Australian Government

Nuclear-based science benefiting all Australians

Submission to House of Representatives Standing Committee on Science and Innovation Inquiry into Pathways to Technological Innovation

Executive summary

The mission of the Australian Nuclear Science and Technology Organisation (ANSTO) includes operating nuclear science and technology based facilities for the benefit of industry and the research community; undertaking research; applying nuclear science, techniques and expertise to address Australia's environmental challenges and increase the competitiveness of Australian industry; and manufacturing and advancing the use of radiopharmaceuticals. Over the past year, ANSTO has been undertaking strategic planning which will, among its impacts, improve the pathways to innovation for both ANSTO's own innovations and those initiated elsewhere in the Australian innovation system.

ANSTO's experience reinforces the importance in innovation of strong relationships between producers of innovations and users. Such relationships lead to new approaches to problems and market opportunities, and reduce the costs of innovation by facilitating information exchange. Among the key elements of strong user–producer relationships are a competitive market; having Australian users that are leaders, especially international leaders; having mechanisms by which users can effectively present their needs to producers; and frameworks and environments that encourage mutual respect, trust and effective communication.

Organisations are also attracted to working with those that are regarded as "thought leaders". A thought leader is seen to know a better way of doing things and to be ahead of trends. Thought leadership is founded on focused and deep research and learning, and ANSTO's thought leadership in its fields of expertise is one of the reasons that Australian businesses collaborate with us. For example, ANSTO has particular expertise in seeing how neutron scattering and synchrotron radiation can address unsolved industry problems, and so is clearly a thought leader in this area.

ANSTO has provided two case studies regarding its relationships with companies in the Australian mining and minerals processing sector and the power industry.

- ANSTO Minerals was established to exploit the thought leadership that ANSTO has acquired over 25 years in the treatment of uranium and other radioactive ores. Its main focus is the front end of the nuclear fuel cycle, including uranium extraction, and addressing issues related to naturally occurring radioactive material. Its breadth of involvement in the mining sector, and issues of radioactivity more generally, enable it to maintain a level of thought leadership that would not be possible for individual in-house R&D units. Industry benefits through a high capacity for innovation at a lower cost.
- In recent years, ANSTO has been making major contributions to enabling power infrastructure operators to safely assess and extend the life of plant, building on the expertise that we have developed in safely operating a nuclear research reactor. ANSTO provides consulting and other specialised services, particularly in remaining life assessment, structural integrity assessment and failure analysis. ANSTO's work yielded savings in excess of $2 million at one power station in New South Wales alone.

The pathway to commercialisation at ANSTO has evolved considerably. Following recent restructuring, the organisation's two business units (Australian Radiopharmaceuticals and Industrials, and ANSTO Minerals), and its intellectual property (IP) manager now report directly to the CEO. A new Innovation Forum fosters and nurtures innovations, while the Executive Committee has taken the lead in decision-making regarding patents and their development to market.

ANSTO has also created new classifications for its research, including a classification of Outreach Research that primarily aims to encourage the take-up by users of ANSTO's IP. This will drive a further focus on commercialisation.

ANSTO overview

The Australian Nuclear Science and Technology Organisation (ANSTO) is Australia's national nuclear organisation and the centre of Australian nuclear expertise. Its mission has five parts, as follows:

- To support the development and implementation of government policies and initiatives in nuclear and related areas, domestically and internationally
- To operate nuclear science and technology based facilities, for the benefit of industry and the Australian and international research community
- To undertake research that will advance the application of nuclear science and technology
- To apply nuclear science, techniques and expertise to address Australia's environmental challenges and increase the competitiveness of Australian industry
- To manufacture and advance the use of radiopharmaceuticals which will improve the health of Australians.

This mission was recently revised as part of ANSTO's strategic planning for the next five years. The organisation has set four strategic directions for the coming years, as follows:

1. Deliver excellence in nuclear science and technology
2. Focus our capabilities to support issues of national importance
3. Maximise return on investment in expertise and specialised facilities
4. Promote understanding of the benefits of nuclear science and technology.

Under these strategic directions are a number of actions through which ANSTO aims to improve the pathways to innovation for both the organisation's own innovations and those initiated elsewhere in the Australian innovation system.[1]

ANSTO's structure and planning process were also adjusted as part of its strategic planning. Research is now undertaken within five research themes:

1. Isotopes in earth systems
2. Materials
3. Neutron and x-ray science
4. Health
5. National interest and capability enhancement.

Overall, ANSTO has approximately 850 staff, the majority of whom are located at the Lucas Heights Science and Technology Centre. Others are based at the National Medical Cyclotron in Camperdown, NSW, in Canberra, in the Australian embassies in Washington and Vienna, and at synchrotron facilities in the USA and Japan.

Underpinning concepts

User-producer relationships

Strong user–producer relationships (UPRs) have been recognised since the 1980s as an important element of national innovation systems.[2] Definitions of innovation depend on the new product or service being put into use, so innovation intrinsically involves users. The concept of UPRs is similar to

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[1] ANSTO will provide the committee with a copy of its strategic directions when they are published in the near future.

[2] References include: Lundvall B-Å (ed), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London, Pinter, 1992; Lundvall B-Å, "Innovation as an Interactive Process: From User-Producer Interaction to the National System of Innovation", in Dosi G, Freeman C, Nelson R, Silverberg G, Soete L (eds), *Technical Change and Economic Theory*, London, Pinter, 1988; Saxenian A, "The Origins and Dynamics of Production Networks in Silicon Valley", *Research Policy*, 20, 1991, pp423-437; Porter M, *The Competitive Advantage of Nations*, Free Press, New York, 1990

that of a customer–supplier relationship: the key difference being that the latter term is based on the concepts of sale and purchase rather than the generation and application of the innovation.

While the relationship between users and producers can be arms' length, strong and close relationships shape the innovation process and can reduce transaction costs. Users can be directly involved in the process of innovation, for example cooperating to solve a problem and exchanging qualitative information. A close relationship is especially needed where technology is complex and changing. UPRs are important in joint design, development and manufacturing, especially where a user wants differentiation in a product or service, either to fit with its existing processes or to differentiate itself in the market. Good UPRs reduce the cost of gaining or providing information and keeping up-to-date. Strong interactions between users and producers that are both based in the same country are a characteristic of national strengths.

ANSTO's own experience reinforces the importance of good relationships between producers of innovations and users. This can be seen in the two case studies below of ANSTO's relationship with companies in the Australian mining and minerals processing sector, and the power industry. It can also be seen in its collaboration with innovative Australian firms such as Advanced Surgical and Medical Devices (ASDM).[3]

For the Committee's Terms of Reference, the question that then arises is: "How can Australia encourage strong relationships between users and producers?"

1. If users have a strong sense of pressure to remain competitive, for example to get to market quickly, they will be more inclined to work with external producers. A strong competitive sense works against the tendency for organisations to reject potential innovations that are 'not invented here'. IBM's decision to use external suppliers for components (notably Intel) and the operating system (Microsoft) in its original personal computer is a classic example from the information technology sector. If market competition is international its impact on producers is even higher. Openness of the Australian economy and of particular industries creates such pressures for users to innovate.
2. Users that are leaders, trend setters and technically sophisticated and demanding are best positioned to show producers what the direction of a market is. National linkages between producers and lead users in particular increases the competitiveness of an industry. If the lead users anticipate *global* demand, they are even more valuable. Policies that encourage Australian businesses to pursue leadership in their field thus build leadership in the organisations that generate innovations. The mining industry is an area in which Australia can be said to be truly a global leader, and this is reflected in ANSTO Minerals having international markets for its services. The public sector also has a role in sectors where it is itself a lead user.
3. A way in which users can influence producers *en masse* can drive innovation. Industry Action Agendas provide one such mechanism. Industry associations, user groups and the like can indicate 'wish lists' and road maps for producers.
4. Because effective channels of communication take time to develop and relationships become more efficient over time, leaving a relationship or having the other party leave can be costly. This encourages good relationships, while a lack of stability in producers, e.g. too high a turnover of research staff or start-up enterprises, can have wider impact on Australia's innovative capacity.
5. Good UPRs require mutual respect. Where producers dominate, there is an inherent tendency to develop costly innovations that are not well suited to users' needs. Where a few large users dominate, it may also result in unsatisfactory innovations. Diversity among producers and close attention to monopsony in purchasing are important.
6. Trust, friendship and a learned ability to communicate effectively all play a role in building strong UPRs. For example, many businesses choose to continue to maintain third-party provider

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[3] Using hot isostatic pressing, ANSTO has helped ASDM to improve the strength, flexibility and fatigue life of its artificial knees to enable it to access the US market. The relationship between ANSTO and ASDM was featured in *Australian Science: Building Our Future*, published by the Government in 2004. Dr Greg Roger, general manager of ASDM, won the Clunies Ross medal in 2004 and a Warren Centre Innovation Heroes award in 2005. See http://www.asdm.com.au/.

relationships via ANSTO rather than directly, even after they have been introduced to those third parties. Environments that encourage trust and communication, such as Cooperative Research Centres (CRCs) and well founded and understood intellectual property (IP) law, therefore encourage UPRs.

7. Technological revolutions break-up and reform UPRs. At such times, mechanisms to encourage awareness of potential new users and producers are valuable.

Thought leadership

A producer provides a product or a service. The provision of "thought leadership" is a more diffuse concept. Thought leadership can be regarded as a "body of intellectual capital"[4], the ability to develop and champion new understanding, insights and ideas, and to persuade others using logic and evidence. Thought leadership is founded on focused and deep research and learning, and ANSTO's thought leadership in its fields of expertise is one of the reasons that Australian businesses and other science organisations collaborate with us. For example, ANSTO has particular expertise in seeing how neutron scattering and synchrotron radiation can address unsolved industry problems, and so is clearly a thought leader in this area.

A thought leader within or outside an organisation is seen to know a better way of doing things and to be ahead of trends. The concept depends on recognition by others of such leadership, not on one's own proclamations. It also depends on being open to providing others with time, knowledge and information. Hence it is not only established by paid research or services, but also through sharing knowledge more broadly e.g. by journal articles, reports, technical articles, conference presentations and the like.

Thought leadership can carry over from one sector to another. ANSTO's reputation for thought leadership in processing of ceramics, for instance, is based on its work over decades on synroc, which was developed to immobilise radioactive wastes. In recent years this thought leadership and associated facilities have contributed to the success of medical device companies such ASDM and new research opportunities in nanotechnology.

Case studies

ANSTO Minerals

The ANSTO Minerals business unit was established to exploit the thought leadership that ANSTO has built up over 25 years in the treatment of uranium and other radioactive ores.[5] Its main focus is the front end of the nuclear fuel cycle, including uranium extraction, and the development of technology to characterise and solve issues related to naturally occurring radioactive material (NORM). It comprises more than 30 professional scientists and technicians with expertise that covers chemical engineering, metallurgy, mineralogy, chemistry, physics and radiation safety. ANSTO Minerals is a core participant in the recently established CRC for Sustainable Resource Processing.

Over the years ANSTO has established deep relationships with major mining industry companies that enable those companies to continue to innovate. They can, in effect, regard ANSTO as an outsourced R&D arm and a source of thought leadership. As an Australian Government agency, ANSTO maintains competitively neutral prices. However, its breadth of involvement in the mining sector, and issues of radioactivity more generally, enable it to maintain a level of thought leadership that would not be possible for individual in-house R&D units. The result is a high capacity for innovation at a lower cost, and thus benefits for national productivity.

Uranium processing

Australia has the largest reserves of uranium in the world and is the world's second largest uranium producer. ANSTO Minerals has built strong relationships with all three current uranium producers in Australia and undertakes contract, collaborative and ANSTO sponsored research in the areas where it has particular expertise such as leaching, solvent extraction, ion exchange, impurity control (including radioactivity) and process water treatment.

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4 As used by global management consultancy, AT Kearney

5 See www.ansto.gov.au/ansto/minerals/

Examples of past projects include:

- Investigation of alternative oxidants and reduced oxidant consumption in uranium leaching
- Development of generic leaching models to minimise reagent consumption
- Development of a solvent extraction process for high chloride liquors
- Application of high-density sludge in water treatment processes to reduce water losses.

ANSTO Minerals has carried out process development projects for all of Australia's current and past uranium operations. ANSTO has also contributed to several committees of the International Atomic Energy Agency (IAEA) regarding criteria for sustainable development of uranium mining and milling operations, NORM in titanium concentrates and waste-water treatment.

Naturally occurring radioactive materials

Radioactivity is ubiquitous in nature, and industries that often see elevated levels of radioactivity in their raw materials and/or processes include the coal, copper, oil and gas, phosphate, tin, tantalum, niobium, garnet and heavy mineral sands industries. Compared to uranium, these industries are not familiar, or equipped to cope, with radionuclides. Downstream processing and refining of these materials can lead to unacceptable concentration of radioactivity in products. The presence of radioactivity, even at low levels, in mineral concentrates and refined products can adversely affect the price and marketability of the product. Increasingly, countries are imposing more stringent regulations on the importation of products containing radioactivity.

There is growing awareness of the implications of the contained radioactivity through exposure of the workforce to process streams and tailings, and exposure of customers to the products. In addition, there is a growing interest in the issue of radioactivity in mineral products, driven by stricter regulations and the threat of legal liability over exposure to NORM and the related environmental impact. Other sectors also increasingly have to take NORM into account. Fertiliser, for example, can contain high levels of NORM.

ANSTO Minerals has undertaken extensive research and development in NORM and today ANSTO is Australia's leading source of information on most aspects of this issue.

ANSTO Minerals provides commercial services and advice to industry on issues such as analysis, site surveys of deportment of radioactivity, processing behaviour of radionuclides, control and removal of radionuclides, and risks associated with regulatory changes. It undertakes research for mineral processing companies, and has worked to build awareness of NORM issues through forums organised by the Australian Radiation Protection and Nuclear Safety Agency and IAEA technical committees.

Examples of projects include:

- Separation of thorium from rare earth containing concentrates
- Investigation of radioactivity issues related to the recovery of rare earths from apatite
- Removal of polonium from copper smelter dusts
- Removal of radioactivity from copper concentrates and anode slimes
- Deportment of radioactivity in fertiliser and alumina production.

Sulfidic waste management

Sulfidic minerals, such as pyrite, are often associated with mine orebodies, including uranium. Ore stockpiles, opencut pits, waste rock dumps and tailings storage facilities may contain sulfides as a result of mining. These entities need to be carefully managed to prevent the contamination of groundwater and surface streams by pollutants that are generated by the exposure of sulfides.

ANSTO began developing its capabilities in this area in the early 1970s with the quantification of pollutant generation rates at the abandoned Rum Jungle copper and uranium mine in the Northern Territory. At Rum Jungle, ANSTO showed that it was the sulfidic wastes at the site that were responsible for the very severe environmental degradation in the area. ANSTO has refined its skills through working at over 25 operating mine sites in North and South America, Europe, South-East Asia and Australasia. This experience has led to an in-depth understanding of the processes that govern the oxidation of sulfidic materials, the chemical composition of effluent and environmental impact.

One of the world's first purpose-built 'store and release' covers was applied to two waste rock dumps at Rum Jungle in the early 1980s. The purpose of the cover was to control generation and release of pollutants. ANSTO developed novel instrumentation to measure the effectiveness of the covers in controlling water infiltration and oxygen flux over the medium term. Ecological studies carried out by ANSTO showed a rapid improvement in conditions downstream of the site after the extensive rehabilitation works had been completed – a new species of fish was even identified. This landmark site provided a benchmark for mine-site rehabilitation for many years.

ANSTO also has capabilities in assessing and advising on mine closure strategies. Advice was provided to Mary Kathleen Uranium on the design of covers for tailings to limit the release of radon gas. More recently ANSTO advised WISMUT regarding rehabilitation of several uranium mine sites in the former East Germany.

Remnant life in power infrastructure

One of the most topical issues in Australia at present is the adequacy of infrastructure for our national needs now and into the future. In recent years, ANSTO has been making major contributions to enabling power infrastructure operators to safely assess and extend the life of plant, building on the expertise that we have developed in safely operating a nuclear research reactor. ANSTO provides consulting and other specialised services, particularly in remaining life assessment, structural integrity assessment and failure analysis.

The CRCs for Welded Structures and Integrated Engineering and Asset Management have played key roles in bringing ANSTO, industry partners and other researchers together. As a result of better understanding industry needs and cooperating more closely with other research organisations, we have been able to increase the production and life of major Australian infrastructure such as power stations and pipelines. ANSTO's work yielded savings in excess of $2 million at one power station in New South Wales alone.

ANSTO has played a major role in developing and promoting a research program within the CRC for Welded Structures for the electrical power generation industry and has been a major research provider to this program. The program attracted sponsorship from 10 electricity power generating companies and helped build ANSTO's reputation in this area. The program's results have helped to extend the life of critical power plant components and reduce the cost and time for maintenance shutdowns.

For example, ANSTO used its expertise in miniaturised creep testing to help a Queensland electrical power industry customer to assess the remaining life of several of its large, high-cost components. This involved taking small samples from the components and testing the deformation rate at high temperatures under steady load. The tests showed that the service life of the components could be safely extended.[6]

Currently ANSTO is examining non-destructive testing methods to evaluate the remaining life of service-exposed metals. The aim is to evaluate and develop non-destructive methods that detect creep damage in power station components. Demonstrating the primary importance of UPRs, one of the earliest activities in this current research was contact with industry sponsors. Meanwhile ANSTO is also researching how to prequalify emergency welds for power stations. To improve gas turbine asset management, a gas turbine rotor has been modelled for transient thermal stress at the centre of the bore and creep damage at the blade attachment point. This work has been carried out in collaboration with MPT in New Zealand. ANSTO has also recently modelled the cost of start-ups and shut-downs of coal-fired power stations. This work aims to provide information to power station operators on the effects of cycling of their plant on the development of damage to the structural materials. This information allows operators to factor downstream costs into bids to supply power to the grid.

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[6] Creep damage is the development of microstructural damage in high temperature materials under load. The damage occurs by the accumulation of micro defects within the material due to the impose load and is exacerbated by changes in the microstructure that occur because of the high temperature. The evaluation of creep is performed either in-situ, using microscopy to assess the microstructure, or if this is not feasible or further information is required, small samples are removed and subjected to accelerated-temperature creep testing. This tests the material by exposing it to higher temperatures than operating. The reduced lifetime is assessed by the use of various algorithms.

Working on its own or in collaboration with industry players such as Connell Wagner, ANSTO has over the past few years performed an extensive range of remaining life assessments and mechanical property measurements on power station components. These include miniature sample creep testing, bolt testing, tensile and fatigue testing, Charpy and fracture testing and replica assessment.

ANSTO has also provided assistance to other industries, working with companies such as Bishop Innovation and Queensland Alumina. To further expand this aspect of ANSTO activities an exhibition stand was prepared for the 2005 Operating Pressure Equipment conference in Melbourne; an event attended by a wide section of key pressure equipment industry personnel.

While such work is undertaken on a fee for service basis, ANSTO continues to publish widely to share its knowledge with others in the Australian innovation system and to increase its international reputation.

Capturing and managing innovation at ANSTO

The pathway to commercialisation at ANSTO has evolved considerably. Three years ago the Business Collaboration division was changed into the Business Development division under new leadership[7], which made a strong push to make ANSTO better known in target markets and among potential commercialisation partners, and to build our IP portfolio. Earlier this year, as part of a broader restructuring to support our new strategic directions, this division was merged into a new Executive division, which is headed by the organisation's Executive Director (its CEO). Within this division, ANSTO is establishing a new team, Access ANSTO, which will provide customers with a single point of entry to the complete capabilities of the organisation; ANSTO staff with business, marketing and contract support; and management with commercial advice. Under the new structure, the IP manager also reports directly to the Executive Director.

Capturing new IP

In 2003 ANSTO established a Patent Management Committee to bring researchers and management together to evaluate innovations for their suitability for patenting and to manage the IP commercialisation process. This committee provided strong peer support to scientists who were pursuing commercialisation. It also progressively reviewed ANSTO's existing patent portfolio, to reduce the cost of renewing patents that were not commercially valuable, and to improve the yield from the portfolio. In 2005, the Patent Management Committee evolved into an Innovation Forum, which is led by the Chief of Research and has a stronger focus on fostering and nurturing innovations. Monthly 'Brown Bags' (bring-your-own-lunch information sessions) had been set up in 2002 to enable targeted ANSTO researchers and management to hear visiting speakers on such subjects as patenting and venture capital. These sessions have been now been merged into the Innovation Forum and are aimed at wider audience, to expand understanding of commercialisation across the organisation.

ANSTO's Executive Committee has taken the lead in decision-making regarding new and renewed patents and their development to market. There is a formal 'gate' in the process when investment in developments is required, usually coinciding with a decision to complete a patent application.

Business units

When Dr Ian Smith became ANSTO's Executive Director in 2004, one of his earliest actions to improve commercialisation was to separate ANSTO Radiopharmaceuticals and Industrials (ARI) and ANSTO Minerals from the divisions of which they had been part, and make them into distinct business units reporting to him. This has brought top-level focus on these two key business areas.

Sharper definition of commercialisation activities

As part of its strategic planning, ANSTO has introduced clearly focused classifications for its activities for use in budgeting, planning and monitoring. Two of these classifications, Business Services and Outreach Research, have a primary emphasis on commercialisation. Both are customer-focused and driven by business plans.

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[7] Rob Muir, who chaired the Coordination Committee on Science and Technology Metrics of Commercialisation Working Group, which reported in April. Mr Muir has retired from his role at ANSTO.

- Business Services includes ARI, ANSTO Minerals, the highly successful neutron transmutation doping of silicon in ANSTO's reactor[8] and Materials Assessment and Processing Services. Such activities do not have a major research component.
- Outreach research primarily aims to encourage the take-up by users of ANSTO's IP. It has quite different outputs and indicators to, for example frontier research, which has a strong emphasis on publications. One of the largest outreach projects is devoted to synroc and associated capabilities in radioactive waste. Another outreach research project is structured as a 'protocompany' with nanotechnology IP that has potential across a broad range of industries. This is the first such protocompany that ANSTO has formed—it being seen as a prelude to a spinoff or spinout business, or a new business unit. These activities have commercial faces as synrocANSTO[9] and CeramiSphere[10].

Conclusion

ANSTO would welcome the opportunity to speak with the House of Representatives Standing Committee on Science and Innovation on the above case studies or any other aspect of ANSTO that will assist the committee in its Pathways to Technological Innovation inquiry.

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8 Which changes the characteristics of pure silicon to make it suitable for use in semiconductors. ANSTO is one of the world's top suppliers.

9 www.synrocansto.com

10 www.ceramisphere.com.au