GREENING AUSTRALIAN CONSTRUCTION
PROCUREMENT: STAKEHOLDER DEVELOPMENT OF
AN OFF-SITE MANUFACTURE ADOPTION TOOL

Russell Kenley, Sittimont Kanjanabootra and Toby Harfield
Faculty of Business and Enterprise, Swinburne University of Technology
P.O. Box 218, Hawthorn, 3122, Australia

ABSTRACT
Australian public authorities responsible for construction have the opportunity to 'green' their procurement processes for improved environmental impact. One method of greening procurement is to use off-site manufacture (OSM). This method of production takes place distant from the construction site thus saving energy through waste reduction and reduced time for project completion. Scholars have listed the benefits of adopting OSM. However, an active program of OSM adoption has not been considered for the Australian construction sector. Proving a mechanism to assist with OSM adoption is the purpose of this research. The Australian state government procurement agencies are the potential key 'leading users' of OSM, but 'leading users' alone are unable to drive innovation adoption. They need to work with industry stakeholders for concept acceptance and implementation. This paper suggests that an OSM concept diffusion mechanism for the construction industry community of practice will result in increased used of OSM. The paper describes the development of an evolving OSM adoption decision-making tool. An action research approach was used because it is both a process for identifying a problem solution and implementing change. A quick-use decision-tree structure based on a question and answer model was the result of the development process. The decision tree leads to both options: traditional production on-site or modern production to off-site manufacture because green procurement is not always the available option, at present. This individual project OSM adoption decision-making tool can also be used for industry concept diffusion and changing industry practice through green procurement processes of 'leading users'.

KEYWORDS
Off-site Manufacture (OSM), Decision-making Tool, Green procurement, Australian Construction

1. INTRODUCTION
Climate Change is recognized as a global problem by the Australian Government. The national policy of sustainability to conserve and enhance the community resources for future generations means changing behaviors is the responsibility of all. The dominant scientific view of a direct relationship between Greenhouse Gas Emissions and human behavior with long-term negative environmental effects has led to increased significance attached to sustainable industry practices (Hill, 2001; Hill and Bowen, 1997). Downie and Stubbs (2012) argue that all organizations have the responsibility of reducing GHGE throughout their supply chain. This is especially true for the construction sector.

The United Nations suggests that 'green' procurement is environmentally responsible in a much as products should be chosen to minimize negative environmental impacts (UNDESA, 2008). Obviously, public authorities responsible for construction have the opportunity to 'green' their procurement processes as one way of driving positive environmental changes. Green procurement might also be considered by contractors as an added competitive advantage over and above being the reasonable sustainability choice (Kenley and Harfield, 2011; Varnä et al., 2009).

One method of greening procurement is to use off-site manufacture (OSM) production for a significant number of components for construction projects. In their review of sustainability in the construction industry Pitt et al. (2009) consider progress in the areas of environmental impact. They discuss waste, energy and water reduction as well as re-use of materials, however, the review does not consider construction production processes. That is the purpose of this paper.
One of the primary methods of introducing sustainability practices into the construction industry has been to change the location of much of the production. This modern method of construction production has many names such as, off-site manufacture (OSM), off-site assembly, off-site fabrication and prefabrication. Each of these processes has specific features, but for simplicity in this paper the term OSM is used to indicate many different production process types that take place distant from the construction site.

Previous research highlights the benefits of adopting OSM production (Nadim and Goulding, 2011; Blismas and Wakefield, 2009; Goodier and Gibb, 2007). Table 1 lists the different locations (on or off) site production and the sustainability benefits. Tradition procurement phases were limited to professional knowledge areas. However, the more modern methods of construction attempt to take advantage of interdisciplinary knowledge sharing (Kanjanabootra, 2011). This change in industry knowledge transfer practices has supported the expansion of OSM production methods, especially for residential structures. Manufacturing components distant from the construction site saves energy through waste reduction and reduced time for project completion as noted in table 1.

Table 1. Comparing construction procurement processes indicating OSM sustainability benefits

<table>
<thead>
<tr>
<th></th>
<th>Design Phase</th>
<th>Tender Phase</th>
<th>Build Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional (on-site only)</td>
<td>Architect/Designer</td>
<td>Client/contractor</td>
<td>Contractor</td>
</tr>
<tr>
<td>Modern (OSM)</td>
<td>Include Contractor Input</td>
<td>Include Supplier Input</td>
<td>Include Supplier Input</td>
</tr>
<tr>
<td>OSM Sustainability Impact</td>
<td>Reduced material waste</td>
<td>Reduced energy use</td>
<td>Reduced re-work</td>
</tr>
</tbody>
</table>

Researchers have suggested that increased utilization of OSM is a green procurement option that would increase sustainable built environment practices. However, an active program of OSM adoption has not been undertaken. It may be that a mechanism to support positive decision-making to adopt OSM for a construction project is required. This paper reports on such an initiative, a research project aimed at the providing a decision-making tool as a mechanism for increasing adoption of off-site manufacture. Section two provides the research context. Section three outlines the research design. Section four describes the development of a decision-making tool for OSM adoption.

2. RESEARCH CONTEXT

2.1 New Concept Adoption

In Australia, government-initiated construction projects account for between 30-40% of total industry turnover (Austen et al., 2008). Thus, any process that assists governments to reduce construction costs is of interest especially one that supports a sustainable built environment. Green procurement processes have been suggested (Kenley and Harfield, 2011). It is possible that increasing support for green procurement practices is also a good method for industry diffusion of the concept of OSM adoption.

Lennie (2005) suggests that concept adoption requires ‘leading users’ to initiate changed industry practice. The state governments in Australia are potential key ‘leading users’ for OSM in the Australian construction industry. However, it can be argued that ‘leading users’ are unable to drive innovation adoption alone. ‘Leading users’ need to work with other industry stakeholders to achieve concept acceptance and increased implementation in construction projects (Smith, 2010; English and Peretz, 2004).

Research also shows that a key to leveraging concept adoption is government action (Ling et al., 2009; Moffat and Auer, 2006). Currently governments at all levels in Australia are proactively embedding sustainability ideals into construction processes. Government departments and agencies are introducing and implementing policies, strategic plans, guidelines, standards, and codes intended to reduce negative environmental impacts by encouraging sustainable construction practices (Bossink, 2002; Morrison and Lane, 2005; Law and Gunasekaran, 2012) and green procurement processes (Kenley and Harfield, 2011).
2.2 Community of Practice (COP)

Another way of looking at the construction sector is to consider it as a community of practice (COP) (Peansupap and Walker, 2004). The Australian construction sector COP includes a variety of practitioners from a number of different types of organizations such as government procurement agencies, international engineering firms and local sub-contracting trades. The sector also has a variety of professional disciplines such as architects, engineers, quantity surveyors, contractors. Designated trades skills are also important for completing projects.

Because construction projects are temporary organizations, the COP has an ad hoc structure with imperfect lines of communication which limits knowledge sharing and diffusion of new concepts (Peansupap and Walker, 2004). Strengthening the lines of communication is an activity at the individual and group level for members of a COP. They often form knowledge networks to facilitate sharing both common practice and new concepts (Kanjanabootra, 2011). Thus, industry networkers are potential diffusers of OSM adoption as a sustainable construction procurement process.

2.3 Knowledge Sharing

Another factor that contributes to successful concept adoption is stakeholder involvement. As mentioned members of the COP play an important role in knowledge sharing and diffusion of new concepts. At the same time, Rodríguez-Melo and Mansouri (2011) suggest that many construction sector stakeholders, including clients, architects, engineers, project managers, builders, contractors and suppliers are unable to make decisions to utilize OSM due to the lack of understanding OSM processes. Smith (2010), however, suggests that some construction stakeholders do have specific domain process knowledge concerning OSM, but do not effectively share this knowledge with other project stakeholders. Thus the vicious circle of lack of OSM concept diffusion means that decision to use OSM production option for a construction project is limited in terms of industry capacity thus retarding growth of a sustainable built environment.

Another factor contributes to limited uptake of OSM. In the infrastructure sector the long lead-time between identified need (a road, hospital or school) and starting construction is often more than five years (Elfving, 2003). The traditional fragmented construction process of designing – contracting – building means that at the conceptual design stage, the government project team does not know which consultant engineers, main contractor or suppliers will actually be involved with the project. This fragmentation has negative effects for diffusion of both the concept of sustainability and an identified green procurement mechanism, off-site manufacture.

However, it is possible that new concept diffusion can be nurtured by providing a diffusion mechanism to assist members from various levels of the construction sector COP in their knowledge sharing activities (Peansupap and Walker, 2004). Development of a decision-making tool concerned with OSM adoption for a construction project could be one such mechanism. This paper describes the construction sector community of practice development of an evolving decision-making OSM adoption tool.

3. RESEARCH DESIGN

Action research is an approach that is concerned with problem solving and changing practice. The approach is both a process for identifying a problem solution and a process for implementing change within a community of practice (Panko and Harfield, 2009). Action research has four essential precepts that relate to the previous discussion. First, it is participatory in as much as the people who research the issues are the ones who will use the outcome of the study. Second, it is concerned with knowledge sharing. Third the process works within a network of domain knowledge with some form of communication system. Fourth, new concept diffusion is considered an important implementation of change activity. In addition, the most effective method of developing decision-making tools is a participatory process with domain knowledge stakeholders according to English and Peretz (2004). Thus, the purpose of this research is to develop a decision-making tool using the action research approach with members from the construction sector community of practice (Harfield et al., 2001).
In this study, industry and government stakeholders collaborated in the development of an OSM adoption decision-making tool. The development process is both iterative and generative which means that both the defined problems and solutions continue to evolve (Panko and Harfield, 2009). The tool development processes to-date can be outlined in four stages.

**Stage 1:** State government construction procurement officials were interested in taking advantage of a green procurement process, off-site manufacture, that is based on sustainability ideals. This collaborative stage of the research focused on identification of a number of OSM related issues to consider before the detail design phase of a construction project. The normal procurement practice of providing a design for tender has been identified by scholars as a limitation on adoption of OSM (Law and Gunasekaran, 2012).

**Stage 2:** An extensive literature review was conducted. The literatures reviewed included: the drivers and barriers in the adoption of OSM in construction; construction industry stakeholder decision-making; knowledge management, concept diffusion, knowledge sharing; OSM in practice and stakeholder participatory tool development.

**Stage 3:** To ensure industry stakeholder involvement for diffusion of the concept of OSM adoption an industry stakeholder change team was formed. Members of the construction sector community of practice (COP) included: professionals from state government procurement departments and construction professionals (architects, engineers and builders). Discussions focused on defining OSM adoption problems and solutions. Change options were discussed based on the needs, expectations and requirements of all participants in relation to OSM adoption at the conceptual phase of a construction project.

**Stage 4:** A number of semiformal meetings were held. This process involved a cycle of defining and validating OSM issues during an iterative series of engagements. Each iteration session with participating industry stakeholders validated, changed, and/or modified the OSM issues framed as question-set based on specific domain knowledge of industry COP.

The result of this participatory process was an evolving set of OSM adoption questions. Answers to the questions provide a series of decision-points related to the appropriateness of adopting OSM. The decision-making tool (as a set of OSM adoption questions) is applicable to any type of construction project, and can be employed at any phase of a construction project.

This small group of members of a COP did focus on concept diffusion by identifying problems and developing of solutions of OSM adoption. In this study stakeholders searched for a mechanism to facilitate industry change to encourage utilization of OSM within the Australian construction sector. Thus industry concept diffusion based on knowledge sharing provided input into the development of a mechanism for industry sustainability change (Kanjanabootra, 2011).

### 4. OSM ADOPTION DECISION-MAKING TOOL

The literatures do not provide a fixed method for developing a decision-making tool to support sustainability measures (Beukman and Harfield, 1999). Researchers provide a wide variety of methods. For example, Bossink (2002) stated that the Dutch government developed a sustainable construction policy based on the strategy of the World Commission on Environmental and Development. Salzmann et al. (2005) in their extensive review identify formal models that can be built through the measurement of constructed preferences related to the problem; typological analysis of previous research to provide a formal classification of outcomes, integration of practices at an operational level, and meta-analysis of empirical studies.

Harfield et al. (2001) suggest that a decision-making tool based on questions and answers provide a logical industry change implementation process for new concept adoption. This type of model seems appropriate for developing a decision-making tool to support increasing green procurement processes such as the adoption of OSM for state government funded construction projects (Pitt et al. 2009).

The community of practice members of the action research team in this study considered a number of aspects. For example, one aspect identified as irrelevant to the builders was availability of suppliers located close to the construction site. However, the government officials indicated this aspect is an important in relation to sustainable procurement process. The problem of balancing the greening of procurement processes agenda with practical problems of project supply chain locations has long-term implications for energy savings. Thus, it is important to consider both aspects for an individual project.
Another example of competing agenda is compulsory standards and building codes. Government departments that control standards and codes are also obligated to incorporate sustainability principles. At present OSM options have not been included in most compliance documents even though waste, from on-site processes and re-work, has been identified as having a negative environmental impact. Leaving change options to the regulators rather than the users, especially for long-term projects, may not be the best sustainability option.

The action research participants identified a number of requirements for an OSM adoption decision-making tool. During the cycles of identification and validation members of the community of practice reviewed problems and solutions until a number of common aspects emerged as important.

It was agreed that the tool structure be a number of important questions. The evolving list includes:

- Does OSM meet client’s specifications?
- Are there potential project risks?
- Does OSM reduce the duration and disruption of the construction project?
- Does using the OSM option reduce the project cost?
- Can OSM reduce the amount of re-work in commissioning phase?
- Does OSM reduce total waste from construction process?

These questions form the decision-making tree shown in figure 1. This quick-use structure is based on the research findings into prefabrication schools in the England (French, 2008). French reported on a number of schools that had used OSM production. His recommendations included the caveat that not all construction projects are the same therefore all projects should consider the OSM option by asking a series of OSM adoption questions.

The Australian context of OSM adoption questions for government funded projects is presented in Figure 1. The decision tree leads to both options: traditional production on-site or modern production to off-site manufacture.

As mentioned the action research team considered these questions as important in relation to sustainability and green procurement processes. The decision to use OSM in a specific construction project is based on a variety of issues from a variety of perspectives found in the construction sector community of practice. However, from the perspectives of concept diffusion and greening procurement, each question also provides an indicator of types of change actions required. For example, if disruption of a project means a significant amount of negative environmental impact, even if the cost is greater, it may be a better option to use OSM production. Thus this individual project decision-making tool for OSM adoption can also be used for industry concept diffusion and changing industry practice through green procurement processes by 'leading users'.

![Decision Tree Diagram](image-url)
5. CONCLUSION

Research shows that a key to leveraging concept adoption is government action. Governments at all levels in Australia are now proactively embedding sustainability construction processes into policies, strategic plans, guidelines, standards, and codes. These are intended to reduce negative environmental impacts by encouraging sustainable construction practices.

Australian public authorities responsible for construction have the opportunity to ‘green’ their procurement processes as one way of implementing positive environmental changes. One method of greening procurement is to use off-site manufacture (OSM). This method of production takes place distant from the construction site thus saving energy through waste reduction and reduced time for project completion.

Over the years a number of scholars have listed the benefits of adopting OSM. However, an active program of OSM adoption has not been considered for the Australian construction sector. This research is aimed at filling that gap. The state governments in Australia are the potential key ‘leading users’ of OSM, but ‘leading users’ alone are unable to drive innovation adoption. They need to work with other industry stakeholders for concept acceptance and implementation. For example, designers, builders, suppliers and manufacturers who are construction sector stakeholders constituting a community of practice (COP).

The COP includes a variety of practitioners from a number of different types of organizations such as government procurement agencies, international engineering firms and local sub-contracting trades. This paper suggests that an OSM concept diffusion mechanism for the COP will result in increased use of OSM.

The paper describes the construction sector community of practice development of an evolving OSM adoption decision-making tool. An action research approach was used for development of the decision-making tool because it is both a process for identifying a problem solution and a process for implementing change within a community of practice.

A quick-use decision-tree structure based on a question and answer model was the result of the development process. The decision tree leads to both options: traditional production on-site or modern production to off-site manufacture because green procurement is not always the correct option, at present. From the perspectives of concept diffusion and greening procurement, each question also provides an indicator of types of change actions required. For example, if disruption of a project means a significant amount of negative environmental impact, even if the project cost is greater, it may be a better option to use OSM production. Thus this individual project decision-making tool for OSM adoption can also be used for industry concept diffusion and changing industry practice through green procurement processes of ‘leading users’.

ACKNOWLEDGEMENT

The authors acknowledge the funding and support provided by Australia’s Sustainable Built Environment National Research Centre (SBEnrc) and its partners. Core Members include Queensland Government, Government of Western Australia, John Holland, Parsons Brinckerhoff, Queensland University of Technology, Swinburne University of Technology, and Curtin University. Project Partners: SurePoint and PrebNZ.

REFERENCES


