EVALUATION FRAMEWORK FOR GREEN PROCUREMENT IN ROAD CONSTRUCTION

Structured Abstract:

Purpose: Most barriers and enablers of sustainable projects are related to procurement. This study proposes a framework for evaluating green procurement practices throughout the lifecycle of road construction projects and demonstrates its application through an Australian case study.

Design/methodology/approach: The study is based on linking the phases of road construction with incentive mechanisms for proactively motivating behavioural change. A holistic view on utilised and potential incentives is attempted with a literature review and a state-of-practice review. The latter is based on interviews and 90 policy and procurement documents across five Australian states.

Findings: An evaluation framework with seven procurement stages is suggested to describe current state green procurement incentives throughout the delivery lifecycle of road construction projects. The Australian case study was found to provide useful data to identify gaps and strong points of the different states regarding their level of integration of sustainability and greenhouse gas emissions (GHG) reduction elements in their procurement practices. This understanding was used to draw recommendations on future advancement of green procurement.

Originality/value: Government entities across the globe can impact considerably the achievement of sustainability and GHG targets, by using their procurement practices and requirements to create incentives for contractors and suppliers to engage in more GHG conscious practices. The present study provides a systematic account of how green procurement practices can be underpinned using the Australian road construction industry as a case study, and distinguish between strong and weak links in the green procurement chain to draw recommendations for future initiatives.

Keywords: procurement, construction, sustainability, infrastructure, Australia.

1. Introduction

Procurement plays a strong role throughout the lifecycle of a construction project and serves to drive many sustainability outcomes (Hardy, 2013). Green procurement in particular can be used as a strategic tool to promote certain behaviour and as an environmental policy instrument to translate environmental policies into environmentally sustainable project processes, products and services (Faith-Ell, 2005). Green procurement, sometimes known as environmentally sustainable procurement, refers to the practice of formulating environmental requirements in the tendering process (Parikka-Alhola and Nissinen, 2008), or more broadly to the process of applying environmental consideration into planning, contracting and monitoring the project delivery, including the use of environmental criteria in contractor selection.

Decision making in green procurement must take into account greenhouse gas (GHG) emissions throughout the project lifecycle including emissions that are created before and after the structure is built and operational (Wyatt, et al., 2000). To achieve an environmentally sustainable construction project, sustainability should be introduced as a decision factor in all strategic, tactical, and operational levels (Vanegas, 2003).

Government procurement often represents a significant share of national GDP, accounting for up to 20% for some countries (Garcia-Alonso and Levine, 2008) and approximately AUD100 billion in Australia in 2007 (APCC, 2007). Therefore, in industry sectors where government entities commonly constitute the largest client, such as in the road construction sector, government procurement practices have a significant impact on *greening* the industry.

Road authorities have the opportunity to apply a coherent and efficient chain of procurement processes and methods to transform sustainability and climate change policies into proactive initiatives (Lehtiranta, et al., 2012). However, green procurement is also an aspirational target concerning the environmental objectives that might help contractors to achieve additional advantages in terms of winning a contract (Uttam, et al., 2012). Under this type of procurement, systems that encourage contractors to *go the extra mile* should therefore be developed as a core component of environmental policies (Sanchez and Hampson, 2012).

Australia has seen an increasingly active debate on how to best approach the challenge posed by the government announcement of a 60% reduction target in national GHG emissions by 2050 (2000 baseline) (Aijun, 2007) and its ratification of the Kyoto Protocol in 2008. Although there have been several national initiatives aiming to provide tools to the construction sector to encourage *greener* and less GHG intensive practices, there has been a lack of conviction in carrying out the action plans to materially affect practices in the road construction sector at a national level (Sanchez & Hampson, 2012). Thus it is important to determine whether individual state authorities are taking steps towards realising the directives of the Federal Government and relevant national bodies.

The present study aims to show a pioneering systematic account on how green initiatives can be underpinned in public road procurement, and distinguishes between strong and weak links in the green procurement chain using the Australian road construction industry as a case study.

GHG emissions are important macro-indicators in sustainable linear infrastructure construction projects (Fernández-Sánchez and Rodríguez-López, 2010), and a key metric of the Australian Federal Government climate change goals. Therefore, green procurement will herein be evaluated in terms of minimising GHG emissions throughout the delivery of road construction projects. This work will assist in identifying and further developing best practices for GHG minimisation from road construction projects through the development of an evaluation framework of procurement practices.

1.1. Standard procurement process

The traditional approach to project procurement in construction involves design development, tender, contract award and construction delivery phases (Walker and Hampson, 2003). Figure 1 shows a general procurement process according to the United Nations Development Programme Procurement Support Office (UNDP, 2008). Under this model 10 stages, from the procurement planning phase to contract management, form the tender lifecycle.

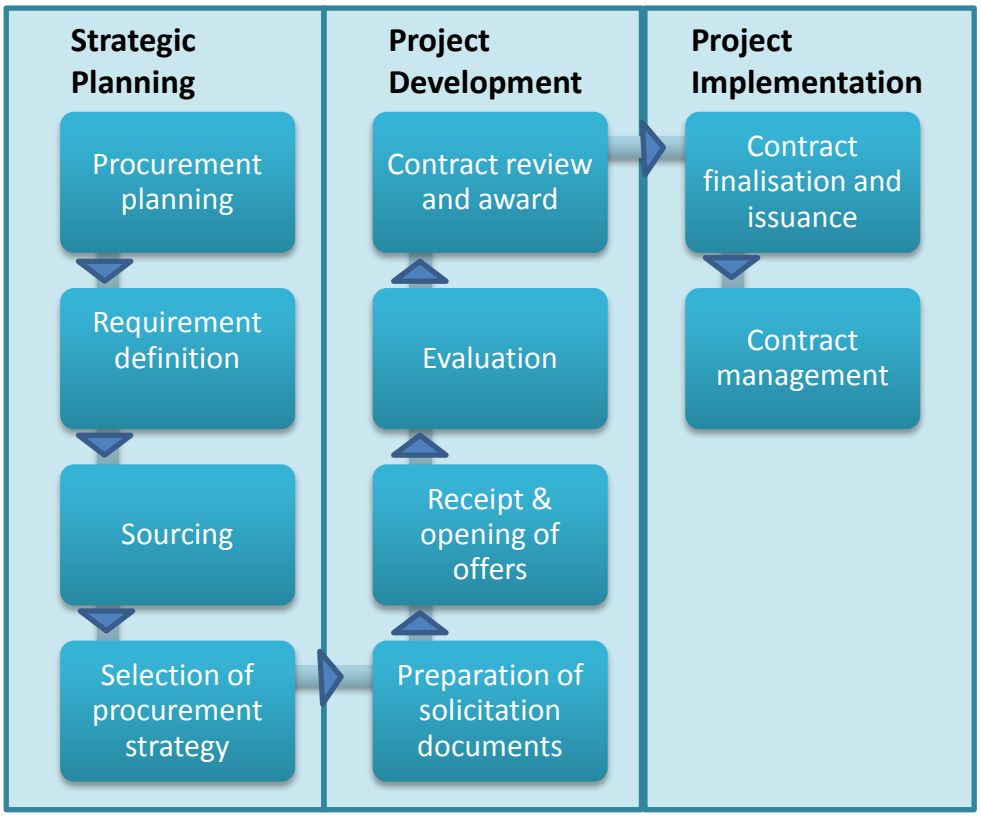

Figure 1: Procurement process as set out in the UNDP Contract, Asset & Procurement Management User Guide (UNDP, 2008) and classification of phases by Authors.

In order to simplify the evaluation framework, the procurement processes have been grouped in three overarching phases: strategic planning, project development and project implementation, as illustrated in Figure 1.

2. Research methodology

The purpose of the present research was to propose and test an evaluation framework for green road construction procurement initiatives. Incentive mechanisms for proactively motivating *green* behavioural change among contractors and designers were identified in a literature review and catalogued according to the project phase where they normally take place and by their sphere of influence. The evaluation framework was created by linking the phases of road construction project lifecycle with applicable incentive mechanisms, hereafter referred to as process indicators as explained in the following section.

The applicability of the framework is assessed through a case study covering the five largest Australian state road authorities: Queensland Transport and Main Roads (QTMR), New South Wales Roads and Maritime Services (NSW RMS), VicRoads, Main Roads Western Australia (MRWA), and the Government of South Australia Department of Planning, Transport and Infrastructure (SA DPTI). Together these road authorities are responsible for 94% of the total 823,217 km of Australian roads, and account for 97% of the almost AUD16 billion annual public road expenditure in Australia (BITRE, 2012).

The case study consisted of the application of the developed evaluation framework to the specified road authorities. This process comprised a series of informal 30-minutes interviews and the review

of 90 policy and procurement documents including procurement guidelines, templates, contractor and designer tender guidelines, policy and strategy documents, action plans, and publicly available reports. Some examples of documents reviewed are: NSW RMS (2011a), NSW RMS (2011b), NSW RTA (2010), MRWA (2008), MRWA (2011a), MRWA (2011b), QTMR (2009b), QMTR (2012), RoadTek (2011), SA DPTI (2009), SA DPTI (2011a), SA DTEI (2011), VicRoads (2011a), VicRoads (2011b), and VicRoads Environmental Sustainability (2011). These documents also included technical, social and other environmental indicators which were out of the scope of this study.

The selection criteria for the interviews were: (i) to have a key procurement management role within the road agencies, (ii) have access to documents that could be used as basis for the case study, and (iii) availability and willingness to participate. The purpose of the interviews was to identify key documentation, including drafts and internal documents not available to the general public, and to have a system in place for industry feedback. The interview questions were a mixture of:

(i) Open-ended questions, such as:
   a. *Is there a document that underpins your agency's approach to green procurement and GHG reduction from road construction?*
   b. *How do you inform designers and contractors of your 'green' strategies?*

(ii) Specific questions, such as:
   a. Do you include requirements and/or incentives related to GHG emissions in your tender and contract documents?
   b. Do you undertake options, risks and opportunities assessment related to GHG emissions?

Altogether, 12 individuals comprising 1-3 representatives of each organisation participated in the interviews and provided additional internal documents. The answers were all supported by the provision of documentation that was then used for the case study. The evaluation framework was used for mapping the findings across the procurement lifecycle of road construction projects where each *tick mark* reflects this indicator being address in at least one document reviewed (please refer to Table 1). The results were later reviewed by sustainability managers within the studied road authorities, and their feedback was taken into consideration and included in the final results presented in this study. Documents collation and interviews were carried out between October 2011 and April 2012.

3. Proposed evaluation framework

This section will expand on specific project lifecycle phases and process indicators of incentive mechanisms for GHG reduction chosen for the development of the evaluation framework.

3.1. Public road procurement lifecycle

Matar, et al., (2008) recommend pinning sustainability principles as parts of project delivery from pre-project planning to, at least, completion of the structure. In the case of evaluating green procurement, the standard procurement process, as outlined by UNDP (2008), was seen as an appropriate basis for developing the evaluation framework.

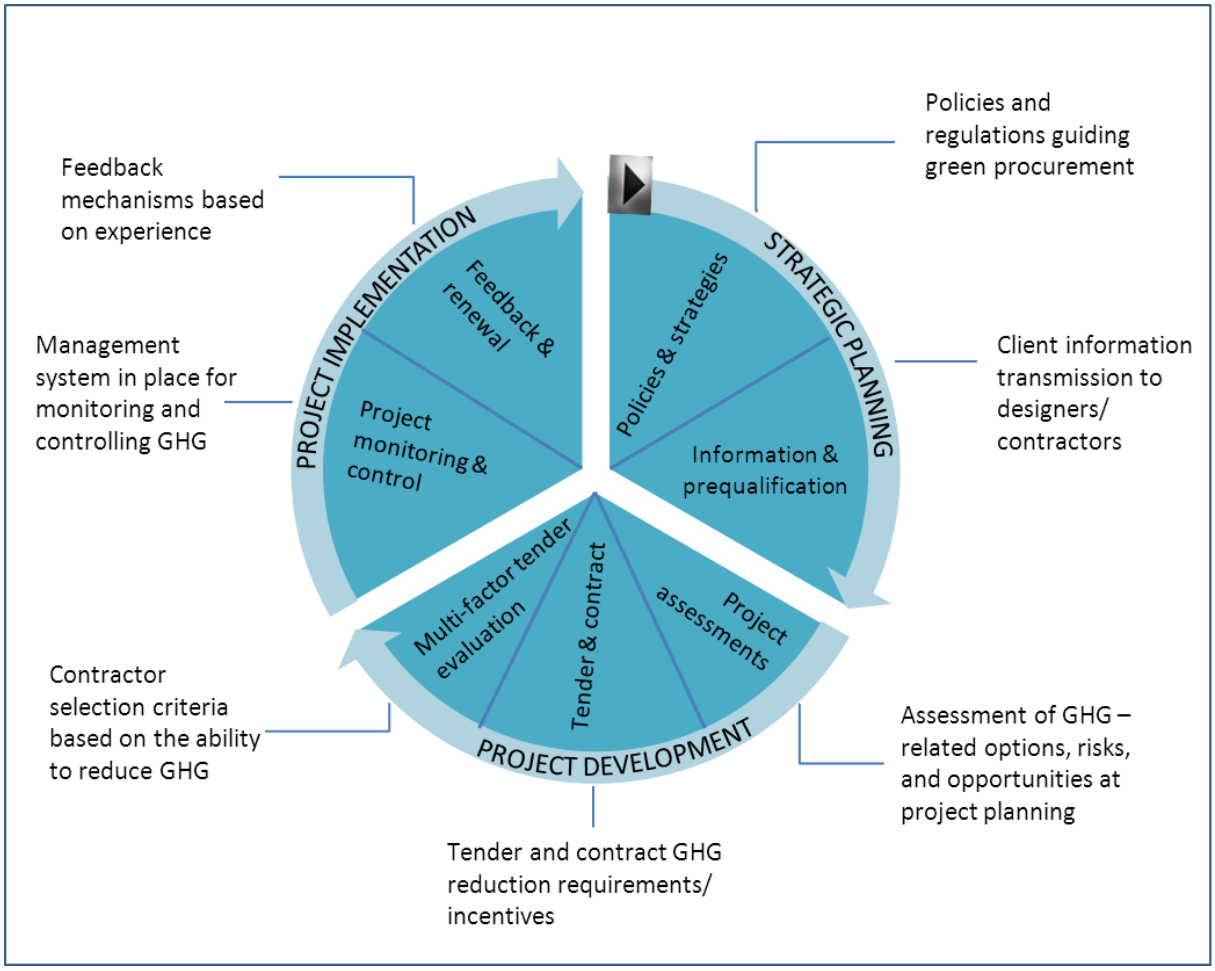

Figure 2: Project procurement lifecycle

The lifecycle consists of three overarching phases that drive decisions impacting GHG emissions from road construction, maintenance and operation (Figure 2). These phases are based on a holistic baseline description of the engineer/procure/construct (EPC) macro model described by Matar, et al., (2008), which includes a preliminary pre-project phase as well as a *start-up* phase, the latter being included here as the post-contract phase; *project implementation*.

The *strategic planning* phase involves policy guidelines at a national level, and the state environmental policies and strategies that guide the operations of each road authority. These strategic schemes are typically translated into more specific guidelines and prequalification criteria for the industry designers and contractors. The second phase is shaped by the *project development* activities and consists of operations that transmit process indicators from the first phase into project specific decisions. This phase defines the contract formation activities, including: (i) GHG related assessment of project options, risks, and opportunities; (ii) project scope definition; and (iii) selection of contract type, tender procedures, contractor, and contract content. Finally, the *project implementation* phase entails the client-side activities that will affect the achievement of green procurement targets, documentation of project outcomes, and learning from the project.

3.2. Green procurement stages

Numerous green processes can be built into public road procurement to translate policies and strategies into proactive initiatives to facilitate the achievement of the overall goals and objectives

(Sanchez and Hampson, 2012). Kenley, et al., (2000) discussed the rewards and incentives that can be used as basis for further developing an evaluation framework. That list includes: prequalification processes, multi-factor tender evaluation, performance selection incentives, finance and payment systems, incentive contracts, contract types and delivery models, tax incentives, and regulation and monitoring. Because tax incentives are not under the control of state road agencies, this category is not included in the evaluation framework.

In addition to the rewards and incentives of Kenley, et al., (2000), it was assessed that pre-tender and post-contract award practices that affect the successful implementation of green procurement practices should also be included in the present study.

Post-project mechanisms, such as benchmarking, best practices, case studies and auditing are not integrated into most procurement models, despite the fact that these processes must be determined during the procurement strategic planning stage and carried throughout project development, ultimately having a significant impact on the environmental outcomes of the project (Sanchez and Hampson, 2012). Therefore, for the purposes of the present study, and following the Matar, et al., (2008) recommendations, two post-contract-award stages will be included as part of the project procurement lifecycle in the implementation phase through to project monitoring & control, and feedback & renewal.

The procurement stages described in this study are equivalent to the second level of detail described by Matar, et al., (2008) as *process units* at the *task* level. These are:

i. *Policies & strategies:* According to Tan, et al., (2011), the establishment of a clear sustainability policy in the construction industry is paramount, if only as a statement of the commitment of top management to protecting the environment and enhancing social responsibility. The resulting policies should then translate into proactive strategies and action plans that improve the sustainability performance of contractors and potentially provide a competitive advantage by integrating long-term profitability with sustainable development positioning. The strategies should also take into account climate protection issues through GHG monitoring and reduction initiatives (Stocker and Luptacik, 2009).
ii. *Information & prequalification*: The information provided to contractors during the early stages of procurement can be seen as the vehicle to communicate instructions about intentions and objectives. At an early stage, the clients must therefore build a framework that facilitates clear communication of client objectives and ensures that they are met by the end product (Ryd, 2004).
    Contractor prequalification is a process used to evaluate the ability of contractors to satisfactorily complete a contract before they are admitted into the bidding process (Lam, et al., 2000). The prequalification process involves establishing a standard for measuring and assessing the capabilities of potential tenderers; standard parameters should, among others, include environmental concerns (El-Sawalhi, et al., 2007).
iii. *Project assessments:* This stage refers to a pre-tender project assessment, carried out mostly by the client, to determine risks and desired outcomes which should then inform potential changes to the design, basic operational plans and contract type. These assessments assist the client in negotiating with the contractors and to understand what the greatest risk areas might be (Winch and Kelsey, 2005).
    It could also be argued that the project will excel only if the right contract type is chosen for the appropriate context (Song, et al., 2009). The delivery model and contract type selection is therefore one of the most critical steps in determining the success of a project (CEIID,

2010) and can also be seen as a tool to assist the government in achieving their broader priorities (QTMR, 2009a).

iv. *Tender & contract:* Contract clauses can be used for sustainability purposes to address issues that pertain to the execution of the contract. Performance-based incentives can be used through the establishment of minimum levels of performance at project completion (*gatepost* incentives) or at milestones (*graduate* incentives) (Broome, 2002). *Raising the bar* for suppliers and contractors should in itself be a performance improvement incentive across the sector (UNEP, 2011).

Additionally, Kenley, et al., (2000) explain that better financial terms on contracts, such as early payments, will always be of advantage to contractors, and could be considered as reward mechanisms. However, the choice of payment method should depend on project specifics and the delivery method (Broome, 2002).

v. *Multi-factor tender evaluation:* Multi-factor or multi-criteria tender evaluation is a way of achieving best value for money instead of a simple reliance on *lowest-price*. This shift in approach to tender evaluation has been seen in contractor selection processes over the last decade (Miller, et al., 2009) and can be done on a project-by-project basis or through a standard set of criteria (Wong, et al., 2000). Fernando and Guppy (2006) also point out that, while cost is a significant factor in contractor selection, non-price criteria should be considered not only to avoid under-performance but also to add value to the end product. Additionally, contractor selection itself is considered a major element of risk and opportunity when complex goals, such as optimising technical sustainability, are established (Kruus, et al., 2010). Sustainability-related non-financial criteria provide explicit financial implications that have direct impact on the current and future environmental costs, especially at a global level.

vi. *Project monitoring & control:* Monitoring and control is the most important interactive process to predict success relative to quality performance in construction (Chua, et al., 1999). Standard monitoring techniques and requirements that assure accurate GHG measurement for construction operations, serving for later benchmarking and definition of specific easily monitored Key Performance Indicators (KPIs) are paramount for any incentive mechanism to be effective. Monitoring throughout construction projects is vital in determining the effectiveness of green initiatives, build credibility (Varnas, et al., 2009), and develop benchmarks.

vii. *Feedback & renewal:* Post-project feedback is often not done or only done when negative outcomes are directly observed during project delivery. However, Winch and Kelsey (2005) highlight that without systematic feedback it is not clear how learning and improvement of the planning process can take place at an organisational level, and therefore total project reviews are necessary to learn from previous projects.

Furthermore, benchmarks of industry best practices for sustainable construction are needed to define the requirements to be met in contributing to the achievement of a more sustainable society (Zimmermann, et al., 2005).

In addition, contract renewal can also be seen as an incentive or reward alternative to monetary rewards and more resilient to collusion among suppliers. The value of future profits is the main motivating factor for firms to maintain quality of performance (Dalen, et al., 2006). The creation of *preferred contractors* based on good project performance related to pre-established KPIs could therefore have a significant impact on project outcomes.

3.3. Procurement process indicators

Matar, et al., (2008) described the process indicators as specific activities that occur in an EPC project and form the last level of detail in the framework. The choice of indicators for this study was driven by the potential impact of the activity on overall project outcomes as they relate to GHG and sustainability, the boundaries and magnitude, and practical aspects.

Use of certified Environmental Management Systems (EMS) has been found to result in business units striving to identify significant environmental aspects of their projects and taking actions accordingly (Wenblad, (2001), Tarbeev, et al., (2004), Tan, et al., (2011)). However, it has also been observed that if not properly materialised through environmental performance measurement tools and indicators, the organisation can have difficulties measuring their environmental performance accurately (Lundberg, et al., 2009).

Lam and Yu (2011) point out that although an EMS has profound positive environmental influence on construction, optimal performance might not be guaranteed by implementing the EMS alone. For this reason, other instruments such as environmental impact assessments (EIA), life-cycle assessment (LCA) and green specifications could also be used as tools for ensuring environmental sustainability from the perspective of GHG in construction.

GHG calculators could conceivably be used to estimate GHG produced by construction operations as well as serving as standardised bid comparison tools. According to Zammataro (2010) these tools can facilitate the comparative analysis of road-building materials and techniques proposed by contractors with respect to climate change targets.

Detailed mass-haul plans could also be used as a prequalification requirement, in order to obtain additional information that will support the informed assessment of the ability of the tenderer to develop the works in an efficient and environmentally conscious way. Kenley, et al., (2011) argue that optimisation of mass-haul activities could potentially lead to a significant reduction of GHG emissions from linear infrastructure construction projects. By using this information, the client is able to analyse the contractor's plan and determine if it is feasible within the time, budget and GHG reduction goals.

The Environmental Impact Assessment (EIA) commonly carried out during tender is an internationally accepted methodology for evaluating the effects of proposed major transport infrastructure projects on the environment (Goodenough and Page, 1999). The EIA is particularly relevant because it dictates the actions that will be taken to avoid or mitigate environmental pollution from the construction works.

Cai, et al., (2009) highlight the importance of defining significant KPIs as a way of monitoring and improving supply chain performance. Furthermore, KPIs that can be used as part of incentive mechanisms must be realistic and relevant to the project, reflect the state of the technical definition and be easily administered (Broome, 2002). To this point, fuel use during project delivery is relatively easy to monitor and record, and has a significant impact on the total GHG generated by road construction projects (Hughes, et al., 2011). Kenley, et al., (2011) add that, for the construction of large projects, it is often the case that earthworks are the largest single contributor to the GHG generated by the construction phase, which itself is in turn dominated by emissions from fuel consumption (Hughes, et al., 2011). Fuel monitoring and the use of biofuel during the delivery phase of road construction projects can therefore contribute significantly to the successful realisation of GHG goals set in the strategic planning phase.

Sustainability rating tools could be used to directly assess contractors' past performance with respect to sustainability, and often give considerable weight to GHG reduction practices. Furthermore, these ratings can be used either to reward high performance through financial

rewards, pending contract renewals or bid selection as a performance selection incentive, or as part of multi-factor tender evaluation.

4. Australian case study: Evaluating green procurement

The Australian case study outlines the green procurement process indicators that are underpinned in five state road authorities' standard procurement practices. Table 1 summarises the findings. The road authorities demonstrate varying levels of progress in the development of green procurement process indicators. All organisations address the need for green procurement through related policies and guidelines in the strategic planning phase. However, application of the policies and guidelines in the project development and implementation phases is predominantly still a work in progress. In addition to the already established practices (Table 1), the studied road authorities are currently working on some of the gap areas. In particular, the industry information, prequalification processes and non-cost criteria for contractor selection are under consideration in several states (Sanchez, et al., 2013). Optimised processes covering the full delivery lifecycle with practically tested techniques and tools are yet to be developed.

Three of the authorities studied are involved in the development of a project benchmarking system that might be used in the future: VicRoads (2011a), RoadTek (2011) and MRWA (2011b). Two of the road authorities (VicRoads and MRWA) also mentioned the possible inclusion of contractual incentives.

PROJECT PROCUREMENT LIFECYCLE		PROCUREMENT PROCESS INDICATORS	Queensland	New South Wales	Victoria	Western Australia	South Australia
STRATEGIC PLANNING PHASE	Policies & strategies	Federal/state policies	√		√	√	√
		Federal/state regulations					
		Process standards/guidelines					√
		Road authority environmental/ sustainability policy	√	√	√	√	√
		Road authority environmental/ sustainability strategy	√	√	√	√	
		Environmental management system (EMS)		√	√	√	√
		GHG reduction action plan		√	√	√	
	Information & prequalification	GHG reduction guidelines for designers			√	√	√
		GHG reduction guidelines for contractors			√	√	√
		Designer prequalification related to GHG					
		Contractor prequalification related to GHG				√	
PROJECT DEVELOPMENT PHASE	Project assessments	Environmental risk or sustainability assessment rel. to GHG (internal or external)		√	√	√	
		Carbon/GHG calculation (road construction)		√	√	√	√
		Carbon/GHG calculation (road operation)		√	√		√
		Mass-haul optimisation plan					√
		Alignment/scope revision based on GHG					√ *
		Delivery method selection based on GHG					
	Tender & contract	GHG reduction plan required					√
		EMS required		√		√	√
		Mass-haul optimisation required/encouraged					√
		Carbon neutrality required					
		Environmental audit required		√	√		√
		Lifecycle analysis required					
		Shared costs of emission reduction or offset			√		
		Shared rewards for superior performance			√		
	Multi-factor tender evaluation	GHG/carbon calculations			√		
		GHG reduction plan			√		
		Lifecycle analysis					
		Green materials			√		
		Use of biofuels					
		Mass-haul optimisation plan					
		Sustainability rating			√		
PROJECT IMPLEMENTATION PHASE	Project monitoring & control	Environmental audits			√	√	
		Monitoring of fuel consumption			√		
		GHG reporting			√		
		Database of carbon calculations			√		
		Project environmental report			√	√	
		Road operations related GHG reporting				√	
	Feedback & renewal	Project reviews includes GHG				√	
		Best practice case studies for industry		√		√	
		Public cross-project environmental report (including GHG)	√	√	√		√
		GHG reduction strategy review					
		Preferred contractor status based on GHG performance					

* *In Design-Build projects managed by the contractor*

Table 1: Australian green procurement evaluation findings

VicRoads (2011a) also recommends the consideration of prequalification requirements and contractual clauses regarding GHG reduction and *savings/gains* sharing (VicRoads, 2011a).

Major gaps found in the Australian state road authority green procurement processes include

i. A lack of established best practices, standardised procedures and guidelines for GHG assessment and reduction

ii. Poor integration between GHG assessment, lacking management mechanisms and platforms for inter-disciplinary collaboration

iii. Scarcity of environmental criteria in designer and contractor selection

iv. Scarcity of incentives for GHG reduction in contracts

v. Incomplete of monitoring, control, and review methods.

5. Discussion

5.1. Evaluation framework

It is necessary to apply a thorough environmental suitability assessment during the planning phase and implement environmental management systems during and beyond the construction phase (Hill and Bowen, 1997). This point applies to individual projects and to the industry as a whole. Without methods to accurately monitor advancement towards accomplishing specific environmental goals and disseminating the lessons learned, it is not possible to propagate change into standardised practice to ultimately achieve the set targets. The suggested evaluation framework can be used as a tool for assessing and monitoring progress on achieving more sustainable development, with particular focus on GHG.

The present research attempted to address all of the desired qualities in a sustainable construction framework outlined by Matar, et al., (2008), which include allowing assessments at single and multiple phases of a project lifecycle and applied to various geographical locations. It was considered that, for the scope of this study, it was not appropriate to include a scoring or weighting system. Therefore, a binary evaluation method was used.

To ensure further change in road construction, it is necessary that policies and targets are propagated throughout the supply chain (Kenley, et al., 2000). Specific process indicators that serve for continued evaluation are therefore needed to determine whether top management policies are being translated into proactive management processes that motivate behavioural changes among designers, suppliers and contractors.

If evaluation frameworks that allow the comparison of project management process (PMP) against some measure of relative success are not in place, then conclusions about how effective or ineffective the PMP is cannot be drawn (Liu and Walker, 1998), resulting in a lack of information about where gaps are and how to bridge them. To understand how the evaluation of a project outcome occurs, a framework for modelling the discrepancy between a project organisation's goal and their performance is required (Liu and Walker, 1998). In the context of the need for a more sustainable construction industry, this creates the prerequisite for a mature and well-developed framework of applications for sustainable practices, highlighting the fundamental role of integration of sustainability elements throughout all project phases (Matar, et al., 2008).

The design of a multi-incentive plan has the power to motivate contractors to indirectly place the same emphasis or weighting on each of the client's project objectives as the client does, while pursuing their business objectives (Broome, 2002). Thus, the steps towards achieving sustainability

and GHG reduction goals should include implementing a combination of project specific and cross-project incentives. When applying an evaluation framework such as that presented in this study, an ideal outcome is consequently to have activities represented by process indicators present at all levels of the delivery lifecycle in an unbroken green procurement chain.

5.2. Australian case study

The identified gaps indicate some of the most crucial development areas in the Australian state road authorities' green procurement practices to help guide agency's efforts to more effectively achieve their sustainability goals.

All road authorities studied utilise different approaches to achieving more sustainable and less GHG-intense operations. While most have developed GHG targets, policies and action plans, it was found that the majority do not have consistent systems in place to ensure the translation of such goals into practice. Nevertheless, the agencies are working towards *greening* their procurement processes and are currently developing sustainable procurement guidelines.

Numerous carbon calculators and sustainability rating tools are already available to the Australian road construction industry. However, these tools are currently used only on a voluntary basis, although they could be profitably used in the future for prequalification and performance-based incentive systems such as those described by Kenley et al., (2000).

Vanegas (2003) highlights that to achieve sustainable project outcomes an uninterrupted chain of supporting management mechanisms and multi-disciplinary collaboration must be established from strategic planning through sustainable design, construction and operation. The present research revealed that, for most Australian state road authorities, the project development and implementation phases are the weakest link in the green procurement chain.

Interruptions of the green procurement chain in project development is the result of inadequately coupling major decisions regarding the project goals, delivery methods, and contractors with the risks and opportunities of minimising GHG emissions. A possible solution to this issue is to merge these processes with a systematic risk and opportunity management framework (Lehtiranta, et al., 2012).

6. Conclusions and recommendations

Government procurement can be a powerful tool to create incentives for the construction industry to adopt less GHG intensive practices (Sanchez and Hampson, 2012). This study presents a systematic analysis and evaluation of process indicators that can be used to monitor the implementation of green procurement practices in the Australian road construction public sector.

Procurement can be used as an incentive mechanism at different project phases through strategic planning, project management, and outcome assessment and dissemination to motivate contractors to improve performance. However, steps towards achieving GHG reduction goals in the road construction industry should also include a combination of project-specific and cross-project incentive mechanisms. These steps should include the definition of specific indicators that ensure objective and accurate performance monitoring for environmental strategies to be as effective as possible.

This Australian case study is a systematic review of current green procurement practices throughout the project delivery lifecycle, thus offering a basis for standardising procedures and best practices. The results also provide a lead for prioritising future research and development. Recommendations include:

I. Developing a set of standardised procedures and guidelines for GHG assessment and reduction through international reviews and engaging multi-disciplinary collaboration between clients, designers, contractors and researchers

II. Linking GHG assessment and reduction with the overall project risk management framework

III. Introducing non-financial criteria for environmental impact as a project planning and contractor selection device

IV. Identifying efficient incentives for GHG reduction to be incorporated in road construction contracts

V. Finding solutions for effective GHG emissions benchmarking, monitoring and reviewing.

For this Australian case study, it was found that interruptions of the green procurement chain in project development are the result of a lack of communication and propagation of policy decisions with respect to overall goals, delivery methods, and contractor preferences into specific processes that account for the risks and opportunities of minimising GHG emissions.

This study was limited to the analysis of standard procurement documents. Therefore, in order to illustrate additional possibilities for bridging current green procurement gaps, further studies are needed to investigate common project practices in Australia as well as the state-of-practice versus international best practices.

Finally, the evaluation presented here should be conducted periodically as means to monitor the progress achieved by Australian road authorities in their efforts to integrate and deliver improved green procurement practices in road construction.

References

Aijun, H. (2007), "Australia joins Kyoto", *Climate Change Media Partnership,* available at http://www.climatemediapartnership.org/reporting/stories/australia-joins-kyoto/ (accessed 30 August 2012).

APCC (2007), *Australian and New Zealand Government framework for sustainable procurement,* Australian Procurement and Construction Council Inc, Deakin West, ACT.

BITRE (2012), *Yearbook 2012: Australian infrastructure statistics,* Bureau of Infrastructure, Transport and Regional Economics (BITRE), Canberra, ACT.

Broome, J. (2002), *Procurement routes for partnering a practical guide.* Thomas Telford Publishing, Thomas Telford Ltd, London.

Cai, J., Liu, X., Xiao, Z. and Liu, J. (2009), "Improving supply chain performance management: A systematic approach to analyzing iterative KPI accomplishment", *Decision Support Systems,* Vol. 46 No. 2, pp. 512-521.

CEIID (2010), *Infrastructure procurement options guide,* Centre for Excellence and Innovation in Infrastructure Delivery.Government of Western Australia, Perth, WA.

Chua, D.K.H., Kog, Y.C. and Loh, P.K. (1999), "Critical Sucess factors for different project objectives", *Journal of Construction Engineering and Management,* Vol. 125 No. 3, pp. 142-150.

Dalen, D.M., Moen, E.R. and Riis, C. (2006), "Contract renewal and incentives in public procurement", *International Journal of Industrial Organization,* Vol. 24, pp. 269-285.

El-Sawalhi, N., Eaton, D. and Rustom, R. (2007), "Contractor pre-qualification model: State-of-the-art", *International Journal of Project Management,* Vol. 25, p. 465–474.

Faith-Ell, C. (2005), *The Application of environmental requirements in procurement of road maintenance in Sweden,* KTH Land and Water Resource Engineering Department, Stockholm.

Fernández-Sánchez, G. and Rodríguez-López, F. (2010), "A methodology to identify sustainability indicators in construction project management—Application to infrastructure projects in Spain", *Ecological Indicators,* Vol. 10, pp. 1193-1201.

Fernando, M. and Guppy, R. (2006), "Expanding the use of non-price criteria for medium sized public sector construction projects", in *Research into Practice: 22nd ARRB Conference Proceedings in Canberra, Australia*, 2006, Australian Road Research Board Group Limited.

Garcia-Alonso, M.D.C. and Levine, P. (2008), "Strategic procurement, openness and market structure", *International Journal of Industrial Organization,* Vol. 26, pp. 1180-1190.

Goodenough, R.A. and Page, S.J. (1999), "Evaluating the environmental impact of a major transport infrastructure project: the Channel Tunnel high-speed rail link", *Applied Geography,* Vol. 14, pp. 26-50.

Hardy, R. (2013) *The role of procurement in embedding sustainability along the life cycle of a construction project,* CIB World Building Congress, Brisbane, QLD.

Hill, R.C. and Bowen, P.A. (1997), "Sustainable construction: principles and a framework for attainment", *Construction Management and Economics ,* Vol. 15, pp. 223-239.

Hughes, L. et al. (2011), "Carbon dioxide from earthworks: A bottom-up approach", *Proceedings of the Institution of Civil Engineers-Civil Engineering ,* Vol. 164 No. 2, pp. 66-72.

Kenley, R., Harfield, T., Kozan, E. and Hampson, K. (2011), "Greening Procurement: A Research Agenda for Optimizing Mass-Haul During Linear Infrastructure Construction*", in Sixth International Conference on Construction in the 21st Century (CITC-VI) in Kuala Lumpur, Malaysia*, 2011, *CITC-VI*.

Kenley, R., London, K. and Watson, J. (2000), "Strategic procurement in the construction industry: Mechanisms for public sector clients to encourage improved performance in Australia", *Journal of Construction Procurement,* Vol. 6 No. 1, pp. 4-19.

Kruus, M., Lehtiranta, L. and Kiiras, J. (2010), "Reducing risks with the Performance Information Procurement System (PIPS) in Finnish construction management projects", in *2010 World Congress of the International Council for Research and Innovation in Building and Construction (CIB 2010) in Salford, UK, 2010.*

Lam, K., Ng, S.T., Hu, T. and Skitmore, M. (2000), "Decision support system for contractor pre-qualification: Artificial neural network model" *Engineering, Construction and Architectural Management,* Vol. 7 No. 3, pp. 251-266.

Lam, K. and Yu, C. (2011), "a multiple kernel learning-based decision support model for contractor pre-qualification", *Automation in Construction,* Vol. 20, pp. 531-536.

Lehtiranta, L., Hampson, K. and Kenley, R. (2012), "Evaluation of green public road procurement in Australia: current practices and gaps to fill", *in 4th CIB International Conference on Smart and Sustainable Built Environment* in *Sao Paulo, Brazil,* 2012, CIB.

Liu, A.M. and Walker, A. (1998), "Evaluation of project outcomes", *Construction Management and Economics,* Vol. 16 No. 2, pp. 209-219.

Lundberg, K., Balfors, B. and Folkeson, L. (2009), "Framework for environmental performance measurement in a Swedish public sector organization", *Journal of Cleaner Production,* Vol. 17, pp. 1017-1024.

Matar, M., Georgy, M. and Ibrahim, M. (2008) "Sustainable construction management: introduction of the Operational Context Space (OCS)", *Construction Management and Economics,* Vol. 26, p. 261–275.

Miller, G. et al. (2009), *Built Environment procurement practice: Impediments to innovation and opportunities for changes,* Curtin University of Technology, Perth, WA.

MRWA (2008), *Environmental management system manual,* Main Roads Western Australia, Perth, WA.

MRWA (2011a), "Prequalification", available at: http://www.mainroads.wa.gov.au/BuildingRoads/ContractingToMainRoads/Prequalification/Pages/Prequalification.aspx (accessed 21 March 2012).

MRWA (2011b), *Main Roads Carbon Reduction Plan,* Main Roads Western Australia, Perth, WA.

NSW RMS (2011a), *Engineering Contract Manual,* New South Wales Roads and Maritime Services, Sydney, NSW.

NSW RMS (2011b), *Climate Change Plan,* New South Wales Roads and Maritime Service, Sydney, NSW.

NSW RTA (2010), *Earthworks. QA specification R44,* Roads and Traffic Authority of New South Wales, Sydney, NSW.

Parikka-Alhola, K. and Nissinen, A. (2008), "Enhancing green practice in public road construction procurement", *in 3rd International public procurement conference proceedings in Amsterdam, the Netherlands,* 2008, p. 655–666.

QTMR (2009a) *Main roads project delivery system.Volume 1. Selection of delivery options*, Queensland Government Department of Main Roads, Brisbane, QLD.

QTMR (2009b), *Project delivery system,* Queensland Government, Department of Main Roads, Brisbane, QLD.

QTMR (2012), "Standard specifications roads", available at: http://www.tmr.qld.gov.au/Business-industry/Technical-standards-publications/Standard-specifications-roads.aspx (accessed 30 August 2012).

RoadTek (2011), *RoadTek environmental sustainability strategy,* RoadTek, Brisbane, QLD.

Ryd, N. (2004) "The design brief as carrier of client information during the construction process", *Design Studies,* Vol. 25 No. 3, pp. 231-246.

SA DPTI (2009), *Contractor's environmental management plan guidelines for construction road, rail and marine facilities,* Government of South Australia, Department of Planning, Transport and Infrastructure, Adelaide, SA.

SA DPTI (2011a), *Contractor pre-qualification scheme. Roadworks and bridgeworks. Guidelines,* Government of South Australia – DPTI, Adelaide, SA.

SA DTEI (2011), *Greenhouse Gas Assessment Tool (GGAT),* Government of South Australia, Department of Transport, Energy and Infrastructure, Adelaide, SA.

Sanchez, A. and Hampson, K. (2012), "Sustainable Road Infrastructure Procurement in Australia", in *Procurement, Innovation and Green Growth: The Story Continues,* International Institute for Sustainable Development, Manitoba, Canada, pp. 33 - 37.

Sanchez, A.X., Lehtiranta, L., Hampson, K.D. and Kenley, R. (2013), "*Sustainable infrastructure procurement in Australia: Standard vs. project practices, in CIB World Building Congress 2013* in *Brisbane, Australia,* 2007, CIB.

Song, L., Mohamed, Y. and AbouRizk, S.M. (2009), "Early contractor involvement in design and its impact on construction schedule performance", *Journal of Management,* Vol. 25 No. 1, pp. 12-20.

Stocker, A. and Luptacik, M. (2009), "Modelling sustainability of the Austrian economy with input-output analysis modelling framework and empirical application", in *Handbook on Input-Output Economics in Industrial Ecology,* Springer, Dordrecht, pp. 735-776.

Tan, Y., Shen, L. and Hong, Y. (2011), "Sustainable construction practice and contractors' competitiveness: Apreliminary study", *Habitat International,* Vol. 35, pp. 225-230.

Tarbeev, V.V. et al. (2004), "Development of environment management system at a glass factory", *Steklo i Keramika,* Vol. 61 No.9, pp. 27-29.

UNDP (2008), *Environmental procurement. Practice guide volume 1,* United Nations Development Programme Procurement Support Office.

UNEP (2011) *Buying for a better world. A guide on sustainable procurement for the UN system,* United Nations Environment Programme, Paris.

Uttam, K., Faith-Ell, C. and Balfors, B. (2012) "EIA and green procurement: Opportunities for strengthening their coordination", *Environmental Impact Assessment Review,* Vol. 33, pp. 73-79.

Vanegas, J. (2003), "Road map and principles for built environment sustainability", *Environmental Science Technology,* Vol. 37 No. 23, pp. 5363-5372.

Varnas, A., Balfors, B. and Faith-El, C. (2009), "Environmental consideration in procurement of construction contracts: current practice, problems and opportunities in green procurement in the Swedish construction industry", *Journal of Cleaner Production,* Vol. 17, pp. 1214-1222.

VicRoads Environmental Sustainability (2011), *Integrated VicRoads Environmental Sustainability Tool (INVEST),* VicRoads, Melbourne, VIC.

VicRoads (2011a), *Sustainable Procurement Guidelines*, VicRoads, Melbourne, VIC.

VicRoads (2011b), *Guidelines national prequalification system,* VicRoads, Melbourne, VIC.

Walker, D. and Hampson, K. (2003), *Procurement strategies. A relationship-based approach.* Blackwell Science Ltd, Oxford.

Wenblad, A. (2001), "Sustainability in the construction business — A case study", *Sustainability and Construction,* Vol. 8 No. 2, pp. 157- 164.

Winch, G.M. and Kelsey, J. (2005), "What do construction project planners do?", *International Journal of Project Management,* Vol. 23, p. 141–149.

Wong, C.H., Holt, G.D. and Cooper, P.A. (2000), "Lowest price or value? Investigation of UK construction clients' tender selection process", *Construction Management and Economics,* Vol. 18, p. 767–774.

Wyatt, D., Sobotka, A. and Rogalska, M. (2000), "Towards a sustainable practice", *Facilities,* Vol. 18 No. 1/2, p. 76–82.

Zammataro, S. (2010), *Monitoring and assessing greenhouse gas emissions from road construction activities: The IRF GHG Calculator,* available at: http://www.irfnet.org/files-upload/pdf-files/CHANGER_Article_May2010.pdf (accessed 12 April 2012).

Zimmermann, M., Althaus, H. and Haas, A. (2005), "Benchmarks for sustainable construction: A contribution to develop a standard", *Energy and Buildings,* Vol. 37 No. 11, p. 1147–1157.