

Industry constructions of waste in building life-cycles: Zero waste and beyond?

Jasmine Palmer¹, Lou Wilson², Stephen Pullen², Keri Chiveralls², Jian Zou² and George Zillante³

¹School of Art, Architecture and Design, University of South Australia

²School of Natural and Built Environments, University of South Australia

³School of Architecture and Built Environment, University of Adelaide

Abstract: The construction of 'green buildings' is promoted by industry organisations and professional bodies as a means of increasing the sustainability of cities. 'Green building' certification schemes and regulatory requirements address many challenges related to waste management, resource consumption, operational efficiency and life cycle performance. Less embraced in current practice is the notion of 'designing out waste' or 'zero waste' in our buildings and cities. This paper discusses research from an ARC funded project that is investigating ways to minimise waste from building conception to end of life. The aim is to understand how building procurement teams (clients, architects, designers, and planners, engineers, building contractors, facility managers and users) might move towards international best practice and total waste elimination. The project methodology incorporates a series of charrettes to develop, reflect on and refine a best practice model of designing, constructing and managing a zero waste building. This paper discusses outcomes from the first of four charrettes, which asked the building procurement team of a world leading 'green building' to reflect on their own perceptions and experiences in relation to managing waste. Importantly, the charrette unpacked the participants understanding of waste and their professional and personal role in its generation. Participants were also asked to envisage a 'zero waste' solution for future development of sustainable buildings. Knowledge gained from the analysis of data from this charrette will inform future stages of this project and provide a framework for the understanding of waste in the design and construction of sustainable built environments.

The Waste Challenge

For thousands of years human settlements have resulted in the generation and accumulation of waste products in the natural environment: waste products of man, animals, resource consumption and material processing. The shell middens of Indigenous Australians have been dated to more than 12,000 years old (DPCD, 2008) at various locations around the country, reminding us that all humans leave a trace of their existence and activity in any place which persists for an extended period of time. In the current context of ever increasing material consumption around the globe we must take the opportunity to consider the 'trace' which will remain from present day occupation. Our ever expanding and renewing cities and towns continually absorb and expel materials and physical wastes, with over 38% of Australia's total solid waste generation being associated with the construction and demolition sector (Pink, 2010). The waste generated in our present day cities will undoubtedly have a far more significant and long lasting environmental impact than the coastal shell middens of the earlier occupants of the land.

It is in this challenging context of unsustainable resource consumption and disposal that 'Green Building' certification schemes and waste regulations and policies have matured. While such certification schemes and legislative requirements seek to minimize harm and maximize material reuse it has been argued that they do little more than set relatively easily achieved targets, enabling minor changes to current procedures without challenging industry enough to require a reevaluation of fundamentally unsustainable practices (Chappells and Shove, 2009; Steemers, 2003; Brown and Cole, 2009). Recognising the built environment as a significant contributor to waste generation, and a potential area for large scale change, the authors are currently engaged in an Australian Research Council funded project titled "Reconsidering Sustainable Building and Design: A Cultural Change Approach." The overall aim of the research is to develop a clear pathway to take building procurement teams (eg the client, architects, designers, planners, building contractors and facility managers) from present levels of knowledge and practice in the minimisation of resource usage and waste reduction towards international best practice and total waste elimination. The project involves ten partners from government and industry, as well as

international university partners from Shenzhen University in China and Karlsruhe Institute of Technology in Germany.

A partner in the project, Zero Waste SA, the South Australian statutory corporation charged with reforming waste management in the state, provides the following definition of 'Zero Waste' as the project aim.

"Zero Waste: Waste minimisation by designing waste out of processes and product; resource recovery and prevention of materials becoming waste; a cultural and social shift in how we perceive and manage resources." (Zero Waste SA, 2011, p.32)

"When we talk about zero waste, we challenge the assumption that waste is inevitable and unavoidable. We shift the focus from disposing of a discarded product to promoting the cyclical use of materials in our economy. Zero waste is a long-term vision for a society that thrives within nature's resource constraints." (Zero Waste SA, 2011, p.20)

The project aims to produce a Best Practice Guide for industry to assist in the evolution of existing waste practices to ultimately achieve a Zero Waste outcome in the building industries. To this end, the multi stage research project commenced in 2011 includes a considerable amount of industry input and consultation through the use of multi-disciplinary charrettes. This paper discusses outcomes from the first of four charrettes, which asked the building procurement team of a world leading 'green building' to reflect on their own perceptions and experiences in relation to managing waste.

The Waste Charrettes

The research method employed in any project necessarily responds to the project objectives, aims and challenges. The first significant challenge this particular research project faces is the establishment of a means through which to draw together and effectively integrate the knowledge and expertise of the many parties involved. The production of the built environment typically involves the expertise of numerous design disciplines that collaborate with specialists and consultants from related fields. The subsequent habitation of the constructed space involves corporations, building managers and individuals. Each of these stakeholders are effectively decision makers in relation to the long term environmental impact of buildings and each bring to their decision making processes a unique combination of knowledge and experiences; of disciplinary expertise and personal preference.

The second challenge is how to encourage the complex web of stakeholders to collectively engage in the reduction of resource consumption and waste given the disconnections which exist between life stages in any building. Each of the stakeholders is engaged with the building during a specific range of its life stages, with no single stakeholder engaged from conception to end of life. Even the developer who instigates a project may not extend their personal or financial involvement beyond occupation, limiting their interest to a single life phase.

Thirdly, it is necessary to overcome the persistence of discipline based innovation to create a culture in which opportunities for change (innovation) are explored in the overlaps of and spaces between existing disciplinary boundaries. Significant reduction in resource consumption and waste generation requires high levels of innovation. In pursuing sustainable outcomes innovation is sought in both process and product, recognizing that function and system level innovations (Brezet 1997) have the greatest potential to achieve more sustainable consumption and behaviour outcomes. Whilst consumable products, including buildings, continue to be re-designed in isolation from the systems in which they operate un-sustainability remains.

In light of these large-scale, system wide challenges to innovation and communication, a charrette approach is to be employed. The multi layered, iterative and reflective processes possible within charrettes can transcend discipline boundaries and facilitate more significant data collection from, and interaction amongst, industry practitioners than might be possible through alternative methods.

Generally speaking, the literature on the use of charrettes as a research tool or method is relatively scarce. Gibson & Whittington (2010) discuss 'research charrettes' specifically in relation to the construction industry, describing them as "an effective interaction and feedback mechanism between industry respondents and academia...for academic researchers to discover innovative and truly useful findings concerning construction industry best practice" (2010, p.66). To define the research method a

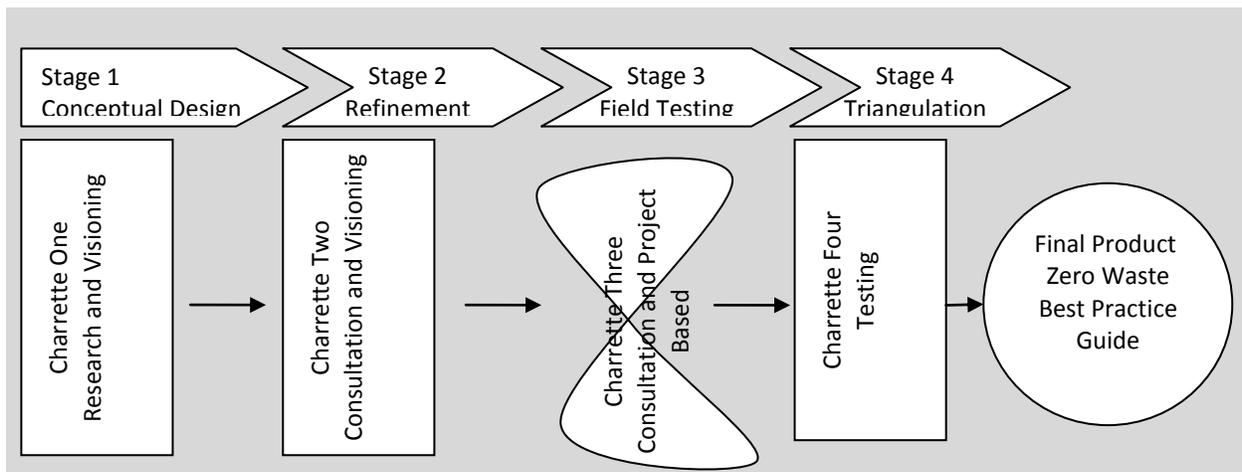
detailed review of charrette types has been conducted. The primary outcome of the review was a unique grouping of charrette types on the purpose of the activity, rather than the usual description based on the type of project undertaken. That is, the literature included mainly project based descriptions including planning charrettes, urban design charrettes, building based charrettes etc. These were analysed in relation to their purpose, which differed greatly by both project type and stage to generate an alternative categorization based on purpose. Table 1 shows the resultant charrette types defined by this process. (For a full discussion of this analysis and project methodology see Palmer et al 2013)

Table 1: Charrette Types established through the literature review.

Charrette Type	Purpose(s)
Research Charrettes	Data collection ¹
Visionary Charrettes	Problem definition / Needs assessment ² Establishing Future Goals Future visions Identifying Opportunities to achieve future goals ³
Consultation Charrettes	Stakeholder engagement ⁴ Positive participation, buy-in, diffusion of confrontation. ⁵
Project Based Charrettes	Iterative design process specific to a defined project Project specific problem solving
Testing Charrettes	Assessment of applicability ⁶ Model refinement ⁷

Each of the five identified charrette types is to be employed over the four main stages of the project. Commencing with the more 'open' charrette types for data collection and opportunity identification the outcomes from each charrette informs the objectives of subsequent research, becoming more focused and specific over time facilitating industry relevant refinement of the research outcomes.

Figure 1: Charrette Types to be employed throughout project.



¹ Walshe et al (2010), Gibson and Wittington (2010)

² Needs Assessment and Visioning discussed by Sutton and Kemp (2006)

³ For example see Remtema and Nyland (2009) discussing use of charrettes to identify opportunities in an institutional operations context

⁴ Stakeholder engagement in relation to Planning Charrettes is discussed by many authors including : Lennertz & Lutzenhiser (2006), Condon (2008), Wates (2008), Gindroz et al(2003)

⁵ It is worth noting that the difference between visionary and consultation charrettes is often the stage of project development, with consultation charrettes generally occurring after a project has commenced and a number of decisions have been made prior to consultation.

⁶ Clayton (1998), Clevenger (2010)

⁷ Gibson and Wittington (2010)

Charrette One: Inkgarni Wardli

The initial stage of the project utilises three methods of data collection in combination to commence the development of the Best Practice Guide.

- 1- Critical Appraisal of current Australian construction and demolition (C&D) waste practices,
- 2- Literature review of Australian and International C&D waste practices and policies,
- 3- Collation of industry members' perceptions and experiences in relation to waste management.

The third of these, Charrette One, was achieved through a 'Research' and 'Visioning' Charrette. To ensure representation from all stakeholders in the building life-cycle participants were recruited for this initial charrette from the procurement team and occupants of the Inkgarni Wardli building at the University of Adelaide, formerly known as Innova 21, which opened in 2010. The Inkgarni Wardli building was the first to receive a 6 Star Green Star rating using the Education V1 tool, defining it as a world leading building in relation to environmental design. The \$100 million dollar, nine storey, 11,000 square meter building houses a variety of educational activities, campus meeting rooms, academic offices and research facilities. It also boasts a range of leading environmental technologies. Members of the building procurement team participating in the Charrette included the Project Director, Project Manager, Construction Managers, Site Manager, Senior Architect, Quantity Surveyor, Sustainability Consultant, Campus Services Manager, client representatives and Structural Engineer. By recruiting participants from a project which sought to pursue a high environmental rating in design, construction and occupation, the research team expected the participants to be aware of current best practice in relation to waste management and therefore be able to provide insights into those current practices from their various professional perspectives. These expectations were not unfounded, with participants demonstrating a high degree of commitment to achieving the best possible outcomes in relation to waste and 'green' building design.

The 'Research' component of the charrette sought to unpack the participants' understanding of waste and their professional and personal role in its generation. It differed from a structured interview or typical focus group in that the semi-structured questions were designed to build upon each other, facilitating the collaborative group construction of a visual chart representing waste definitions, waste types, processes, causes, barriers, opportunities and responsible stakeholders correlated against stages of the building lifecycle. Data generated from the charrette therefore included the individual comments of participants (recorded and later transcribed for analysis as per a typical focus group) as well as a complex visual chart developed by the participants indicating the correlations between stakeholders and waste generation throughout the building lifecycle.

The 'Visioning' component of the charrette was intended to encourage exploration of possibility; to consider what might be desired in a zero waste construction future. Participants were also asked what indicators might be used to measure future success. In addition to the 13 charrette participants, three members of the research team, one PhD scholar and a research fellow associated with the project were in attendance. The session was led by an external facilitator⁸.

Whilst the charrette participants were all engaged in the Inkgarni Wardli building, the experiences of the group across the broader building industry makes the outcomes applicable to a broader context. The shared experiences of this particular building acted as a commencement point through which examples could be both drawn and contrasted. The outcomes of both components of the charrette are discussed in the following sections of the paper.

⁸ Charrette One was conducted on March 15th 2013 on site at the Inkgarni Wardli building. Helen Fischer, Research Manager, Harrisons Research facilitated the discussion to construct a collaborative representation of waste in construction utilising questions and guidance provided by the project Chief Investigators. The final outcome of the visual chart was recorded photographically. The discussions were audio recorded and later transcribed by Harrisons Research for analysis.

Findings of Charrette One

Charrette one aimed to collate industry members' perceptions and experiences in relation to waste management, as well as briefly discussing an ideal future vision for the industry. The participant's understandings (or definitions) of waste and the perceived 'cost' of this waste were two main topics of conversation during the charrette session. A third main theme arising was the apparent conflicts between causes of waste, possible solutions and barriers to change. The outcomes of Charrette One are presented using these three main themes.

Current understandings of waste in construction

Zero Waste SA refers to the following definition of waste provided in the South Australian Environment Protection Act of 1993:

- *any discarded, rejected, abandoned, unwanted or surplus matter, whether or not intended for sale or for recycling, reprocessing, recovery or purification by a separate operation from that which produced the matter; or*
- *anything declared by regulation or by an environment protection policy to be a waste; whether of value or not.* (Version 1.1.2013 p.6)

Such 'matter' based definitions of waste are typical in waste management and policy. The European Waste Framework Directive defines waste as "(a)ny substance or object the holder discards, intends to discard or is required to discard" (Directive 2008/98/EC 2008 p.9). Such definitions not only ignore non-matter wastes but also fail to recognize the potential resource value of some forms of waste. The initial item discussed at the charrette revealed an industry understanding of waste which extends far beyond waste 'matter.' Participants were asked "What do you first think of when waste is mentioned in relation to construction?" Of the six initial rapid-fire responses to this prompt

1. By-products of what we use.
2. An opportunity.
3. Something that's discarded before the end of its useful life.
4. Inefficient.
5. Wasted effort in design.
6. Wasting opportunity.

only two referred specifically to solid waste. These responses, and those offered in the followed discussion, expand beyond the typical legislative view of waste, providing a more holistic conception. The McMillan Dictionary definition of waste includes a 'matter' based definition,

- "the useless materials, substances, or parts that are left after you use something"

but it also includes less tangible forms of waste:

- "a situation in which time, money, or energy is used without bringing any useful result"

- "the failure to use something valuable in an effective way, so that it does not produce the benefits that it could"

This distinction between tangible and intangible waste offers a basis upon which to interpret and communicate the construction industry understanding of waste as demonstrated by the charrette participants. The resultant Table 2 below highlights the disjuncture between 'green building' certification schemes, legislative requirements and the industry members priorities in relation to waste, with the former two failing to consider the intangible wastes which place considerable limitations on the industry and inhibit change.

Table 2: Waste Types highlighted by Charrette One participants.

Tangible [matter] Waste Types	Intangible [non-matter] Waste Types
a building you don't need components disposed before end of useful life damaged/ contaminated goods excess material use incorrect/ inappropriate goods interiors disposed before end of useful life material contingencies material inefficiencies / over specifying rubbish from packaging and consumables site waste structural inefficiencies / over engineering sub-optimal building life unnecessary replacement of existing building stock valueless good, materials & by-products waste energy in occupation waste water in occupation wasted energy in construction wasted water in construction	cost of delays in approvals excess cost financial contingencies labour contingencies productivity of occupants reworking / change time inefficiencies in construction waste as opportunity / resource waste derived from delays waste due to perceived risk wasted effort wasting an opportunity to innovate

Intangible waste has been identified in relation to the construction industries previously. Pheng & Tan (1997) discussed waste in relation to construction projects in Singapore:

“Waste is considered as non-value adding to an activity. In any operation, it comprises of motion and work. However, only work is a value-adding activity. Hence, motion is regarded as a form of waste. Wastes include over-production of components and products, delays in materials and information, material transportation, unnecessary processing, excess stocks, unnecessary human activities and defects in material and information.”

Diverging from the typical definitions, Zero Waste America describes waste as "a resource that is not safely recycled back into the environment or the marketplace." (ZWA, 2010) Although this remains a 'matter' based definition of waste⁹ it highlights also the potential negative impact to people and the environment of inappropriate waste management. Recycling matter into the marketplace was raised by charrette participants as a point of contention regarding the definition of waste. Whilst green building rating schemes and government strategic plans rely primarily on measurable diversions from landfill to quantify waste reduction, participants questioned whether waste building site materials (e.g. timber and plastics) diverted from landfill and utilised as a fuel for manufacturing (e.g. cement production) should be truly considered as recycling or re-use. Following from this discussion the research team suggest all material should be considered waste from the site, regardless of the means of disposal and priority should be given to reducing the amount of waste generated, rather than the amount diverted from landfill.

The information gathered from charrette participants highlights the need to clarify definitions of building related waste with regard to intangible (non-matter) wastes and their relationship to value-adding; and to develop means of measuring tangible waste practices beyond landfill diversion.

‘Cost’ of waste

Whilst the charrette participants were not specifically asked to address the issue of costs in relation to building waste, the importance of waste costs to those present was demonstrated by its general persistence throughout all discussion. This was not an unexpected outcome given the nature of the industry. Following the collaborative group construction of a visual chart representing building lifecycle stages the location of cheap and expensive waste in those stages were discussed. The following

⁹ Whilst ‘resources’ can be interpreted to incorporate matter and non-matter resources it is not interpreted as such in this case as human or other non-matter resources (financial resources, time resources etc) are not generally conceived as being recycled into the environment or the market place.

comments made by individual participants in relation to the broad stages of preparation, design, approvals, delivery, use and recycling received general agreement from those present.

Table 3: Participants comments relating waste to building lifecycle.

Preparation	"It's cheaper to waste at the time of planning. In a sense to get the plan right, than it [is] once you've already started."
Design	"That's where it costs. You might throw any amount of money during construction and fit-out and you can fix the problem, but if you are actually building the wrong design, well then you have wasted money, time and materials all the way through." Discussion of 'the wrong design' continued to include locally available materials and labor skills and spatial solutions suitable for the cost efficient material technology of the time. "if you get those decisions wrong, you know, you've built a whole building that's wrong."
Approvals	".....time wastage, because [the approvals] process is so inefficient it takes so long for someone to give you a tick, and say yeah or approve your proposal." "Depending on the complexity some of those planning approvals can take years."
Delivery	"Can you make changes down at this end? Yes you can, it just costs money, and it's going to take time."
Use	Numerous comments were made regarding the difficulty of educating end-users and achieving user satisfaction whilst maintaining building energy use targets. There was general agreement that end-user dissatisfaction is directly related to past building experience and reticence to change expectations, resulting in resource waste during use.
Reuse	"the way we build [changes], what is economical now may not necessarily be economical in 10 years time or 20 years time."

The financial implications of wasted time in approval and delivery stages were of high concern to the participants. So too was the industry trend to focus on the economics of project delivery over and above life-cycle costs. Whilst it was acknowledged this tendency is changing, it remains a dominant parameter for development. It was generally agreed that the financial cost of waste (tangible and intangible) typically increases as any project progresses, but that this was dictated by decisions made in early project stages, most significantly, the client's initial decision to build. The charrette participants identified that an extremely waste efficient approach may be taken, but if the project is ill conceived, the entire process and its outcomes will be a waste.

Specifically discussing the Ingkarni Wardli building a University of Adelaide Senior Manager in attendance outlined the extensive economic evaluation undertaken to inform university decision making

"which took on not only the construction costs but the operating costs, and also looked at demolishing the [existing] building here versus leasing the space in the city, versus doing nothing..... what I was trying to do was change the debate in the decision making process from construction costs. So I think we, as [clients] do have the ability to change the parameters of the way the board, and senior management are thinking about the decisions they are about to make, including things like operation costs"

The client's decision to proceed with a project also frequently involves the demolition of existing structures and infrastructures, which can be argued to be wasteful in itself. The charrette participants expressed the difficulties in determining whether to retain a building as a means of avoiding tangible waste production. It was generally agreed that the existing building quality, maintenance requirements, upgrading requirements and effective site utilization should all be considered in making such a decision,

as retention of existing buildings may result in operational inefficiencies and wasted site opportunities. These parameters had been considered in the decision to demolish the exiting building on the Ingkarni Wardli site in preference for new development.

Participants agreed that costing waste over building lifecycles is highly complex, particularly considering the tendency to not cost resource consumption (e.g. water, energy, land etc.) to include environmental impacts. The information gathered from charrette participants highlights the need for future development of information and systems to establish closer links between stakeholders currently engaged in different stages of building life, particularly at early points of decision making, to minimise waste in the later stages of delivery and use; increase efficiency of approvals processes to minimise financial costs associated with wasted time; and support clients and developers in making effective assessments in relation to life-cycle waste outcomes of different development scenarios.

Causes, Solutions and Barriers to Change.

All stakeholders present at the charrette recognized they do contribute to the generation of waste through their professional and/or personal roles within the built environment. Whilst no individual saw their role in the building life-cycle being waste neutral, neither did any single stakeholder put forward the proposition that they (or their role) contributes significantly to waste generation through their decision making. The majority however, did re-direct some responsibility for their role in waste generation to other stakeholders. That is, site based workers saw their ability to totally eliminate waste as limited by the decisions made prior by the design team. Various services designers were limited in delivering an ideal outcome due to the architectural design, and consultants generally acknowledged they are “just that, consultants. The building owner [client] is still the responsible person.” Five major challenges to innovation were identified by participants and will inform future stages of the project.

1-The challenge of role delineation. Delineation of roles and responsibilities is required in the management of any large scale ventures, however it may also play a role in initiating waste patterns and acting as a barrier to change. Numerous stakeholders present at the charrette promoted a higher degree of stakeholder interaction and collaborative decision making, not dissimilar to Integrated Design (Lewis, 2004; Mendler et al. 2005; Cole et al, 2012) methods promoted as a tool to ‘green building’ solutions. Participants suggested it was important to ask:

“Do you have the right people on your team? Those people that are inputting, are they inputting at the right time? Is everyone on the same page, continually through the process?”

However, it was all noted that it is rare to obtain “sufficient funding up early in order to be able to bring in the right people at that early stage.”

2-The challenge of risk aversion and financial imperatives. A number of relatively obvious causes and solutions to waste generation in buildings were raised by participants, as summarized in Table 4.

Table 4: Examples of Causes and Solutions discussed by participants.

Causes of Waste	Suggested Solutions
Lack of communication	improved communication between stakeholders
High maintenance requirements	improved design and material specification to reduce maintenance requirements
Short building life	flexible design to facilitate building refit and upgrading over life
The challenge of constructing unique buildings with standardized products	Improved knowledge of products, increased knowledge sharing

In most cases it was indicated the perceived barrier(s) to desired changes were associated with funding, and subsequently limited by the investors (developer/owner/client) priorities. The typical focus on up-front construction costs rather than life costs was identified as a barrier to change, so too was the risk-adverse nature of the construction industry. In relation to the Ingkarni Wardli project, the client commitment to aspirational goals at the early design briefing stages was discussed as a positive process. Prioritizing performance outcomes over initial construction costs and ultimately aiming for savings on a life-cycle basis enabled a number of cost barriers to be removed and more innovative outcomes achieved.

3-The challenge of unique design and knowledge development. The oft heard term 'nearly all buildings are prototypes' results in an industry relatively slow to learn from, and build upon, previous experiences and to develop new quality processes. A charrette participant contributed the following comments:

"There's a key factor and that is each building is unique, delivery is unique, if you talk manufacturing you can get it down pat, because it's a structured process right through..... People are starting to realise that the way to get efficient is to try and almost adopt a manufacturing type model." ".....every building is a unique project so you have got an opportunity of accepting some waste in refining during the design and the concept phases and minimising real waste later on. Is that waste up front or is that actually perfecting it?"

This outlook of encouraging time 'wasted' in early project development to be viewed as an investment in perfection is advisable not only within a single project but also leading into subsequent projects.

4-The challenge of the intangible. Further discussion regarding perceived solutions or preferred practices in relation to waste generation identified an interesting challenge. Whereas the above actions proposed involve a degree of cultural change within the building procurement team to deliver a lower waste outcome, subsequent suggestions from participants focused purely on design based and technological solutions. These included such things as building component prefabrication, global sourcing of alternative materials, design for deconstruction, automated environment controls etc. It was interesting that after initially focusing on process-based solutions the group reverted to a techno-remedial approach to system improvement, adding onto existing practices with specifiable and tangible objects to improve outcomes.

This process demonstrated a disjuncture between the causes of waste identified by the group earlier in the session and the technical solutions typical of the contemporary industry media. The authors hence suggest progress in this field may be limited by the industry desire to be the first to integrate a new technology rather than the first to innovatively and effectively remove entrenched negative practices.

5-The challenge of 'true costing'. Participants alluded to the role of legislation in driving innovation in waste practices through the implementation of 'true costing' of both building materials and the materials utilised in packaging. Frustration was expressed in relation to the limited choices available when specifying, purchasing and transporting materials and building components. The following conversation discussing packaging materials highlights the need for full environmental costs to be considered across the industry as a means of driving innovation.

"..probably one of the key barriers is we don't see the true cost of waste, we are not paying the full environmental cost so it is easy to put plastic packaging and foam and all that sort of stuff around materials and send them around the country because it is very cheap to dispose ."

"But then if you think about it if you don't package in foam you get them on site all broken."

"But if we pay the true cost for all that foam and packaging would people come up with smarter ways to transport the goods?"

"Absolutely"

The information gathered from charrette participants in relation to these five main challenges to waste innovation highlights the need for development of information to:

- 1- demonstrate the positive benefits of a life-time, integrated approach to waste
- 2- support integrated project teams to generate life-time waste targets and effective implementation strategies
- 3- enable sharing of learnt experiences throughout the industry
- 4- ensure solutions engaged in the name of waste reduction act directly upon an identified waste cause rather than introducing additional technology without identified benefit
- 5- support innovation across the industry through legislative requirements such as 'true cost pricing' or extended producer responsibility.

Summary of Recommendations

The following recommendations are among those drawn from this first charrette which will be used to inform future stages of the project:

Clarify definitions of building related waste with regard to:

- Intangible (non-matter) wastes and their relationship to value-adding;
- Means of measuring tangible waste practices beyond landfill diversion.

Develop information and systems to:

- Establish closer links between stakeholders currently engaged in different stages of the building life, particularly at early points of decision making, to minimise waste in the later stages of delivery and use;
- Increase efficiency of approvals processes to minimise financial costs associated with wasted time;
- Support clients and developers in making effective assessments in relation to life-time waste outcomes of different development scenarios.

Develop information to:

- Demonstrate to developers/owners/clients the positive benefits of establishing an integrated approach to waste early in the project;
- Support such an integrated project team in generating a project based life-time waste target together with implementation strategies;
- Enable sharing of learnt experiences throughout the industry to encourage uptake and collaborative refinement of alternative solutions, possibly drawing upon a manufacturing model;
- Support project teams in ensuring solutions engaged in the name of waste reduction act directly upon an identified waste cause rather than introducing additional technology without identified benefit
- Support innovation across the industry through legislative requirements such as 'true cost pricing' or extended responsibility.
- Examine impacts of supply chains and other issues associated materials sourcing and supply.

These recommendations will be employed by the research team to define the future direction of the project and inform the development of subsequent charrettes. For example Charrette Two, a 'consultation' and 'visioning charrette' will engage a larger number of stakeholders and revisit a number of the recommendations above. Charrette Two will seek to confirm the validity of these recommendations by consulting with a broader stakeholder group and gather further information required to commence implementation.

Conclusion

This paper has discussed research into how the designers, builders and users of buildings, might move towards international best practice and total waste elimination. That is, how such teams might design, construct and manage a building to achieve zero waste. Participants in the first charrette were drawn from the procurement team of a world leading, mixed use 'green' building. The participants were asked to provide an understanding of waste and their professional and personal role in its generation. Their knowledge as revealed in the charrette will provide talking points that will be unpacked in three more

charrettes involving clients, architects, designers, and planners, engineers, building contractors, facility managers and lay users. The desired outcome of the research is to offer a guide to achieving zero waste in the design, construction and management of buildings.

The charrette research method employed in the project has been effective to date in responding to the challenges of working with a broad range of stakeholders and provided a productive environment for research. This first charrette has provided researchers and participants alike with an improved understanding of current waste practices and clarified the need for the eco-efficiency focus of current building waste practices to be expanded to introduce increased focus on project culture, process and design.

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