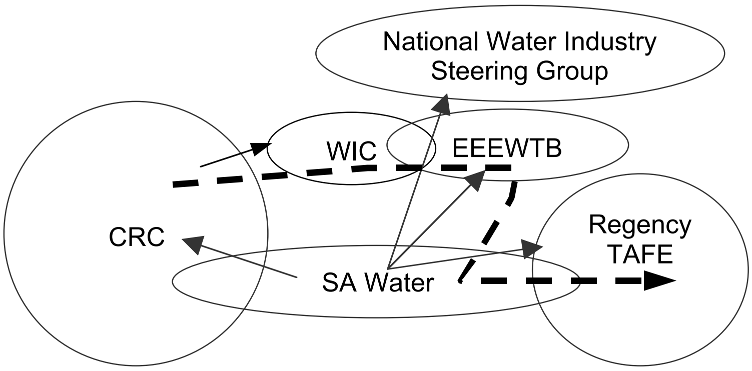
However, while industry and the general community are targetted for dissemination of information, the transfer of relevant information to the vocational education and training sector is not currently part of the technology transfer program.

Vocational education and training involvement

As noted before, the CRC has not had a direct involvement in vocational education and training, either through its education and training program or the technology transfer program. Nor was it involved in the development of competency standards for the industry, despite its involvement in various industry committees such as the Water Industry Council (WIC) of South Australia, a sub-group of the South Australian Electrical, Electrotechnology, Energy and Water Training Board (EEEWTB) and the Water Industry Education and Training Association of Australia.

There are, however, tenuous links (see figure 2) through the strong industry connections of both the CRC and South Australian technical and further education (TAFE) institutes. A series of links exists through the SA Water Corporation because a member of the National Water Industry Steering Group from SA Water Corporation, who has close links with staff at Regency TAFE South Australia, also sits on the state's Electrical, Electrotechnology, Energy and Water Training Board (SA) committee.

Figure 2: Links between CRC, TAFE and industry

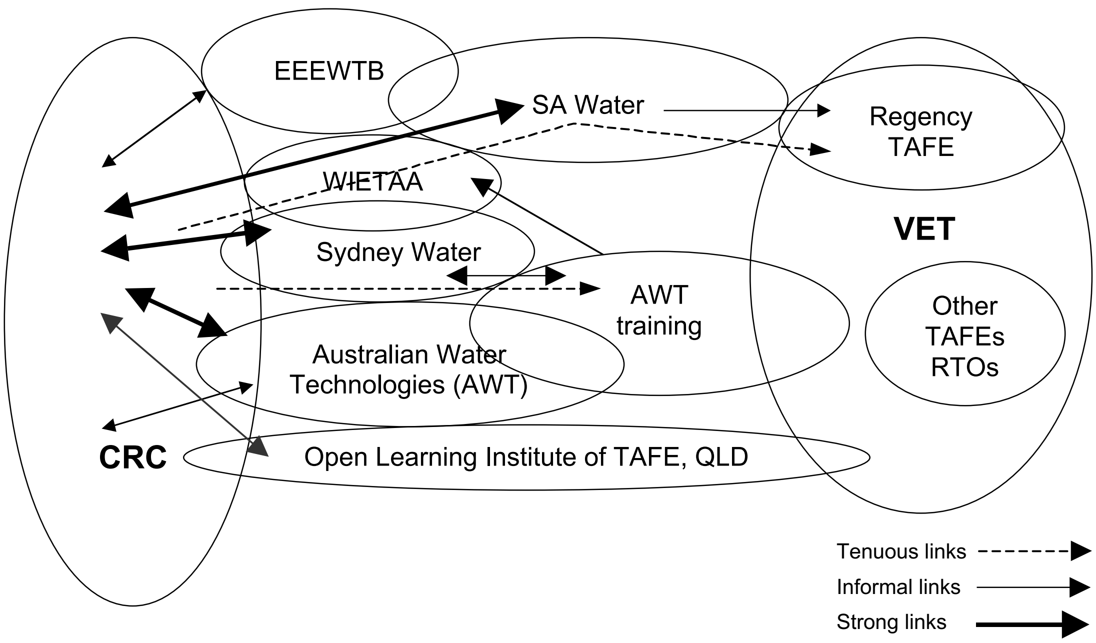


With the National Water Industry Steering Group leading the development of the industry training package, a tenuous link through the EEEWTB therefore exists for CRC knowledge to find its way to VET through the training package and, in this case, to a particular college.

Another link could exist through Australian Water Technologies (AWT), a core participant in the CRC also involved in the research program. The AWT has a training section that provides much of NSW water training and so could provide a more direct route for new knowledge. However, the evidence from those working in the training centre suggests that little information, if any, currently makes its way through to the operator training level.

A different situation occurs at the Open Learning Institute, TAFE Queensland, where the laboratory for the water and wastewater treatment section is located at Griffith University and all the teachers in the section hold degrees. As a consequence, they have strong university connections and are comfortable with attending and participating in water industry conferences. The links are still informal, but their background clearly gives them an advantage in finding, relating to and understanding research work. This, in turn, supports the inclusion of relevant information from the research into their teaching and their specific course content.

Figure 3: Links between CRC, ITABs and VET



Discussions with the industry training advisory boards also indicate that there is no transfer of knowledge into the VET sector at their level, despite CRC membership and attendance at the state and national ITAB meetings and conferences. The generally tenuous and localised nature of these links (see figure 3 for an overview) do not, in our view, do justice to the potential of a CRC–VET exchange.

This view was supported by comments from the principle teacher at the Open Learning Institute, TAFE Queensland, who believes that VET had good cause to be involved in the CRC in order to 'become involved in R&D [research and development]', to 'make better teachers with new ideas' and to enable the VET sector to 'support the introduction of new ideas into the industry'. Despite these views, the current demand for information and knowledge from the CRC to VET is considered low. However, the continued development of industry training will see a take-up of diploma and advanced diploma courses, in which the need for a higher level of up-to-date, cutting-edge information and technical skills will become more evident.

In this context, it should be noted that the education and training program manager for the CRC is interested in supporting VET but is unsure, like his colleagues in other CRCs, of the approach needed to engage with the VET system. For those familiar with the higher education system, the national VET system presents a complex interplay of institutions, organisations and boards in the development, accreditation and regulation of national training.

The CRC would like to encourage the use of CRC material in courses and has indicated a desire to work at the various information interfaces, once identified, in order to develop pathways for information to flow into industry training. The CRC is also at present re-evaluating its role in the dissemination of knowledge to users and potential users and it may, through this process, determine a way to develop closer links to the VET sector that will ensure relevant knowledge is diffused into training at that level.

Areas of concern

In general, there are few concerns articulated by the industry, CRC, ITABs or VET about new knowledge and skills development. However, there was a concern from one industry representative that TAFE had not caught up with the industry's training needs. Given the early stages of national accreditation in the industry and the need to utilise on the job training to minimise capital outlay and provide site contextual training, TAFE has been slow to respond. The industry tradition of in-house training also makes the industry a new area for many TAFE systems. NSW TAFE, for example, does very little training in this area.

The CRC also drew attention to the complexity of the VET system, noting that 'the pathway is a bit complicated'. This unfamiliarity of dealing with multiple organisations at many levels has been confusing for other CRCs and, as a result, they often withdraw from involvement in the VET sector. While the CRC is not entirely comfortable or happy with the current arrangements and would like to improve the opportunity for knowledge flow, it will need the active involvement of the VET sector to support the CRC in further diffusing its research.

It is also clear that at a range of levels, VET awareness of the research and development occurring in the industry is marginal. Consequently there is little effort to source relevant new information direct from the CRC for inclusion in course delivery. A more proactive VET sector would seek out and articulate its needs to the CRC.

Conclusion

The CRC for Water Quality and Treatment is playing an important role in the development of a high quality water industry. Its research is relevant to the industry and has a high practical application and social value. Through its education and training program, the industry's research base and skills are achieving significant development. However, its connection with the VET sector is at best marginal. The current connections rely on personal contact and interest, or an understanding of the academic world, in order to seek out relevant information. The lack of more formal involvement in the VET sector, either through the ITABs or VET institutions, inhibits the flow of information into that sector.

Developing stronger links or more formal arrangements with the VET sector would enhance the introduction of new information into the formal training of industry personnel. The responsibility to engage is shared between all stakeholders.

The CRC's current re-evaluation of its position with regard to technology diffusion is an indication of its concern to disseminate knowledge more efficiently. This evaluation may well indicate the need to investigate further its role at a level that impacts more directly on the emerging development of the industry's operational skills base.

In the light of the experiences of the Open Learning Institute of TAFE staff, the VET sector would also do well to re-evaluate its capability in sourcing relevant and cutting-edge knowledge from the CRC to include in its training programs, in order to better support industry training and the development of qualified staff.

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