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EXPERT FORUM - NATIONAL ENABLING TECHNOLOGIES STRATEGY

Report of the Uptake of Enabling Technologies Foresight Workshop:

Food Industry

for

The Department of Innovation, Industry, Science and Research

National Enabling Technologies Strategy
Expert Forum

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Executive Summary

The Enabling Technologies for the Australian post-farmgate food industry Workshop forms part of the foresighting program of the Expert Forum, established under the National Enabling Technologies Strategy (NETS). The Forum is tasked with identifying new and converging enabling bio- and nano- technologies that may have implications for policy makers and regulators, including industry uptake and international activities that improve the understanding of the potential for enabling technologies to address major global and national problems and to understand and help resolve potential impediments to their uptake.

The Workshop drew together a range of stakeholders to explore the potential contribution of enabling biotechnologies and nanotechnologies to the Australian food industry over the next ten to twenty years, to consider the potential of new technological applications within the food chain post-farmgate, and to identify resulting issues and challenges.

Australia has a strong food industry, with $81b turnover, $16b in exports, and 200,000 direct jobs. However the trade surplus in elaborately transformed food products has halved in the last 5 years to $6b pa, suggesting a declining competitive position.

The immediate challenges identified by the industry are rising input costs in raw materials, energy and labour, the high exchange rate, regulatory compliance costs, infrastructure inefficiencies and skilled labour shortages at all levels. In the longer term, the challenges are to contribute to feeding the exploding world population, address the costs of a carbon economy, the need for substantial savings in water use, adequate food security, and the delivery of nutrition and health.

The involvement of stakeholders was structured through a focus on four distinct, but connected components of the post-farmgate food industry:

- ***food processing***, including applications of enabling technologies to enhance sustainability, recycling and more efficient water use;
- ***packaging and storage***, including intelligent materials, preservatives, biosensors and improved barrier properties to increase shelf life, increase efficiency in handling and provide information to consumers;
- ***nutrition***, Including nano-encapsulation, nutraceuticals, probiotics and glycol nutrients; and
- ***waste management***, including reducing food waste in production and consumption, and in diverting food waste from landfill, by the application of biorefinery and other techniques.

Significant opportunities for the enabling technologies were identified in more efficient and sustainable food processing, more effective integrated food packaging, the enhancement of the nutritional value of foods and the reduction of waste and water use through increased recycling.

It was recognised that food is the focus of a high level of consumer interest and concern, and that the introduction of any new technologies would need to adequately address any possible safety issues and allow early informed input from consumer representatives.

A range of constraints to the effective development of the food industry over the next twenty years were identified, including more effective use of Brand Australia labelling and marketing, adequate support for research, testing and training, appropriate recycling and waste management standards, adoption of latest technology by food manufacturing firms, and consumer acceptance of 'designed' foods.

Three major initiatives were proposed:

- a well-developed and articulated vision and strategy for the future of the Australian food industry
- the establishment of a Food Forum to provide a vehicle for education and communication between all those with interests in the food industry
- the building of an extensive research capacity of a multi-disciplinary nature addressing not only new food products, processing and packaging, but also material life-cycle assessment, environmental impact evaluation, technology assessment, waste stream analysis, and the need and basis for regulation.

1. Background and Aims of the Workshop

Under the National Enabling Technologies Strategy, the Government has established an Expert Forum comprising a number of experts in biotechnology and nanotechnology, regulation and foresighting. The Expert Forum assists the Department of Innovation, Industry, Science and Research (DIISR) with developing policies to ensure the responsible uptake of enabling technologies, focused particularly on new forms of nanotechnology and biotechnology, including areas of intersection and those enabled by information and communication technologies. The Expert Forum is charged with examining how the use of enabling technologies might address global and national problems and to more effectively plan for the future, given the transformative nature of these technologies and their impact on a range of industry sectors.

Foresighting comprises strategic analytical tools to prepare for uncertainties and transformative developments in society and the business environment. As new enabling technologies are expected to impact on a range of industry sectors, under the auspices of the Expert Forum, DIISR has been working with different stakeholder groups to undertake a series of industry uptake foresight workshops to explore the potential contribution of these technologies to the future of the industry and the issues and challenges posed by their uptake.

The general purpose of this Workshop was to explore the potential contribution of enabling biotechnologies and nanotechnologies to the Australian food industry over the next ten to twenty years, to consider the potential of new technological applications within the food chain post farmgate, and to identify resulting issues and challenges.

Specific aims included:

- engaging a wide range of stakeholders in the Australian food industry, including producers, manufacturers, distributors, retailers, regulators, researchers, consumer interests and relevant government agencies, in a shared consideration of the possible future of the Australian food industry;
- developing a broad interdisciplinary understanding of the range of factors affecting the food industry, with an emphasis on the role that enabling technologies can play in addressing challenges to the Australian food supply chain;
- informing Government policy addressing the future of the Australian food industry.

2. Workshop Design and Methodology

The design of the workshop built on the experiences of the two earlier workshops on building products in the built environment and assistive technologies in aged care.

It involved:

- the preparation of a background information paper (by DIISR officials) designed to inform all Workshop participants about the characteristics of the Australian post-farmgate food industry, and the experience and potential applications of the enabling technologies to it - see Appendix One;

- identification of appropriate possible participants through consultation, scanning of publications, advice from Expert Forum members and application of the 'snowball' technique (requesting experts to identify other possible invitees) – see Appendix Two;
- design of a one-day program to facilitate achievement of the Workshop objectives; this involved presentations by experts from the perspectives of the food industry, food-related research and food regulation, followed by a series of structured small-group discussions – see Appendix Three;
- development of a scenario of a possible future of the Australian food industry in 2025, highlighting the uptake of bio- and nano-technologies – see Appendix Four.

The involvement of stakeholders was structured through a focus on four distinct, but connected components of the post-farmgate food industry:

- ***food processing***, including applications of enabling technologies to enhance sustainability, recycling and more efficient water use;
- ***packaging and storage***, including intelligent materials, preservatives, biosensors and improved barrier properties to increase shelf life, increase efficiency in handling and provide information to consumers;
- ***nutrition***, Including nano-encapsulation, nutraceuticals, probiotics and glycol nutrients; and
- ***waste management***, including reducing food waste in production and consumption, and in diverting food waste from landfill, by the application of biorefinery and other techniques.

The Workshop process involved each of the four groups responding to the scenario by considering how the enabling technologies might contribute to their segment of the food industry over the next 10-20 years, followed by a backcasting exercise in which the four groups identified what might have been the major initiatives taken since 2012 to enable the effective uptake of enabling technologies within the food industry. In the concluding session, the focus was on identifying useful initiatives on the part of governments, industry, researchers, regulators and consumers.

3. A Vision of the Australian Food Industry in 2025

The growth in the world's population from 7 billion in 2011 to over 9 billion by 2050, combined with economic development and consequent changes in diet composition and consumption levels, indicates there is a need to increase gobal food production by about 70%. Threats to food security, whether through availability, price, or threat, are matter of concern worldwide.

A recent Chatham House report on the Future of Food[1] noted "the ability to secure raw materials and the effective utilization of resources will become key influences in the structuring of alternative food supply arrangements. Part of the solution lies in developing the capability of the food supply system as a whole. This will require a set of related initiatives including ones built round new frameworks for technological innovation, waste reduction, partnership-led approaches and acceptance of possible changes in consumption patterns. "

[1] Chatham House, 'Thinking about the Future of Food', http://www.chathamhouse.org/events/view/155013, accessed 3 November 2011.

Australia has a strong food industry, with $81b turnover, $20.4b value added, $16b in exports, 200,000 direct jobs and indirect employment estimated at 800,000, and a contribution of 20% of GDP.[2] However the trade surplus in elaborately transformed food products has halved in the last 5 years to $6b pa, suggesting a declining competitive position.

The immediate challenges identified by the industry are rising input costs in raw materials, energy and labour, the high exchange rate, regulatory compliance costs, infrastructure inefficiencies and skilled labour shortages at all levels. In the longer term, the challenges are to address the costs of a carbon economy through mitigation and adaptation, the need for substantial savings in water use, through reduction and recycling, adequate food security, and the delivery of nutrition and health, through the provision of wholesome, nutritious, affordable food.

For food researchers, the objectives are to support the efficient and sustainable conversion of agri-food materials into value-added ingredients and products. Emerging food processing technologies include innovative approaches to component separation using chromatography, pulse electric field which allows pasteurisation without destroying protein structures, cool plasma to sterilizes surfaces, with potential use in packaging sterilization. through ultrasound high pressure and micro-fluidisation. This allows the adding of value efficiently to waste streams, the structural design of food to control sensory perception and in-body functionality, fat reduction in manufactured food, and the micro- or nano-encapsulation of food to assist the delivery of bioactive capabilities.[3]

There is also a substantial drive to enhance food packaging. Major drivers for these changes are the ageing of the population, the demand for more information but at the same time convenience, increased health, environmental and safety awareness, and the interest in choice and exclusivity. Potential developments include barrier packaging, anti-microbial packaging, and active and smart packaging.[4]

Regulators face substantial challenges in this environment. For example, both technology promotion and stakeholder concern precedes data and technological application, with the consequence that positions can become established before facts become apparent. There are constraints on the regulatory response that it be proportionate, balanced, contextual and iterative. Appropriate communication strategies for complex technical issues can be challenging.[5]

Consumers are concerned about being sufficiently well informed and their views taken into account sufficiently early in the product development process, and of having sufficient information to be able to make safe and informed choices.

[2] Dr Geoffrey Annison, Australian Food and Grocery Council, Workshop presentation
[3] Dr Mary Ann Augustin, CSIRO, Workshop presentation
[4] Mr Phil Casey, CSIRO, Workshop presentation
[5] Dr Andrew Bartholomaeus, Food Standards Australia and New Zealand

4. The Contribution of the Enabling Technologies to the Post-Farmgate Food Industry

4.1 Food Processing

A key area of application of nanotechnology in food processing involves the development of nanostructures in foodstuffs, which have been claimed to give new tastes, improved textures, consistency and stability of emulsions, compared with equivalent conventionally processed products. Another use for enabling technologies is in the form of nanocoatings for food contact materials during food processing to resist microbial infection.

Participants emphasised the value of addressing the obesity epidemic through the redesign of foods. The extra costs could be offset by an appropriate tax on food fat content. Another substantial innovative possibility is the development of 'synthetic meat' – animal protein that is grown in a laboratory or factory, rather than being a part of an animal. While the concept may produce consumer resistance for being "not natural", the ability to mass produce animal protein, and the avoidance of cruelty to animals could generate a strong market demand.

4.2 Food Packaging

Unlike other enabling technology applications for food and beverages, which are not yet on the market, the applications for food packaging are rapidly becoming a commercial reality. A contributing factor is that, due to the fixed or embedded nature of engineered nanoparticles in plastic polymers, they are not likely to pose any significant risk to the consumer.

Participants argued for a dual approach, involving packaging of nutrients within food and designing food itself as the package) - packaging can become part of the food product, both food and package being consumed together. The emphasis needs to be on bio-degradable packaging, sourced from waste products.

Other important issues Included having sufficient land to grow the feedstock for bio-based packaging, reuse of packaging without extra energy requirements, identification of food-waste through system-wide analysis, multifunctional packaging, and packaging of fresh food at the site of production eg apples that have no blemishes and oranges with sunscreen - Packaging needs to be built into the production and processing stages.

Particular emphasis was placed on improving the carbon footprint, carbon pricing and labelling, including for green plastics, taking into account the total life cycle of food and its packaging. Exports also need to be considered. There was significant potential for the more effective packaging of bulk commodities such as wheat and rice.

4.3 Nutritional and Functional Foods

Consumer interest in the nutritional and health benefits in food focus on avoiding allergies, using foods to treat disorders such as diabetes and high blood pressure, increasing the nutrient density of food for children while keeping it lower in fat, calories, sugar and sodium,

antioxidant foods, and foods and beverages that boost energy and mental alertness in adults and brain development in children.

Uses of nanotechnology and biotechnology to increase the health benefits of foods have potentially wide applications. Advanced delivery systems can enhance solubility, facilitate controlled release, improve bioavailability and protect the stability of micronutrients and bioactive compounds during processing, storage and distribution. Incorporation of bioactive compounds such as vitamins, probiotics, bioactive peptides and antioxidants into food systems provides a simple way to develop novel functional foods that may have physiological benefits or reduce the risk of diseases.

Participants identified a range of promising developments: using cell culture to address the need for protein ("grow your own meal in a petri dish"), replacing diminishing fish stocks with algae-based proteins, providing labelling that clearly identifies caloric and nutritional values, manipulating taste response to 'fool' people into getting a better taste, controlling the nutrition and biological function of food, eg control the rate of digestion (therefore don't necessarily reduce fat/fuel, just slow rate of digestion), technology that will improve taste while reducing fat or fuel density, and recovering nutrients from waste.

4.4 Waste Management and Water Reuse

Biological processes could enhance food processing and manufacturing to reduce wastage, such as using enzymes to maintain freshness, boost yields and increase the efficiency of processes. Nanopackaging and other advanced packaging technologies have the potential to both preserve food for longer and provide unambiguous indicators of spoilage. Enabling technologies, particularly biotechnologies, have significant potential to convert food waste and other biomass into useful materials such as compost, fertiliser and energy via a biorefinery.

Participants emphasised three elements to reducing food waste in production -enhanced enzymes, enhanced microbial products, and genetically modified enzymes and food processing components. There is an opportunity in waste management for nanoparticles to identify waste streams more effectively e.g. compostable plastic bags and for the recovery of nutrients from digestate. Another possibility is the diversion of food waste through synthetic biology organisms will completely change products and create value from waste - concerns include the life cycle footprint including energy and water demands; safety; and environmental control.

5. Supporting the Effective Uptake of Enabling Technologies

5.1 Food Processing

Developing Australia's capacity as a leading food processing nation was seen as paramount. This required building strongly on a 'Brand Australia' with associations of clean, green food, freshness, and the highest standards of manufacturing and safety. This would require the attraction of extensive foreign investment, together with strong support from Federal and State Governments. It would also be appropriate for Australian firms to pursue strategic partnerships with the dominant global food supply firms.

This would need to be supported by appropriate infrastructure for the industry, including Innovation centres based on public/private partnerships which could bring in $5billion over the next 10 years, a strong system of education and training at University and TAFE level based on clear analysis of the skills needed, and a well-developed capability to structure foods and assess their safety.

5.2 Food Packaging

Wastage, contamination and consumer acceptance are the main issues identified. There is a strong possibility of developing 100 % recyclable products. It should be noted that water is hard to recycle due to consumer acceptance, so requires proper infrastructure. There is also a need to find an appropriate combination between biodegradable products and recycling. The diversity of products in the market is an issue for recycling. It may be possible to establish a set of approved generic formulations which would help recycling. But different recycling processes can compromise the packaging.

A distinct issue was the provision of interactive use by dates on packaging that will advise consumers about the relative freshness of the food, and when it should no longer be used.

5.3 Nutritional and Functional Foods

One major initiative was to diversify food sources; it was important to avoid the loss of further nutrient sources, including native Australian foods, and to resist the apparent mass production advantages of monocultures. This diversification included food production, by facilitating development of community gardens, vertical farming, etc.

There is a need for much greater levels of investment in new healthy foods. Instead of relying on producers and manufacturers, the retailers (ie supermarkets) need to be encouraged to invest in broadly targeted R&D. A broad commitment across all components of the industry is needed to establish the necessary critical mass of technology partnerships. Economic modelling, linked to medical studies, is also needed to demonstrate the effectiveness and efficiency of personalised nutrition.

It will also be necessary for food manufacturers in Australia to be adopting the latest technology and to be focusing on maximising the value added to their products.

5.4 Waste Management and Water Reuse

The three greatest challenges are social acceptance through communication and education, greater social participation and choice and effective consultation processes. There are a variety of disparate concepts about waste management which are not clearly understood by all players. Industry and regulators need to jointly determine what can be implemented, which would ensure information being provided by both sides to the public and interested parties is current.

There is a clear role for governments in supporting the food industry to build pilot plants, as a national pilot program with regional connectedness, in order to be able to trial at an adequate scale new processing, packaging and recycling processes. There are also problems of varied regulations between the States, each of which has their own EPA. This could become a COAG

responsibility, addressing in particular new technologies for organic feedstock (covering food, other biomass, and waste streams).

One possibility for more effective consumer engagement is by establishing a limited range of options for consumers to select from.

6. Recommended Initiatives

In response to the challenge to "develop an integrated response in terms of the role of industry, research, government policy and regulation", three major initiatives were identified.

The first of these addressed the need for a well-developed and articulated vision and strategy for the future of the Australian food industry. Government, industry and other key players need to collectively formulate a view of the future desired structure and performance of the industry, in the face of the many challenges and opportunities arising from the need to feed the global population within the constraints imposed by sustainability requirements. The preparation of a National Food Plan could provide an appropriate vehicle for the pursuit of this objective.

There are many different interests and perspectives associated with the Australian food industry, including growers, manufacturers, retailers, logistics providers, workers, media, researchers, regulators and consumers. In order to share and enhance understanding between these various interests, and to develop greater common purpose, a Food Forum should be established, using all available means of modern communication, to share information, express concerns, reveal the views of consumers and provide a source of reliable information.

The many challenges facing the food industry require extensive research of a multi-disciplinary nature addressing not only new food products, processing and packaging, but also material life-cycle assessment, environmental impact evaluation, technology assessment, waste stream analysis, and the need and basis for regulation. This requires a highly coordinated research effort which is strongly driven by the views of all the stakeholders of the food industry, with a charter to deliver information and advice and articulate possible futures.

This could be pursued through strengthening the existing Food Futures National Research Flagship within the CSIRO, and ensuring it is drawing on relevant knowledge in a range of other Flagships, such as Future Manufacturing, Preventative Health, Climate Adaptation and Water for a Healthy Country. Alternatively, a new Centre of Excellence might be established between a consortium of universities.

7. Outcomes and Conclusions

The purpose of this Workshop was to explore the potential contribution of enabling biotechnologies and nanotechnologies to the Australian food industry over the next ten to twenty years.

It succeeded in engaging a range of stakeholders in the Australian food industry in a shared consideration of the possible future of the Australian food industry. However the inability to

attract representatives from the major global food companies which dominate the Australian market may have somewhat limited the effectiveness of some of the deliberations.

It provided the opportunity for an exploration of the factors affecting the Australian food industry, with an emphasis on the role that enabling technologies can play in addressing challenges to the Australian food supply chain. Key structural factors identified were the growth in global demand for food, the limited size of the Australian market, and the possibly diminishing competitiveness of the Australian food industry.

Significant opportunities for the enabling technologies were identified in more efficient and sustainable food processing, more effective integrated food packaging, the enhancement of the nutritional value of foods and the reduction of waste and water use through increased recycling.

It was recognised that food is the focus of a high level of consumer interest and concern, and that the introduction of any new technologies would need to adequately address any possible safety issues and allow early informed input from consumer representatives.

A range of constraints to the effective development of the food industry over the next twenty years were identified, including more effective use of Brand Australia labelling and marketing, adequate support for research, testing and training, appropriate recycling and waste management standards, adoption of latest technology by food manufacturing firms, and consumer acceptance of 'designed' foods.

Three major initiatives proposed were a well-developed and articulated vision and strategy for the future of the Australian food industry, the establishment of a Food Forum to provide a vehicle for education and communication between all those with interests in the food industry, and the building of an extensive research capacity of a multi-disciplinary nature addressing not only new food products, processing and packaging, but also material life-cycle assessment, environmental impact evaluation, technology assessment, waste stream analysis, and the need and basis for regulation.

Australian Centre for Innovation Limited

Appendix One

Background Briefing Paper

Enabling Technologies in the Food Industry

Prepared by the Enabling Technologies Policy Section,
Department of Innovation, Industry, Science and Research

Food Industry Foresight Workshop

Melbourne

17 November 2011

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Introduction

Under the National Enabling Technologies Strategy, the Government has established an Expert Forum comprising a number of experts in biotechnology and nanotechnology, regulation and foresighting. The Expert Forum assists the Department of Innovation, Industry, Science and Research (DIISR) with developing policies to ensure the responsible uptake of enabling technologies, focused particularly on new forms of nanotechnology and biotechnology, including areas of intersection and those enabled by information and communication technologies. The Expert Forum is charged with examining how the use of enabling technologies might address global and national problems and to more effectively plan for the future, given the transformative nature of these technologies and their impact on a range of industry sectors. More information can be found at: www.innovation.gov.au/Industry/Nanotechnology/NationalEnablingTechnologiesStrategy/Pages/NationalEnablingTechnologiesStrategyPlanningfortheFuture.aspx

Foresighting comprises strategic analytical tools to prepare for uncertainties and transformative developments in society and the business environment. As new enabling technologies are expected to impact on a range of industry sectors, under the auspices of the Expert Forum, DIISR has been working with different stakeholder groups to undertake a series of industry uptake foresight workshops to explore the potential contribution of these technologies to the future of the industry and the issues and challenges posed by their uptake. Workshops have already been undertaken looking at enabling technologies in the building products industry and enabling assistive technologies in aged care.

Aims of the Workshop

The Food Industry Foresight Workshop will consider the changes facing the Australian food industry and its supply chain post farm gate, with a focus on the issues and challenges posed by the uptake of new enabling technologies in this sector. This background paper presents an overview of the following factors affecting the future of food production in Australia:

- Issues faced by the Australian food industry
- Emerging enabling technologies relevant to the food industry
- Uptake of enabling technologies by the food industry
- Regulation of nanotechnology and biotechnology in food.

Overview of the Australian Food Industry

One of the strongest trends identified by Food Science Australia[6] is the search for convenience by consumers who are time poor, many of whom are looking for food with non-fat, high nutritional and 'gourmet' value. Social values identified as forming an important part of the value chain include good product and packaging design, waste management, good use of resources, high workplace and labour standards, occupational health and safety in the workplace, staff training, fair wages, equal opportunity and workplace diversity.[7]

The Australian government is currently developing a National Food Plan, a whole-of-government initiative, led by the Department of Agriculture, Fisheries and Forestry (DAFF). The recently released issues paper[8] acknowledges that whilst technological innovation is critical for improving productivity from paddock to plate, there is some consumer concern about the use of some new technologies, such as genetic modification and nanotechnology, in food production and food products. It also states that consumers demand more traceability and information about ingredients in food products, and summarises the wide range of food and nutrition-related government policy and programs.

The goal of a recent meeting on sustainable food was to share ideas that could "form a vision for Australia's food system in 2030; to examine the challenges and constraints of the current food system, and explore opportunities for change that would support a transformation to a resilient, adaptable and sustainable food system". Issues discussed at the Summit included:

- Providing industry incentives for innovative and healthy food products
- The role that biofuels can play in a climate of food scarcity
- Taking a life-cycle approach to the food system to minimise waste and support a culture that values food as a resource.[9]

Enabling Technologies in the Food Industry

Enabling technologies are defined as new technologies or new uses for existing technologies that enable new products or services or more efficient processes. A recent UK Government project explored the pressures on the global food system between 2011 and 2050 to identify the decisions that policy makers need to take today, and in the years ahead. Its key conclusions of relevance to the uptake of enabling technologies in the food industry were:

[6] Roupas P & Margetts C. *National Food Industry Strategy Foresighting, Consumer and Technology Trends*, Food Science Australia, April 2007, p. 70-72
[7] Ibid.
[8] DAFF (2011). *Issues paper to inform development of a national food plan*. Department of Agriculture, Fisheries and Forestry, Canberra.
[9] National Sustainable Food Summit (2011) Conference Report.

- Investment in research on modern technologies is essential in light of the magnitude of the challenges for food security in the coming decades
- The human and environmental safety of any new technology needs to be rigorously established before its deployment, with open and transparent decision-making
- Decisions about the acceptability of new technologies need to be made in the context of competing risks (rather than by simplistic versions of the precautionary principle); the potential costs of not utilising new technology must be taken into account
- New technologies may alter the relationship between commercial interests and food producers, and this should be taken into account when designing governance of the food system. There are multiple approaches to addressing food security, and much can be done today with existing knowledge. Research portfolios need to include all areas of science and technology that can make a valuable impact – any claims that a single or particular new technology is a panacea are foolish
- Appropriate new technology has the potential to be very valuable for the poorest people in low income countries. It is important to incorporate possible beneficiaries in decision-making at all stages of the development process. [10]

Australian Experience

A study commissioned by the Australian Office of Nanotechnology, DIISR, found little literature on the use of molecular level technologies in the food sector and at the time of the report's writing (2009) the authors found nanotechnology was not being used in the Australian Food industry. The report concluded that internationally, the main categories of nanotechnology applications in the food sector were:

- packaging/protection to improve the properties of the packaging
- safety/sensors in food labels or packaging
- additives, encapsulation and emulsions
- processing[11]

A recent study commissioned under the National Enabling Technologies Strategy (NETS) investigated the uptake of enabling technologies in the agriculture sector. This report[12] focused on agriculture and did not analyse the application of enabling technologies to food production post farm gate, on which this workshop will be based.

A foresighting exercise under the National Food Industry Strategy in 2007 concluded that future technologies and their applications will play a major role in addressing the future

[10] *Foresight. The Future of Food and Farming* (2011). Final Project Report. The Government Office for Science, London.
[11] AECOM (2009). *The Social and Economic Impacts of Nanotechnology on Australia*. Australian Office of Nanotechnology, Canberra
[12] Have J, Hattersley P, Mewett O and Stoutjesdijk P (2011). *Enabling technologies in the agriculture sector: meeting demands for food security and sustainability*. Draft. Department of Agriculture, Fisheries and Forestry, Canberra.

needs of the food industry. The report[13] found that there was significant potential to fast track food R&D using new enabling technologies to identify new food applications. It identified the major areas of food production that may benefit from enabling technologies as:

- Increased security of manufacturing, processing and shipping of food products through sensors for pathogen and contaminant detection
- Devices to maintain historical environmental records of a particular product and tracking of individual shipments
- Systems that provide integration of sensing, localisation, reporting and remote control of food products (smart/intelligent systems) and that can increase efficacy and security of food processing and transportation
- Encapsulation and delivery systems that carry, protect, and deliver functional food ingredients to their specific site of action.

However they concluded that while new technologies hold great potential, a cautionary note lies in the history of the non-acceptance of genetic modification (GM) of plants and food products by many consumers. This cautionary note is supported by the views of the Australian Food and Grocery Council[14], which regards consumer concerns driven by consumer activism as potential barriers to the adoption of nutraceuticals by food manufacturers in the food industry.

Food Processing

Applications of Enabling Technologies

A key area of application of nanotechnology in food processing involves the development of nanostructures (also termed nanotextures) in foodstuffs. The nanotexturing of foodstuffs has been claimed to give new tastes, improved textures, consistency and stability of emulsions, compared with equivalent conventionally processed products. A typical benefit of this technology could be in the form of a low-fat nanotextured food product that is as "creamy" as the full-fat alternative, and hence offers a "healthy" option to the consumer. Currently, there is no clear example of a proclaimed nanostructured food product that is available commercially, although some products are believed to be at the R&D stage, and some may be nearing the market.[15]

Another use for enabling technologies is in the form of nanocoatings for food contact materials (FCMs) during food processing. Antimicrobials used during food processing are of severe concern because of their residual presence in surface and ground waters and the consequent propagation to the food-chain, with risks to the public health. Work is underway

[13] Roupas P & Margetts C (2007). *National Food Industry Strategy Foresighting, Consumer and Technology Trends*, Food Science Australia.
[14] Geoffrey Annison. Deputy Chief Executive, Australian Food and Grocery Council.
[15] FAO/WHO (2009). *Expert Meeting on the Application of Nanotechnologies in the Food and Agriculture Sectors: Potential Food Safety Implications*. Meeting Report. Rome, Italy.

to develop nanostructures with functionalized surfaces that carry the antimicrobial agent. This will save significant amounts of the antimicrobial agent, prevent undesirable reactions with other components that can lead sometimes to the formation of potentially carcinogenic compounds, and reduce the costs of wastewater treatment.[16]

Water Re-use

Water use is a major component in food processing. The Australian food processing sector uses 215 GL per annum, which represents 1 per cent of water used in the agri-business sector; agriculture constitutes 66 per cent of Australia's water use. The Australian food processing sector has the opportunity to re-use 33 GL of water per year according to a survey by Food Science Australia in 2009.[17] There are many benefits to re-using water, particularly as some food manufacturing businesses operate in regions where water stress is very high.

Technologies available to manufacturers interested in re-using water include; physical screening; sedimentation to remove suspended solids; biological processes and removal of pathogens, chemical contaminants and nutrients to purify wastewater to a drinking quality standard. Industry sectors that use enabling technology to re-use water are the:

- Beverage industry – re-uses spent water after purification through stage nanofiltration or a combination of biological treatment and membrane separation.
- Fruit juice industry – floating media and nanofiltration.
- Margarine and soup production – membrane bioreactor technology.

Packaging

Unlike other enabling technology applications for food and beverages, which are not yet on the market, the applications for food packaging are rapidly becoming a commercial reality. A contributing factor to the rapid commercial developments in this area appears to be the expectation that, due to the fixed or embedded nature of engineered nanoparticles in plastic polymers, they are not likely to pose any significant risk to the consumer. Nanotechnology applications for FCMs are the most common use of nanotechnology in the food industry. It has been estimated that nanotechnology-derived packaging will make up to 19% of the share of nanotechnology products and applications in the global consumer goods industry by 2015.[18]

[16] Ferreira C, Pereira AM, Melo LF, Simões M. *Advances in industrial biofilm control with micro-nanotechnology*. In: Méndez-Vilas A, (Ed.). Current Research, Technology and Education Topics in Applied Microbiology and Microbial Biotechnology. Singapore, World Scientific Publishing Co., 2009.
[17] DAFF (2011). *Australian Food Statistics 2009-10*. Department of Agriculture, Forestry and Fisheries, Canberra.
[18] Chaudhry Q, Watkins R & Castle L (2010). *Nanotechnologies in the Food Arena: new opportunities, new questions, new concerns*. The Food and Environment Research Agency, UK.

Applications of Enabling Technologies

Advances in biotechnology have led to the development of biodegradable packaging derived from natural polymers such as cellulose or starch. Emerging technologies suggest the future of biodegradable packaging will be bioplastics produced from natural or genetically modified organisms.[19] Nanotechnology applications have also led to improved food packaging in areas such as:

- 'Improved' FCMs in terms of flexibility, gas barrier properties and temperature/moisture stability.
- 'Active' FCMs incorporating metal or metal oxide nanoparticles for antimicrobial properties.
- 'Intelligent' and 'Smart' packaging incorporating nano-sized sensors that can monitor the condition of the food during transportation and storage
- Nanocoatings for FCMs with barrier or antimicrobial properties, and for 'active' or self-cleaning surfaces in food processing facilities such as abattoirs.

Nutrition

Consumer interest into the nutritional and health benefits in food involves issues around:

- Allergies to wheat, dairy, peanuts, tree nuts, seafoods and eggs, leading to demands for increased labelling of foodstuffs.
- Using foods to treat disorders such as diabetes, high blood pressure, heart disease, high cholesterol, arthritis, obesity and various eating disorders
- Increasing the nutrient density of food for children while keeping it lower in fat, calories, sugar and sodium, and ensuring adequate intake of fibre, calcium, vitamin A and C, and more recently D, folate, potassium and magnesium
- Foods which act as antioxidants, such as those containing lycopene, lutein and resveratrol, flavonoids and carotenoids
- Healthy, more expensive, cooking oils and reformulations of dressings and mayonnaise to promote healthy oils as well as non trans fat varieties of existing oils
- Foods and beverages that boost energy and mental alertness in adults and brain development in children.

Applications of Enabling Technologies

Uses of nanotechnology and biotechnology to increase the health benefits of foods have potentially wide applications. Advanced delivery systems can enhance solubility, facilitate controlled release, improve bioavailability and protect the stability of micronutrients and bioactive compounds during processing, storage and distribution. Incorporation of bioactive compounds such as vitamins, probiotics, bioactive peptides and antioxidants into food systems provides a simple way to develop novel functional foods that may have

[19] Leatherhead UK (2010). *PHA and bio-derived PE to Drive Bioplastic Packaging Market to 2020*, retrieved from [http://www.intertechpira.com/pha-and-bio-derived-pe-to-drive-bioplastic-packaging-market-to-2020.aspx]

physiological benefits or reduce the risk of diseases.[20] The emerging science of nutrigenomics focuses on the interaction between bioactive dietary components and the genome. It is expected that the use of new and innovative technologies will provide needed insights into molecular targets for specific phenotypes.[21]

Recent developments include:

- Nanoencapsulation – fortification of foods with nutraceuticals, probiotics and glycol nutrients
- Nutrigenomics – the interaction of dietary components such as essential nutrients with genes
- Metabolomics – diagnosing individual variations in metabolism and solutions to improve it, leading to personalised nutrition for better health.

However, as noted, the uptake of these technologies in the food industry is likely to be hindered by consumer acceptance, concerns about safety, and the cost premium for such foods over other foods. Although some see the supermarket of the future being another form of pharmacy, others consider that consumers are more likely to want to restrict these attributes to products available through the traditional pharmacy.[22]

Waste Management

The Australian Government report, Waste Technology Innovation Study[23], commissioned by the Department of Environment, Water, Heritage and the Arts, found that improving access to existing technologies, alongside further research into improving recovery and reprocessing technologies, is needed to improve waste management. Enabling technologies have the potential to impact significantly on food waste issues. They can play a part both in preventing food from becoming waste, and in using waste more effectively by diverting it from landfill. Existing biorefinery techniques have significant potential but have had limited usage so far. Increased adoption of current biorefinery techniques, combined with improved effectiveness of biological processing through the application of enabling technologies, could have a considerable impact on how food waste is processed in Australia.

Reducing Food Waste in Production

Collaboration between the World Wildlife Fund and Novozymes indicated several areas where biological processes could enhance food processing and manufacturing to reduce wastage, such as using enzymes to:

- maintain freshness of dairy and baked products

[20] Roupas P & Margetts C (2007). *National Food Industry Strategy Foresighting, Consumer and Technology Trends*, Food Science Australia.
[21] Roupas P & Margetts C (2007). *National Food Industry Strategy Foresighting, Consumer and Technology Trends*, Food Science Australia.
[22] Ibid.
[23] *Waste Technology Innovation Study* (2009). Department of Environment, Water, Heritage and the Arts, Canberra.

- boost yields during juice and wine extraction
- enhance brewing and distilling processes[24]

Reducing Food Waste in Consumption

Wastage of food at points of consumption is a significant problem. The Australia Institute estimates that Australia wastes $5.3 billion of food annually.[25] Food is wasted at various points in the supply chain: agriculture, supermarkets and retail, households and hospitality. In the United Kingdom, 70 per cent of household food waste is collected by local governments; the figure is likely to be similar in Australia.

In the UK, 64 per cent of household food and drink waste has been classed as avoidable (food and drink that was initially edible).

- 55 per cent was disposed of due to being past the use-by date or looking rotten
- 42 percent was due to cooking too much food and discarding the surplus[26]

Nanopackaging and other advanced packaging technologies have the potential to both preserve food for longer and provide unambiguous indicators of spoilage. This approach has also been recommended by the UK's Foresight project, in their report on the future of food and farming.[27] Such packaging could reduce food waste in retail, households and hospitality sectors.

Diverting Food Waste from Landfill

Although much food waste can be avoided by effective application of enabling technologies as discussed above, a certain amount of waste is inevitable. Enabling technologies, particularly biotechnologies, have significant potential to convert food waste and other biomass into useful materials such as compost, fertiliser and energy via a biorefinery. In Australia, the Environmental Biotechnology Cooperative Research Centre (EBCRC) aims to improve the effectiveness of these processes.

A biorefinery approach is used to break food waste down into solid material (often used as compost or fertiliser) and biogas. The process of anaerobic digestion uses microorganisms to decompose organic matter in the absence of oxygen. In this case, the biogas is largely methane, which can be captured and burnt to produce electricity in a cogenerator; this may be used to power the facility or be fed back into the grid as green energy. Anaerobic digestion typically requires large and complex facilities, making it suitable for handling waste from municipal collection or a network of stores.

[24] Buttazzoni M (2009). *GHG Emission Reductions With Industrial Biotechnology*. WWF and Novozymes.
[25] Baker D, Fear J, Denniss R (2009). *What a waste: An analysis of household expenditure on food*. The Australian Institute.
[26] WRAP (2009). *Household food and drink waste in the UK*. Report prepared by WRAP. Banbury.
[27] *Foresight. The Future of Food and Farming* (2011). Final Project Report. The Government Office for Science, London.

A key example of the biorefinery approach is the DiCOM process operated by AnaeCo Ltd in Perth in conjunction with the EBCRC. The facility accepts non-segregated waste and separates out contaminants (including recyclable materials which can be resold), before using a combined aerobic and anaerobic process to convert the organic waste into compost and biogas. The combined approach reduces the processing cycle time leading to decreased plant size and running costs.

Enabling technologies may also improve the function of simpler waste processing techniques. For example, open windrow composting is a cheap system where biomass is heaped in rows and mechanically churned during the composting process. This process is unsuitable for use in urban areas as strong, offending odours are emitted during churning. Researchers have developed ways in which these odours can be trapped in absorbing particles before being broken down by bacteria and enzymes, thus removing the offending odours and making municipal scale composting facilities more viable.[28]

Regulation and Risk Management

The International Handbook on Regulating Nanotechnologies states that "… the current regulatory frameworks for food and FCMs within jurisdictions such as the EU, the US and Australia, are broad enough to 'catch' foods and FCMs which incorporate nanotechnologies".[29]

Food Standards Australia New Zealand (FSANZ) regulates food standards in Australia, including regulation of nanotechnology and biotechnology in food and food packaging. It has adopted a range of strategies to manage potential risks associated with nanotechnologies in foods with the aim of ensuring the protection of public health and safety, and drawing on the best available scientific evidence. In 2010-2011, FSANZ work in this area included:

- Establishing the extent to which existing food additives and processing aids may require additional consideration during risk assessment to inform whether restrictions in the Food Standards Code are justified based on the best scientific evidence.
- Identifying, assessing and managing any potential impacts of nanotechnologies on the safety of food packaging as part of a broader review of Standard 1.4.3 in the Food Standards Code, Articles and materials in contact with food.

The recent Australian Food Labelling Law and Policy Review (2011) made several recommendations relating to enabling technologies:

[28] Environmental Biotechnology CRC, news release: "Biotechnology combats offending odours", 23 April 2009, retrieved from [http://www.ebcrc.com.au/pdf/EBCRC_Odour_Control_Media_Release.pdf].

[29] Gergely A, Chaudhry Q, and Bowman DM. *Regulatory perspectives on nanotechnologies in foods and food contact materials*. In: Hodge GA, Bowman DM, and Maynard AD, (Ed.). International Handbook on Regulating Nanotechnologies. Cheltenham, UK, Edward Elgar, 2010: p338

- (No. 2) that food labelling policy should be guided by an issues hierarchy in descending order of food safety, preventative health, new technologies and consumer values issues
- (No. 28) all foods or ingredients processed by new technologies be required to be labelled for 30 years
- (No. 29) only food or ingredients that have altered characteristics or contain detectable novel DNA or protein be required to declare the presence of genetically modified material on the label
- (No. 30) any detection of an adventitious genetically modified event be followed by a period of monitoring and testing of that food or ingredient
- (No. 31) that foods or ingredients with flavours containing detectable novel DNA or protein not be exempt from the requirements to declare and the presence of genetically modified material on the label
- (No. 32) that foods or ingredients that have been genetically modified be declared on the menu in chain food service outlets and on vending machines
- (No. 33) that governments ensure effective monitoring of labelling requirements in the Food Standards Code relating to genetically modified foods or ingredients through support for sufficient Australian and New Zealand laboratories, observing world best practice protocols, and with the necessary resources and analytical skills
- (No. 35) that the relevant food agency develop as a matter or urgency a standard for regulating the presence of nanotechnology in the food production chain.

The Australian Government is currently formulating its response to this Review.

Appendix Two

List of Attendees

Participants	Position/Organisation
Andrew Bartholomaeus	General Manager, Risk Assessment, Food Standards Australia New Zealand (FSANZ)
Anna Graham	R&D Program Manager, Agritechnology
Barrie Chalkley	Organiser, Australasian Meat Industry Employees Union (AMIEU)
David Cox	Senior Research Scientist, CSIRO Food and Nutritional Sciences, Commonwealth Scientific and Industrial Research Organisation (CSIRO)
David Doral	Manager, Processing Efficiency and Sustainability, Meat & Livestock Australia (MLA)
David Halliday	Director, Active Research Pty Ltd
David Hudson	AusBiotech; Chief Executive Officer/Director, SGA Solutions
Fran Murrell	Mothers Are Demystifying GE (MADGE)
Geoffrey Annison	Deputy Chief Executive/Director, Health, Nutrition and Scientific Affairs, Australian Food and Grocery Council (AFGC)
Georgia Miller	Friends of the Earth
Ingrid Appelqvist	Theme Leader, CSIRO Food and Nutritional Sciences, Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Jay Sellahewa	Stream Leader, CSIRO Food and Nutritional Sciences, Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Kel Dummett	Project Manager, Business Transformation, Sustainability Victoria

Participants	Position/Organisation
Ken Van Langenberg	Manager, Small Technologies Program, Department of Business and Innovation, Victoria
Maree Lang	Principal, MLG Consulting Pty Ltd
Mark Globan	Victorian Organics Manager, SITA Australia
Mary Ann Augustin	Research Program Leader, CSIRO Food and Nutritional Sciences Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Michael Cowley	Director, Monash Obesity and Diabetes Institute (modi), Monash University
Michael Thomas	Assistant Manager, Food Industry Policy, Department of Innovation, Industry, Science and Research (DIISR)
Nick McCaffrey	General Manager, Technology, Plantic Technologies Ltd
Peter Halley	Group Leader, Australian Institute for Bioengineering and Nanotechnology; Professor/Director of Research, School of Chemical Engineering, The University of Queensland
Phil Casey	Research Program Leader, CSIRO Materials Science and Engineering, Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Ragini Wheatcroft	Strategic Relationship Manager, Food & Plant Industries, Department of Primary Industries, Victoria
Robert Solomon	Manager, Food Regulation Policy, Department of Agriculture, Fisheries and Forestry (DAFF)
Robert Sward	Policy Manager Biotechnology, Agriculture & Food Industries Policy, Department of Primary Industries, Victoria
Roger Stanley	Principal Research Fellow, Centre for Nutrition and Food Sciences, Queensland Alliance for Agriculture and Food Innovation (QAAFI). The University of Queensland
Sarah Haydon	Research & Commercial Manager, Water Recycling Centre of Excellence

Participants	Position/Organisation
Stuart Smith	Australian Institute of Food Science and Technology (AIFST); Senior Lecturer, School of Exercise and Nutrition Sciences, Deakin University
Terry Turney	Professor, Centre for Green Chemistry, Monash University; Chief Technical Officer, Micronisers Australasia Pty Ltd
Ulrich Diekmann	Project Officer, International Relations & Food Sector Collaboration, National Measurement Institute (NMI)
Veronica Graham	State Public Health Nutritionist, Department of Health, Victoria

Facilitator	
Ron Johnston	Executive Director, Australian Centre for Innovation (ACIIC); Chair, National Enabling Technologies Strategy Expert Forum

DIISR Support Staff	
Alanna Cresp	Policy Officer, Enabling Technologies Policy, Innovation Division; Secretariat, NETS Expert Forum
Alison Hemmings	Manager, Enabling Technologies Policy, Innovation Division
Cassandra Adofo-Kissi	Policy Officer, Enabling Technologies Policy, Innovation Division
Hayley Brindell	X, Enabling Technologies Public Awareness, Innovation Division
Paul Stockwell	Policy Officer, Biotechnology Innovation Policy, Innovation Division

Working Groups

1. Food Processing

Group Facilitator: *Robert Solomon*

Scribe: *Hayley Brindell*

Barrie Chalkley

David Doral

Geoffrey Annison

Jay Sellahewa

Ken Van Langenberg

Mary Ann Augustin

Michael Thomas

3. Nutrition and Functional Foods

Group Facilitator: Ingrid Appelqvist

Scribe: Alison Hemmings

Anna Graham

David Cox

Fran Murrell

Michael Cowley

Ragini Wheatcroft

Roger Stanley

Stuart Smith

2. Food Packaging

Group Facilitator: Terry Turney

Scribe: Cassandra Adofo-Kissi

Andrew Bartholomaeus

Maree Lang

Nick McCaffrey

Peter Halley

Phil Casey

Ulrich Diekmann

Veronica Graham

4. Waste Management and Water Reuse

Group Facilitator: David Hudson

Scribe: Paul Stockwell

David Halliday

Georgia Miller

Kel Dummett

Mark Globan

Robert Sward

Sarah Haydon

Appendix Three

Agenda

"The Potential Role of Enabling Technologies in the Future of the Australian Food Industry"

Food Industry Foresight Workshop

8.30	Registration; coffee/tea on arrival (small group facilitators and note takers meet with workshop facilitators to discuss process and aims)
9.25	Alison Hemmings, DIISR: Welcome: aims of the National Enabling Technologies Strategy
9.30	Ron Johnston, Expert Forum Chair: Introduction to Foresight
9.40	**"Overview of the issues facing the Australian food industry"**: Dr Geoffrey Annison, AFGC
10.00	Discussion
10.10	**"Enabling technologies in the food industry"**: Dr Mary Ann Augustin, CSIRO (10 mins) Mr Phil Casey, CSIRO (10 mins)
10.30	Discussion
10.40	**"Regulatory issues surrounding the use of enabling technologies in the food industry"**: Dr Andrew Bartholomaeus, FSANZ
11.00	Discussion
11.10	*Morning Tea*
11.30	Facilitated discussion between panel of presenters and audience about key issues that will need to be addressed
12.00	**Future Scenario Presentation** - Ron Johnston

12.10	**Implications of the Scenario** (group-based) - *how might enabling technologies contribute to the food industry in 10-20 years time?* Each table considers this question in relation to their focus area, including regulatory implications.
12.40	Reports from each table - mapping developments and possibilities
13.10	*Lunch*
14.00	**Backcasting** (group-based) - *what were the major initiatives taken from 2012 to enable the effective uptake of enabling technologies within the food industry?* Each table examines this question in relation to their focus area.
14.30	Reports from each table - mapping issues and potential responses
15.00	**Key Actions** (group-based) - *develop an integrated response in terms of the role of industry, research, government policy and regulation.*
15.30	Reports from tables - an integrated approach
15.50	Facilitated discussion on the **Priority issues identified by workshop participants**
16.20	Ron Johnston: Summary of Priority issues to be addressed through the **National Enabling Technology Strategy**
16.30	*Close*

Appendix Four
A Scenario of the Australian Food Industry in 2022

The destabilising economic effects of the global financial crisis have finally been overcome, though economic growth continues at a modest pace. However, the economic order has been significantly changed, as reflected in the membership of the G7 – USA, China, India, Germany, Brazil, Russia and Japan.

The world population, as previously predicted, is approaching 8 billion. This, together with the increased demand for animal protein in the newly advanced countries, has significantly increased the demand for food, leading to a shortage of supply, and ever higher prices. This has been exacerbated by frequent major weather events, dramatically impacting on food production.

One predicted problem however has been largely overcome. The looming shortage of oil with its dire consequences for transport, manufacturing, fertiliser and materials has largely been managed through the surge of non-petroleum-based transport though the 2010s.

But in Australia, as in the past, we are not exposed to the worst of these effects. The cost of food in the supermarkets has risen substantially, taking a larger share of the family budget, but the continuing strength of the economy has generally made that bearable.

The relatively early move to an effective carbon pricing mechanism allowed markets to set an appropriate price, and producers and investors to pursue innovations that reduced carbon dependence and costs, while catering for the strong public commitment to greater levels of sustainability. Carbon price labelling has been adopted by some companies to demonstrate the “carbon footprint” of products and/or packaging.

An excise based on fat content is hoped to lead to a decline in the national obesity figures. The healthy food movement has also produced a strongly growing market in high nutrition, affordable foods, and foods targeted to specific medical conditions.

A significant development arising from higher food prices, the need to use resources sustainably and the soaring costs of waste disposal, has been the drive to dramatically reduce food wastage. Householders have been encouraged by a range of educational and incentive schemes to reduce their levels of food wastage through prudent purchase, improved storage and recycling. Restaurants and supermarkets are required, under their operating licenses, to produce no more than 2% of food wastage. Food processors face increasing limits on their production of waste, particularly in regards to water. New packaging laws demand that packaging is either 100% biodegradable or 100% reusable/recyclable.

The combination of high quality sustainable food production and processing, together with the focus on specialty foods, has provided a platform for significantly expanded exports of fresh and processed foods

into Asia. Delivery of fresh foods into these markets has relied critically on major advances in food packaging, tracking and supply chain logistics.

An emerging trend, in line with the decentralised approach to energy and water management, has been in the home and community production of food. This has gone well beyond the familiar produce markets in every suburb, to the establishment of community cooperatives negotiating and filling contracts with major food manufacturers. This has required the development of new capabilities to manage and process small batches of specialised food products.