AUSTRALIAN ACADEMY OF TECHNOLOGICAL SCIENCES AND ENGINEERING (ATSE)

ATSE

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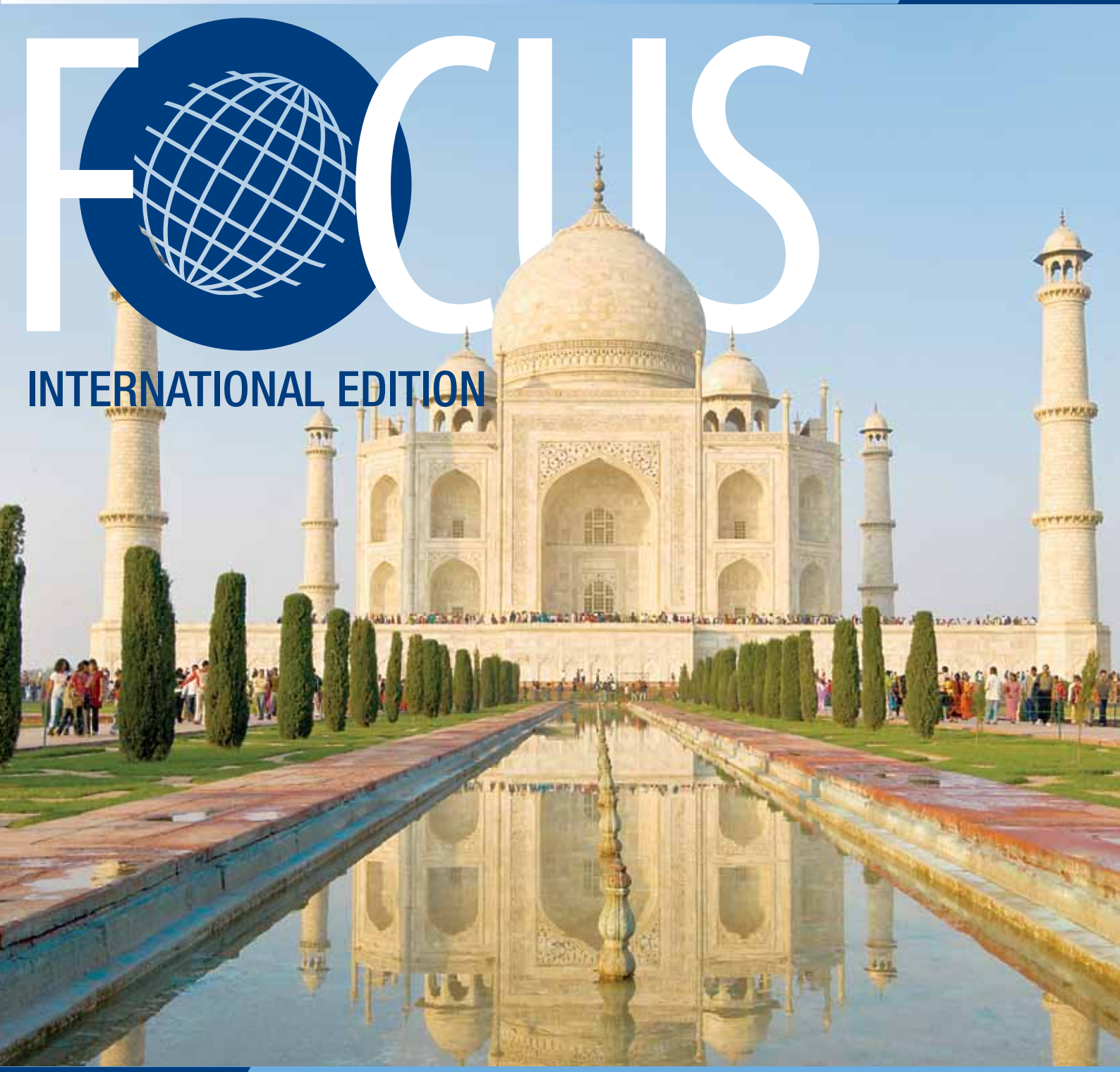

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AUSTRALIA / INDIA

A STRONG AND BURGEONING RELATIONSHIP

Contributors assess the current S&T links between the two countries and look at where our research links have been – and are going

Bringing Focus to Australia's relationship with India

This first edition of ATSE International Focus has the strong and burgeoning relationship between Australia and India as its theme and links with the developments flowing from the recent visit to India by Australia's Prime Minister Kevin Rudd.

The historic announcements by the Prime Minister and his Indian counterpart on science and technology research funding highlight the vital strategic research partnerships in science and technology between Australia and India that are shaped to lead to productive outcomes for both countries.

The Academy of Technological Sciences and Engineering has a key role to play in this relationship in fostering relationships between the S&T communities in both countries and encouraging and acclaiming high-impact applied research – particularly that directed to the major challenges we face in energy, food and water, health and the environment.

ATSE plans to publish two to three editions of International Focus each year, concentrating on the relationships with Australia's major international partners in S&T applied research.

We acknowledge and thank those who have contributed and hope you enjoy and value this inaugural edition of ATSE International Focus.

Front cover: The iconic face of India – the Taj Mahal (iStockphoto)

FOCUS

ATSE Focus International is produced to highlight Australia's relationship with the international community in the areas of science and technology and the Academy's role in engaging with partner countries. It will be produced from time to time to reflect a key aspect or development in the science and technology relationship between Australia and another nation.

Its purpose is to stimulate interest, discussion and development of research and research application opportunities for the benefit of both nations, and the world. Articles are contributed by ATSE Fellows with particular expertise in topic areas and by key figures in the relationship.

Please address comments, suggested topics and article for publication to **editor@atse.org.au**.

ATSE is an independent body of technologists, scientist and engineers established to drive technological change for a better Australia. ATSE *Focus International* is produced to serve this goal.

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Government commits to major boost to science collaboration

Committed to engaging with India on a long-term, strategic basis, recognising the central role science and technology collaboration plays in the broader relationship.

The science and technology cooperation platforms between Australia and India received their biggest boost in history with the Australian Government's announcement in November 2009 of a major new investment commitment.

Prime Minister Kevin Rudd announced during his visit to India that Australia would make a major new investment in building scientific links with India, with support for research efforts targeted at the challenges both countries face in energy, food and water, health and the environment.

The Indian Government has agreed to match Australia's increased investment.

As part of the program the two governments have introduced a new 'grand challenge' component, which will fund projects of larger scope and scale – designed to deliver tangible outcomes in areas where the two countries share 'grand challenge' issues.

Mr Rudd said the Government would invest:

- $50 million in the Australia–India Strategic Research Fund (AISRF);
- $1 million in an innovative Australia–India solar cooling research project; and
- $20 million in research into dryland farming in India.

The additional $50 million over five years for the AISRF would commence in the current financial year (2009-10).

The expanded fund would:

- continue the successful competitive grants program which supports 'bottom-up' investigator-initiated research;
- introduce new projects demonstrating both excellence in science and a clear path to end use for either commercial or public good; and
- introduce a fellowship program to support exchanges for Australian and Indian researchers.

The further $1 million committed for an innovative Australia–India solar cooling research project aims to develop a zero-emission solar cooling system for use in remote rural communities in un-electrified areas.

An estimated 400 million Indians do not have access to electricity, in many cases because they live too far from the main grid infrastructure.

The dryland farming research program will be supported with $20 million over five years through the Australian Centre for International Agricultural Research (ACIAR), which is chaired by ATSE Fellow Dr Meryl Williams FTSE.

The Prime Minister's announcement said the Government was committed to engaging with India on a long-term, strategic basis and recognised the central role science and technology collaboration plays in the broader relationship.

The increased investment in the AISRF would, in particular, seek to support more applied research and engagement of industry partners in order to produce outcomes that helped address some of the pressing challenges that both countries faced.

ATSE President Professor Robin Batterham FREng FAA FTSE has been appointed Chair of the AISRF Advisory Panel for 2009-10. AISRF has two competitive components – the Indo–Australian S&T Fund and the Indo–Australian Biotechnology Fund, as well as the new 'grand challenge' component. The main role of the panel is to provide independent review and assessment of applications for AISRF funds, working with Joint S&T and Joint Biotechnology committees which will bilaterally decide on funding of new project proposals for each round of AISRF funding. The Advisory Panel includes a number of ATSE Fellows: Professor Lorenzo Faraone FTSE, Dr Tony Fischer AM FTSE, Dr Gary Fitt FTSE, Professor Christopher Hudson FTSE, Professor Chennupati Jagadish FAA FTSE, Professor John Lovering AO FAA FTSE, Dr Ian Poiner FTSE, Dr John Ramshaw FTSE, Dr John Sligar FTSE, Professor Tam Sridhar FAA FTSE and Mr Martin Thomas AM FTSE.

PHOTO: DAVID FOOTE, AUSPIC

Prime Minister Rudd at The Energy and Resources Institute (TERI), in Delhi, during his November visit.

Collaboration is the key to world challenges

CSIRO and its Indian collaborators are sure to make a difference in a world facing extraordinary challenges.

By Megan Clark

The international research and innovation landscape has undergone immense change in the past 20 years, with increasing mobility of talent, emerging research areas, increased investment in research and the rapid expansion of the Indian, Chinese and, more recently, Brazilian economies.

These changing trends in the global innovation system are occurring at a time when the world is facing an extraordinary range of challenges such as food security, resource constraints, energy security, climate change and increasing urbanisation.

Many of these challenges are global in nature and impact on communities in different countries and regions. These challenges cannot be addressed by individual organisations or countries. To develop effective responses to these issues, research organisations all over the world must develop new ways of collaborating with each other, with policy makers, with industry and with communities.

To address these challenges, over the past few years many countries such as the US, China, India and Australia have significantly increased investment in research, while CSIRO introduced its multidisciplinary National Research Flagships.

As a medium-sized economy Australia produces about two per cent of the world's scientific knowledge, yet as a nation we also need access to the remaining 98 per cent. In a world of expanding research effort Australian research organisations, including CSIRO, can maximise their research influence and impact by increasing engagement with traditional partners and developing new partners in Asia and Africa.

CSIRO has been engaged with international partners since its inception. In 2008-09 it contributed to more than 1000 international activities in 66 countries and is actively responding to global challenges and changes.

CSIRO has focused on building its interactions with key partners in India, which has firmly established itself as a major participant in the international innovation scene. Within this broader picture, over the past four years we have been forging relationships and growing activities in India.

Since Independence, successive Indian governments have affirmed the importance of science and technology to assist economic development and prosperity.

With its rapidly developing economy, large research capacity and infrastructure, and significant numbers of skilled researchers, India has a number of major achievements in science and technology. This includes its high-profile space and nuclear program, as well as biotechnology research, software development and ICT industries.

India's government wants India to be a global innovation leader in all areas of science and technology, providing substantial increases in funding in the current Five Year Plan.

Key initiatives in the plan include:

- enlarging the pool of scientific and engineering talent;
- strengthening the S&T infrastructure and attracting and retaining young people to careers in science;
- establishing globally competitive research facilities and centres of excellence;
- identifying ways and means of catalysing industry–academia collaborations; and
- promoting strong linkages with advanced countries, including participation in mega international science initiatives

In parallel with the growth in funding has come an increasing focus on strengthening international links in science and technology.

India has formal bilateral S&T cooperative arrangements with a range of countries including the US, the United Kingdom, Japan, France, Germany and Australia.

To date CSIRO has developed a strategic partnership with India's Council of Scientific and Industrial Research (CSIR), as well as a Memorandum of Understanding with the Department of Biotechnology to address issues of mutual national significance. CSIRO is also a partner with CSIR in the Global Research Alliance, which is made up of nine research organisations around the world to deliver

long-term solutions to problems affecting the developing world.

CSIRO is also a foundation partner in the new Indian Institute of Technology Bombay – Monash University Research Academy, which has been set up to undertake research on cross-disciplinary grand challenges and to train the next generation of internationally mobile researchers.

CSIRO also has collaborative projects with a number of different Indian research organisations as part of the Australia–India Strategic Research Fund and the Asia–Pacific Partnership on Clean Coal Development, which has led to improved knowledge, capacity building and information exchange.

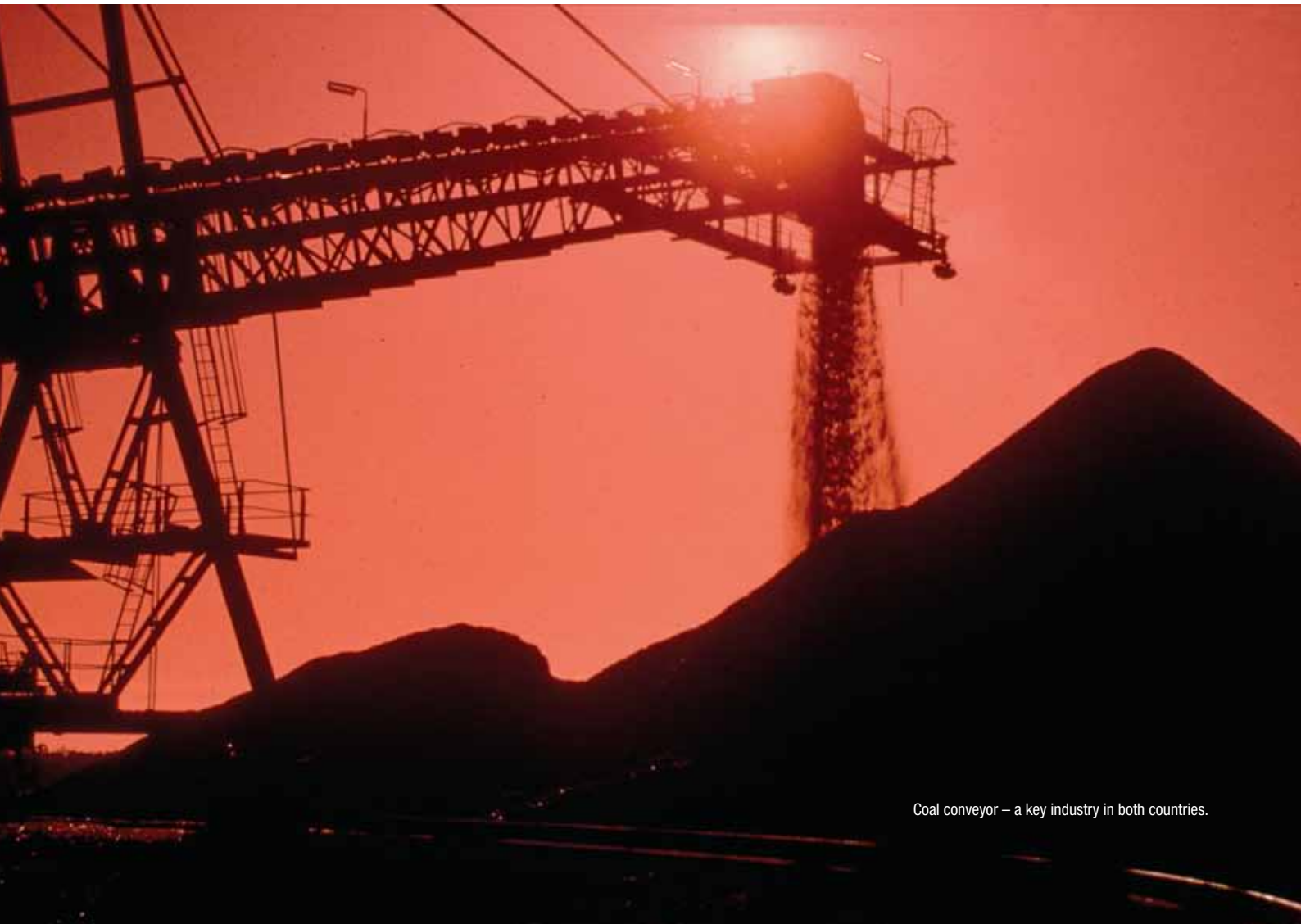
Some of the outcomes of CSIRO's collaborative research have resulted in the introduction of improved mining techniques in Indian coal mines, the development of capabilities for the genetic transformation of certain crops and zero emissions electrification for rural areas. A joint program has led to a greater understanding of the underlying mechanisms of mitosis, which has potential for future crop production. In addition we are working with Indian partners on global issues such the effect of diseases on major food crops and the impacts of climate change on the environment.

CSIRO's aim is to be a globally respected R&D organisation with a range of international linkages. India, with its strong academic traditions and an expanding, highly mobile and well-educated workforce, is centrally placed in the global transformation of the innovation system.

By investing in productive relationships, sharing information and together addressing major global challenges, CSIRO and its Indian collaborators are sure to make a difference in a world facing extraordinary challenges.

DR MEGAN CLARK FTSE, Chief Executive, CSIRO, is a member of the St Vincent's Hospital Foundation Board, the Prime Minister's Science, Engineering and Innovation Council and the Automotive Industry Innovation Council. She began her career as a mine geologist and subsequently worked in mineral exploration, mine geology, research and development management, venture capital and technical strategy areas with Western Mining Corporation for 15 years. More recently she was Vice-President Technology and Vice-President, Health, Safety, Environment, Community and Sustainability with BHP Billiton. Dr Clark served on the Expert Panel for the Review of the National Innovation System.

PHOTO: CSIRO



Coal conveyor – a key industry in both countries.

Australia and India: building a knowledge partnership

Recognition of the importance of international collaboration in science and the potential to work together to address some of the "grand challenges".

By Mary Finlay

Science was a key focus for the Prime Minister's November 2009 visit to Delhi, which provided an opportunity to highlight some of the excellent work already underway and to announce a major expansion in government support for the science relationship.

With its immense population, growing economy and rising investment in education and research, India is set to play an increasingly important role in international science. Its globally competitive space and biotechnology industries point to what the country might achieve in other sectors.

At the same time, science and technology are fundamental to meeting the challenges that India – and Australia – face in providing our populations with sufficient energy, drinkable water, affordable healthcare and safe food, and doing so in a sustainable manner.

For these reasons, science has an important role to play in the bilateral relationship. This is a view that both governments share, reflecting our recognition of the importance of international collaboration in science and the potential to work together to address some of the "grand challenges" we both face.

The Australian Government provides support for collaboration with India through a range of programs, including the Cooperative Research Centres network, the Asia–Pacific Partnership on Clean Development and Climate, the Australian Research Council and the Australian Centre for International Agricultural Research (ACIAR).

The Australia–India Strategic Research Fund

The most important platform for government-supported science collaboration is the Australia–India Strategic Research Fund (AISRF), which is jointly funded by the two governments. Established in 2006 with an initial Australian commitment of $20 million over five years, matched by the Government of India, it has been since its inception Australia's single largest fund for bilateral research.

Reflecting the high-level commitment to working more closely together in an area of shared strength, Australian Prime Minister Kevin Rudd and his Indian counterpart, Dr Manmohan Singh, announced on 12 November their agreement to extend and expand the AISRF. Australia will increase its contribution to the fund to $10 million a year for the next five years, which India will match.

PHOTO: DAVID FOOTE-AUSPIC

Prime Minister Kevin Rudd and Dr Rajendra Pachauri.

To date, the fund has supported more than 50 high-quality joint projects across a range of disciplines including astronomy, biotechnology, agricultural research, nanotechnology and renewable energy. It has also provided targeted assistance to build a stronger relationship between CSIRO and its Indian equivalent, CSIR, and to help establish the IITB–Monash Research Academy, an exciting new joint venture between Monash University and one of India's most prestigious tertiary institutions that will see up to 350 doctoral students conducting research under joint supervision by Australian and Indian researchers.

With the expansion of the fund, two new components will be introduced. The first will fund large-scale projects (up to $2 million a year) designed to deliver tangible outcomes in areas of shared "grand challenge". The priority areas for this new "grand challenge" component were developed with input from a joint panel of eminent researchers and individuals with experience in the translation of research into commercial and other applications.

The initial areas of focus will be food and water security and the environment.

The second new component is a major fellowship program, which will support exchanges for Australian and Indian researchers. The program will fund placements for early career and established researchers for periods of up to 12 months, and will also support shorter exploratory visits for senior researchers.

Under the expanded fund, the successful Indo–Australian Science and Technology Fund and Indo–Australian Biotechnology Fund will be continued. The maximum amount of funding that can be awarded to a successful project from each government has now been capped at $300,000, although consistent with both governments' intention to increase the level of industry and other 'end user' engagement in publicly funded research, a larger cap of $400,000 applies for projects that can demonstrate at least one active end-user partner.

Further information, including the funding guidelines, is available at www.innovation.gov.au/aisrf.

A broad-based cooperation agenda

While in Delhi, the Prime Minister visited The Energy and Resources Institute (TERI), a highly regarded research and policy advocacy organisation headed by the current chair of the Intergovernmental Panel on Climate Change, Dr Rajendra Pachauri. He met scientists engaged in a joint project funded through the AISRF involving TERI, Flinders University and the University of New South Wales and students working towards a PhD with Deakin University through the Deakin India Research Initiative.

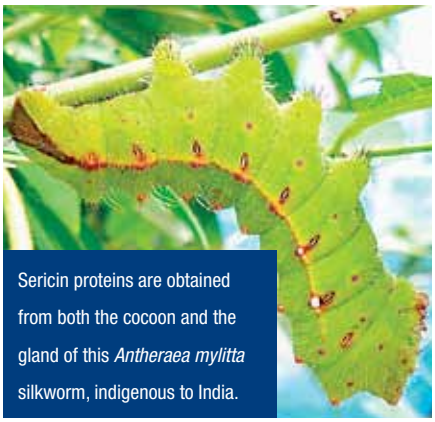
At TERI, the Prime Minister announced significant additional commitments to funding for bilateral research efforts.

Building on a project originally supported through the Asia–Pacific Partnership on Clean Development and Climate, Australia will provide an additional $1 million for a joint project between TERI and CSIRO on solar cooling and smart mini-grids. The project aims to develop and test a zero emissions 15kW solar cooling system for remote rural applications in un-electrified areas of India.

The lack of proper cold storage facilities in India leads to the spoilage of an estimated 20 million tonnes of fruit and vegetables annually, about one-third of all agricultural produce. The project will include demonstration of an alternative desiccant cooling method, which produces potable water as a by-product.

With this high-level commitment and substantial new investments these are exciting times for the bilateral science relationship.

MS MARY FINLAY is General Manager, International Science and EIF Branch, Department of Innovation, Industry, Science and Research.



Sericin proteins are obtained from both the cocoon and the gland of this *Antheraea mylitta* silkworm, indigenous to India.

PVA polymer being 'injected' via syringe.

Biomaterials and biomedical devices are a key research sector

One key driver of growth is population and rising life expectancy, which will place an enormous burden on India's infrastructure.

John Ramshaw, Penny Martens and Laura Poole-Warren

Collaborations and interactions between Australian and Indian researchers in the area of biomaterials and biomedical devices have developed significantly over the past 10 years.

While this is a key research area for both countries, neither has a broad nor strong domestic manufacturing base for biomedical devices, so at present both are generally reliant on the need for imported devices.

For India in particular this means that device-related aspects of healthcare are typically neither affordable nor cost-effective for most of the population. The need for innovations for cost-effective devices is therefore of particular interest, and collaborations can provide benefits to both countries.

In India, healthcare is one of the largest sectors, in terms of revenue and employment, and the sector is expanding rapidly, both scientifically and in manufactured products. The private sector accounts for more than 80 per cent of total healthcare spending, and this is unlikely to change too much in the short term.

One key driver of growth in the healthcare sector is population and the rising life expectancy, which will place an enormous burden on India's infrastructure.

Relative domestic purchasing power favours domestic

NEW PROTEIN–POLYMER COMPOSITE BIOMATERIALS

A research area supported by the AISRF has been the development of biosynthetic silk-hydrogel extracellular matrix analogues for mammalian cell support and drug delivery. This project is a collaboration between Dr Penny Martens and Professor Laura Poole-Warren of the University of New South Wales, and Professor S.C. Kundu of the Indian Institute of Technology, Kharagpur.

Synthetic hydrogels have a wide range of medical applications from contact lenses to wound dressings and are attractive candidates for tissue engineering and regenerative medicine. Poly (vinyl alcohol) (PVA) hydrogels are versatile polymers with negligible toxicity, a stable hydrocarbon backbone and many modifiable pendant hydroxyl groups.

However, PVA has the disadvantage of having low protein binding, which is associated with poor cellular interactions and is common with many synthetic polymers. This is being addressed by incorporation of proteins within the synthetic network, while trying to avoid any deterioration in the hydrogel properties. The proteins being examined are two different varieties of sericin (silk protein), which can be chemically modified to allow covalent incorporation within the PVA hydrogels by crosslinking with UV light.

These novel materials show beneficial effects on cell viability within the PVA composites, while not having a significant effect on the hydrogel's macroscopic properties. Results indicate that there are differences between the two types of sericin proteins, which suggests that one of the types of sericin is better at promoting cell attachment and proliferation, while the other sericin type is better suited for cell differentiation. Research is ongoing to further investigate this, and determine if the hydrogels can be therefore tailored to specific applications.

Examining silk worm cocoons.

Examining a silk-polymer composite scaffold for tissue engineering.

manufactures as exchange rates and the lower local remuneration make purchase of imported biomedical devices very expensive. This provides a very strong driver for the development of the domestic device-manufacturing industry.

In India, there is a very clear recognition of and priority placed on the need to replace imports in a move towards affordable healthcare. The same could also be true for Australia, but relatively little medical device manufacturing has emerged despite the opportunities.

In Australia, two significant biomedical device companies have emerged in recent years, Cochlear and Resmed. However, these companies illustrate the difficulties in Australia in funding early stage development of biomaterials and medical devices, particularly where the local funding emphasis has at times seemed to be on pharmaceutical development.

In India there are already successes, such as the Indian heart valve, that are coupled to enhanced manufacturing capabilities and companies that are focusing on device manufacture. This will undoubtedly continue to grow, while being further enhanced by initiatives such as the Stanford India Biodesign initiative and the Government's focus on enhancing the output of engineering and other higher degree graduates.

Interactions between scientists in the areas of biomaterials, tissue engineering and medical device development have been steadily developing. In recent years, for example, both the Australian and then the Indian societies for biomaterials have both become members of the international group that links these professional societies, the International Union of Societies for Biomaterials Science and Engineering (IUSBSE). The Indian researchers were a significant delegation to the 7th World Biomaterials Congress that was held in Sydney in May 2004.

Arising from this a biennial meeting has been established, on Biomaterials, Implanted Devices and Tissue Engineering (BITE). This series was inaugurated in 2005 in Trivandrum, and since held again in India and most recently in Sydney in January 2009, which was supported by the Australian Department of Innovation, Industry, Science and Technology (DIISR).

In addition, scientists from Australia have attended similar conferences in India, including those held by the Society for Biomaterials (India) and the Materials Research Society.

The recent Australia–India Strategic Research Fund (AISRF) opportunity has had a significant impact on the extent and nature of interactions and collaboration in biomedical device development between the two countries.

There has been a long-standing background of inter-

action, arising from Indian scientists travelling abroad for both PhD and postdoctoral training, and through academic and research-based appointments. Typically, this leads to Indian scientists coming to Australia, with fewer Australians spending time in India. However, recently the AISRF funding scheme and other initiatives have changed this perspective.

The AISRF funding scheme has been particularly significant in that it has led to new research collaborations between the two countries. In the three rounds of grant applications for collaborative research in the initial scheme, various activities in the identification and treatment of ophthalmic and cardiac diseases and new implantable materials for orthopaedic and connective tissue repair have been supported.

This involves collaborations with leading Indian research centres, including the Indian Institute of Technology, LV Prasad Eye Institute (Hyderabad) and CSIR's (India) Center for Cellular and Molecular Biology. To date, however, no research has been supported in this priority area by the Targeted Allocations part of the AISRF.

Most recently, a workshop on biomedical devices was held in March 2009 in New Delhi, with the financial support of the Department of Biotechnology (DBT) of the Ministry for Science and Technology (India), and DIISR, from the AISRF. This workshop focused on emerging technologies for medical devices balanced against the need for affordable healthcare for all. The workshop successfully built new interactions and strengthened existing interactions and identified key drivers where collaboration could bring mutual benefits.

Undoubtedly there were many areas where different skills exist in Indian versus Australian laboratories, which could form the basis of successful product developments. Also, it was felt that exchange of students and postdoctoral fellows was a key area that should be developed further and that, when possible, early involvement of companies could be valuable.

In addition to the Government initiatives, a wide variety of other interactions have developed. These include the close interaction of the Vision CRC, including the University of New South Wales (UNSW) and CSIRO, with the LV Prasad Eye Institute in Hyderabad for evaluation of new ophthalmic devices.

UNSW has also developed strong interactions with the Sree Chitra Tirunal Institute for Medical Sciences and Technology in Thiruvananthapuram. This institute is a world leader in medical device technologies, and has been recognised as an Institute of National Importance by an Act of the Indian Parliament. Among the key achievements has been the development and local manufacture of the Indian heart valve, allowing cost-effective treatments for more than 50,000 patients.

Other universities have also established linkages, with many researchers involved in collaborative interactions. In some case specific programs have been started.

These include, for example, Deakin University, which has established collaboration with CSIR (India) and sponsored joint PhD studentships, with interests in stem cell and tissue engineering activities. Queensland University of Technology has appointed a Director South Asia to facilitate collaborations with India, including in biomaterials research, and has established strong interactions with various institutes, including the Indira Gandhi National Open University in Delhi. Monash University has built a relationship with the Indian Institute of Technology Bombay to form a Research Academy (which CSIRO has also joined as a Foundation Partner), which will provide opportunities for collaborative activities in biomaterials.

The many scientists and researchers involved hope that this increased level of interaction and collaboration between Australia and India will lead not only to significant breakthroughs in biomaterials science and engineering, but also to a boost in the current medical device industry in both countries.

A more developed medical device industry should lead to better and more affordable health care for the populations.

Australia-India Strategic Research Fund, https://grants.innovation.gov.au/AISRF

DR JOHN RAMSHAW FTSE is a Chief Research Scientist at CSIRO Molecular and Health Technologies. His research activities have been in protein chemistry, including biomaterial product developments based on collagen structure and function. He was the inaugural President of the Australian Society for Biomaterials, served as the Australian delegate to the International Union of Societies for Biomaterials Science and Engineering for 14 years, and was Secretary from 2000–08.

DR PENNY MARTENS is a Lecturer/Research Fellow in the Graduate School of Biomedical Engineering at UNSW. Her research activities involve the development of biosynthetic polymeric composites for use in biomaterial applications and the evaluation of their material and biological properties. She is currently serving as Treasurer of the Australasian Society for Biomaterials and Tissue Engineering, and is on the board of the Federation of Australian Scientific and Technological Societies.

PROFESSOR LAURA POOLE-WARREN is the Associate Dean Research in the Faculty of Engineering at UNSW and Professor in the Graduate School of Biomedical Engineering. As Associate Dean Research, her roles include the development of research strategy, while her research activities have an emphasis on development of bioactive polymers and understanding cell and tissue interactions with these materials. She is a past president of the Australasian Society for Biomaterials and is the current Australian delegate to the International Union of Societies for Biomaterials Science and Engineering and a council member of the Asian Biomaterials Federation.

Opportunities for India–Australia collaboration on GM crops

The high cost of GM approaches requires that both countries focus on the 'big' common diseases and pathogen groups and work towards broad-spectrum, durable resistance.

By Gary Fitt

Australia and India share a number of challenges and constraints in agricultural production. Issues of food security, population growth, climate change and sustainable land management loom large.

Both countries are exploring opportunities to apply modern biotechnology in the form of GM crops to help address key biotic and abiotic threats or to enhance the nutritional or other qualities of food and fibre crops, thereby enhancing productivity and sustainability of agriculture.

GM crops have now been grown commercially for some 13 years since the first releases in 1996. Currently more than 140 million hectares are sown to GM crops (mostly soybean, corn, canola and cotton) in 22 countries, including both Australia and India.

Australia, together with the US, has been producing GM cotton for more than 12 years, while India's first commercial GM crop, also cotton, was grown in 2002. While the first generation of GM crops has focused exclusively on so-called input traits – associated largely with biotic stresses of pest, disease and weed management – there are numerous opportunities now to address a wider range of traits and issues.

Opportunities for collaboration in the development and deployment of GM crops were significantly enhanced in 2006 by the establishment of the Australia–India Strategic Research Fund (AISRF). This initiative of the Australian and Indian governments facilitates collaborative research across a range of science and technology arenas including biotechnology and transgenic crops.

In support of the AISRF, a joint Australia–India Workshop on Transgenic Crops was held in New Delhi in April 2008, under the auspices of the Indian Department of Biotechnology (DBT), the National Institute for Plant Genome Research (NIPGR) of India and the Australian Academy of Technological Sciences and Engineering (ATSE).

The workshop brought together a small group of leading experts from both Australian and Indian institutions who worked to identify critical issues where transgenic crops could be relevant and to enhance connections between their research groups as a platform for future collaborations in agricultural biotechnology. This article summarises the workshop presentations and discussions.

Challenges for crop-production systems

Food security depends in part on the ability to manage constraints on crop productivity and to minimise the impacts of a range of biotic and abiotic stresses. Biotic stresses come in the form of pests, weeds and diseases, while abiotic stresses include issues such as drought, high temperature and soil constraints – such as salinity or sodicity – all of which may also reduce productivity. Collectively these stresses impose economic losses on producers, which are magnified through the food chain and many are important constraints for both India and Australia.

Most GM crops deployed to date address biotic stresses through the introduction of novel genes for insect resistance or herbicide tolerance – so-called input traits. The *Bacillus thuringiensis* (Bt) genes deployed in GM cotton are one example where pest damage and the need for pesticide applications has been dramatically reduced.

Herbicide-tolerant crops, in the form of glyphosate-tolerant corn, soybean, cotton and canola, likewise address the stress imposed by weeds by providing a novel means of 'over the top' weed control that avoids long residual herbicides and excessive tillage. Such technologies bring both benefits and risks, and over-reliance on single technologies raises the spectre that the target pests or weeds may evolve resistance to the GM traits. Consequently GM crops with input traits rely critically on well-researched management strategies to protect the GM technology to ensure long-term gains.

A common constraint in both countries is plant diseases, particularly fungal pathogens. Key fungal diseases in Australia include: cereal rusts, fusarium wilts, fusarium crown rot, cereal and legume necrotrophs, wheat take-all, canola blackleg and sugarcane smut. India suffers from related but different pathogens such as rice blast, rice sheath blast, rice brown spot, wheat rusts, wheat loose smut, karnal bunt, wheat spot blotch, chickpea fusarium wilt and ascochyta blight and sugarcane red rot.

Collectively these diseases cover the spectrum from biotrophs (multiply in living tissues) to nectrotrophs (colonise dead tissue) and involve different mechanisms of cell response, signalling and resistance. Biotechnology, particularly through the application of RNA interference (RNAi) (a system within living cells that helps to control which genes are active and how active they are) offers many potential solutions to fungal diseases – through antimicrobial peptide genes; phenolics and lignin defences; various regulators of the natural plant defence response; and disease-resistance genes.

However, the high cost of GM approaches requires that both countries focus on the 'big' common diseases and pathogen groups and work towards broad-spectrum, durable resistance. Fungal pathogens remain a very challenging area where collaboration will be the best route to hopefully deliver a significant outcome.

Real advances are now being made with abiotic stress tolerance to deal with the constraints of drought, flooding, high temperatures, low temperatures (frost), hostile soils (salinity, sodicity, acidity), micronutrient toxicities and deficiencies. With the majority of agricultural lands in both countries grown under rain-fed conditions, drought tolerance is a high priority. Current research efforts utilise a wide range of genes and promoters seeking drought and/or salinity tolerance in rice, wheat, groundnut, potato, mustard, tomato and cotton.

Mechanisms discussed for salinity tolerance in rice included over-expression of helicase genes, while for drought tolerance genomic tools have helped to define several families of water stress-responsive genes. Examples include over-expression of trehalose biosynthetic genes, over-expression of stress-responsive genes in rice, and specific water-use-efficiency genes. Drought-tolerant crops are at varying stages in the pathway to commercial use but, while progress in addressing single abiotic factors is promising, there are few field situations where only one stress is operative, and most traits are multigenic, so it is highly unlikely that single genes could be effective. Again this is a challenging area where collaboration will be beneficial.

Beyond constraints

Beyond the necessary focus on production constraints, the next generation of GM crops will also include crop varieties with enhanced quality traits. Modification of oils produced from canola or other oilseeds to achieve improved nutrition or health – or for industrial uses – is one real example. Through the application of RNAi to silence specific genes in the fatty acid pathway it is now possible to alter which products accumulate.

Examples include the production of high-oleic-acid oils in cotton, canola and mustard (*Brassica juncea*). Applications of biotechnology to modify feed quality or enhance fodder biomass for livestock, or to change the characteristics of biofuel crops, represent looming frontiers.

Biofortification – an approach to dealing with chronic nutritional deficiencies in the developing world – is another approach being applied to bananas, a staple food in some parts of Africa. Bananas are naturally deficient in vitamins A and E and iron. A Gates-funded collaborative project with Uganda, Kenya and Tanzania is targeting improved nutritional quality of bananas and could have spin-off applications in India and Australia through associated work on disease tolerance of bananas.

Finally the plethora of crops now being developed as biofactories for the production of pharmaceuticals, nutriceuticals and other valuable proteins is staggering, but opens up a real debate about the provision of agricultural lands for the production of food, fuel or other high value products.

Management systems for sustained benefit from transgenic crops

The workshop highlighted a huge raft of opportunities to develop and implement GM crops for a range of beneficial outcomes. However there are also risks to be managed once these crops have passed the formal risk assessments applied through the regulatory system.

The Workshop emphasised the importance of management strategies to be deployed with transgenic crops to maximise and prolong benefits. The best example comes from crops engineered with Bt genes to protect against various insect pests (for example *Helicoverpa armigera*), many of which have a history of evolving resistance to traditional pesticides.

The risk that they could do the same to transgenic Bt proteins is very real. Bt cotton is now grown successfully on more than 15 million hectares in 10 countries. Pre-emptive resistance management strategies derived from sound ecological understanding of the systems are a key requirement, but a global review indicates considerable divergence among countries in the rigour of management strategies. In part this reflects the difficulties of implementing novel and sometimes restrictive strategies, particularly in developing countries. Perhaps as a result there is some evidence of changing tolerance to Bt proteins in some countries, but not in others. Ongoing vigilance is critical.

Priority Crops	Priority Traits
Wheat	Yield in water-limited environments; rust tolerance
Chickpea	Insect pest and disease resistances – *Helicoverpa*, fusarium wilt
Brassica napus/B. juncea	Oil composition – high oleic content; *Alternaria* resistance
Sugarcane	High sugar content
Banana	Micronutrients

Implementing management systems for GM crops with smallholder farmers is a major challenge, which is not helped by the appearance of illegal and fake transgenic seed in some markets in India. Efforts to introduce Bt brassicas to India in an effort to reduce the pesticide burden on human populations and the environment highlights the importance of public/private partnerships and appropriate engagement with smallholders to fully assess the socioeconomic opportunities and best deployment strategies.

Priority crops and traits

Australia and India are blessed with some outstanding expertise in agricultural biotechnology and possibilities for valuable collaboration can be found among numerous crops and issues. However, identifying the most beneficial collaborations requires a formal process to consider the likelihood of success against the potential benefits in order to identify win-win opportunities that have a high probability of success in delivering a product to market.

DR GARY FITT FTSE, Deputy Chief, CSIRO Entomology, has a long background in agricultural sustainability with a focus on ecologically based pest-management systems for Australia. He joined CSIRO in 1983 and worked at the Australian Cotton Research Institute, Narrabri, for some 20 years. He was Program Leader for Cotton in CSIRO for 10 years from 1990 and the CEO of the Australian Cotton CRC from 1999 to 2003. In 1992 he began involvement with research of the first insect-tolerant GM cotton varieties and coordinated the development of the pre-emptive management strategies to protect the technology from the evolution of resistance.

Factors to consider in identifying key crops and traits for Australia–India collaboration include:

- significant crop in both countries;
- with significant constraints that might be amenable to GM solutions;
- availability of good transformation systems;
- candidate genes available;
- can a business case be made;
- nature of consumer and political awareness;
- possibilities to ramp-up production of transgenic events;
- capacity to
  - demonstrate efficacy of transgenes in the field;
  - complete an environmental risk assessment;
- awareness of bio-safety and regulation processes;
- infrastructure for seed dissemination and interaction with grower groups; and
- potential to put in place post-release stewardship programs.

From such an analysis it is possible to identify the following suite of priority crops and traits for future collaborations:

Cotton is a notable exception here. Although a key crop for India and important for Australia, the development of GM cotton is dominated by commercial entities and there are few opportunities for collaborative transgenic crop development between Australia and India.

Across all these crops a key question that challenges any future collaboration is whether a business case can be made to justify the long timeline and the costs of achieving regulatory approval in either country. Collaborations that typically involve public research institutions will always strug-

Workshop participants

Australia

Dr Bernard Carroll, Associate Professor, School of Molecular and Microbial Sciences, University of Queensland, Brisbane

Dr James Dale, Director, Centre for Tropical Crops and Biocommodities, Queensland University of Technology, Brisbane

Dr Gary Fitt FTSE, Deputy Chief, CSIRO Entomology, Brisbane

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Professor Roger Leigh, Head, School of Agriculture Food and Wine, University of Adelaide, Adelaide

Dr John Manners, Deputy Chief, CSIRO Plant Industry, Brisbane

Dr Sue Meek FTSE, (then) Gene Technology Regulator, Office of the Gene Technology Regulator, Canberra

Professor Stephen Powles FTSE, Professor and Director, Western Australia Herbicide Resistance Initiative, University of Western Australia, Perth

Professor Derek Russell, Adjunct Professor, Bio21 Institute, University of Melbourne, Melbourne

Professor Mohan Singh, Group Director, Plant Molecular Biology and Biotechnology, Faculty of Land and Food Resources, University of Melbourne, Melbourne

Dr Surinder Singh, Group Leader, Oilseeds Group, CSIRO Plant Industry, Canberra

Professor German Spangenberg FTSE, Executive Director, Biosciences Research Division, Victorian Department of Primary Industries, Melbourne

Indian

Professor Deepak Pental, Vice-Chancellor, Delhi University, New Delhi

Dr Narendra Tuteja, Associate Scientist, International Centre for Genetic Engineering and Biotechnology, New Delhi

Dr Ajay Parida, Director, M.S. Swaminathan Research Foundation, Taramani, Chennai

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Dr K.C. Bansal, Professor, NRC on Plant Biotechnology, IARI, New Delhi

Professor Arun Lahiri Majumder, Head, Plant Molecular and Cellular Genetics, Bose Institute, Kolkatta

Professor Akhilesh Tyagi, Professor, PMB, South Campus, Delhi University

Prof P. Balasubramanian, Director, Centre for Plant Molecular Biology, Tamil Nadu Agricultural University

Dr P Anand Kumar, Head, National Research Centre on Plant Biotechnology (NPCPB), IARI, New Delhi

Dr Keshav Kranthi, Central Institute for Cotton Research, Nagpur, Maharashtra

Dr Vibha Dhawan, Vice-Chancellor, TERI School of Advanced Studies, Darbari Seth Block, IHC Complex

Professor Asis Datta, Professor of Eminence (Former Director, NIPGR and former VC, JNU), NIPGR, New Delhi

gle to adequately resource such long-term commitments.

Estimates of 10 to 12 years of R&D funding and $25 million per trait per crop seem necessary to transition through the evaluation, regulatory and commercialisation process.

The need for workable and consistent regulatory systems is a clear need for the future of Australia–India collaborations, which might be based on consortia accessing platform technologies to leverage wider outcomes.

Overall, the need and opportunities for successful collaboration between Australia and India in GM crops research seem clear. Both countries face multiple constraints on agricultural productivity, both have outstanding scientific resources, and both have the broad underpinning of basic agricultural research capability needed to facilitate GM crop deployment.

Consistent, science-based regulatory systems are needed in both countries, while adequate long-term funding remains the key obstacle.

ACIAR and India find new ways to work together

The greatest number of poor and undernourished people in any country is found in India, and most live in rural areas.

By Paul Fox

The Australian Centre for International Agricultural Research (ACIAR) currently invests about $3 million a year in India through financing research in international agricultural research centres active in India, as well as collaborative bilateral projects commissioned through Australian research providers.

Generally ACIAR-funded projects – now 19 in India – are more impact-driven and 'down-stream' than those of the Australia–India Strategic Research Fund (AISRF), although the two institutions communicate closely to harmonise potential synergies.

India and ACIAR consult intensively on research priorities, currently focusing on three key areas:

1. application of marker-assisted selection as a tool in wheat breeding;
2. water management and productivity for enhanced livelihoods in rainfed areas of the central plateau; and
3. policy options for trade and market reform to underpin agribusiness development.

India was one of the first countries to become involved in collaborative projects commissioned by ACIAR. Over the past 25 years, ACIAR has maintained activity in India through wide-ranging collaborative projects. Several of these Australian–Indian partnerships have resulted in major benefits, such as avoidance of major wheat rust epidemics via identification and deployment of rust-resistance genes, as well as better weed management and reduced inputs through adoption of minimal tillage in rice–wheat farming systems.

India confronts very significant problems in its rural sector, even as the overall economy forges ahead. The greatest number of poor and undernourished people in any country (some 300 million) is found in India, and most live in rural areas. At the same time India faces trade liberalisation and rapid diversification of diets towards high-value agricultural products.

New co-funding modality

In 2007 sustainable wheat-cropping activities were formed into a program based around the application of DNA-based technology to achieve greater efficiencies in wheat breeding.

The underlying philosophy of the Indo–Australian Program on Marker-Assisted Wheat Breeding (IAP-MAWB) is to apply useful molecular markers (for example, for the rust diseases) immediately to practical wheat breeding, while in the longer term supporting the use and development of new markers, including those applicable to waterlogging, water-use efficiency and nutrient stresses.

After a quarter of a century of the Indian Council of Agricultural Research–ACIAR collaboration, the IAP-MAWB represents a paradigm shift from a portfolio of projects to a more closely planned and integrated overarching program. It takes into account both Indian national agricultural priorities and the key themes for which synergies can be achieved by the two countries.

The program structure also recognises the advanced

research capabilities in India and Australia, and shares program costs and benefits between the two countries.

Wheat and wheat rust – still fundamental

The success of previous collaborations built on similarities between the Australian and Indian wheat industries, with both countries recognised on the world stage as key players in white and amber-grained spring wheat.

This mutual interest is reflected in wheat pedigrees where Hard Red Calcutta and NP4 have greatly influenced Australian genealogies and Australian Gabo is found in most Indian wheat pedigrees. Interestingly, the use of cutting-edge techniques in bioinformatics is increasingly uncovering these significant genetic interchanges between the two countries. One particular gene influencing grain quality of Australian wheats has recently been traced to a 19th century introduction from India by William Farrer, the renowned Australian agronomist and plant breeder.

The focus on wheat rust is as important as ever to both countries. India and ACIAR moved rapidly to confront the new threat to food security from the 'Ug99' variants of stem rust first detected in Uganda. With ACIAR funding, the Australia Cereal Rust Control Program (ACRCP) was deployed with Indian institutions against the new threat and research has already delivered a new robust DNA marker for Sr22, a gene effective against Ug99 stem rust.

The advantage of the new marker is its ability to tag a small section of the DNA very close to the effective gene, so that breeders can now systematically avoid incorporating unfavourable traits ('linkage drag') previously associated with Sr22 through linked or adjacent genes on the chromosome. Collaboration on this new threat from rust to food security is truly international, with the core functions of the ACRCP supported by Australia's Grains Research and Development Corporation, and with strong interactions formed with the Bill and Melinda Gates Foundation, the Borlaug Global Rust Initiative and many other institutions beyond India and Australia.

The Happy Seeder.

DR PAUL FOX is Research Program Manager for Crop Improvement and Management for ACIAR, with responsibilities in East Timor, India, Bangladesh, China, Afghanistan and Iraq. He spent more than 20 years overseas in agriculture and development activities ranging from on-farm agronomic research in marginalised communities to applying cutting-edge biotechnology. He returned to Australia in 2003 to lead Grain Biotech Australia through the privatisation of breeding and Western Australia's first field trial of GM wheat. His most recent publication in crop science is a conceptual model for describing processes of crop improvement in database structures.

Sustainable agricultural systems

ACIAR also works 'hand-in-glove' with India on making both countries' agricultural systems more sustainable. For the past two decades ACIAR has supported Indian research on the planks of sustainability – retaining crop residues on the soil, use of crop rotations and minimising soil disturbance through modified tillage. Adoption of zero tillage for wheat in India is a significant impact of this research.

Notable success has been achieved through a harvester that chops rice stubble and leaves it in the field to improve soil structure and minimise erosion while sowing the new wheat crop in one pass of the machine. This equipment for wheat sowing and management of rice straw now offers a viable alternative to the farmers' traditional practice of burning straw and incurring heavy environmental and health costs.

ACIAR continues to fund research into specialised machinery to bring about these sustainable improvements. A current focus is improved agronomic management of rice, including weed control and crop establishment, in the broader context of developing no-till practices for both staples of the rice–wheat rotation system.

Activities addressing climate change management and climate adaptation strategies for farmers have been integrated into ACIAR's water productivity program in India. Better water management is one of the highest priorities for improving livelihoods in the more marginal, rain-fed areas of north-east and central India. Water harvesting, as part of a broader watershed development agenda to increase water availability, is a key policy initiative of the Indian Government.

The current program includes a set of interlinked and complementary projects looking at a range of biophysical, social and economic issues related to water management, including adaptation to climate change and variability.

ACIAR operates as part of Australia's international development cooperation program, with a mission to achieve more productive and sustainable agricultural systems for the benefit of developing countries and Australia. ACIAR commissions collaborative research between Australian and developing-country researchers in areas where Australia has special research competence. It also administers Australia's contribution to the International Agricultural Research Centres.

Promoting Australia–India links on a broad front

Increasing India's understanding of contemporary Australia as scientifically, technologically and educationally advanced, economically enterprising and culturally diverse.

By Suzanne Davies

The Australia–India Council (AIC) was established by the Australian Government in 1992, predating much of the recent interest in India that has been generated by its remarkable economic growth. To the AIC, India is more than a market.

The AIC is Australia's principal vehicle for public diplomacy in India, and the only government-funded body charged with identifying, initiating and supporting projects to promote Australia–India links across the broad spectrum of bilateral activity.

Its objectives are to foster the deepening and strengthening of relations between the two countries, to demonstrate Australian excellence in a broad range of fields, and to promote knowledge in both countries about the society and culture of the other. It primarily focuses on increasing India's understanding of contemporary Australia as scientifically, technologically and educationally advanced, economically enterprising and culturally diverse.

The AIC receives an annual budget from the Australian Government, which it uses to fund projects in five core program areas: the arts (including film and literature), education, social initiatives (including public health and sport), science and technology (including environment and heritage) and public policy (including media). The funds are spent on a range of projects that are either initiated by the AIC itself, or by individuals and organisations that obtain funding under the AIC's competitive funding application process.

The AIC usually runs three competitive grant-funding rounds each year. The process enables the initiative and enthusiasm of a wide range of individuals and organisations to be encouraged and supported in furthering the AIC's objectives. It has also helped to identify areas worthy of more systematic or long-term AIC involvement.

This flexible, dual approach has ensured that the AIC has many successful activities in all of its core program areas.

In the arts and culture program the AIC supports a wide range of exchanges, exhibitions and performances. In literature, the Australian author's tours of India have featured artists such as Peter Carey, Kim Scott, Tim Winton, Kate Grenville, Tom Keneally, Alexis Wright and Les Murray. The tours have included participation at book fairs, academic seminars, visits to schools and wider trade promotions. These award-winning authors have generated tremendous media attention and interest among Indian academics and the general public for Australian writing.

In education, the AIC initiated the Australian Studies Fellowships in 2003 to enable established Indian academics and postgraduate students from Indian tertiary institutions to spend up to 10 weeks in Australia undertaking special projects in Australian studies. The research undertaken and the contacts developed have helped deepen India's understanding of Australia's vibrant and diverse society.

In sport, part of the social initiatives program, the AIC initiated the Border–Gavaskar Scholarships for outstanding young Indian cricketers in 2000. The alumni of that program have included many players who have gone on to international selection for India, including Gautam Gambhir and R.P. Singh. The Border–Gavaskar program has been so successful that it was extended to female cricketers in 2008, and the concept has also been taken up by the hockey world. The new AIC Hockey Scholarships are expected to commence in 2010, with Indian players to be hosted at the Hockey Australia High Performance Unit in Perth.

In public policy the AIC provides substantial funding support to the Australia–India Roundtable, which the Lowy Institute for International Policy convenes in partnership with the Indian Council of World Affairs. The roundtable brings together leading experts from both countries to discuss topics of mutual interest. The AIC also sponsors a series of major public lectures, including the K.R. Narayanan Oration with the Australia South Asia Research Centre at the Australian National University (ANU), the Australia–India Strategic Lecture with the Lowy Institute, and the Sir John Crawford Lecture with the National Council for Applied Economic Research (NCAER) in Delhi.

The AIC also seeks to raise awareness of Australia by

Dr Rajendra Pachauri speaking at ANU.

SUZANNE DAVIES is Director and Chief Curator of the RMIT Gallery in Melbourne. She has more than 150 exhibitions to her credit in fine arts, design, craft, fashion, architecture and new media, and her writing has been published nationally and internationally. In 2003 she was awarded a Centenary of Federation medal for services to the arts. Suzanne was appointed Chair of the Australia–India Council in 2008 and has been a Board Member since 2004.

Tim Flannery speaking in Delhi.

John McCarthy to head AIC

Mr John McCarthy AO was appointed Chair of the Australia-India Council (AIC) on 14 December 2009, succeeding Ms Suzanne Davies.

Mr McCarthy will bring a wealth of experience to his role as Chair of the Council. He served with distinction as Australia's High Commissioner to India for five years from 2004 to 2009.

His distinguished 40-year diplomatic career has included postings as Australia's Ambassador to the United States, Japan, Indonesia, Thailand and Vietnam. Mr McCarthy is currently Australia's Special Representative to Sri Lanka.

facilitating visits to Australia by prominent Indians. The visits provide an extended opportunity for Australians to interact with and influence key Indian opinion-makers. Some of the outstanding Indians who have visited Australia with AIC support include: Dr Rajendra Pachauri, Chairman of the Intergovernmental Panel on Climate Change (who went on to win the Nobel Prize two months after his Australian trip); Mr Tarun Das, Chief Mentor of India's premier business association; Ms Sunita Narain, an influential climate change and environmental activist; and Mr Rahul Gandhi, a prominent Indian MP and General Secretary of the Indian National Congress Party.

Finally, the AIC has a substantial program in science and technology. The most recent initiative in this area is the establishment, in partnership with ATSE and the Indian National Academy of Engineering, of the Australia–India Science & Technology Research Award. The award will facilitate a two-way exchange between young scientists in Australia and India. The focus topic for the inaugural awards – 'Energy generation in a low-carbon future' – is a very fitting theme, as the AIC is giving increasing prominence to environmental matters in its suite of activities. India and Australia share many of the same environmental challenges and there is great scope for closer cooperation on these issues.

After a very successful tour of India by 2007 Australian of the Year Tim Flannery, the AIC has also initiated an annual tour of India by a prominent Australian environmentalist to continue building linkages in this area.

The AIC Board advises the Australian Government on how to best utilise the funding allocated to advance the Australia–India relationship. Each Board member brings professional expertise and a strong interest in the Australia–India relationship to the work of the AIC.

The current board members include myself as the Chair, Mr Vinod Daniel (Chairman, AusHeritage and Head, Cultural Heritage and Science Initiatives at the Australian Museum), Professor Brien Holden OAM (CEO, Institute for Eye Research), Professor Robin Jeffrey (Emeritus Professor of Politics, ANU and La Trobe University), Mr John McCarthy AO (former Australian High Commissioner to India), Professor Margaret Sheil FTSE (CEO, Australian Research Council), Professor Gillian Whitlock (Professor of English, University of Queensland) and Mr Miles Kupa (Deputy Secretary with responsibility for India within the Department of Foreign Affairs and Trade).

Australia's relationship with India has never been more important, and the AIC plays an important role in ensuring our engagement is as deep and as broad as possible. I would encourage readers to visit the AIC website (www.dfat.gov.au/aic) to learn more about the council and the exciting programs and projects we support.

India's science impact ranges from moon shots to biotechnology

India's science research output has increased substantially in the past 10 years, and has led to India being referred to as a 'sleeping giant'.

By John Webb

On the anniversary (14 November 2008) of the birth date of India's first Prime Minister, Jawaharlal Nehru, India's inaugural lunar satellite released a 30-kilogram probe for a hard landing on the lunar surface. The Indian flag was now on the moon.

Until the loss of radio contact in September 2009, after more than 3000 orbits the satellite had provided crucial data to the international search for the presence of water on the moon.

This lunar mission, named Chandrayaan (moon vehicle), positioned India as one the few countries in the world with the capability to explore space.

The images we see of Earth from space are abiding reminders of how far technology has come. Some of the images taken from Chandrayaan can, however, take time to recognise. They show a less familiar region of the Earth – the Indian Ocean and the Indian subcontinent.

The achievements of satellite launches and a moon mission are just two of India's notable scientific successes since the nation gained Independence in 1947. Others include self-sufficiency in grain food production, an atomic energy program, missile development, exports in biotechnology, pharmaceuticals and IT services.

India's science research output has increased substantially in the past 10 years, after a long period of modest output, and has led to India being referred to as a 'sleeping giant'.

While the significance of research metrics is a matter of continuing debate, a recent analysis by Thomson-Reuters of India's research output observed that, at the current rate of increase, India's productivity will, within 10 years, be on a par with that of most of the Group of Eight (G8) nations, and overtake them soon thereafter.

The Indian Government's increased investments in science R&D will help drive this growth trajectory – the 2009 expenditure of 0.9 per cent of GDP is expected to grow to 1.2 per cent by 2012.

In this context, it is not surprising that international collaboration with India is also growing strongly. The above study estimates that, based on the metric of collaborative research papers, Australia ranks number nine as a collaborative partner with India. Ahead of Australia are the expected major players (the US, Germany, the UK, Japan, France) but also Canada, Italy and China.

As a response to the opportunities presented by India's scientific progress, all of these countries, including Australia, have established bilateral funding programs for collaboration in science and technology.

In March 2006, Australia and India established the Australia India Strategic Research Fund (AISRF), with A$20 million over five years from Australia and matching funds from India, making this Australia's largest bilateral cooperation fund in science and technology. Only one Australian university is listed in the Thomson-Reuters Global Research Report of international organisations frequently collaborating with India – the University of Melbourne.

In the first three rounds of the AISRF, 36 competitive grants were awarded to 16 Australian universities with the largest individual number of grants (four) being awarded to Deakin University, the University of Melbourne, UNSW and the University of Sydney. The 16 universities are distributed across Australia with the exception of Tasmania and the Northern Territory. The remaining 10 grants were shared between CSIRO and several independent research institutes such as the Walter and Eliza Hall Institute.

Moreover, substantial targeted awards were made to CSIRO (for collaboration with its counterpart CSIR), to Monash University (for its Joint Research Academy at and with the Indian Institute of Technology, Bombay), to UNSW (nanoscience) and to Queensland University of Technology (IT security). Although the funds initially committed to the AISRF were exhausted by the end of the third round (with forward commitments), it is widely expected that the Fund will be replenished and indeed increased. The recent early notice of round four of the AISRF is consistent with this expectation.

The University of Melbourne established the Australia India Institute in October 2008 to strengthen its research and

professional engagement with India and to build on the expertise of more than 100 staff already strongly connected to India. The staff is distributed across all faculties from medicine to architecture and engineering. Subsequently, in partnership with UNSW and La Trobe University, the University of Melbourne was successfully awarded A$8.1 million for the Australia India Institute from the Department of Employment, Education and Workplace Relations (DEEWR).

Liftoff aboard the PSLV-C11 launch vehicle.

Chandrayaan-1 spacecraft undergoing pre-launch tests.

PROFESSOR JOHN WEBB OAM is Deputy Director of the recently established multi-disciplinary Australia India Institute based at the University of Melbourne. From 2005 to early 2008, he was Counsellor (Education, Science and Training) at the Australian High Commission in New Delhi with responsibilities that included Nepal and Pakistan. Professor Webb has published widely in biological inorganic chemistry with particular reference to biological solids, nanoparticles and the genetic disease of thalassemia. In 1996 he was awarded the Medal of the Order of Australia for establishing collaborative research networks in Asia and for research achievements in chemistry.

In her Press Release, the Minister (and Deputy Prime Minister), Julia Gillard, noted that the Australia India Institute "will aim to strengthen and sustain bilateral relationships between Australia and India ... Australia welcomes India's growing global role and is working with India to strengthen our relationship in pursuit of our many shared interests. To underpin this, the Australian Government is committed to building a greater understanding between our two peoples and Australians' understanding of India, its culture, its history and its place in the world."

In September 2009 the Deputy PM launched the Institute in India at the Australian High Commission in New Delhi.

The funding provided by DEEWR to the Institute will be used to establish a program of conferences, seminars, visiting fellows, postgraduate scholarships, bilateral research projects and an outreach program to the general Australian community and to the business community in partnership with the Australia–India Business Council.

The priority themes for the institute focus on the major issues of importance to both countries:

- the environment, including energy, food and water security, climate change, resources;
- education, especially around the major policy reforms underway in both countries;
- health, including public health and pharmaceuticals; and
- regional relationships such as trade, investment, diplomacy and security.

ATSE and its Fellows have already made substantial contributions to the growing relationship between Australia and India. Several bilateral workshops have been organised and managed by ATSE which has also managed competitive government funding for other bilateral workshops.

Very recently, funding was provided to the University's Melbourne School of Engineering to support a bilateral workshop, 'Water Security Under Climate Change', held in Delhi in September, together with several Indian partner organisations. The workshop provided the opportunity for researchers to share data and develop plans for further collaboration.

The Australia–India Institute aims to develop into a centre of national significance through cooperation with partners across Australia and India. Australia needs to engage with India – this awakening 'sleeping giant' – now more than ever. It is important to strengthen research and professional links while also increasing student and researcher exchanges.

It is an historic opportunity. National organisations such as ATSE and other learned Academies will be key partners in this process.

Renewables research has potential for electricity supplies

Neither economy has significant renewable generation at present, but both economies have expectations for much greater levels in the near future.

By John Sligar

Australia and India have marked differences – and similarities – with respect to electricity generation and supply. Both economies are heavily dependent upon various fossil fuels, although the actual resource mix is somewhat different.

This implies both economies have serious problems in reducing their carbon emissions and corresponding opportunities in converting some of their electricity generation to utilise renewable resources.

Australia and India: electricity generation and supply

Factor	India	Australia
Area, million square km	3.2	7.6
Population, million	1,119	20.4
Installed capacity, GW	152	49
Generation, billion kWh	723	237
Reserve margin	negative	positive
Population connected, %	~60	~95
Generation resource		
Coal, %	53	81
Oil, %	31	low
Gas, %	8	11
Hydro, %	6	5
Nuclear, %	1	nil
Renewables, %	~1	~1

National power supply

While energy security is reasonable in Australia – with a positive power system reserve margin – the system reserve margin in India is at times negative, with consequential inadequate energy security and loss of productivity.

The Government of India has major initiatives in place to improve this situation. It is proceeding with a number of 'mega' coal-fired power station projects, with contribution from private industry.

Fossil electricity generation resources in the two economies are quite similar in overall proportion, with India having a significant percentage of oil firing in addition to coal. Both economies are heavily dependent upon fossil fuels with consequent climate change implications.

Neither economy has significant renewable generation at present, but both economies have expectations for much greater levels in the near future. This reinforces the need for cooperative action on research and developing appropriate renewable energy resources.

To clarify understanding with respect to a power system, renewable generation may be divided into 'reliable' resources, such as geothermal and biomass, and 'natural' resources, such as wind, solar and wave action.

Reliable resources have properties similar to fossil resources in that the availability of generation using these resources is about 95 per cent – that is, power is essentially available when required by the community.

Natural resources are characterised by being somewhat less predictable and having an availability of perhaps 30 per cent. This, of course, requires more generation plant to be installed for a nominal output.

Both of these types of renewable resources have their place in an economy's power supply, the natural resources requiring some form of energy storage such as a battery to cover low availability periods. Special arrangements are required for low- system load operation and maximum load on the power system where there is a significant proportion of renewable generation.

The proportion of households connected to the main power system in India is about 60 per cent. At present the reserve margin on the main grid is negative at certain times resulting in inadequate security and significant loss of productivity. While this is presently being addressed using fossil generation, there is considerable interest in developing geothermal resources. Extensive use of biomass resources is more problematic, as they may compete adversely with food production. The Government of India is investing and promoting private investment to bring the reserve

PHOTO: STEFAN MOORE

Energy from the sun – the National Solar Energy Centre, Newcastle.

margin to a positive value at all times to improve Indian national productivity.

The remaining 40 per cent of households, generally in local villages, is not connected to a major grid but may have some smaller local generation. Heating, cooking, hot water and domestic respiratory problems are provided – in general – as a compact package by burning wood, dung or coal with an overall efficiency of perhaps five to eight per cent and consequent greenhouse gas release.

Changing this condition to one using an electricity supply from a combination of modern fossil electricity resource with more than 40 per cent efficiency and suitable renewable generation will reduce climate change problems dramatically, in addition to respiratory health benefits.

This provides a major market to be supplied from smaller renewable resources. Solar is seen as more likely because the solar insolation pattern over India covers a greater area than wind resource measurements at present. Solar also lends itself to smaller multiple unit size, appropriate for ordered development of a free-standing village power supply.

Renewable research initiatives

Some years ago the Indian and Australian Governments instituted the Australia India Strategic Research Fund (AISRF). This promoted cooperative projects, with both Indian and Australian researchers working together in a number of research areas. One of the areas agreed between the respective governments was that of renewable energy. There have been three rounds of applications for funding and a total of five projects have been approved with a renewable energy focus and are proceeding.

Three of the projects were on more fundamental topics concerned with degrading organic pollutants, catalytic conversion of carbohydrates into chemicals and liquid fuels and the application of novel nano particles to energy fields. While separately important, these did not suggest immediate application to alleviating the present power problems.

Two projects were of more immediate interest.

A project on determining the possible extent of geothermal and 'hot rock' potential on the Indian continent was seen to have broad potential for development of large geothermal generation supplying the main grid. This would help supply about 60 per cent of the population with minimum addition of carbon dioxide to the atmosphere. While there is some geothermal generation at present in India, this novel approach may yield far stronger prospects for commercial development in India. The developed process may also assist in the Australian geothermal 'hot rocks' prospecting.

The other research project with relatively short-term implementation potential was on identifying the potential for manufacture of linear solar concentrators in India for photovoltaic, heat and combined heat and power facilities. These would absorb heat from the sun and provide local electricity to isolated communities. These concentrators provide a more efficient utilisation of available sunlight, helping to reduce the overall cost of electric power.

Every one of these projects has the potential to grow into a commercial success as well as contribute to the mix of renewable energy resources utilised in both India and Australia. The level of cooperative research project presented was of a high standard and capable of absorbing further funding if this became available.

It should be noted that as a result of this project ATSE has developed a renewable energy network of more than 50 researchers in both India and Australia, following a major renewable energy workshop in Australia with Indian participation.

(The assistance of Australian Government staff associated with the AISRF is gratefully acknowledged in developing this document.)

DR JOHN SLIGAR FTSE has had a long association with the energy industry and with the energy scene in India. He has carried out a number of projects for the Australian Government within AusAid concerned with Indian electricity generation, led an ATSE delegation to a workshop on 'Energy for growth and sustainability' in Chennai and is presently the committee member representing renewable energy on the Australia India Strategic Research Fund.

References

EDMC Energy trends
Electricity Gas Australia 2009
Government of India, Central Electricity Authority
UD DOE Energy Information Administration
World in figures 2009, *The Economist*

Indian Academy puts sustainable energy in the spotlight

Indian National Academy of Engineering (INAE) International Conference on Research Policy for Sustainable Energy, New Delhi, 12 to 13 October 2009.

By Martin Thomas AM FTSE

The ATSE/INAE relationship

Three important initiatives underpin the warm ATSE/INAE relationship.

1. The Presidents of ATSE and INAE, Professor Robin Batterham and Dr P.S. Goel, enthusiastically re-signed the memorandum of understanding (MoU) on mutual cooperation at the International Council of Academies of Engineering and Technological Sciences (CAETS) Convocation in Calgary in July 2009.

2. ATSE, with the Australia–India Council, has launched a program to optimise the skills of each nation's early career researchers through the Australia–India Science and Technology Research Award. The 2010 program with a 'Energy Generation in a Low Carbon Future' theme (for which nominations have closed), provides for two-way research placements in India and Australia for promising young scientists.

3. INAE will be working with ATSE on the multi-academy CAETS Project 'The Analysis of Strategies to Accelerate the Deployment of Low Emissions Technologies for Electric Power Generation in Response to Climate Change'. Other participating academies include those from Canada, Germany, South Africa and the UK.

A galaxy of eminent Indian thinkers in the area of energy highlighted the opportunities ahead for India at the recent INAE conference, 'Research Policy for Sustainable Energy', at which I represented ATSE.

A number of first-class presentations were made by INAE Fellows, senior government officials, leading researchers and invited experts.

Dr R. R. Sonde, a member of INAE's Governing Council and Conference Co-Chair with Professor S. S. Murthy, well-known in Australia, made it clear that India's intention is to become an energy superpower, subject only to appropriate RD&D policies and international collaboration. This was an oft-repeated aspiration.

Although short in energy resources, unlike the 'lucky country', India has a massive population, high intellectual capacities for focused RD&D and relatively low-cost labour.

Professor Murthy, from the Department of Electrical Engineering, Indian Institute of Technology Delhi, emphasised the crucial importance of harnessing India's human and intellectual resources, and of getting the policy settings right – hence the mounting by INAE of this international conference recognising the vital relevance of global synergies.

India and Australia were following parallel paths in establishing RD&D institutes to serve as technology foci – a point I was later to support in my presentation. Already India was collaborating with Canada in establishing a potential centre for off-grid systems to supply the rural poor.

Policies ahead of technologies

Dr P.S. Goel urged delegates to focus more on appropriate policies and less on technologies, which would follow. India, like China, anticipated staggering growth in the years ahead, perhaps 10 per cent GDP (compound annual growth rate) for many years, he said, with consequent huge demands for reliable, low-cost energy.

Dr Goel doubted that hydrocarbons would play as great a role as previously. He foresaw nuclear power with a 10 to 15 per cent growth rate and fairly rapid transition to 'closed loop' fast neutron reactors from the current generation of fission reactors as the way ahead, with hybrid renewables (typically solar and biogas) serving off-grid rural communities for many years.

Dr R. Chidambaran, Principal Scientific Advisor to the Government of India, gave a superb and far-sighted keynote address on the challenges ahead for sustainable energy RD&D in India, citing the crucial importance of leveraging international collaboration. His remarks suggested significant opportunities for Australia, especially where we have niche advantages in, say, low-cost solar technologies

or advanced coal treatment and combustion skills.

Dr Chidambaran made a compelling plea for measuring CO_2 emissions on a per capita basis, rather than signing on to heroic CO_2 reductions, which will almost certainly be unachievable in a fast-expanding economy, and which are arguably inequitable.

Clearly if India was to ascend the human development index (HDI) its people would need to consume far more energy, not less, he said. However, rather than commit India to inevitable increases in CO_2 emissions, he urged policies aimed towards sensible adaptation to climate change, the accelerated deployment of renewable and nuclear energy and a much stronger focus on energy efficiency.

Expanding the nuclear discussion he also urged closing the loop with fast neutron reactors, where India has significant know-how, and thorium reactors where India has both know-how and fuel resources. He saw a longer-term role in fusion reactor development.

He concluded with a prescription for research policies – supporting directed basic research and pre-competitive applied research with high-level foresight analysis to select critical sustainable technologies upon which India must focus.

His 'three-step' conclusion for India was

- to make optimal use of visible capabilities;
- to stimulate latent capabilities; and
- to leverage international collaboration.

But to achieve this he wanted to see far stronger global coherence in sustainable energy policies. He received a near standing ovation for the clarity of his vision and his inspiring expression of hope.

Energy conservation

Points repeated by many speakers included, predictably, the huge potential of energy conservation – doing more with less. Some doubts exist as to the economic feasibility of carbon capture and storage (CCS) – a technology in which Australia is a leader – and little has been done in India to date, which may provide an opportunity for Australian collaboration.

Speakers highlighted the near-voiceless 500 million Indian citizens, half India's people, who have never seen electricity and rely on biomass alone for life-giving energy. This challenge would seem to offer a humanitarian and practical opportunity for Australia, already well-skilled in energy delivery to remote communities.

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Speakers on resources pointed out the looming limits to indigenous coal supplies (perhaps only 45 years); the huge value of sustainable small hydro (hydel) for remote communities; and the still untapped potential for hybrid solar systems – as well as the huge supplies of thorium and the potential for more efficient energy end use.

Speakers looking over the horizon saw advanced clean coal, solar PV and thermal, biomass, biogas and biofuels, and especially nuclear as being key to freeing many citizens form grinding energy-deprived poverty.

Dr Baldev Raj, Director of Kalpakkam's world-renowned Indira Gandhi Centre for Atomic Research (IGCAR), spoke powerfully of the crucial role of nuclear energy in India's modernisation, giving detailed insights not only into emerging technologies but also the importance of training and education if India's nuclear aspirations were to be realised.

He called for a paradigm shift in thinking, noting that India's nuclear program, albeit inspiring, still needed much promotion if the needs of the people for reliable, moderately priced electricity were realistically to be met.

Dr V. Raghuraman, a truly valued ally and supporter of my World Bank energy management work in India in the 1980s, showed he had lost none of his dynamism in extolling the value of hydro while urging the clear need for a powerful central authority and heightened attention to sound engineering and first-class project planning before construction.

Other addresses covered the significant energy potential of urban wastes; RD&D for biofuels (another already active opportunity for collaboration with Australia); and advances in PV technologies (yet another opportunity for Australian collaboration).

An inspiring address on advanced electronic controls for wind turbines, HVDC systems, variable speed drives for industry, braking energy recovery, super efficient LED lighting, better PC power supplies and much more suggested that many of today's technology bottlenecks could well be leapfrogged by nations such as India in which 'heritage' investment levels in energy systems are relatively small.

Monika Chawla of GE's Global Research Centre in Bangalore comprehensively reviewed the RD&D in India and worldwide on electricity storage, essentially batteries. This is a domain of crucial importance if transient solar and wind are to play a reliable role in bulk electricity supplies. Again this is a domain in which RD&D collabora-

tion would be fruitful. The problem is universal as must be the solutions.

Gaurav Gupta, CEO of the Karnataka State Road Transport Group, exemplified the inspirational levels of visionary management allied to advanced hardware and software technological solutions in the delivery of a world-class integrated transport system.

The ATSE presentation

My presentation explored Australia's present and potential contribution to international sustainable energy RD&D. It outlined Australia's most recent high-level policy and funding initiatives, emphasising those related to meeting national and international targets for the reduction of carbon dioxide and other environmentally negative emissions.

These included the 2008 Clean Energy Initiative (CEI) and its attendant funding elements, the A$2.4 billion CCS Flagships Program, the A$1.6 billion Solar Flagships Program and the A$465 million Australian Centre for Renewable Energy (ACRE).

The paper commented on the technologies which, in my view, supported by ATSE reports and other studies, are most likely to contribute to sustainable energy futures and the achievement of carbon reduction targets, some of which are extraordinarily heroic.

It outlined those technology RD&D programs where Australia is best placed to contribute collaboratively to the international imperative. These include clean coal technologies, carbon capture and storage (CCS), solar PV, thermal and syngas, geothermal exploitation, some elements of nuclear energy, biomass combustion, second generation transport biofuels, wave energy capture, energy storage, distributed generation, 'smart grids' and energy management.

After two stimulating days in New Delhi I came away invigorated and impressed, aware of the tremendous potential for collaborative RD&D opportunities between Australia and India. This short article can do no more than encourage ways forward on just some of these.

Concluding as a principal of Sinclair Knight Merz, Mr Martin Thomas AM FTSE had an extensive career in energy consulting and then became founding MD of the CRC for Renewable Energy, ACRE. Other roles included deputy chairman of Australian Inland Energy, directorships of Tyree Group and Enviromission, chairmanships of Austenergy, NSW Electricity Council and Sydney 2000 Olympic Energy Panel. He is chairman of Dulhuntly Power, adviser to ZBB Energy and was a member of the Uranium Mining, Processing and Nuclear Energy Task Force. He is a past president of the Institution of Engineers, Australia, and of the Australian Institute of Energy, and a past vice-president of the Academy.

Right segment, right partner key to tremendous opportunities

What unique factors exist that contribute to lasting, successful mutually beneficial relationships with India?

By Hutch Ranck and Homi Bhedwar

While the case for science and technology collaborations between Australia and India is well established, the practical reality for many Australian companies is that the potential uncertainties may outweigh the potential benefits.

In a number of cases this caution may be well founded, but as an emerging economy with a rapidly growing capacity and willingness to invest in foreign collaborations, there are tremendous opportunities for Australia in India. The challenge for Australian business is establishing 'who and where' to commit resources, and being prepared at the outset to be in it for the long haul.

As an emerging country and relatively new player in the global economy, India is gradually increasing its level of exposure to global trade. As is typical in a developing economy, working collaboratively with foreign partners comes with challenges and preconceived ideas about how business is conducted.

Many family-owned companies have become large players on the international scene. Many still believe that local and ethnic cultures were the reasons for their success. It is important to understand the roots of the company you are dealing with.

India is home to some of the most prestigious companies in the world (Tata Group being a good example). Nonetheless, it is essential for any Australian company to make sure the partnering source in India is compatible, ethical and stable, and to invest time up front to determine the potential of the partnership on this basis.

This is certainly a fundamental of any robust business relationship, but what unique factors exist that contribute to lasting, successful mutually beneficial relationships with India?

DuPont has a long history of collaboration dating back to the 19th century. Recognising the importance of India as a developing nation, DuPont set up a wholly owned

subsidiary in India in 1995. In 2008, DuPont India constructed and commissioned a world-class R&D centre, the DuPont Knowledge Centre in Hyderabad, which fosters collaborations on a large scale.

Director of the DuPont Knowledge Centre, Dr Homi Bhedwar, who assisted with the preparation of this article, emphasised the following key attributes to underpin successful collaboration with India.

Win–win for both parties

Some of the most robust collaborations occur when partners bring synergistic technologies/resources or business models to the table. There may be instances when one collaborator brings know-how that fills the gap of the partner and together they achieve more than either could alone.

The DuPont Knowledge Centre in Hyderabad.

HUTCH RANCK was appointed Managing Director of DuPont Australia and New Zealand in October, 1999. In addition to his role as Managing Director he is also Group Managing Director for DuPont operations in ASEAN. Mr Ranck is the Business Council of Australia (BCA) appointee on the Prime Minister's Science, Engineering and Innovation Council and Chair of the BCA Education, Skills and Innovation Task Force. Mr Ranck is a Director of the Australian Bush Heritage Foundation, BCA and Elders Ltd. He has a BS in Economics from the Wharton School University of Pennsylvania.

DR HOMI C. BHEDWAR is Director, DuPont Knowledge Centre, in Hyderabad. He graduated from the Indian Institute of Technology, Bombay, and has a Master's degree in Materials Engineering from Cornell University and a doctorate in Materials Science and Engineering from Carnegie-Mellon University. He joined DuPont in 1977, as research engineer in the US and has held a number of technical and leadership roles in Engineering, Electronics, Fluoroproducts and Central Research & Development. Prior to his current role he was Research Manager for long-term growth programs.

Particular advantage

Collaborations that bring a particular advantage, whether it is market access, international presence, new technologies or an unmet need, tend to last longer and are more stable.

Cost avoidance for Indian company

If there is the potential of working on a differentiating technology but its development would be so expensive that sharing it with a partner is more attractive.

Start small and be patient

Don't attempt to go into something large – start small and grow as the relationship develops and matures.

Negotiate IP rights

It is critical to ensure that intellectual property (IP) issues are discussed well in advance of starting a collaboration. Very often they are an afterthought and one of the main reasons for the break-up of a collaboration.

Develop an exit plan

Not every collaboration is sustainable. Once the euphoria of the partnership dies down and realities begin to emerge, quite often there is regret and the need to break off the relationship. It is prudent to have an exit plan that ensures stability for partners after the relationship has ended.

We also need to ask if we're targeting the right segments appropriate to an emerging economy and where gaps that offer potential for successful collaborations exist, such as infrastructure, energy and security.

The Indian Government has put a strong emphasis on energy and growth of renewable energy sources, such as photovoltaics, wind farms and, to a lesser extent, biofuels. Security and protection are also high-demand areas, with strong market potential for protective garments and equipment.

It makes sense therefore for Australian industry to target these high-demand areas, taking a strategic approach to developing collaboration where there is a willingness and need to collaborate.

A good example of this is the strategic partnership between CSIRO and CSIR (India's equivalent agency), with a focus on environmental sustainability issues. The partnership covered three initial projects – new membranes for water desalination made from carbon nanotubes, technologies for improving crop yield and protecting the environment, and new materials and methods for separating hydrogen for future pollution-free fuels.

So, while proceeding with caution is essential, there are tremendous opportunities in India if we can get the channel, the partner and the offering right.

Data Sphere technology ripe for strong collaboration

The new information infrastructure will move from the emphasis of managing data, to making sense from the data.

By Rao Kotagiri

PROFESSOR RAMAMOHANARAO (Rao) KOTAGIRI FAA FTSE has been at the University Melbourne since 1980, serving as Head of Computer Science and Software Engineering and Head of the School of Electrical Engineering and Computer Science. He was Deputy Director of the Centre for Ultra Broadband Information Networks, Co-Director of the Key Centre for Knowledge-Based Systems and Research Director for the CRC for Intelligent Decision Systems. He served as a member of the ARC Information Technology Panel and on the Prime Minister's Science, Engineering and Innovation Council working party on Data for Scientists. He was awarded a Distinguished Contribution Award in 2009 by the Computing Research and Education Association of Australasia.

Society is undergoing a major shift towards new data environments – the Data Sphere – based on scientific and personal applications, underpinned by the popularity of the internet. Scientists are generating vast amounts of data using new devices, individuals are connecting together to create an abundance of content for the World Wide Web and organisations are trying to make sense of diverse streams of information.

We are now living in a Data Sphere of rich data, and are presented with the challenge of comprehending overwhelming amounts of data, which provides opportunities for both India and Australia.

Individuals, communities and organisations in this Data Sphere will be better equipped to form hypotheses, make evidence-based decisions and understand their consequences. Such decisions may draw upon both private and public data and require the efficient processing of large amounts of complex and possibly incomplete information. Effective use of this mass of information can help deal with many critical issues in fields such as agriculture, climate, health, logistics and education, as decisions can be based on evidence. This explosion of information will also raise many social issues of data security and privacy.

Current information technology has been developed mainly for business and enterprise applications, which share common data characteristics. While such data management tools are still highly desirable today, many new personal and scientific applications demand new techniques for database information management.

The new technologies should be able to connect, store and query the massive repositories now being generated by high-throughput scientific instruments with different levels of data quality. For example, next-generation DNA sequencing machines can generate several terabytes of output a day. The value of this information will be lost unless accompanying integration and access methods are developed.

This change calls for new database management systems. The new information infrastructure will move from the emphasis of managing data, to making sense from the data. It is a great new opportunity for high-quality and high-impact IT research to develop next-generation information infrastructure for the modern information society.

Australia has committed in excess of $40 billion to roll out the National Broadband Network for Australia in the next few years. This infrastructure, with its associated computing and storage facilities, will provide an excellent basis for developing these new technologies that can deal with massive amounts of information.

Australia is also well prepared in terms of research strengths with its high-quality educational institutions and its established research institutions such as CSIRO and NICTA. Australian academics have an excellent reputation in the area of databases, data mining, distributed computing and broadband networks.

Excellence in these fields is essential to make a major impact in the emerging field of Data Spheres.

India is a leading IT country and, with its very talented young population well trained in hard core sciences, is uniquely positioned to take great advantage of the emerging IT revolution.

Strong collaboration between India and Australia both in academia, research organisations and industry will make both countries not only improve utilisation of information for the benefit of their own, but will lead to developing tools and technologies which will have great global market potential.

Nations that can exploit these Data Sphere technologies will be those nations that can maximise their resources in a sustainable way with minimal waste.

India and Australia, with their combined strengths in IT, can reap the benefits from these emerging Data Sphere technologies.

Global links in S&T for a better world

The ISL SAP program is recognised as a major enabling mechanism to promote significant international networking and collaborative opportunities.

By Michael Manton

Through its international program of missions, workshops and delegations, the Academy's International Strategy Group is strengthening Australia's access to global science, engineering and technology (SET) and maximising the benefits of Australia's science base and its global linkages.

2008-09 was a very active and productive year in strengthening overseas linkages, particularly with India, through the strong contribution by the ATSE Fellowship and the innovative leadership of the members of the Academy's International Strategy Group.

Our strong linkages with the Indian National Academy of Engineering (INAE) and the Australia–India Council (AIC) were keys to deploying this energy into productive activities.

ATSE, in association with the Australia–India Council, launched an award program to facilitate a two-way exchange between young Australian and Indian scientists (under 40 years of age) to complete a three-month research placement during the first half of 2010. ATSE will administer the award, in association with the Indian National Academy of Engineering.

ATSE Fellow Mr Martin Thomas AM FTSE participated in the INAE International Conference on Research Policy for Sustainable Energy held in New Delhi on 5 and 6 October 2009 (see separate article). The conference identified and highlighted the areas of potential sustainable energy cooperation between India and Australia.

ATSE's established partnership with the Australian Government was a key aspect in strengthening international engagement. The Government continued to support investment in national and international research, innovation and commercial cooperation. This has led to the International Science Linkages – Science Academies Program (ISL SAP) program being recognised as a major enabling mechanism to promote significant international networking and collaborative opportunities.

ATSE international activities during the year included:

- workshops to enable the exchange of technical information and identification of collaborative activities;
- missions of invited experts from industry, academia and government agencies to develop new alliances; and
- visits to universities, research institutes and industry in other countries, to build productive alliances.

Dr R. A. Mashelkar, recently retired Director General of the Indian Council of Scientific and Industrial Research (CSIR), was elected to Foreign Fellowship of the Australian Academy of Technological Sciences and Engineering in March 2008.

ATSE's history with India

ATSE began exploring the possibility of closer cooperation with the Indian National Academy of Engineering (INAE) with visits by Fellows Dr Bruce Sheldon and Dr John Possingham in 1996 and the two academies signed their first MoU in July 1997. This was renewed as an agreement on S&T cooperation in 2005 and 2009.

RECENT ACTIVITIES HAVE INCLUDED:

Australia India Broadband and IT Workshop – Melbourne, July 2006

This brought together outstanding researchers from India and Australia in areas of broadband, wireless systems, sensor technologies and issues related to the digital divide, which are very relevant to the Australian context. The workshop was hosted by ATSE and co-organised by INAE. Several areas of research interest were identified and ATSE invited Australian participants to explore such opportunities for funding through the Indo–Australian Science and Technology Fund.

Australia–India Workshop on Renewable Energy – Newcastle, December 2006

The Australian Government invited ATSE to organise a research workshop on sustainable energy for 20 Australian and Indian senior researchers to meet over two days, before visiting key energy sites in Sydney and Newcastle.

The CSIRO Energy Technology Centre in Newcastle was the workshop venue. The workshop provided an excellent opportunity to explore topic areas for possible cooperative energy projects between research organisations in the two economies.

India–Australia Remote Sensing Workshop – sBangalore, December 2007

This was organised and hosted by INAE and led to clearer understandings of the interests and capabilities of India and Australia in remote sensing and a clear set of outcomes.

India–Australia Transgenic Crops Workshop – New Delhi, April 2008

The Australia–India Transgenic Crops Workshop at the National Institute for Plant Genome Research was organised by ATSE (on behalf of DIISR) and the Indian Department of Biotechnology and covered:

- challenges for crop-production systems in India and Australia;
- available transgenes to modify specific traits;
- biotech approaches for development of targeted GM crops;
- regulatory frameworks and assessment protocols; and
- management systems for sustained benefit from transgenic crops.

India–Australia Workshop on Biomedical Devices – New Delhi, March 2009

Twelve Australian and 14 Indian experts in biomedical devices and the various key input technologies met to explore rapidly emerging new technology for medical devices and the need for affordable healthcare. The focus was on a number of potential areas where opportunities had previously been identified – orthopaedics, wound management and cardiovascular devices.

PROFESSOR MICHAEL MANTON FTSE is Chair, International Strategy Group, ATSE. He was a research scientist for a decade in the CSIRO Division of Cloud Physics, then in 1984 became the Chief of the Bureau of Meteorology Research Centre. He retired from that position in 2006 and has had a part-time position as professor in the School of Mathematical Sciences at Monash University since. He has been a Director of ATSE since 2008. He is a member of the Audit and Investment Committee and the Membership Committee.

ATSE International Strategy Group

The Academy's International Strategy Group comprises seven ATSE Fellows and the Chief Executive Officer.

Professor Michael Manton FTSE, Professor, School of Mathematical Sciences, Monash University (Chair and Director of ATSE)

Professor Erol Harvey FTSE, CEO MiniFAB (Aust) Pty Ltd)

Professor John Langford AM FTSE, Co-Director, Australia–China Centre on Water Resources Research

Professor Mike Miller AO FTSE, Chair Mnet Corp Ltd; Board Member Australia Korea Foundation (Director of ATSE)

Professor John O'Callaghan FTSE, Consultant, Victorian Life Sciences Computation Initiative

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