



Industry Foresight Workshop:

Building Products

National Enabling Technologies Strategy Expert Forum

PROJECT REPORT

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Executive Summary

The National Enabling Technologies Strategy (NETS) Expert Forum leads a program of work on identifying new and converging technologies to inform government policy and strategy, and to improve how science and technology are utilised by industry, government and society in general.

Part of this program of work is a series of industry foresight workshops. This workshop focused on the Building Products Industry and explored **how the uptake of enabling technologies might assist the Building Products Industry to create an economically and environmentally sustainable industry and community in the future.**

The foresight approach to this exploration included examining various drivers and decision points for change to understand possible scenarios for the future. The first step was to understand what might drive different rates of technology uptake in the industry by considering social, technological, economic, environmental and political/legal (STEEP) factors.

- **Social** factors included population growth and demographics, the availability of a skilled workforce, changing shareholder expectations of companies, affordability and aesthetics.
- From the **technological** perspective, consumer attitudes may affect technology uptake. Commercialisation processes and the costs and availability of resources may drive availability of new technologies. Specific technologies of interest included new materials sciences and information and communications technologies.
- **Environmental** impacts would be felt in the response to climate change and energy use, as well as the global impacts of natural disasters. Sustainability was an important recurring theme for how the Building Products Industry sees its future.
- There were a couple of important **economic** issues such as competition from new entrants and the way that property is currently valued in the Australian market. High impact events such as financial downturns, skills shortages and ongoing housing affordability were also identified.
- Regulatory reform and the political will to set targets and make structural changes were identified in the **political and legal** space.

Thinking through these drivers and the types of technologies under development revealed the contexts for innovation. Enabling technologies are likely to be developed and used when they provide solutions to sustainability, for coping with extreme weather events (in terms of providing durability and safety features), smart functionality through the use of ICT and conditions for design and affordability. Leadership from existing companies and new entrants was also an important context for the uptake of new technologies.

In some cases the development and uptake of enabling technologies like Building Information Management and Integrated Building Systems were seen to be potential drivers of change, in others the provision of enabling technologies would assist in addressing broader challenges like a low-carbon future and responses to regulation.

These insights helped to craft three possible scenarios. The scenarios were built on a mix of factors already discussed, specifically a response to climate change and including the introduction of a carbon tax, the degree

of industry participation in global markets, the value placed on innovation and the availability of appropriate skills.

By considering these scenarios it was possible to identify opportunities and threats for the Building Products Industry in the future.

Opportunities included how the industry could respond to the prioritisation of a low-carbon vision and the development of new materials, devices and processes to meet sustainability targets. Access to global markets and supply chains might open up through virtual product design and the development of cost effective materials. Finally growth in the industry could drive a supply of specialist skills and expertise.

Threats may arise from a lack of skilled labour to meet the demands of new technologies and markets. Cost considerations could lead to competition on price rather than on quality or differentiation, especially if accompanied by a lack of innovation. Alternatively, global competitors might take up innovative research and specialist skills. The introduction of a high-impact carbon emissions scheme may threaten local industries in the short to medium term, or affect Australia's position in global supply chains.

The threats are compounded by existing **weaknesses** identified in the industry. These include gaps in the commercialisation process and the time taken for new technologies to come to market, especially with low levels of private funding. There is a lack of expertise in the market for undertaking technology transfer and the industry does not necessarily have the culture to adapt and innovate in response to external pressures such as regulation. Furthermore, industry will need to meet training demands for new skills.

However, the Building Products Industry also has many **strengths** including a strong base on which to continue development. There is some existing expertise in responding to changes such as the introduction of Green Building codes and large company engagement in adopting enabling technologies. Furthermore, Australia has a strong portfolio of relevant research within the CSIRO and other research institutions and universities.

Understanding these factors creates the conditions for more effective uptake of relevant technologies. The implications for policy development can then be summarised as requiring focus on the following:

- **Commercialisation processes** to accelerate technology transfer from research to market and provide a competitive advantage in a global market.
- Demonstration of how low carbon materials and other new technologies could support the achievement of **sustainability targets**.
- **Identification of priority technologies** that might include Integrated Building Processes, Building Information Modelling (Virtual Design) and new materials for energy efficiency and low carbon processes.
- **Industry awareness** regarding the range of enabling technologies, their applications and timelines to market in order to assist different parts of the industry to identify relevant technologies for consideration in their part of the sector or supply chain.

Overall the uptake of enabling technologies in the Building Products Industry can be promoted through research and commercialisation processes for priority technologies that support the needs of the industry. This will be particularly important in addressing issues relating to sustainability, smarter functionality and better design in terms of environmental impacts and affordability. Doing so will assist the Building Products Industry to create an economically and environmentally sustainable industry.

1. Introduction

The National Enabling Technologies Strategy (NETS) Expert Forum leads a program of work on identifying new and converging technologies to inform government policy and strategy, and to improve how science and technology are utilised by industry, government and society in general.

As part of this body of work, the Expert Forum has a number of activities to share insights about new and converging technologies and get input from industry, government and society on key issues and priorities. One set of activities is a series of industry foresight workshops to identify how industries might use future enabling technologies to address industry and market needs. Industries to be addressed in addition to the Building Products Industry include assistive technologies for the aged and future manufacturing.

The Building Products Industry was selected as the first foresight exercise because of the strong interest of the Built Environment Innovation Council, and the important role of this industry sector in the Australian economy. The revenue for the building supplies wholesaling sector in Australia is forecast to increase by 5.0% in 2010-11, to \$21.0 billion (approximately 1.7% of GDP), 70% of which is derived from the household construction market.¹ Building boards, bricks and other concrete product contributed \$2.6 billion in 2010, 40% from sales to the residential market².

The future projected changes with regards to resource and energy efficiency, as well as a range of other factors, are likely to impact the types of products and services supplied by the Building Products Industry. The key question for this report is **how might the uptake of enabling technologies assist the Building Products Industry to create an economically and environmentally sustainable industry and community in the future?**

The report draws on a brief review of the research being undertaken into relevant enabling technologies for the Building Products Industry, and a foresight workshop conducted jointly with the Built Environment Industry Innovation Council and featuring industry representatives and stakeholders that was held on 30 March 2011.

2. Methodology

The foresight process for the Building Products Industry workshop - including preparatory materials, the facilitated workshop and this report - was designed in order to meet three main objectives:

- to explore alternatives regarding the contribution of enabling technologies to the Building Products Industry;
- to demonstrate the application of foresight thinking to industry strategy and capability building; and
- to engage industry in a process to plan for the future of the Building Products Industry.

¹ <http://www.ibisworld.com.au/industry/default.aspx?indid=349>

² <http://www.ibisworld.com.au/industry/default.aspx?indid=217>

The aim of using a foresight approach or futures thinking in this workshop was to expand the thinking of representatives from the Building Products Industry so that a number of possible outcomes regarding industry needs and the uptake of enabling technologies could be explored. The specific qualities of foresight thinking that were established and emphasised during the workshop were as follows:

1. Ensuring a participatory process through a mixture of small group and large group discussions and recognising the breadth of expertise and opinions within the participants.
2. Taking into account a breadth of perspectives by using the STEEP framework to consider drivers of change (see Section 3).
3. Allowing for a greater depth of understanding by providing background information and presentations on enabling technologies (Section 4, Appendix 4 and Appendix 5) and considering the effects of the STEEP drivers on uptake of new technologies.
4. Developing a range of possibilities rather than focusing only on a “probable” future or one version of a “preferred” future (as illustrated in the following figure). This was explored in the workshop by considering various decision points that could possibly affect the future uptake of enabling technologies in the Building Products Industry (Section 5 and Appendix 6).

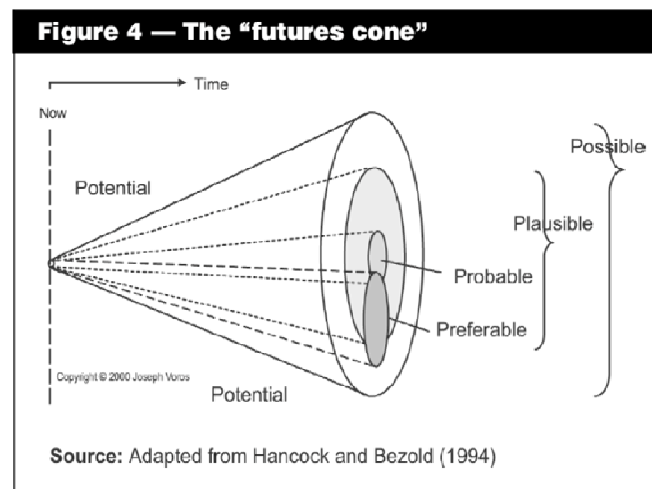


Figure: The Futures Cone (Voros *Foresight* 2003)

5. Finally, the workshop sought to find ways in which the insights of the process could become action-orientated through specific recommendations regarding industry initiatives or policy implications for government (Section 6).

Note that the agenda for the workshop is in Appendix 1 and the list of invited participants is in Appendix 2.

3. Drivers of Industry Change

Focusing Question: What are the factors that are likely to affect the Building Products Industry over the next 5-10 years?

The Building Products Industry is currently facing a number of potential challenges in order to develop a sustainable future within a global economy. The challenges and potential drivers of industry change – social, technological, environmental, economic, and political/legal (STEEP) – were explored in the workshop and through background briefing materials³. The STEEP analysis developed during the workshop is included in Appendix 3.

This section outlines the potential STEEP drivers and the implications for uptake of enabling technologies in the Building Products Industry.

3.1.1 Social

Population Growth and Demographics

Without radical policy changes, the population of Australia is expected to grow to approximately 30 million by 2021⁴. The ageing of the population is expected to increase from a median age of 36.8 in 2007 to between 38.6 and 40.7 by 2026. Population growth is likely to place demands on urban areas, resulting in changes to planning, transport and housing and placing demands on sustainability. The ageing population may look for safe, low-cost and low-maintenance housing options.

Demand for materials with sustainable properties including energy and resource efficiency, and products that are low-maintenance and durable.

Skills availability

In addition to population growth, the ageing population has implications for the number of people in work and therefore available to the Building Products Industry. Declining numbers of students enrolling in STEM (science, technology, engineering and mathematics) courses may also affect provision of relevant tradespeople, engineers, scientists and researchers.

Skills shortages may affect the ability to design, develop and manufacture building products in Australia.

Shareholder expectations

As some companies move towards triple bottom line and corporate social responsibility agendas, there may be greater shareholder expectations around the “social conscience” of companies in how they source materials, deliver projects and benefit communities in addition to delivering shareholders’ investment returns.

A focus on corporate social responsibility may put pressure on supply chains, especially around the traceability of source materials, accelerating the uptake of RFID (radio frequency identification) tags. It may also increase uptake of environmentally sustainable materials and technologies.

³ Sources: CSIRO, BEIC, Arup

⁴ <http://www.abs.gov.au/Ausstats/abs@.nsf/mf/3222.0>

Affordability & Access

Housing affordability and access to the market were seen as critical to the industry's future.

Affordability concerns may put pressure on building costs, limiting the uptake of enabling technologies to those that reduce material costs.

Aesthetics & Design

At the other end of the affordability spectrum, there may be a desire for high-end design that distinguishes the owner and designer/builder in the market.

Design and aesthetics may be reflected through the uptake of sustainable housing, new materials and automation.

3.1.2 Technological

Consumer attitudes affect technology uptake

Often changing consumer demands drive or affect technology uptake. For example, consumer demands for qualities like personalisation, reliability and accessibility.

Changing consumer tastes may drive demands for different types of materials, devices or building systems.

Commercialisation

A key factor in how technology might drive is the path to market. The speed and effectiveness of the commercialisation process will affect technology uptake and effectiveness in the market.

New materials and incremental changes to existing products may have an easier path to market than technologies and processes that are more transformative and more difficult to commercialise for funding and adaptation reasons.

New materials science

New material science was singled out as key contributor to the Building Products Industry.

Applicable new materials including coatings, steel, wood, concrete and glass products with new characteristics for materials that could be lighter, more sustainable, self-healing, responsive and stronger.

ICT convergence

Emerging information and communication technologies, and their convergence with design, may produce a range of new applications and processes.

For the Building Products Industry, ICT convergence could include human/technology interfaces, sensing, augmented reality, virtual design, services models and integrated delivery of manufacturing.

Cost and availability of resources

The uptake of new technologies will be affected by their cost compared with existing technologies, the value they add and how scarce or difficult they are to source.

Some geo-polymers require a source of fly-ash; other products may rely on raw materials that become scarce over time. The uptake of new technologies will depend on value and comparisons with existing products.

3.1.3 Environmental

Climate change and energy

There are a number of potential effects of climate change on the way we live, including the direct impacts of a changing climate, plus our responses in terms of water use, energy efficiency, coping with extreme weather events, carbon emissions schemes and social impacts. Regulation in these areas will force change within the industry.

New opportunities for uptake of sustainable and low-carbon materials, plus materials and coatings that can withstand extreme weather events (floods, bushfires).

Globalisation including effects of high impacts events eg natural disasters

The connected supply chain and markets mean natural disasters (for example the earthquake in Japan) affect supply chains for a range of manufactured products, and markets into which the industry may sell.

Flexible and responsive supply chains or systems such as virtual design may help provide alternatives when existing supply chains are threatened.

Sustainability

In addition to considerations around climate change, there is growing consumer demand for understanding the life cycle of products and ensuring responsible and efficient use of resources.

There may be opportunities for materials that provide durability such as coatings, or recyclable systems out of integrated building processes.

3.1.4 Economic

Competition from new entrants

As global supply chains improve through the adoption of integrated building products, the Australian Building Products Industry may face competition from external entrants with skills in assembly (for example IKEA or car manufacturers like Toyota).

The uptake of Integrated Building Products, virtual design and construction assembly may need to be prioritised to compete in a global market.

High impacts events like the GFC

Exposure to global markets also means exposure to global fluctuations.

The Australian Building Products Industry may need to specialise in niche products and processes to ensure they have resilience in a global market.

Skills

There may be further skills shortages in the industry due to generational change, transition to new skills, or a lack of appropriate education and training, especially around the specialist skills required with new technologies.

Uptake of enabling technologies in the industry also requires the availability of specialist skills.

Housing affordability

Housing affordability means many buyers are cost-driven which in turn affects the design, materials selection and speed of construction.

Cost pressures provide opportunities to innovate to make materials cheaper, but also barriers in terms of using more sophisticated and expensive technologies in the absence of regulatory or other pressures.

Different valuation approaches

A key economic issue in terms of housing affordability is different approaches to valuation and intergenerational equity. There are a number of economic and/or political responses that may allow the market to respond to sustainability pressures more effectively (for example retrofitting).

Changes that allow for renovation and retrofitting may require new approaches around integrated building products and the use of new materials.

Size of markets

Australia is perhaps too small for effective commercialisation. Population growth may affect future domestic market opportunities, but these may still be insignificant compared with global markets.

Uptake of expensive or complex technologies may not occur due to the difficulties in funding or developing away from large markets.

3.1.5 Political/Legal

Political will

Political will is an important enabler for the industry, especially in terms of setting clear targets for sustainability and safety through planning and regulation.

Setting clear targets on sustainability and medium-high density housing may help to prioritise technologies for uptake within the industry.

Regulatory reform

Regulatory reform could take place in a number of areas including government innovation policy, incentives, green buildings, use of energy and water, specifications for waste, carbon emissions schemes, as well on investment and taxation reforms.

Regulatory pressures such as green building codes have accelerated the uptake of new practices and new materials - new regulations may further drive uptake of enabling technologies.

4. Enabling Technologies for the Building Products Industry

Focusing Question: What are the types of enabling technologies that will be relevant for the Building Products Industry over the next 5-10 years?

4.1 Definition

The Expert Forum of the National Enabling Technology Strategy is focused particularly on new forms of nano- and biotechnologies, including synthetic biology, and those enabled by ITC and cognitive science. The following diagram illustrates the interplay between these enabling technologies:

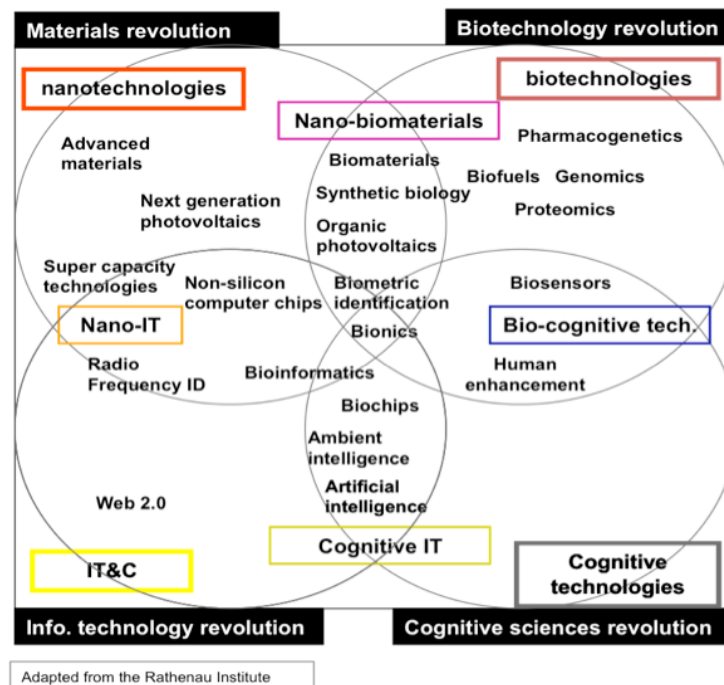


Figure 2: Enabling Technologies (via Dr Craig Cormick, NETS-DIISR)

Enabling technologies are defined as having the following characteristics:

- show high interdisciplinarity;
- are transformative in nature and have the potential to disrupt or create entire industries;
- have the potential for significant, systemic and long-lasting economic, social and political impacts;
- have the potential for development of new capabilities that address existing problems and/or open up new possibilities and markets, and therefore new risks impacting on regulation;
- create new opportunities for responses to global issues.

This definition embraces both the cross-disciplinary natures of enabling technologies and their place in a broader social context. The application and uptake of enabling technologies in the Building Products Industry over the next 5-10 years are presented in the context of this definition.

4.2 Applications of Enabling Technologies

The following tables summarise the enabling technologies that may be most relevant for the Building Products Industry. Further information is available from the presentations by Dr Stuart Bateman and Tristram Carfrae referenced in Appendix 4.

4.2.1 Concrete Products

Technology	Benefits	Market Issues/Problems
Nano-silica SiO ₂	Densifying the micro and nanostructure resulting in improved mechanical properties. Controls degradation of calcium-silicate-hydrate reaction. Improves compressive strength of refined material 3 to 6 times Addition of SiO ₂ nanoparticles part of cement replaced but density and strength increased.	Cement industry CO ₂ emissions (0.97 tonnes for each tonne of clinker produced)
Haematite nanoparticles Fe ₂ O ₃	Added to concrete increases strength and monitors stress through section electrical resistance.	
Titanium Oxide TiO ₂	Reduces airborne pollutants when applied to outdoor surfaces, produces a white colour that retains whiteness and does not stain.	Ordinary cement stains on external surfaces.
Oxidized multi-walled nanotubes (8 times strength and 1/6 th density of steel)	Improves compressive strength and flexural strength, and promises to improve mechanical properties of composite.	Clumping together of tubes and lack of cohesion between them and matrix bulk material, leading to entangling ropes.
Calcium carbonate biosealant, genetically engineered common soil microorganism	Seal or heal cracks in concrete. Part of wider field of 'self-healing' materials.	
Coatings – epoxy resin and nano-clay particles	Blocking the transmission of chloride ions, resistance to carbon dioxide, diffusion of water vapour, water uptake, depth of penetration.	Surface protection of concrete.
Smart aggregate and nano dust sensors	Wide-scale monitoring in a co-ordinated smart network.	Quality control and durability monitoring.
Self compacting concrete using polycarboxylates	Reduces labour costs 50%, poured 80% faster, reduced wear and tear on formwork.	

Technology	Benefits	Market Issues/Problems
Nano-silica particles and hardeners in fibre sheet matrix wrapping of concrete	Increases strength, closes small cracks and forms a strong bond between surface of concrete and fibre reinforcement	

4.2.2 Steel Products

Technology	Benefits	Market Issues/Problems
Sandvik Nanoflex	Desirable qualities of a high Young's Modulus and high strength and is resistant to corrosion due to presence of very hard nanometre-sized particles in the steel matrix.	Matches high strength with exceptional formability.
MMFX2 Steel	Modified nano-structure that makes it corrosion resistant.	Provides an alternative to conventional stainless steel at a lower cost.
Vanadium and molybdenum nanoparticles (research phase)	Improve delayed fracture problems associated with high strength bolts.	
Magnesium and calcium nanoparticles	Increased in weld toughness for steel joints important in welds and heat affected zone adjacent to welds.	

4.2.3 Wood Products

Technology	Benefits	Market Issues/Problems
Use of natural nanotubes, 'nanofibrils' the lignocellulosic (woody tissue) elements in wood to produce passive nanoscale sensors	These are twice as strong as steel. Utilising building functionality onto lignocellulosic surfaces at the nanoscale leading to self-sterilizing surfaces, internal self repair and electronic lignocellulosic devices.	
Silica and alumina nanoparticles with hydrophobic polymers	Water repellent coatings based on actions of the lotus leaf.	Water resistance

4.2.4 Glass Products

Technology	Benefits	Market Issues/Problems
Titanium dioxide to coat glazing	Sterilizing and anti-fouling, by breaking down organic pollutants, volatile organic compounds and bacterial membranes.	
	Hydrophilic properties convert water drops to sheets that wash off dirt particles to produce self cleaning glass.	

Technology	Benefits	Market Issues/Problems
Fumed silica nanoparticles to form rigid and opaque fire shield when heated	Fire-protective glass	
Thin film coatings (passive)	Filter out unwanted infrared frequencies of light which heat up a room and reduce heat gain in building.	Thermal and energy efficiency
Active thermochromic technologies	Thermal insulation while maintaining adequate lighting.	Thermal and energy efficiency
Electrochromic coatings using tungsten oxide layer	React to changes in applied voltage .	Thermal and energy efficiency

4.2.5 Coatings Products

Technology	Benefits	Market Issues/Problems
Self-healing and self-assembly nano-engineered coatings in paints and insulating materials	Corrosion protection	
Coating materials for roadways	Reduces nitrous oxides, breaking down organic and inorganic air pollutants.	

4.2.6 ICT & Electronic Products

Technology	Benefits	Market Issues/Problems
Flexible Electronics <ul style="list-style-type: none"> • OLED, OPV, OFETS • R2R printing • Devices 	New interfaces and devices	
Integrated Design, Integrated Building Products (RFID)		
Virtual Design (BIM)		

4.2.7 Biomimicry & Biotechnology

Technology	Benefits	Market Issues/Problems
Bio-based feed stocks		
Biomimicry		

4.2.8 Fire Protection

Technology	Benefits	Market Issues/Problems
Carbon nanotubes mixed with cementitious material to make fibre composites, use of polypropylene fibres	Fire resistance through tough, durable high temperature coating	Fire prevention and rapid response
Nano-electrical sensors	Whole buildings become networked detectors	

4.2.9 Sustainability and Environmental Issues

Technology	Benefits	Market Issues/Problems
Nanoporous aerogel structures	Repels water and mould	Sustainability of materials
Silica based transparent insulation	Super-insulating windows	Energy efficiency
MEMS and NEMS, micro or nano-electromechanical system devices using microfabrication methods		Energy efficiency
Layered double hydroxide materials	Slow release of admixtures in concrete to increase workability with time.	Sustainability of materials
Iron nanoparticles	Transform and detoxify chlorinated hydrocarbons in groundwater. Transform heavy metals such as soluble lead and mercury to insoluble forms, thus limiting their transport and contamination.	Clean water Remediation of contaminated sites
Dendrimers	Trap metal ions in their 'pores' as form of water filtration – can work on metallic and organic contaminant ions.	Clean water Remediation of contaminated sites

4.3 Contexts for Innovation

The uptake of enabling technologies should be considered within the context of the market needs and drivers and how enabling technologies offer solutions. From the background preparation, guest presentations and also out of the STEEP analysis, there were five major categories that could be seen as driving innovative solutions.

1. **Sustainability.** Arup has reconceived sustainability as “delightful efficiency”. Sustainability drives the uptake of enabling technologies that reduce household energy consumptions, allow for consideration of a whole of life cycle footprint and take embodied energy into account.
2. **Extreme environments.** Particularly sought after qualities include durability, safety and flexibility to cope with storms, floods and fires.

3. **Smarter functionality** and IT as an enabler. This can be demonstrated through new approaches to sensing, virtual design, manufacturing instead of construction, improved asset management and smart Infrastructure.
4. **Leadership** in terms of which companies are driving the uptake of new technologies and which competitors might start to enter the building products market (eg Toyota, IKEA)
5. **Aesthetics and affordability**. The trade off between cost, design and functionality.

The background briefing materials provided to participants that summaries some of the enabling technologies with these contexts in included in Appendix 5.

5. Future Possibilities

Focusing Question: **Where are enabling technologies likely to play a role in the future?**

5.1 Key Influencing Decisions

In the workshop, participants discussed major decision points - how key challenges might be addressed or in turn drive change in the industry. Out of this process emerged a recognition that innovation happens in both pull and push directions. In some cases the development and uptake of enabling technologies will drive change, in others the provision of enabling technologies will assist in addressing broader challenges. A summary of the raw decision point analysis is included in Appendix 6.

5.1.1 Uptake of Industry-Changing Technologies

The championing of new enabling technologies may create opportunities for the Building Products Industry that aren't yet being realised, creating new avenues for economic and social contribution.

Building Information Modelling: Virtual Building

An option is to actively encourage Building Products manufacturers to develop virtual models of their products for including in virtual design systems, leading to access to a global market. The critical decision points relate to how fast the industry responds to the challenge of enabling its products as virtual models for broad application.

Integrated Building Products

The adoption of Integrated Building Products means adopting an assembly approach to construction and requires the uptake of enabling technologies including sensors and identification (eg RFID) as well as changes to skills sets. Key to uptake is the strength of the local industry to respond, against the importation of manufactured components from overseas.

The critical decision-making trajectory for the adoption of enabling technologies such as these includes commercialisation pathways, support for innovation and market opportunities. The timing and provision of support for making investment decisions in enabling technologies would result in different scenarios.

5.1.2 Technologies as a Response to Challenges

Addressing current cultural and structural challenges requires a mix of political, regulatory and industry responses. However in addressing major current issues like planning and a carbon tax, new avenues for the adoption of enabling technologies may be created.

Carbon tax and the move to a low-carbon future

Current uncertainty is sending mixed signals into the market. In the workshop, a clear direction on a carbon tax was considered as having the potential to open up opportunities to drive change. While a current issue, the carbon tax is a symbol of the pressure towards a low carbon future. Applicable enabling technologies that would support a low carbon future include energy and resource efficient building materials, energy-creating coatings and/or panels and sensing technologies.

Specifications in building codes and planning policies

The uptake of sustainable materials may be driven by consumer demand or by regulation such as the introduction of stricter planning processes and Green Building codes. Additional reasons for regulation could include housing affordability and safety (eg disaster mitigation).

The timing of regulatory intervention and the setting of targets were discussed in the workshop as either an inhibitor or an enabler to the uptake of new technologies.

5.2 Alternative Possible Scenarios

Three possible scenarios were developed from the key considerations raised during discussions, specifically a response to climate change through a Carbon Pollution Reduction Scheme or carbon tax, the degree of participation in global markets, the value placed on innovation and the availability of appropriate skills. The three scenarios are called “Carbon Attached”, “Carbon Mandated” and “Carbon Compromised”.

5.2.1 Carbon Attached

- 2013-15 sees total community rejection of any action on reducing a carbon-dependent economy by taxation or trading scheme, particularly in the light of no progress in an international agreement.
- This is linked to a significant protectionist, anti-globalisation swing.
- The Australian economy becomes even more dependent on mining exports.
- A modest level of subsidized manufacturing continues but with little interest in innovation.
- Traditional models hold firm, so there is little progress on introducing integrated building systems.
- Little shift in housing affordability.
- With a somewhat stagnant Building Products Industry, there is limited interest in working in the industry, leading to continued skill scarcity.
- Moderate progress towards higher sustainability targets.
- Little interest or capability in the development or take-up of enabling technologies.

5.2.2 Carbon Mandated

- 2013-15 sees the establishment, against strong opposition, of a high-impact national emission trading scheme, supported by a shift in public opinion driven by the worst cyclone season in Australian history, with high force cyclones tracking as far south as Perth and Sydney.
- Local energy and manufacturing industries are hard hit, and there is a significant shift overseas and an increase in manufacturing imports, with a consequent sharp rise in the trade deficit.
- Sustainability targets are strengthened, and there is some progress towards them in a low growth economy.
- Some imported housing products are substantially cheaper, but inefficient assembly and construction processes limit the impact on housing affordability.
- The skill requirements are largely in assembly.
- Some applications of enabling technologies are identified as central in a low-carbon housing industry, but sluggish economic conditions limit investment and take-up.

Possibly transitioning to

5.2.3 Carbon Compromise

- 2013-15 sees the emergence of a strong community and political consensus on the appropriate model for economic development over the next decade, based around a committed but gradual transition to a moderate carbon economy. Factors leading to this outcome include the public's rejection of conflict-based politics and the Chinese decision to set tough carbon reduction targets for all their imports.
- There is a strong growth in specialist design and manufacturing capability, sold globally.
- A concerted housing plan to address the needs of the growing population leads to a significant restructuring of the financial and land development systems to improve housing affordability.
- This is linked to a big push to adopt integrated building systems approaches.
- Strong growth in training and availability of relevant specialist skills.
- Strong progress in sustainability opening a wide range of new markets and services.
- Strong investment in and uptake of enabling technologies – world- leading products developed in CSIRO and universities are taken to global markets by Australian and international companies.

5.3 SWOT Analysis

Focusing Question: **Where are the gaps and opportunities in the uptake of enabling technologies?**

Each of the three scenarios presented pose opportunities and threats for the Building Products Industry in Australia. These are summarised in the table overleaf:

Scenario	Opportunities	Threats
Carbon Attached	<ul style="list-style-type: none"> • Building Products Industry not disadvantaged by local carbon price in a global market. • Some opportunities for sustainable building applications. 	<ul style="list-style-type: none"> • Locked out of global supply chains due to focus on local industry. • Lack of skilled labour and labour supply. • Competition on price rather than on quality or differentiation due to lack of innovation.
Carbon Mandated	<ul style="list-style-type: none"> • Materials, devices and processes to meet new sustainability targets. 	<ul style="list-style-type: none"> • High-impact emissions scheme impacts profitability. • Increase in manufacturing imports threatening local industry. • Difficulties in ensuring appropriate skills sets.
Carbon Compromise	<ul style="list-style-type: none"> • Access to global markets and supply chains. • Changes to housing affordability means changes to types of materials under consideration if cost not prohibitive. • Materials, devices and processes to meet new sustainability needs. • Growth in industry leads to provision of specialist skills areas. 	<ul style="list-style-type: none"> • Innovation in Australian research is taken-up faster by international companies. • Competition for specialist skills from Australia overseas.

In light of the opportunities and threats posed by each of the scenarios, and in consideration of technology uptake and broader industry challenges, the strengths and weaknesses of the Building Products Industry to respond to these opportunities and threats are summarised in the following table:

Influencing Decisions	Strengths	Weaknesses
Uptake of new technologies	<ul style="list-style-type: none"> • Research portfolio within CSIRO and other Australian universities. • Some large company engagement in adopting enabling technologies. 	<ul style="list-style-type: none"> • Commercialisation gaps in terms of timelines. • Low institutional/private investment and funding for commercialisation of research. • Lack of expertise in undertaking technology transfer.

Influencing Decisions	Strengths	Weaknesses
Response to challenges	<ul style="list-style-type: none"> Stronger market for housing and building products demonstrated during financial downturns means there is a base for further growth. Existing expertise within the industry in response to changes in regulations such as Green Building codes. 	<ul style="list-style-type: none"> Industry culture not well adapted for innovating to external pressures such as regulation. Ability to meet training demands for specialist skills.

5.4 Preferred Future

Focusing Question: What is the preferred future as outlined by these stakeholders?

As scenarios were developed using the STEEP and decision point analyses after the workshop, it is not possible to say which scenario would have been the preferred option for the group. Certainly some participants called for a strong signal on carbon and/or sustainability targets and showed an appetite for moving towards Building Information Modelling and Integrated Building Products. However some participants seemed to prefer perseveration of the local industry, and saw addressing current issues such as affordability to be a greater priority than the uptake of enabling technologies.

Overall, the ideas about preferred futures that emerged from the workshop included the following:

- A new vision, one that re-imagines the future, eg “delightful efficiency”.
- A clear signal on the need for a low carbon economy to pursue appropriate technologies.
- A local building products manufacturing industry.
- An industry that is supported by data and measurement systems to inform minimum standards and then enforcement.
- A sustainable industry, environmentally in terms of carbon and materials, socially in terms of affordability and economically.
- Support for R&D and innovation to accelerate commercialisation to assist in leveraging industry advantage and competitiveness in a globalised market.
- More rapid progress towards the adoption of an Integrated Building Products approach to design and construction.

6. Policy Implications

Focusing Question: What are the priority issues that NETS and the BEIIC need to address to progress the uptake of relevant enabling technologies in the Building Products Industry?

In expanding the thinking developed at the workshop, there are a number of potential policy implications to be considered by stakeholders in the Building Products Industry:

- **Commercialisation processes.** How might industry and government accelerate the commercialisation process to ensure industry can implement commercially viable products for advantage in a global market?
- **Sustainability targets and incentives for low-carbon materials.** How might NETS demonstrate the link between enabling technologies that support low carbon and sustainable futures?
- **Priority technologies.** While a range of new technologies have been identified and discussed, there seems to be a few that could be transformative rather than incremental. Based on the discussions during the workshop these may include Integrated Building Processes, Building Information Modelling (Virtual Design) and new materials for energy efficiency and low carbon processes. Commercialisation and uptake of these technologies should be given priority.
- **Industry awareness.** Further communication of the range of enabling technologies, their applications and timelines to market might assist in helping industry identify relevant technologies for their part of the sector or supply chain. Links to research processes and institutions could continue to assist in this process of technology transfer. Demonstration projects could provide a powerful learning and awareness tool.

7. Conclusions

The key question for this report was how might the uptake of enabling technologies assist the Building Products Industry to create an economically and environmentally sustainable industry and community in the future?

From the analyses conducted across the workshop process including preparation of materials, the facilitated workshop and for this report, there are a number of ways in which the uptake of enabling technologies might create an economically and environmentally sustainable industry into the future. These include:

- The commercialisation of new materials for energy efficiency and low carbon processes, as well as those that provide cheaper options for the housing affordability.
- Differentiation in the market through the adoption of innovative materials, coatings and devices that arise from new materials and smarter functionality.
- The use of new materials and design features that provide safety and durability to cope with extreme weather events.
- Access to a global market with product participation in Building Information Modelling systems.
- More competitive processes through the uptake of Integrated Building Products systems.

The adoption of enabling technologies may assist the Building Products Industry in becoming more responsive to environmental and industry changes, and establishing competitive strengths in a global market.

Appendix 1: Workshop Agenda

Program of the Building Products Foresight Workshop

9:30 am	Registration and coffee
10:00 am	Opening remarks <ul style="list-style-type: none"> • Peter Chesworth, Department of Industry, Innovation, Science and Research • Tristram Carfrae, Built Environment Industry Innovation Council
10:05 am	Objectives and Introduction to Foresight <ul style="list-style-type: none"> • Dr Kristin Alford, Bridge8 Pty Ltd • Prof Ron Johnston, Australian Centre for Innovation Ltd
10:15 am	Overview of the potential applications of new enabling technologies in the Building Products Industry. Speakers: <ul style="list-style-type: none"> • Dr Stuart Bateman, CSIRO
11:00 am	Break
11:15am	Speakers: <ul style="list-style-type: none"> • Tristram Carfrae, Fellow and Group Board Director, Arup
11:45 am	Identification of key drivers of the Building Products Industry
1:00 pm	Lunch
1:45 pm	Alternatives and decision points for the future of the Building Products Industry
3:20 pm	Implications for uptake and identification of policy issues
4:00 pm	Summary of workshop findings
4:30 pm	Close

Appendix 2: List of Invited Participants

Adrian Haddock	On Site Building Ltd
Andrew Parratt	Clean Technologies Supplier Advocate, DIISR
Anthony Butler	BEIIC Design Manager, Leighton Contractors Pty Ltd
Barbara Lepani	Expert Forum Secretariat, Enabling Technology Policy Section, Innovation Division, DIISR
Bill Burns	Australian Institute of Building Surveyors, State Executive Officer Building Products Innovation Council (BPIC).
Bill Thompson	GM, Innovation & Market Development, CSR Ltd
Bob Appleton	Director, Technical & Regulatory Policy, Master Builders Australia
Bruce Robb	General Manager, Delfin Residential, Lend Lease
Caroline Pidcock	Pidcock Architects
Craig Johnson	Assistant Manager, Co-ordinator of the Health, Safety and Environment Working Party, Enabling Technology Policy Section, Innovation Division, DIISR
Craig Simmons	Director, Construction Services ACT Government
David Lyons	James Hardie R&D, JH Global Research Development Centre
Des Chalmers	Group Product and Process Technology Manager, Cement Australia
Elisabeth Egle	BEIIC Secretariat, DIISR
Ellaine Atwood	Consumer Federation of Australia representative on NETS Stakeholder Advisory Council
Glenn Simpkin	BPIC, Chair National Manufacturer's Council, Marketing Manager, Boral
Greg Foliente	BEIIC and Senior Science Leader, CSIRO Ecosystem Sciences
Greg Simpson	CSIRO, Deputy Chief, Materials Science and Engineering Division
Harry Stulajter	CEO, Nanovations (nano coatings on building products)
Ian Frame	CEO Building Products Innovation Council
James Kell	BEIIC CEO Kell & Rigby
Ken Slattery	CEO, Cement Concrete & Aggregates Australia

Kristin Tomkins	BPIC, Housing Industry Association
Lance Jeffrey	Project Manager Sustainable Buildings Research Centre, UOW
Nigel Carpenter	BPIC, Australian Glass and Glazing Industry
Paul Cooper	Professor, Director Retrofitting for Resilient & Sustainable Buildings, University of Wollongong
Peter Chesworth	General Manager, Pharmaceuticals, Health Industries & Enabling Technologies Branch, Innovation Division, DIISR
Phil Toner	Senior Research Fellow, University Western Sydney Centre for Industry and Innovation Studies
Renata Musolino	Union representative on NETS Stakeholder Advisory Council
Sari Ruuska	Biotechnology Innovation Policy Section, Innovation Division, DIISR
Sean McDonald	Assistant Manager, Supplier Advocate Secretariat, Manufacturing Division, DIISR
Stuart Bateman	CSIRO, Theme Leader Sustainable Materials
Swee Mak	CSIRO, Acting Director, Future Manufacturing Flagship
Tim Davey	Senior Team Leader, Latex Research, Dulux
Tito Ceuva	Engineers Australia, Nano Subcommittee
Tone Wheeler	Principal Architect Environa Studio
Trent Bourne	Australian Building Codes Board
Tristram Carfrae	BEIIC Arup Fellow and Chair Global Building Sector, Arup

Appendix 3: Raw STEEP Analysis

What are the potential drivers that might impact on the uptake of enabling technologies within the Building Products Industry?

Factors	Issues Identified
Social / Environmental	<p>Population growth and demographics and resulting effects on mobility, transport and housing</p> <p>Climate change, particularly water, energy, weather extremes, carbon and the costs or social impacts</p> <p>Political will</p> <p>Skills availability resulting from an ageing workforce and a decline in baby boomers</p> <p>Taxation</p> <p>Shareholder expectations around the social conscience of companies.</p>
Technological	<p>Consumer attitudes affect technology uptake eg demand for personalisation, reliability and on demand. Also issues re ownership, leases and community assets</p> <p>Competition from new entrants include larger integrators</p> <p>Commercialisation</p> <p>National and local developments including government policy, regulations and incentives</p> <p>Globalisation including effects of competition and high impacts events like the GFC or natural disasters</p> <p>New materials science</p> <p>ICT convergence, human/technology interfaces, augmented reality, integrated delivery of manufacturing or services models</p> <p>Cost and availability of resources</p>

Factors	Issues Identified
Economic	<p>Skills shortage, generational change, transition to new skills, education and training</p> <p>Housing affordability, costs of funding and making a profit</p> <p>Short term measures of success</p> <p>Intergenerational equity (tax is currently on equity of current generation)</p> <p>Energy efficiency needs and cost of energy (currently low and/or undervalued in Australia, as it the benefit of effective/efficient buildings)</p> <p>Research – Australia is too small, small market for commercialisation</p> <p>Different valuation approaches</p> <p>Derivative financial instruments (doing better job) to transform to longer, better measureable, etc. For example, mandatory disclosure, increasing knowledge and enable market to respond more effectively eg retrofitting, increase visibility and incentives.</p> <p>Population growth is change-inducing on economic markets, economic growth</p> <p>Multi-faceted approach, education, information, tools, policies, self-regulation, incentives and disincentives.</p> <p>Tax and regulatory reform</p>
Legal / Political	<p>Housing affordability and effects from trade barriers and competition in the global supply chain</p> <p>Legislation and changes to rules around energy, water and waste; regulation on carbon</p> <p>Investment and how this affects affordability</p> <p>Also affordability measures including zoning and medium/high density living</p> <p>Building codes, especially in relation to extreme weather events such as fire and floods</p> <p>EH&S, safety</p> <p>IP</p> <p>Product stewardship</p>

Appendix 4: Guest Presentations

For presentations by Dr Stuart Bateman, CSIRO and Tristram Carfrae, Arup please see separate PowerPoint attachments.

Appendix 5: Technologies in the Building Products Industry

	Energy Efficiency	Resource Efficiency	Life Cycle Sustainability & Resilience	Affordability & Access	Aesthetics & Design
Overall	<ul style="list-style-type: none"> Zero-emission design 	<ul style="list-style-type: none"> Improved manufacturing processes using recycled materials and/or generation of less waste Better processes for demolition, reuse and recycling of building and inherent materials 	<ul style="list-style-type: none"> Management systems for declaring content of all building materials on products 	<ul style="list-style-type: none"> 	<ul style="list-style-type: none"> Design of components that easily assemble and dissemble for reuse
External Walls	<ul style="list-style-type: none"> Nano-structured phase change materials for super-insulation Heat-absorbent nano-particulate paints Building envelope technologies and air handling systems that reduce heating and cooling Energy-generating exteriors using solar technologies (eg sails, coatings) 	<ul style="list-style-type: none"> Low carbon footprint geopolymer technologies 	<ul style="list-style-type: none"> Fire-resistant materials Nano-structured high strength, light weight materials for severe events Self-repairing materials and paints Nano-silica particles and hardeners for better concrete and fibre reinforcement Corrosion resistant steel materials eg MMFX2 	<ul style="list-style-type: none"> Self-compacting concrete for reducing labour costs 	<ul style="list-style-type: none">
Roofs	<ul style="list-style-type: none"> Nano-structured phase change materials for super-insulation 	<ul style="list-style-type: none"> 	<ul style="list-style-type: none"> 	<ul style="list-style-type: none"> 	<ul style="list-style-type: none">

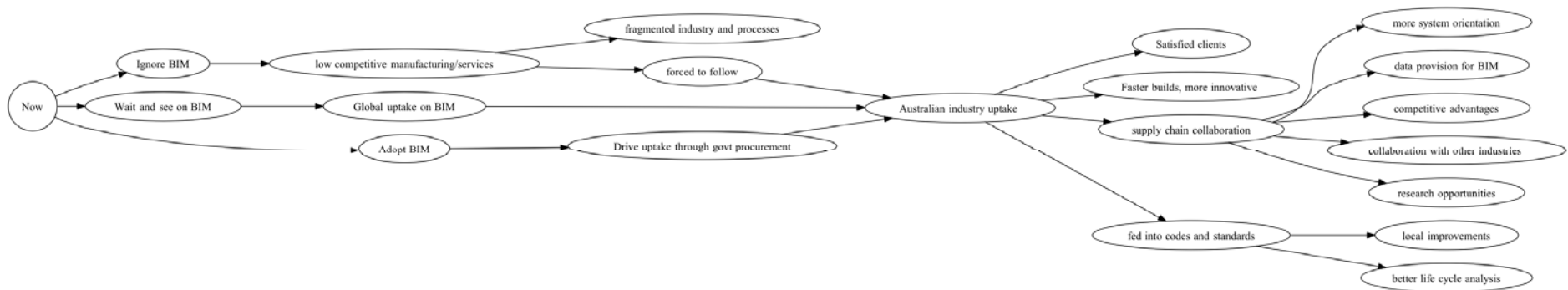
	Energy Efficiency	Resource Efficiency	Life Cycle Sustainability & Resilience	Affordability & Access	Aesthetics & Design
Floors		<ul style="list-style-type: none"> Carpet materials from bioproducts eg DuPont's Sonora cornstarch polymer, NatureWorks poly-lactic resin 			
Windows	<ul style="list-style-type: none"> Smart glazing, heat and UV blocking transparent coatings 		<ul style="list-style-type: none"> Smart coating systems including self-cleaning, odour eliminating, biocidal 		<ul style="list-style-type: none"> Smart coating systems including self-cleaning
Energy & Electricals	<ul style="list-style-type: none"> OPV Solar Cells Nano-scale sensors Energy management systems (eg CSIRO's AusZEH) Bio-generation of electricity Distributed and local power systems 	<ul style="list-style-type: none"> Sucrose-based polyether polyols for insulation of refrigerators 			<ul style="list-style-type: none"> Zero-emission design principles
Water, Waste & Plumbing		<ul style="list-style-type: none"> Nano-scale sensors Water reuse systems 	<ul style="list-style-type: none"> High strength materials for pipes 		
Interiors		<ul style="list-style-type: none"> Biodegradable plastic from plant oils for wood composites 	<ul style="list-style-type: none"> Fire-resistant materials Smart coating systems including self-cleaning, odour eliminating, biocidal Self-repairing materials and paints 		<ul style="list-style-type: none"> Silica and alumina nanoparticles with hydrophobic polymers for self-cleaning and water resistance.

	Energy Efficiency	Resource Efficiency	Life Cycle Sustainability & Resilience	Affordability & Access	Aesthetics & Design
Exterior living spaces & Garden		<ul style="list-style-type: none"> Nylon 11, a polyamide bioplastic for outdoor furniture Self-healing concretes using calcium carbonate biosealant Surface protection of concrete using nano-clays to reduce water uptake 	<ul style="list-style-type: none"> Use of TiO₂ to reduce airborne pollutants 	<ul style="list-style-type: none"> Self-compacting concrete for reducing labour costs 	<ul style="list-style-type: none"> Smart aggregate and nano dust sensors

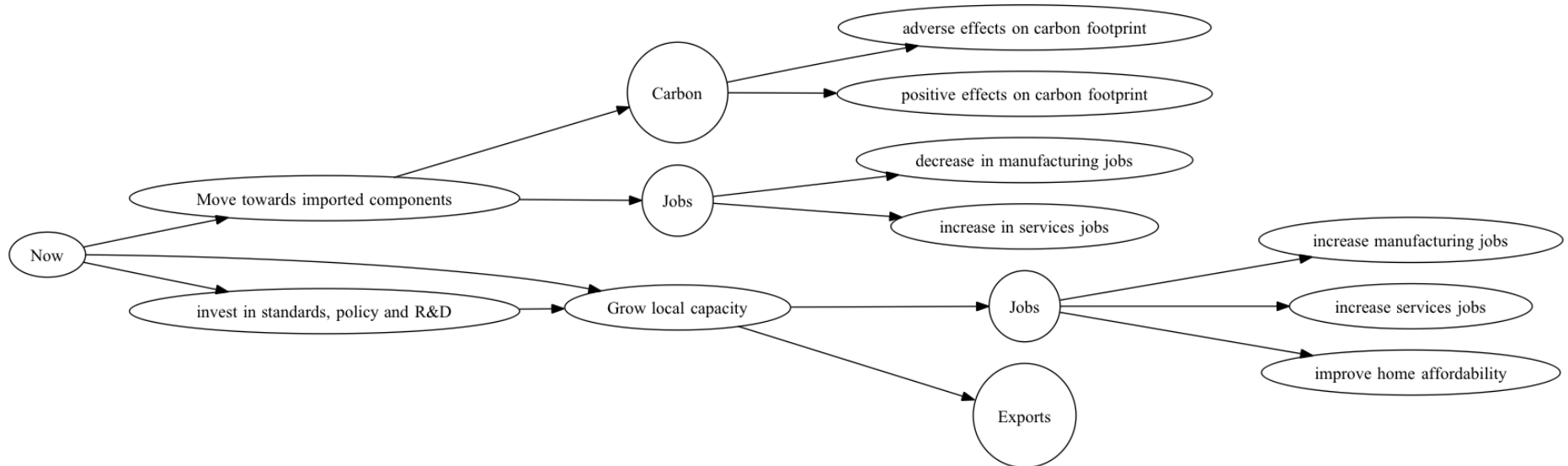
Sources: CSIRO, BEIIC, Arup

Appendix 6: Decision-Tree Analysis

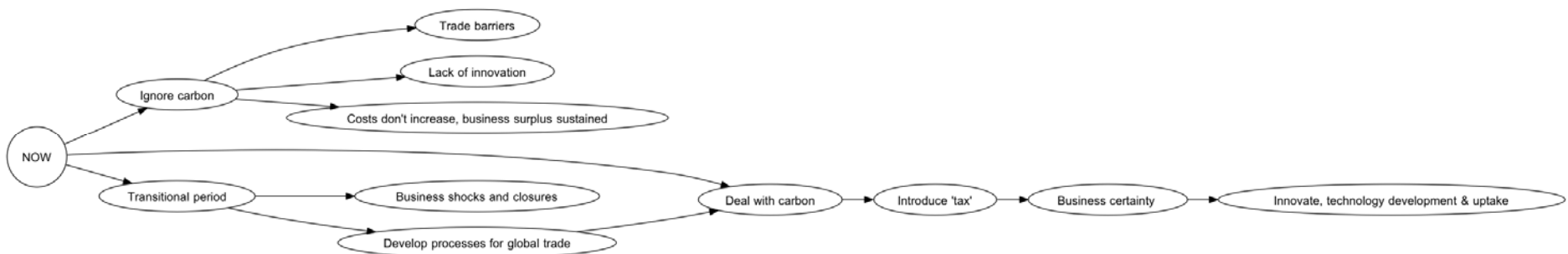
Building Information Modelling: Virtual Building



Integrated Building Products



Carbon tax and the move to low-carbon futures



Specifications in building codes and planning policies

