SUSTAINABLE ROAD MAINTENANCE AND CONSTRUCTION UTILISING NEW TECHNOLOGIES

By

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Abstract

Road sustainability might sound like a misnomer. However, international initiatives include example of roads sustainability frameworks based on life cycle assessment. Nationally, we can also find increasing examples of sustainability being seriously considered in infrastructure projects.

The main elements covered in road sustainability are:

1. Environment and economic decision-making
2. Public Engagement
3. Decision for long-term environmental performance
4. Construction planning
5. Planning for lifetime monitoring and maintenance

Earthco Projects Ltd is a distributor of a stabilisation product manufactured in Australia. Their product, PolyCom Stabilising Aid®, is listed with Eco-Buy and with Sustainable Choice NSW.

Earthco Projects Ltd wanted to evaluate the extent of the significant reductions in the carbon footprint, material and water resources usage and financial savings they observed on projects they worked on. A life-cycle based assessment of a project using PolyCom and a project using conventional methods of re-sheeting was conducted by the Factor Ten sustainability consultancy.

The findings for this specific project were significant:

- Close to 90% reduction in greenhouse gas emissions
- 80% reduction in water usage
- 70% / year financial savings on the maintenance of the road

Thinking and designing sustainably can make a big difference to the triple bottom line.

Key Words: Roads, Sustainability, PolyCom, Stabilisation, Environmental, Re-sheeting, Unsealed, Carbon Footprint, Life cycle assessment, Life cycle costs

Introduction

Local Governments, Public Works engineers, Elected representatives are under pressure to design, build and maintain road infrastructure within tighter economic conditions, increased social awareness and strong environmental constraints (VAGO, 2012; NSW Division of Local Government, 2013; LGA SA, 2004).

Sustainability as a Triple Bottom Line approach is expected at all levels of the decision-making process (Hes D and Bates M, 2003) supported by a number of infrastructure rating tools both globally and nationally.

Earthco Projects Ltd proposes a different approach to the construction and maintenance of unsealed roads which provides local governments and other road makers with the ability to reduce project costs and significant opportunities to reduce their carbon liabilities and environmental impacts generally.

The main elements which can support this assertion are highlighted below and were defined during a high-level carbon footprint which was conducted in February 2013:

1. PolyCom Stabilising Aid® (roadbase) carbon footprint for manufacturing activities in the baseline year 2012 is estimated at *3.14 kg of CO_2-e per 2 kg bottle.*
2. When comparing the re-sheeting (over one year) of 1 km unsealed roads (see details in report below), the traditional method would emit at least 7,160 kg of CO_2-e per km. The same activities using PolyCom Stabilising Aid®® method would emit *741 kg of CO_2-e* per km. A possible *reduction in greenhouse gas emissions of close to 90%.*
3. *Water usage could be reduced by up to 80% over one year* (see details in report below) when using the PolyCom Stabilising Aid® method: 600kL for the traditional method, 116.40kL when using PolyCom Stabilising Aid®.
4. Comparative cost study demonstrates that the project would *save more than 70% of the costs* normally incurred for the maintenance and re-sheeting of unsealed roads.

Other significant benefits are:

- Significant cost reductions due to the elimination of quarry material in the re-sheeting process
- Reduction of the damage to roads caused by the transport and tipping of quarry material en route to the site
- Overall reductions in plant and machinery use
- The product is environmentally inert and is listed with Eco-Buy (2013) and Sustainable Choice NSW (LG NSW, 2013).

Finally, we have listed a number of collateral benefits such as:

- PolyCom containers are fully recyclable (HDPE #2)
- Reduced sediment to receiving waters during rainfall events of treated roads

In opening up the door to innovative environmentally friendly products and methodologies such as PolyCom Stabilising Aid®, municipal work engineers and officers unlock opportunities for significant environmental and financial savings.

Building a knowledge base on road sustainability anchored in real-life projects significantly contributes to the development of green skills and future thinking for the sector.

In this paper, we will establish the basis of a road sustainability approach. We will present a case study on the sustainability benefits of using PolyCom Stabilising Aid® compared to re-sheeting of unsealed roads.

Finally, we will assess the achieved benefits against the core elements of sustainability rating systems reflecting on lessons learned and future possibilities.

Project Context

Climate change and the issues related to its impact on the environment, governments, industry and communities is one of the major challenges facing Australia [and the rest of the world] (IPCC, 2007; Garnaut, 2011)).

Resource depletion, quality of water run-off, health and safety of workers and road users and land-use are high on the list of issues facing the industry (Pears, 2004).

Environmental, Financial and Social Issues

Across the life cycle, direct impacts of roads construction include (Pears, 2004):

- Impacts of materials used (in mining/harvesting, processing and during construction)
- Design, which influences quantities and types of materials, scale of disturbance, future energy and resource usage, etc
- Site impacts, such as biodiversity loss, social impacts (eg dividing communities) and future noise, run-off, etc
- Transient construction impacts such as on-site energy use, dust, noise, water pollution, occupational health and safety, etc
- Lifetime issues, including design for flexibility regarding upgrading or changing uses, longevity, and potential for recovery of materials at end of life

Additionally, local governments carry much of the responsibility for financing the construction and the maintenance of assets over its lifetime, ensuring the health and safety of project workers and users of the infrastructure (WALGA, 2008; ALGA, 2010).

They have an increased responsibility to report on all these aspects. The States which haven't yet put in place a reporting framework are in the process of doing so.

	VIC	NSW	QLD	SA	WA
Community Plan	No	Yes 10yrs	Yes 10yrs	No	Yes 10yrs
Council/Corporate Plan	Yes 4yrs	Yes 4yrs	Yes 5yrs	Yes 4yrs	Yes 4yrs
Financial Plan	Yes 4yrs	Yes 10yrs	Yes 10yrs	Yes 10yrs	Yes 10yrs
Asset Management Plan	No	Yes 10yrs	Yes 10yrs	Yes 10yrs	Yes 10yrs
Workforce Plan	No	Yes 4yr	No	No	Yes 4yrs
Budget	Yes 1yr	Yes 1yr	Yes 1yr	Yes 1yr	Yes 1yr

Illustration 1: Planning and Accountability Frameworks, (FINPro, 2012)

However, funding for road construction and maintenance are tightening and several if not all local government authorities have identified a need to understand and match future costs and services consequences of their current portfolio (LGA-SA, 2004; ALGA, 2010).

Sustainability assessment in Road Works

In order to analyse and estimate the road projects alignments to sustainability principles, a range of assessment tools have been developed.

Globally

In Europe, studies have been conducted around Energy efficiency of Roads construction and maintenance since 2007. EACI (2010) has supported a number of research projects including road construction and maintenance over 20 years and innovation linked to intelligent energy opportunities in sustainable infrastructure projects. CEEQUAL (2013) in the UK has been one of the first sustainability rating systems in infrastructure projects and has since inspired a number of other rating systems including the IS Rating Tool (ICSA, 2013).

In the US, Green Roads (2011) and Green Lites (NYSDOT, 2009) sustainability frameworks were launched in 2008/10 and have brought enormous changes to the Industry (GreenRoads, 2013) thanks to well designed rating systems.

Other rating systems have been launched since which cover similar areas with an emphasis and weight slightly different from each other.

These rating tools evaluate projects according to (TRB, 2012):

- Stakeholder Relationships
- Community Wellbeing
- Land Use and Heritage
- Ecology and Biodiversity
- Transport
- Materials and Resources
- Water
- Energy and Emissions
- Project Management

In Australia

Initiatives in sustainability from VicRoads (2010), IPWEA (2013) , ISCA (2013), RTA NSW (2012), ARRB (Houghton, 1998), IRF (2011), MAV (2013), AustRoads (2012) and WALGA (2008) have laid the basis for reductions in resource consumption, greenhouse gas emissions, waste generation and cost of road construction and maintenance.

Main challenges

As identified by Shaw et al (2012), despite a strong environmental approach, several issues have been identified in the different assessment tools as lacking in coverage or focus:

- Operations/Maintenance and Deconstruct / Decommission of infrastructure assets
- Social criteria
- Economic criteria

PolyCom Stabilising Aid® Case Studies

Many organisations have decided to calculate their carbon footprint and start implementing measures which will lead to reduction, avoidance, management and offset of carbon emissions.

Reputation, recruitment, cost savings, risk reduction and competitive advantage are all part of the drivers for carbon accounting as a necessary step towards sustainable business planning.

Earthco Projects Ltd felt their product was contributing positively to reducing the traditional environmental impacts generated by road construction and maintenance activities. They decided to take actual measurements of their own carbon footprint and to start tracking comparisons of traditional methods vs. their methods in terms of carbon emissions and other environmental impacts.

Life cycle thinking

When initiating the case study, we put a specific emphasis on the need to account for the full life cycle of a project rather than to have a partial view of its impacts.

We first assessed the life-cycled based carbon footprint of the product itself.

The product – PolyCom Stabilising Aid® - footprint covers Inputs (Raw materials / Energy) and Outputs (Waste and Emissions) and includes:

- Production and supply of materials and components
- Factory production
- Distribution
- Use or Utilisation
- End of life system / final disposal

We then measured different unsealed road re-sheeting projects using the same life cycle approach. This ensured us we have looked at the impacts and benefits over the life time of the asset.

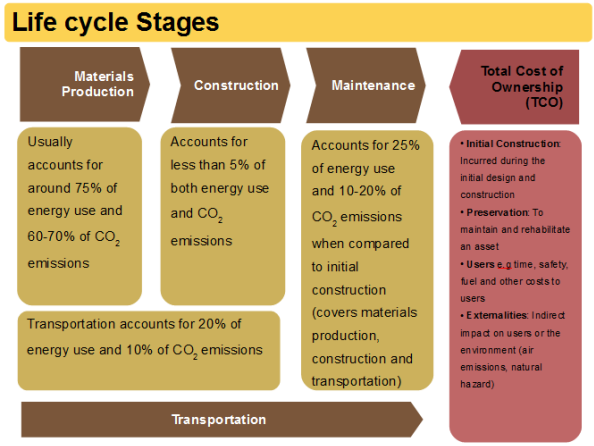

Illustration 2: Life Cycle Stages of a road construction project - Proportion of Greenhouse Gas Emissions

Method

The inventory was developed according tho the GHG Protocol – a corporate and accounting standard from the World Resource Institute and World Business for Sustainable Development (WRI, 2011).

Factors mainly found in the National Greenhouse Accounts Factors from the Australian Government – Department of Climate Change unless otherwise indicated in the detailed inventory (DCCEE, 2012).

This is the first inventory developed for Earthco Projects Ltd. It has been compiled thanks to direct access to the organisation data and clients information. We also used the Greenhouse Gas Assessment Workbook for Road Projects (TAGG, 2011).

Assumptions

PolyCom Stabilising Aid® carbon footprint
The following elements were measured:

- Bottle production (HDPE made in Australia, Transport to manufacturing site)
- Electricity / gas usage (used electricity and gas data from the manufacturer for the reference period)
- Waste production (volume of recycled and non-recycled waste attributable to the production of PolyCom Stabilising Aid®)
- Production and transport of material inputs (accounting for all material inputs and the embodied energy included in each, transportation of the materials to the factory)

Case study – unsealed roads re-sheeting
The assumptions listed below are all based on a range of real-life projects which were documented through the 2010/11 period in the regions of Mildura and in the Alpine Shire in Victoria. The scope is on unsealed roads re-sheeting and maintenance over one year.

Assumptions which apply to both methods:

- 1 km unsealed road
- Located in Australia
- 6m width
- Average weather conditions
- Post-2004 vehicles
- All fuel is diesel
- Fuel consumption is calculated for 8 hours operations on site for standard machinery

Assumptions which apply to the traditional method:

- Include water only compaction to place 75mm of new gravel, and tippers to cart gravel to the site
- Requires grader, roller and water cart at initial construction + an additional 4 times a year for re-sheeting
  - Grader uses 90 litres of diesel for 8 hours operations
  - Roller uses 45 litres diesel for 8 hours of operations
  - Water cart uses 55 litres diesel for 8 hours of operations
  - Transportation and fuel consumption to and from site is not accounted for
- Quarry material required is 900 tons for the year
  - 36 loads required for 2 hours each to haul material to site
  - 414 litres of diesel used
  - Transportation of material on site is calculated on a 20km haul (40km return)
- Water usage is 120,000 litres initially then 4 times a year for re-sheeting

Assumptions which apply to PolyCom Stabilising Aid® method:

- Requires grader, roller and water cart at initial construction only
  - Grader uses 90 litres of diesel for 8 hours operations
  - Roller uses 45 litres diesel for 8 hours of operations
  - Water cart uses 55 litres diesel for 8 hours of operations
  - Transportation and fuel consumption to and from site is not accounted for
- No quarry material required in this example
- Water usage is 84,000 litres initially only
- No re-sheeting required on road for at least 1 year
- 12 bottles of PolyCom Stabilising Aid® required
- Bottles are not recycled by client

Life cycle costs:

- Cost of material: $ / ton including fuel, delivered to the site
- Estimated cost of water (Victoria): $/kL including sewage

- Cost of Grader/Roller/Watercart including staff: $ for 8 hours on site including fuel and staff
- Cost of PolyCom : $ for # bottles required

Findings

PolyCom Stabilising Aid® Footprint

The life cycle based GHG emissions calculations for the manufacturing of PolyCom Stabilising Aid® was calculated for the year 2012. We note that it is a 23% improvement from the 2010 carbon emissions footprint.

Key Performance Indicator :
3.14 kg of CO_2-e / 2kg bottle of PolyCom Stabilising Aid®

It serves as a basis for the data on embodied energy contained in the product and was used in the comparison of the two methods of re-sheeting unsealed roads (traditional vs. PolyCom Stabilising Aid®)

Unsealed Road Re-Sheeting Project - GHG Emissions

When comparing the re-sheeting (over one year) of 1 km unsealed roads (see project assumptions above), the traditional method would emit at least 7,160 kg of CO_2-e per km (Scope 1). The same activities using PolyCom Stabilising Aid® method would emit *741 kg of CO_2-e* per km (Scope1). A possible *reduction in greenhouse gas emissions of close to 90%*.

Unsealed Road Re-Sheeting Project - Life Cycle Costs

An important component of the life cycle analysis is the comparison between the costs of maintaining and re-sheeting unsealed roads using the traditional method compared to using PolyCom Stabilising Aid®.

Using the same assumptions as for the rest of the life cycle, we have evaluated the costs of each method and estimated the differences.

Comparative cost study demonstrate that the project would *save more than 70% of the costs* normally incurred for the maintenance and re-sheeting of unsealed roads over 1 year.

Unsealed Road Re-Sheeting Project - Water Usage

Water usage could be reduced by up to 80% over one year when using the PolyCom Stabilising Aid® method: 600kL for the traditional method, 116.40kL when using PolyCom Stabilising Aid®.

Unsealed Road Re-Sheeting Project - Other findings

- Significant cost and GHG reductions due to the elimination of quarry material in the re-sheeting process
- Reduced sediment to receiving waters during rainfall (Similar product to the ones used for water filtering)
- Reduction of the damage to roads caused by the transport and tipping of quarry material en route to the site
- Overall reductions in plant and machinery use
- A reduction in number of complaints due to potholes on the roads treated with PolyCom Stabilising Aid®
- The product is environmentally inert and is listed with Eco-Buy and with Sustainable Choice New South Wales.

Case Study as a model in Sustainability Implementation and Assessment

When we review what requirements of roads sustainability were actually met during the case study we found the following.

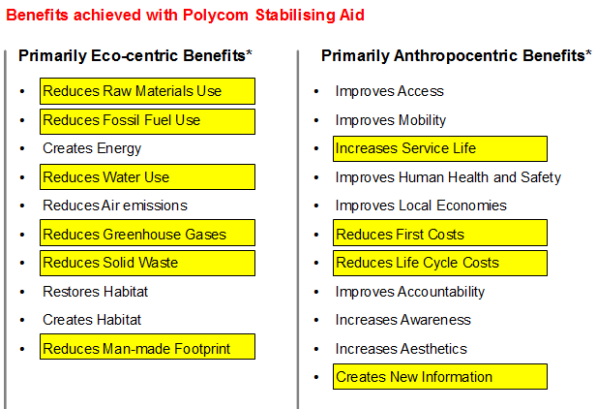

Illustration 3: PolyCom Stabilising Aid® - Achieved Benefits on GreenRoads Sustainability

We believe the results show a significant improvement in the long-term sustainability of the project on many fronts. We have highlighted the areas where data was made

available to the project to be able to back any assertions that we might have.

We have noted that there is a significant amount of information available already which would support the following additional benefits:

- Improves mobility
- Improve human health and safety
- Improves accountability
- Increases awareness

Further studies will be conducted in the near future to evaluate the potential additional benefits.

Responding to criteria not well covered by sustainability assessment schemes

As mentioned above, ratings systems do not cover Social, Economic (Goh, Kai Chen & Yang, Jay, 2009) and maintenance criteria very well (Pears, 2004).

The case studies presented in this paper started to create data around specific aspects of

1. Costs (life-cycle costs over defined period 1, 5 and 10 years)
2. Maintenance and operations (average grading and re-sheeting activities over a 1, 5 and 10 years period)
3. Social (started data gathering and comparison of complaints raised to Local Authorities for the treated section of the asset)

Earthco Projects Ltd has been engaging with its clients in order to help them develop an awareness of the sustainability issues which characterises the type of activities. They provide solutions to resolve them and get involve with the training and education of the workforce.

Future Case Studies

The case studies mentioned in this paper where initially conducted in 2010 then reviewed and validated again in 2012.

On the 7th May 2013, the CityWide Group and Earthco Projects conducted a live demonstration of PolyCom vs. cement treament of a sealed road in Yarra Glen (VIC). This also marks the start of a new case study which will be delivered in the next few months.

A number of underground mines have been using the product regularly on their roads network (WA and NSW). We are working on developing more papers specific to that area.

Conclusion

Triple Bottom Line (Economic, Social, Environmental) has proven to be a great driver of improvement in any industry.

The PolyCom Stabilising Aid® case study provided the data necessary to support that innovation in product selection and in methodology achieve great financial, environmental and social outcomes.

In an industry that is required to be more sustainable, the study also shows that resources can be used more efficiently.

This was proven by the results achieved using PolyCom Stabilising Aid® product and methodology:

- Close to 90% reduction in greenhouse gas emissions
- 80% reduction in water usage
- 70% / year financial savings on the maintenance of the road

In researching this topic and undertaking this project, it is apparent that a lack of data exists in relation to road qualitative and quantitative information:

Whilst data is scarce and gathering methods underdeveloped, some good infrastructure sustainability rating systems exist. Producing quantifiable, reliable and peer reviewed data is critical to proving efficiency gains and providing examples and results to support change within the industry.

References

Australian Local Government Association (2010) The Local Roads Funding Gap, Prepared by JRA, accessed at http://alga.asn.au/site/misc/alga/downloads/transport/LocalRoadsFunding.pdf , viewed on 23/05/13

Austroads (2012) *AustRoads Strategic Plan 2012-2016*, accessed at http://www.austroads.com.au/images/stories/Austroads_Strategic_Plan_FINAL.pdf , viewed on 23/05/13

BioCentral (2011) *PolyCom Stabilising Aid®, Material Safety Data Sheet*, accessed at http://www.biocentral-labs.com/download.php?filename=polycom_msds.pdf&filetype=msds, viewed on the 21/05/2013

CEEQUAL (2013) *Assessment & Award Scheme for improving sustainability in civil engineering, infrastructure, landscaping and the public realm*, accessed at http://www.ceequal.co.uk/ , viewed on 23/05/13

DCCEE – Department of Climate Change and Energy Efficiency (2012) *Australian National Greenhouse Accounts*, accessed at http://www.climatechange.gov.au/~/media/publications/nga/NGA-Factors-20120829-PDF.pdf , viewed on 23/05/13

DPCD - Department of Planning and Community Development Victoria (2012), *Local Government Performance Reporting Framework*, Appendix A - Page 14, Accessed online at http://www.dpcd.vic.gov.au/__data/assets/pdf_file/0006/125592/Directions_Paper_-_Local_Government_Performance_Reporting_Framework_December_2012.pdf , accessed on the 23/05/13

EACI – Executive Agency for Competitiveness and Innovation (2010) *Energy Conservation in Road Pavement Design, Maintenance and Utilisation,* accessed at http://eaci-projects.eu/iee/fileshow.jsp?att_id=13942&place=pa&url=ECRPD_PR.pdf&prid=1518 , viewed on 23/05/13

EcoBuy (2013) *PolyCom Stabilising Aid® listing*, accessed at http://www.ecobuy.org.au/director/ecofind.cfm?itemID=A82A15ACC982CD0DAAF18F9A6471D8E3 , viewed on 23/05/13

FINPro (2012) *Presentation to the Local Government Finance Professionals*, accessed online at http://www.dpcd.vic.gov.au/__data/assets/pdf_file/0005/142763/FINPro_Conference_Presentation_on_Local_Government_Performance_Reporting_Project_21_February.pdf , accessed on 23/05/13

Garnaut, R. (2011) *The Garnaut Review 2011 – Australia in the Global Response to Climate Change*, Cambridge University Press, Port Melbourne

Goh, Kai Chen & Yang, Jay (2009) *Developing a life-cycle costing analysis model for sustainability enhancement in road infrastructure project., Faculty of Built Environment and Engineering*, Queensland University of Technology, Brisbane, Queensland

GreenRoads (2011) *Green Roads Manual*, accessed at https://www.greenroads.org/1429/greenroads-manual.html , viewed on 23/05/13

Greenroads (2013) *GreenRoads Selected as White House Champion of Change*, media release 8 May 2013, Seattle, accessed at https://www.greenroads.org/files/1854.pdf , Viewed on 23/05/13

Hes D and Bates M (2003) *Concrete and Sustainability- Supporting environmentally responsible decision making PRO 31*, in BDP Environment Design Guide Royal Australian Institute of Architects, Melbourne

Houghton, N (1998) *Ecologically Sustainable Development: Indicators and Decision Processes*, ARRB Transport Research, Report No319

IPCC – Intergovernmental Panel on Climate Change (2007) *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change 2007*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

IPWEA (2013) IPWEA Sustainability Update April 2013, accessed at http://www.ipwea.org.au/Sustainability/LibraryDocuments/ViewDocument/?DocumentKey=8cbaad7b-2ef2-4c02-bb7a-3bcb165b79b5 , viewed on 23/05/13

IRF – International Road Federation (2011) Policy Statement – Environment, accessed at http://www.irfnet.org/files-upload/pdf-files/statement_enviro_WEB_final.pdf , viewed on 23/05/13

ISCA – Infrastructure Sustainability Council of Australia (2013) *IS Rating Tool*, accessed at http://www.isca.org.au/is/is-rating-tool , viewed on 23/05/13

Local Government Association of South Australia (2004), *Development (Sustainable Development) Amendment Bill 2004*, Issues Paper 2: Infrastructure Planning, accessed online at http://www.lga.sa.gov.au/webdata/resources/files/Sustainable_development_Bill_Issues_paper___infrastructure1.doc , viewed on the 20/05/2013

LG NSW (2013) Sustainable Choice, accessed at http://www.lgnsw.org.au/sustainablechoice/ , viewed on 23/05/13

Municipal Association of Victoria (2013) *Step Planning Programme*, accessed at http://www.mav.asn.au/policy-services/planning-building/planning-system/Pages/planning-system.aspx , viewed on 23/05/13

New South Wales Division of Local Government (2013) *Integrated Planning and Reporting Manual for Local Government in NSW*, Department of Premier and Cabinet, accessed at http://www.dlg.nsw.gov.au/dlg/dlghome/Documents/Information/Intergrated%20Planning%20and%20Reporting%20Manual%20-%20March%202013.pdf , viewed on 23/05/13

NYSDOT - New York State Department of Transportation (2009) GreenLites, accessed at https://www.dot.ny.gov/programs/greenlites , viewed on 23/05/13

Pears, A. (2004) *Sustainability and Roads: Capturing the ESD Opportunity, presented at the 10th Australasian Flexible Pavements Industry Conference on Health, Safety and Environment*, accessed at http://www.naturaledgeproject.net/documents/sustainabilityandroadsapjuly04revised.pdf, accessed on 20/05/2013

QTMR – Queensland Department of Transport and Main Roads (2013) Environmental Management, accessed at http://www.tmr.qld.gov.au/Community-and-environment/Environmental-management.aspx , viewed on 23/05/13

RTA NSW (2012) *Environmental Policy Statement 2012*, accessed at http://www.rta.nsw.gov.au/environment/downloads/2012_rms_environment_policy.pdf , viewed on 23/05/13

Shaw, G, Kenny, G, Kumar, A & Hood, D (2012) *Sustainable infrastructure operations: A review of assessment schemes and decision support*, presented at the 25th ARRB Conference – Shaping the future: Linking policy, research and outcomes, Perth, Australia 2012, accessed at http://www.arrb.com.au/admin/file/content128/c6/Shaw.pdf , viewed on 23/05/13

TAGG – Transport Authorities Greenhouse Group Australia and New Zealand (2011) Greenhouse Gas Assessment Workbook for Road Projects, accessed online at https://www.mainroads.wa.gov.au/Documents/Greenhouse%20Gas%20Assessment%20Workbook%20for%20Road%20Projects%20June%202011.u_3523839r_1n_D11%5E23328187.PDF , viewed on 23/05/13

TRB – Transportation Research Board (2012) *Overview of Sustainability Rating System Trends in Transportation*, Presented by Terralogic at the TRB Annual Conference – Session 449 on the 23 January 2012, accessed at www.terralogicss.com/LiteratureRetrieve.aspx?ID=122006 , viewed on 23/05/13

VAGO - Victorian Auditor-General Office (2012) *Performance Reporting by Local Government*, accessed online at http://www.audit.vic.gov.au/publications/20120418-LG-Reporting/20120418-LG-Reporting.pdf , accessed on 23/05/13

VicRoads (2010) *Sustainability and Climate Change Strategy 2010-2015*, accessed at http://www.vicroads.vic.gov.au/NR/rdonlyres/4DB4B3E3-E5E9-4DD6-8F15-9B7EBB33D90C/0/SustainabilityandClimateChangeStrategy20102015.pdf , viewed on 23/05/13

WALGA - Western Australia Local Government Association (2008) The Journey - Sustainability into the Future, accessed at http://walga.asn.au/Portals/0/Templates/docs/the_journey_final_report.pdf , viewed on 23/05/13

WRI (2011) *Product Life Cycle Accounting and Reporting Standard*, accessed at http://www.ghgprotocol.org/files/ghgp/Product%20Life%20Cycle%20Accounting%20and%20Reporting%20Standard.pdf , accessed on 21/05/2013

Author's Biography:

Stephanie Camarena (GradCert. Sustainability) possesses more than 15 years international experience in Information and Business Technology. In 2009, after completing tertiary education in carbon management, life cycle assessment and sustainability, she started a consultancy in Design for Sustainability, Factor Ten.

With a mission to demonstrate achievable changes with a no nonsense approach, Factor Ten empowers businesses and industries in their leading roles towards a sustainable world.

In four years, Stephanie has developed trusting relationships with many manufacturing companies, venues and local governments.

At the end of 2009, Stephanie became a regular contributor to Australia's Best Manufacturing magazine writing articles on Sustainability.

She also lectures at Swinburne University of Technology in Systems Thinking and in Design for Sustainable Production and Consumption.

As a personal note, Stephanie ’s vision is to lead and inspire a conscious way of conducting business, of living our lives, fully aware and in control of our impact on our world [planet and people].

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