The Future of Roads

Reducing Environmental Pressures, Managing Carbon, and Considering Future Scenarios

Australia's road network and transportation infrastructure faces increasing pressure from a range of factors, including: population growth and urbanisation; changes to weather patterns; increases in energy and resource prices; road material resource shortages; and the changing usage and expectations of roads and transport. There is a growing imperative for road agencies to address such pressures with informed and transparent approaches. SBEnrc's research has found that significant sustainability gains are feasible in design, construction, maintenance and operation. They focus on three specific needs:

1. To reduce greenhouse gas emissions related to road construction;
2. To identify reporting frameworks and key reporting areas for roads; and
3. To identify potential trends and future risks affecting roads.

The key findings inform a range of actions for moving forward, namely: capacity building to identify short term options to 'reduce greenhouse gas emissions' during construction, design, maintenance and operation on existing and future road projects; enhancing 'sustainability reporting' efforts, such as to AGIC and the GRI; and ongoing strategic consideration of the '*risks and opportunities*' associated with current and future trends.

Benefits to industry include: Improving strategic positioning; providing guidance on areas of specialisation; and understanding market gaps and arising business opportunities.

Benefits to government include: informing policy and management decisions; providing insight into changing roles and leverage points for action; providing a scenario planning framework; and informing further research areas.

Both will need transparent and strategic reporting mechanisms to show how the new challenges for road delivery and operations are being addressed.

The research

As part of the SBEnrc focus on industry-led research, two stakeholder workshops were held in the early stages of the project, and two more in the later stages, hosted by SBEnrc partners, Main Roads Western Australian and the Queensland Department of Main Roads and Transport. The initial workshops involved the research team presenting the key findings of a literature review and working with key stakeholders to identify areas of interest for the project to develop. A wealth of evidence and precedent was produced to show that road projects can improve sustainability outcomes through design, construction, maintenance and operation. The result of the workshops was a project scope that investigated key areas of interest to partners and that were seen to be areas that would provide clear benefits to industry and government. Following the initial workshops a series of meetings were held with SBEnrc partners to refine the scope in light of the key findings of the research team. The second stage of stakeholder workshops focused on trends and future risks affecting roads; and involved a run through of a new methodology for undertaking trend assessments that will be the basis of the next stage of the project.

Sustainable Built Environment National Research Centre

Aims

Based on industry feedback the project focused on:

1. Providing a '*clear description*' of a range of options for reducing the carbon intensity of roads in the design and construction phases, in particular considering aggregates and asphalt as key areas with concrete and road lighting also topics of interest.
2. Investigating how '*sustainability reporting*' applied to road projects and identifying relevant assessment and rating tools. This focused on understanding the level of sustainability reporting in road projects in Australia and Internationally.
3. Developing a '*strategic process to consider future trends*' to provide government and industry with a tool to consider future trends, consider the likely intensity of such trends over time, identify risks, identify interactions, and brainstorm strategies that can minimise risk and delivery with multiple benefits across key trends.

Key findings

In a September 2012 edition of the Economist, a lead article examined the emerging global awareness that car use has peaked in the world's developed cities.[1] It quotes an Australian Government report examining the phenomenon and speculates on what may be causing it and what it could mean for government policy—especially on roads. The factors considered to be significant were those impacting many other areas of the economy, including: the use of digital communications instead of travel; internet shopping; changing demography with younger people more urban and less oriented to the attractions of the car; and increased fuel costs due to oil scarcity and climate policy.

While road agencies are digesting what this may mean for their priorities and approaches to road building and management, they are also under increasing pressure to provide solutions to congestion and the political cycle of promised new roads. This SBEnrc project identifies three key needs that are becoming pressing priorities for road agencies that are facing such a conflicted future.

1. The need to reduce greenhouse gas emissions related to road construction

One of the most immediate pressures is the need to respond to climate change, and in particular the need to reduce carbon intensity through options such as: reducing automobile fuel consumption through the design of road alignments (vertical and horizontal); adapting roads for multiple users; reducing embodied energy of aggregates, cement and asphalt; reducing and avoiding fossil fuel use in hauling and onsite transport of materials and water; and reducing energy requirements of route and signal lighting.

Table 1: Impacts of Climate Change on Road Infrastructure

Issue	Implication for Roads
Costs of greenhouse gas emissions	• Reducing automobile fuel consumption through the design of road alignments (vertical and horizontal) • Reducing energy intensity of aggregates, cement and asphalt • Reducing and avoiding fossil fuel use in hauling materials and water • Reducing energy requirements of route and signal lighting • Adapting roads for multiple users
Temperature increase & severe droughts	• Increasing road maintenance of surface cracking due to changing landscape topography caused by evaporation • Increasing maintenance due to wear and tear of road surfaces from higher temperatures • Increasing rehabilitation of road surfaces due to surface cracking, warping and asphalt bleeding (flushing)
Increased extreme rainfall events & flooding	• Increasing road maintenance due to potholes from water entering the road surface • Increasing road rehabilitation due to flooding events affecting large expanses of roadways • Decreasing ability for maintenance and rehabilitation to take place due to extreme wether events affecting construction days and access • Increasing pressures on road network and drainage systems due to road flooding
Sea Level Rise	• Increasing salt-water corrosion of roads due to higher water tables from flooding and sea level rise. • Increasing regularity of storm surge and wave impacts on coastal and low-lying areas
Increased Cyclones	• Increasing road damage and traffic hazards due to debris on roads • Increasing regularity of storm surge and wave impacts on coastal and low-lying areas

Five key focus areas for reducing greenhouse gas emissions and other environmental pressures are: road design, aggregates, asphalt, concrete, and road lighting.

For example, in Australia there are now a number of states with specifications and guidelines that regulate the use of recycled materials in roads. Such efforts in construction and other areas are providing a wealth of experience and knowledge in innovative approaches to road construction and maintenance, including: road bases that reuse previous pavement layers; road surfaces that use scrap tyres, plastic bags and plant based bitumen alternatives; and lighting designs that achieve radical energy and cost reductions by implementing new lighting and signal technology.

1 Economist (2012) The future of driving, Seeing the back of the car, In the rich world, people seem to be driving less than they used to, 22 September 2012

Key areas for reducing environmental pressures related to roads

DESIGN

Route design
Pavement design
Material specifications
Alternative road users
Knowledge transfer

CONCRETE

Materials
- Use of alternative aggregate material.
- Use of cement alternatives including sulfo-aluminate, magnesium-phosphate, and alumino-silicate cements.

Processes
- The potential to achieve carbon storage in concrete, in particular magnesium-phosphate cements.
- Innovations in methods and techniques for cement placements.

AGGREGATES

Placement
- Saline or non-potable water stabilisation.
- Non-potable water for dust control.

Alternative Materials
- The use of waste products-concrete, tyres, glass, bauxite residue, and waste building materials.
- Plant based bitumen alternatives.
- The use of in-situ stabilisation techniques such as foamed bitumen to reduce the need for aggregate.

LIGHTING & SIGNALS

Potential to reduce consumption of electricity and associated greenhouse gas emissions through lighting choices, such as using energy efficient route lighting using LEDs, and demand management.

ASPHALT

Materials
- The use of alternate materials such as rubber crumb and recycled asphalt.
- Opportunities to innovate bitumen mix design.

Processes
- The use of warm mix technologies.
- The use of cold mis applications.
- Innovations in methods and techniques for bitumn placement.

2. The need to measure and report on the sustainability of roads

Road agencies in Australia are experiencing an increasing focus on reporting on the performance of projects. Beginning with an initial focus on '*environmental reporting*', focused on ecological impacts and disturbances of road construction, the focus of reporting has broadened to '*sustainability reporting*'. Much of the data that is required to fulfil the new generation of project reporting is already being collected across many road construction projects. However, it is clear that the data is not systematically presented in a way that encourages use or transparency in reporting. There is an increasing focus on appropriate sustainability metrics for reporting performance that capitalise on measurement and reporting already undertaken. This includes identifying the effective use and implementation of recycled materials, ameliorating in-situ materials, and using industrial by-products. In addition, metrics are increasingly being used to monitor the environmental and carbon performance across a number of factors.

Developed and administered by the Australian Green Infrastructure Council (AGIC), the 'Infrastructure Sustainability' (IS) tool uses a framework of 15 categories within six broad themes, developed in collaboration with industry. The categories '*Energy and Carbon*' and '*Materials*' directly focus attention on carbon reporting through prioritising reducing greenhouse gas emissions, minimising energy demand, recognising the use of greenhouse gas emissions offsets, and considering material life cycle impacts. Fourteen pilot trials for the rating tool were undertaken nationally and showed how useful the tool could be if mainstreamed, especially if aligned to the tender stages of the project.

The Global Reporting Initiative (GRI) was developed by the US non-profit organisations the Coalition for Environmentally Responsible Economies (CERES) and the Tellus Institute. This tool provides a comprehensive sustainability reporting framework that is widely used around the world, including by road agencies. The framework enables all organisations to measure and report their economic, environmental, social and governance performance. Based on the outcomes of this project the next phase of the research will inform a process by the *Global Reporting Initiative* to explore important topics in the transport sector to enhance their important organisational sustainability reporting process. It is a significant achievement for SBEnrc to be invited to contribute to this process.

3. The need to identify potential trends and future risks affecting roads

Future environmental, economic, and social trends associated with roads will have a significant impact on their associated costs and impacts. The project considered a short list of 10 potential trends, their interactions and implications for future risk.

1. Increase in the cost of road maintenance;
2. Increase in extreme weather events;
3. Oil based road surfacing unfeasible;
4. Trips by walking, cycling and public transport increase;
5. Aggregate shortages;
6. Freight vehicles increase in size and quantity;
7. Funding constraints on new projects and on maintenance of existing infrastructure;
8. Transport infrastructure reaches capacity;
9. Electric and alternative fuel vehicles are mainstream;
10. City planning requires intensification along rail lines & infill development.

When looking at such trends the project considered how their intensity might change over time through 'trend profiles', providing a structure to consider associated risks and opportunities for road agencies. This project then distilled a number of strategies that could underpin transport agencies to prepare for the future risks associated with key trends, in particular strategies that are able to address multiple trends. These included:

- Road pricing mechanisms
- Government action to support change
- Investment in research and development
- Analysing investment priorities
- Incentivising preferred practices
- Increasing the efficiency of existing infrastructure
- Creating adaptable design standards
- Sharing knowledge and building capacity
- Investing in carbon management
- Transit oriented development.

These strategies highlight the changing role of road agencies, and importantly, the structural shift that is occurring within organisations, focusing less on new infrastructure and more on maintenance and enhancing the efficiency of existing roads.

Benefits to industry and government

Industry Benefits: This research project seeks to contribute to industry conversation around 'sustainable road infrastructure', providing an extensively researched context to inform future innovation. Specifically:

- *Understanding emerging options to reduce greenhouse gas emissions associated with road construction*: Clear guidance on what these options are and how they can be realised, with precedents from around the world.
- *Improving strategic positioning*: Insight into future areas for risk management through considering global population, resource and climate trends.
- *Providing guidance on areas of specialisation*: To focus resources into areas that will provide the largest reduction of environmental impacts during road construction.
- *Understanding market gaps and arising business opportunities*: Targeting new business opportunities and strategic areas for research and development collaborations.

Government Benefits: This research creates a clear platform for government to consider emergent opportunities for addressing environmental impacts, and future risks to be addressed in managing road infrastructure in a changing climate. Specifically:

- *Informing policy and management decisions for a resilient road network*: Innovations to incorporate into road management planning, tenders, and reporting.
- *Providing insight into changing roles and leverage points for action*: informing a shift to focusing on maintenance and enhancing the efficiency of existing roads.
- *Providing a scenario planning framework to stimulate responses*: Unique scenario planning process to identify emerging trends, risks and strategies impacting road networks.
- *Informing Further Research Areas*: Understanding of critical areas to invest government research funding, and specific design and technical solutions requiring further development.

Both industry and government will need transparent and strategic reporting mechanisms to show how the new challenges for road delivery and operations are being addressed.

The Sustainable Built Environment National Research Centre (SBEnrc) is the successor to Australia's CRC for Construction Innovation. The SBEnrc is a key research broker between industry, government and research organisations servicing the built environment.

The SBEnrc is continuing to build an enduring value-adding national research and development centre in sustainable infrastructure and building with significant support from public and private partners around Australia and internationally.

Benefits from SBEnrc activities are realised through national, industry and firm-level competitive advantages; market premiums through engagement in the collaborative research and development process; and early adoption of Centre outputs. The Centre integrates research across the economic, social and environmental sustainability areas in programs respectively titled: Driving Productivity through Innovation; People, Processes and Performance; and Greening the Built Environment.

This research wouldn't be possible without the ongoing support of our industry, government and research partners:

Queensland Government · GOVERNMENT OF WESTERN AUSTRALIA · NSW Government Transport Roads & Maritime Services · John Holland · PARSONS BRINCKERHOFF · Curtin University · QUT · SWINBURNE UNIVERSITY OF TECHNOLOGY

Project partners:

- Main Roads WA
- QLD Department of Transport and Main Roads
- Parsons Brinckerhoff
- John Holland
- Curtin University
- Queensland University of Technology
- Australian Green Infrastructure Council

Queensland Government · PARSONS BRINCKERHOFF · Curtin University · mainroads WESTERN AUSTRALIA · QUT · John Holland · AGIC AUSTRALIAN GREEN INFRASTRUCTURE COUNCIL

For further information:

Professor Peter Newman
Program Leader
Curtin University
Email: p.newman@curtin.edu.au

Mr Charlie Hargroves
Project Leader
Curtin University
Email: Charlie.hargroves@curtin.edu.au

Dr Cheryl Desha
Project Leader
Queensland University of Technology
Email: cheryl.desha@qut.edu.au