The production, re-use and disposal practices of custom-built wood-based exhibition stands

In South Africa and abroad

For: The Event Greening Forum

By University of Pretoria

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Contents

1 Executive summary

This study explored the perceptions of three stakeholder groups in the exhibition industry, namely, event organisers, events venues and stand builders. This study consisted of a review of literature, an analysis of secondary sources (existing documents, websites etc.), and fieldwork among South African and international participants currently working in the exhibition industry.

International participants in this study indicated a clear trend toward re-usable systems and custom-built elements made from sustainable material like fibre board; a clear move away from wood-based products was evident from the international response set. In contrast, South African stand builders indicated that wood-based custom built stand still make up the majority of the stands they produce.

While wood constitutes only 8% of the total waste for which event organisers are responsible (including waste managed and generated by event organisers) and 9% of venues' waste, it makes up a notable 37% of stand builders' waste. This discrepancy could be part of the reason why venues and event organisers feel that wood waste is not a great concern.

Most wood waste are discarded to landfill using either private or municipal waste management companies without definite efforts to manage (lessen) such waste throughout the production process. Potential solutions emerging from the research identified a few solutions to minimise wood waste, including gasification of the wood waste to generate electricity; refuse derived fuel plants; as well as industrial symbiosis programs and beneficiation approaches. Only beneficiation was however regarded by participants as a foreseeable way of managing their wood waste.

Only a few companies monitor wood waste both in South Africa and internationally, while none report on wood waste in any official way such as year reports.

The research highlights the perception amongst many stand builders, event organisers and venues, both nationally and internationally, that wood waste is not a pressing issue, but waste minimisation would nevertheless be supported by top management. This is primarily due to the cost benefit of efficient use rather than environmental concern. Most participants do not believe wood waste to be of great concern. The current scenario is thus one of inaction with an absence of intention to plan for improved wood waste management going forward.

Challenges in wood waste management, as identified in the international sphere, originate mostly from client needs; in many instances insisting on unsustainable exhibition stands, thus making it difficult to move away from the "status quo" in the industry. Lack of knowledge on managing wood waste and the lack of the necessary systems to support effective wood waste management are also problems. The Event Greening Forum (EGF) is the most important source of information on sustainability in the South African exhibition industry with South African Association for the Conference Industry (SAACI) and the Exhibition and Event Association of South Africa (EXSA) also considered useful for information on sustainability.

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1 Background

Global environmental challenges and resource constraints have led to increased pressure on industries to operate in a more responsible, efficient and sustainable manner. The exhibition industry is no exception. However, despite this growing awareness, toxic and energy intense materials and processes are continually used to construct exhibition display stands with a very short usage cycle and are often discarded after a single use. This modus operandi is perpetuated by various industry specific challenges such as rapid turn-around times and long working hours – or what is known as "build-and-burn" (Newton, Charnley, Rowe, Tymms & Mills, 2014). "In the past, exhibitions have been completely wasteful, bespoke stands that were only designed for one event. The whole lot would end up in the skip after the show" (Forse, director of stand design specialist Apex, 2018). These exhibition booths often contain toxic glues and paints, branding, PVC stickers and different types of MDF, chipboard, Perspex and other plastics regarded as non-recyclable due to their varied content. Stands are either burnt or sent to land-fill; with both options becoming increasingly problematic.

At the same time exhibition industry in South Africa contributes significantly to the South African GDP annually. According to Weaving (2015), the exhibition industry in South Africa grew from 120 to 180 exhibitions between 2006 and 2015, with an increased focus on trade specific exhibitions. An estimated 36 662 exhibitors and 2.9 million visitors participated in exhibitions in 2015; generating as much as R 4 172 382 million in spending along with creating 151 950 jobs per annum (Weaving, 2015). This lucrative industry impacts on the tourism industry in particular and inevitably also contributes to high consumption levels, transport emissions and waste in an economy. Still, internationally Africa only serves 2% of the global exhibition market, and South Africa showed a 2% decline in available exhibition space between 2006/7 and 2011/12 (UFI, 2014); highlighting the growth potential of this industry in South Africa in particular.

The Event Greening Forum (EGF), the client in this research, identified a trend in the South African exhibition industry toward the use of custom-built exhibition stands. In contrast to shell schemes and modular aluminium systems which are re-usable, custom-built stands are single-use wood-based stands and may or may not be responsibly re-used/disposed of. The EGF expressed their concern that current wood waste management processes are not able or responsive to this increase in custom-built stands and should the industry and the trend toward custom-built stands continue, it could present a significant problem in future. This trend may also manifest internationally.

2 Problem statement

The University of Pretoria was contracted to conduct an international benchmark study on the management of wood waste deriving from exhibition stands. The aim was to determine the prevalence of wood-based stands used in South Africa; the types and weights of wood used in the production of these exhibition stands; and resultant waste management and recycling practices in the exhibition industry. This study considered production practices, materials used, design guidelines employed with the aim to reducing waste, raw wood recycling practices, re-use and recycling practices, as well as alternatives considered.

The next section, Section 3, provides an overview of available literature. Subsequent Sections 4 to 6 explore international standards in wood waste management practices; the value and challenges in recycling or re-using wood in the South African exhibition industry; as well as description of international strategies employed to green exhibition stands. Unique South African solutions are explored and suggestions for beneficiation are considered in more detail (data for this section collected from existing source). Section 7 gives a description of the methodology followed for the fieldwork among event organisers, venues and stand building contractors in both South African and abroad; with the sample description and results in Section 8.

3 Literature review

In this review of the available literature, brief attention will be given to international exhibition waste management and challenges before we turn our focus on wood waste. A description of the hierarchy of emission limitation practices are reviewed, followed by an exploration of the cradle-to-grave and cradle-to-cradle concepts. Wood waste in context of exhibition waste

An ambitious waste audit study was conducted in 2001 in the UK exhibition industry – called the Sustainable Exhibitions Industry (SEXI) project. The study was funded by several industry role players, with the support of the Environment Agency and the UK government; conducted by the Midlands Environmental Business Club (MEBC, 2002). This audit offered a snapshot view of the waste perceptions, attitudes and practices of event organisers, exhibition venues and exhibition contractors in the UK. The study highlighted that exhibition waste consisted of:

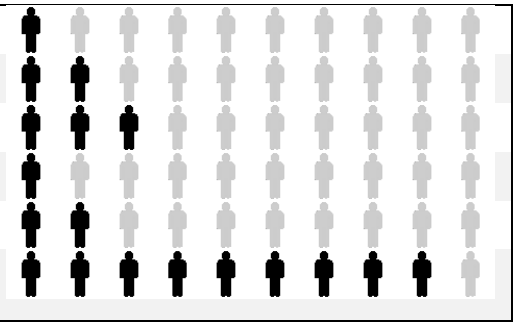
- 29% packing
- 26% paper and promotional literature
- 18% carpet
- 17% wood and
- 10% other

The MEBC study found that attitudes toward monitoring waste in the exhibition industry in the UK in 2002 were very low. While venues were indicated as the most responsible, very low levels of waste monitoring and establishing waste targets were still registered.

Table 1 Sustainability in exhibition industry study summary

			2001
Monitoring waste	Venue	36%	
	Event organisers	0%	
	Contractors	12%	
Targets for waste reduction	Venue	9%	
	Event organisers	0%	
	Contractors	6%	
Named individual to	Venue	41%	

manage waste	Event organisers	11%
	Contractors	17%
Environmental policy	Venue	32%
	Event organisers	6%
	Contractors	17%
Top management would support waste reduction initiatives.		



Source: MBEC (2002, p. 13)

These attitudes were recorded in 2001 in the UK and may indeed not be reflective of the current exhibition industry attitudes toward waste management. However, these are indicative of the industry at the time and create an international context for exhibition waste management.

This study dealt with exhibition waste in general of which wood waste made up only 17% of all waste. In South Africa, the situation is not the same. A recent waste audit conducted by Steadfast Greening (2018) at the Meetings Africa Conference identified wood as a significant portion of waste, especially on the final day of break-up.

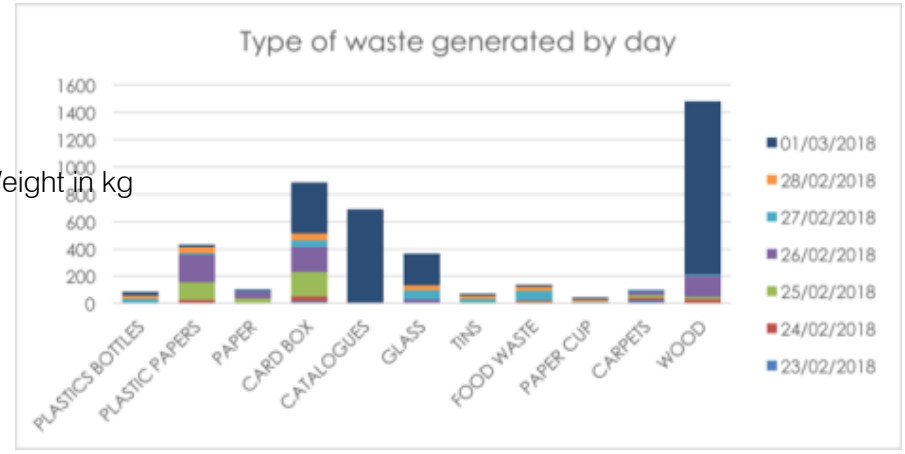


Figure 1 Types of waste generated at Meetings Africa 2018.

Source: (Steadfast Greening, 2018)

Wood, cardboard and catalogues contributed significantly to the waste generated on the final day of the conference. While cardboard and paper catalogues are generally recyclable, mixed wood waste is not as easily recycled and therefore emphasises the need to address wood waste, and to estimate the extent of the problem in the South African exhibition industry.

3.1 Hierarchy of waste and emissions

The South African National waste Management Strategy delineates several hierarchical steps in limiting waste, these are relatively well-known.

Table 2 Waste hierarchy

Hierarchy step	*Description*
Avoid and	Design principles that incorporate the re-use of goods or their

reduce	dismantling into components for re-use. Reduction of quantity and toxicity of waste generated during the production process.
Re-use	Diversion from the waste stream for use in a similar or different purpose without changing its form or properties
Recycle	Separation of items in the waste stream and processing them as products or raw materials
Recover	Reclaiming of components or materials, or using the waste as a fuel
Treat	Treatment in preparation for disposal
Dispose	Final disposal in the safest manner possible
Remediate	

Source: National Waste Management Strategy (2010)

Morris (2008), calculated green house gas (GHG) emissions that can be avoided in the recycling of virgin wood as a result of each hierachical step. Most notably highlighting that the hiercharchy is not simply the order of *possible actions* to take during waste management, but it is represents the *hierarchy of the GHG emissions avoided*. In other words, not only is "reduce" the first step in becoming more sustainable, it is also the step containing the most GHG emission savings.

*Table 3 Estimated GHG Increase/(decrease) from clean wood waste management methods**

Management method	*Pounds eCO2/ton*
Re-use	(5,572)
Recycling to Paper Pulp	(4,733)
Fuel Sub for Coal	(3,306)
Landfill with Energy Recovery	(1,297)
Landfill with LFG Flaring	(1,115)
Fuel Sub for Natural Gas	(1,072)
Landfil without LFG Capture	825

Note*: Pounds CO2 equivalents per ton wood waste)
Source: Morris (2008)

Eco-efficiency strategies are the norm in the exhibition industry in the UK (Newton et al. 2014), with the focus on the economic output alongside the reduction of the impact on ecological systems. In other words, resources are linear and progress from 'cradle-to-grave'.

3.2 Cradle-to-grave vs cradle-to-cradle

Steps toward mitigation of the environmental impact of the exhibition stands are largely intent on increasing the eco-efficiency of the stand design and supply system. Eco-effectiveness would entail causing less-harm and have less bad impacts, or "to get more from less: more product or service value with less waste, less resource use or less toxicity" (Braungart, McDonough & Bollinger, 2018, p. 1337). Some experts argue that creating less waste and having a 'less-bad' impact is no longer enough. Eco-effectiveness is a more challenging approach in resource management wherein the "cyclical relationship between the ecological and economical system is encouraged through the cradle to cradle design" (Newton et al, 2014, p. 208). The gist is that either through biological or technical metabolism, products and materials used in the construction of an exhibition stands could 'nourish' either a) biological systems when broken down or b) nourish economic systems in which the waste is designed to be an input into another system; the aim is to maintain resource quality through multiple cycles

of use as opposed to simply aiming at zero waste. Even Newton et al (2014) concede however that this approach is often “considered impractical during and after and exhibition” (p. 209).

In the following section the potential wood waste recycling and re-use practices are explored.

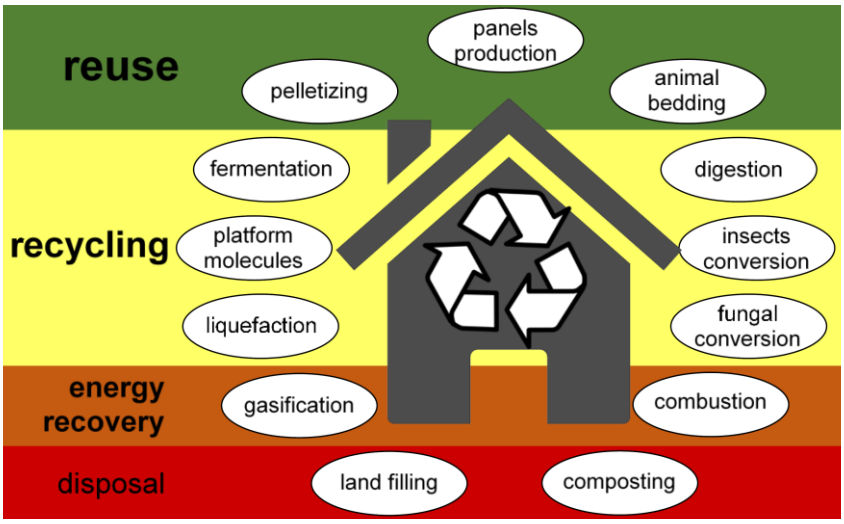
4 Wood waste recycling uses and standards

Both internationally, and in South Africa, waste wood is used to produce new composite panels, animal bedding and compost or for energy recovery. All over the globe, however, the challenges posed by mixed wood with multiple finishes of varying degrees of toxicity, and a range of fixings are experienced.

4.1 International waste wood uses

Tellness (2016) indicated that Norway’s wood waste is primarily used for energy recovery to supplement fossil fuel energy generation. Alternative uses include using wood for landscaping, animal bedding or particle board. Sandak and Sandak (2016) indicate the end-of-life cycle of bio-based construction products, categorising the practices into re-use, recycling, energy recovery, and disposal.

Figure 2 End-of-life cycle



Source: Sandak and Sandak (2016)

Daian and Ozarska (2009) emphasise that wood would need to adhere to a specific standard to be used or recycled in a specific manner. The table below indicates the expected standards into each waste stream.

Table 4 Expected standards in waste streams

Use	*Example*	*Standard*
Landscaping and organic re-use	Mulch and compost	• Clean wood, 'green waste' • Any moisture contents • Particle sizes 3-50mm
Bioenergy		• Moisture content lower than 6% • Pre-treatment/chipping is necessary • Technology used will dictate use • Cement
Animal products		
Engineering woods		

Source: Daian and Ozarska (2009)

4.2 Waste wood as a resource

One of the waste streams identified by GreenCape (2018) as a potential market, was 760 000 tonnes of treated wood per annum in the Western Cape, which is not taken up by large companies due to logistical constraints or a current lack of market. Treated wood made up the largest portion of all underutilised waste streams in the Western Cape Industrial Symbiosis Programme, which included slag, paper and pulp effluent, foundry sand, laminated glass and cardboard cores (p. 64).

Recycling mixed wood waste is labour intensive and time-consuming. When wood waste streams such as treated and untreated wood, laminated material and plywood are mixed, these need to be sorted and separated before it can be managed better (Prinsloo, 2017). Prinsloo (2017) comments that the abundance of unskilled labour could present a solution unique to developing countries, highlighting the role timber recycling plants can play in the separation of wood waste streams. Many concerns have been raised however in both the

exhibition industry and by GreenCape that mismanaged mixed wood waste could result in several health implications, specifically for the poor. Research on the impact and use of waste wood are discussed in the following section.

4.3 Health implications of mixed wood waste

Nissing and Von Blottnitz (2007) estimated 142 000 tonnes of wood is used for heating and cooking in informal settlements in the Cape Town region annually. The use of treated wood for fuel may present several health hazards. According to Maas, Patch and Berkowitz (2004), inorganic Arsenic, as emitted when CCA-treated wood is burnt, is not only a dangerous human pollutant but also contributes to the faster growth of existing cancerous tumours.

Niyobuhungiro, Naidoo, Dalvie and Von Blottnitz (2013) found that 11 out of 16 wood stock samples taken in peri-urban informal settlements around Cape Town used chromated copper arsenate (CCA) treated wood for cooking and catering purposes. The wood was sourced from demolition sites, pallets and fencing. This presents public health risks and highlights the challenges in wood re-use and recycling practices.

The use of waste wood for fuel is nonetheless thought be an important contributor to address the energy demand in Cape Town. Nissing and Von Blottnitz (2007) show that ~70% of the renewable energy target of the City [City of Cape Town] (10% of energy demand to be covered by renewables by 2020) could be met via the redirection of woody material flows within the Cape Metropolitan Area and the utilisation of innovative transformation technology" (p. 147).

4.4 Wood recycling: South African context

Wood waste is classified as Construction and Demolition waste (GW30), unless treated with hazardous chemicals when it would either be classified as Hazardous waste HW09 – Organic waste containing halogen or sulphur; or Hazardous Waste HW11 – Organic waste without sulphur or halogen (DEA, 2012).

Although virgin wood waste is easily re-used as fuel or mulch and organic waste, treated wood is much more difficult to address. The Institute of Waste Management in South Africa (IWMSA) notes the challenges with recycling treated wood as being collection and transportation issues, as well as sorting, cleaning, compacting and baling of the materials. The quality of the materials available for recycling is also in question because of the mixed nature of the material.

Following several discussions with waste management entities such as GreenCape and Use-it, a few potential solutions for management of mixed waste wood was recommended (as subsequently presented).

4.4.1 Potential solution: Use Stickers instead of paint

Since virgin wood is easily recyclable, a potential solution of using stickers to adhere branding to exhibition stands instead of harmful paints would enable virgin wood to be recycles once stickers are removed. The amount of glue residue that might still adhere to the wood as well as the harmful impact of gasification of PVC stickers (which gives off Chlorine when burnt) is not an ideal solution. Therefore, this is not considered a viable option. Alternatively, a standardisation of paints could enable better management of emissions should the wood waste be used as fuel in a gasification program. Another problem that was identified is that PVA is not permitted in the Meganika gasification process discussed below.

4.4.2 Potential solution: Gasification

The thermal process breaks down many harmful chemicals, this leads to it being ideal to deal with otherwise difficult waste streams. Meganika delivers small scale, on-client-site, waste-to-energy processing plants. Their first product is a patented wood gasifier, where we are targeting (processed) wood manufacturers (e.g. MDF, Melamine), converting their waste wood into electricity. This product creates 1-2 (operator) jobs per machine placed, allowing their clients to convert their own waste product to electricity, saving them money, and making their business more competitive and sustainable (http://meganika.com/meganika-green/#aboutus). Some chemical contaminants not suitable for gasification, include wood contaminated with chlorine-containing compounds, such as PVC, or CCA-treated wood.

4.4.3 Potential solution: Interwaste Refuse Derived Fuel

Interwaste, who owns one of the only Refuse Derived Fuel plants in South Africa, focus their waste treatment efforts on using 'fluff' (plastic fibres) to generate energy. Therefore wood – either treated or untreated – cannot be incorporated into this waste stream at present.

4.4.4 Potential solution: Industrial symbiosis programmes

Industrial Symbioses programmes are free facilitation services offered by Green Cape, the Gauteng Industrial Symbiosis Program (GISP) and the Kwazulu-Natal Industrial Symbiosis Program (KISP)

4.4.5 Potential solution: Beneficiation

Beneficiation is the process in which items are diverted from landfill and then used to create employment. Beneficiation nonetheless start with limiting the raw product used in the design, designing for lasting use and re-using the exhibition stand as often as possible. As stated by Prinsloo (2017), beneficiation should have a unique potential for success in South Africa because of the labour-intensive work necessary in sorting mixed waste streams. Steps in enabling beneficiation:

- Separating waste at source into different waste streams, treated from untreated wood.
- Identifying local companies who would be able to use your waste:
  - larger pieces of wood, such as couch manufacturers for re-use within the furniture or to 2nd hand dealers,
  - smaller pieces of wood could be used by architecture design schools from time to time,
  - carpentry schools often need raw product for students to practice on,
  - small local companies who upcycle waste, and
  - allow employees to use waste material for construction of their own projects in their own time

Waste management is predicted to become increasingly expensive due to limited land fill space. Although the above-mentioned potential solutions are not easily attainable, the need to both reduce the amount of waste generated and handle the waste that is generated in a more responsible manner will become increasingly important.

Waste wood management therefore starts with limiting its use, re-thinking the design and ensuring materials are both recycled and recyclable. If not recyclable, seek alternatives or ensure that you have a plan of where it will go by finding beneficiation partners in your area.

5 Strategies to address exhibition waste

This section provides a synthesis of waste reduction strategies employed internationally by exhibition stand contractors, event venues and organisers. This includes strategies reported in journal articles, popular magazines and newspaper articles by Expomobilia, Apex, Clarity!, Sustainability UK, and Green Guide Exhibition advice. A detailed list of each entity's recommendations can be found in Appendix A.

Table 5 Synthesis of international waste reduction strategies

Sustainability in design, i.e. choice of materials, supply chain system and design. Keep it simple and focussed
Long lasting re-usable modular stands
Re-useable modular custom items
Material choices: – Flooring: eco-fleece, wood and carpet tiles – Bamboo, hemp and straw products, recycled rubber – Timber from FSC sources – Formaldehyde free MDF – Completely recyclable Engineered fibre board – Recycled plastic, wood
LED lights
Water coolers
OVC Free paints – use water-based paints, vegetable-based ink
Reduce printed material, use digital methods, QR codes etc., allow for more streamlined follow up
Optimise logistics: Hire equipment, use local suppliers, reduce weight
Identify beneficiation partners
Promote green credentials, improve sentiment and trust toward company
Offset additional carbon

5.1 International challenges with exhibition waste

Several challenges have been highlighted internationally and are also experienced in South Africa, specific challenges reported by the participants in this study are discussed in Section 8.

Table 6 International challenges

– Lack of education, awareness, and training around proper waste management.
– Improper sorting by public and event staff creates additional operational challenges to separate waste post events.
– Low cooperation level from contracted cleaners and vendors to effectively separate waste streams.
– Compostable flatware breaks down slowly, therefore, some compost farms reject this material.
– Limited number of vendors accepting materials for diversion.
– Certain materials, common to events, are not easily recycled by commercial and municipal haulers. (e.g. foam core signage, carpet scraps etc.)
– Facilities available for accepting front-of-house compost and compostable service ware are scarce.
– Limited space to offer waste sorting programs back-of-house.
– Poor market incentives to recycle materials vs. landfill or incineration options.

Source: www.Greenview.sg

5.2 Consumers seek more options to engage in CSR efforts

The international trend is for consumers to become increasingly engaged and aware of companies' corporate social responsibility efforts, and this awareness in influencing real consumer sentiment and loyalty. Sustainable Brands (2018) research indicated that consumers want to engage with companies CSR efforts; with 89% stating they are more likely to buy from a company with responsible practices and 90% stating they are willing to boycott companies with irresponsible practices.

Communication of sustainability efforts and a commitment to find solutions to the specific problems faced by the exhibition industry are therefore important to communicate widely to clients and customers alike.

6 Conclusion

The potential growth in the exhibition industry and the trend toward more custom-built exhibition stands emphasise the importance of exploring international best practice as well as local implementation of re-use and recycling of these stands. Identification of alternative re-use schemes for social upliftment should be highlighted.

7 Fieldwork approach

Clearly waste wood management is not a simple task – specifically mixed and treated wood waste. It is therefore important to determine the extent of wood-based stand construction and re-use or recycling practices employed in the South African exhibition industry.

7.1 An exploratory study

The study intended to use a qualitative approach in understanding the re-use and disposal practices in the exhibition industry by exploring this phenomenon from several stakeholders' point of view. These included Event Organisers, Event Venues and Stand Building contractors. Waste management companies who are specifically involved in the management of exhibition waste were sought, but the study yielded 5 partial responses with no contact information.

7.2 Study objectives

This research endeavoured to achieve an indication toward the following objectives:

- Understand the trend in the use of custom-built wood-based stands
- Explore the materials used by stand construction companies and the management requirements employed by event organisers and venues in terms of materials prescribed/banned from venues
- Waste management practices at premises
- Wood use management practices in terms of design, re-use and recycling
- Client education and information sources
- Challenges

This research made use of a structured questionnaire consisting of both structured quantitative and open-ended qualitative questions. The research took on a phased approach with South African data collected during July and August. The international portion of this study took place in September due to the summer holiday season in the northern hemisphere.

Due to the qualitative nature of the researcher, all respondents in this study are referred to as participants.

In the following section, the South African data is discussed followed by the findings from the international study and finally, an integrated discussion on the South African and international state of affairs.

8 Results from the fieldwork

In this section the results from this study are discussed in detail.

8.1 South African sample

The sample was as indicated below. Stand builders made up the bulk of the participants with event organisers and event venues making up approximately a quarter of the participants respectively.

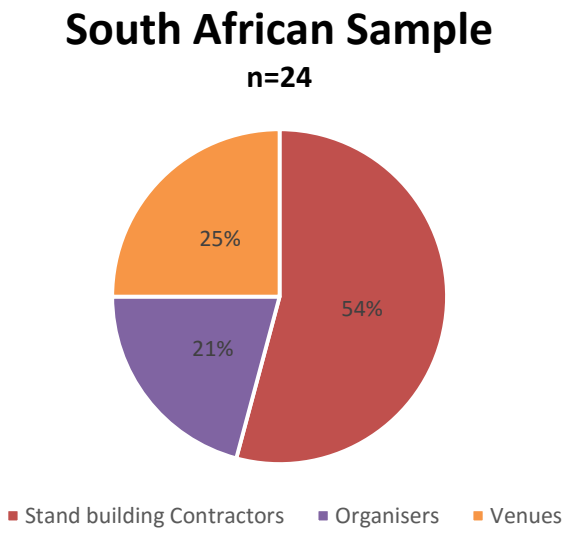


Figure 3 South African sample

The target sample included top management of small businesses (managing directors, general managers, and directors or partners), middle management (technical, events, cleaning and waste, facility, finance and marketing managers) as well as logistics co-ordinators and technical sales representatives.

The sample represented a set of extremely experienced participants. Table 6 below indicates the average years at the specific company and average years in the exhibition industry, per sample group.

Table 7 Levels of experience

	Number of participants	Average years at company	Average years' experience in the exhibition industry	Representing exhibition booths per year
Event Organisers	5	11	18	1 350
Event Venues	7	10	15	16 329
Stand building contractors	12	13	20	2 813

8.2 The international sample

Data for the international study was collected in September after the summer holiday period in the northern hemisphere concluded. The qualitative questionnaire achieved candid responses from participants and highlighted the ways in which the wood waste problem is dealt with in Europe, the USA and further afield.

The international participants consisted of 20 participants, of which most (12) were stand builders.

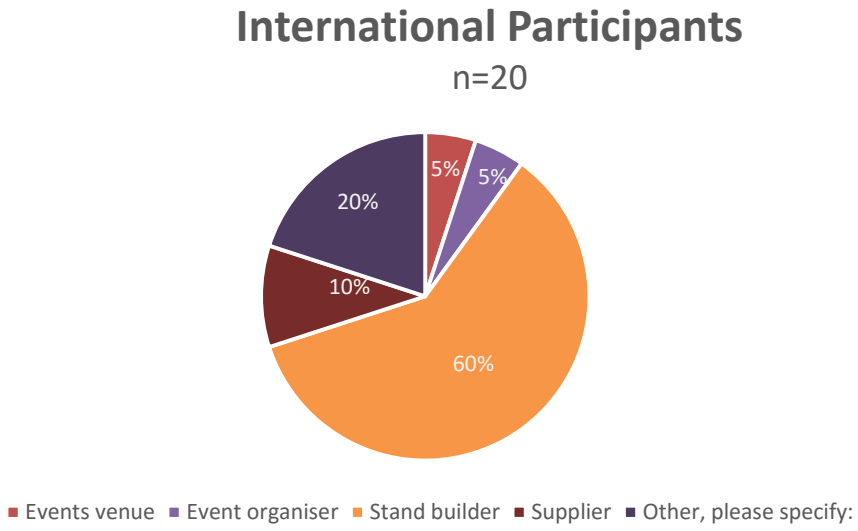


Figure 4 International Sample

Participating institutions and their international reach are indicated in the table below:

Table 8 International participating institutions

Participating institution	Head Office	Major countries in which they operate
Laguna Displays	USA	USA and UK
beMatrix	Belgium	Belgium, UK, Germany, Sweden, USA
Dubai World Trade Centre LLC.	United Arab Emirates	United Arab Emirates
Czarnowski	USA	China, Germany
KOPexpo	The Netherlands	The Netherlands, Germany, France, Belgium,
Barsa Design Company	Iran	Iran, Iraq and some countries in Europe
Kadmon-Brin LTD.	Israel	all over the world
stevensE3	Canada	Canada, United States
MEISSNER EXPO GmbH	Germany	Germany, EU, North-America, Asia
Studio Image Expo	Greece	Mostly Europe
Vision Ltd	Greece	Greece, Spain, Germany, France

The sample included highly experienced people in the international exhibition industry, including CEO's, general managers, sustainability managers and marketing managers. These individuals have been employed an average of 20 years at their respective companies, with an average of 24 years of experience in the industry.

8.3 International and local stand types and trends

8.3.1 Types of stands used

South African participants had to indicate the types of stands used at their venues and events, or which they construct in the case of stand building contractor companies. Although this is an estimate and venues and event organisers are not typically aware of the type of stand used, this estimation gives some insight into the perceived differences between event organisers, venues and the stand construction companies.

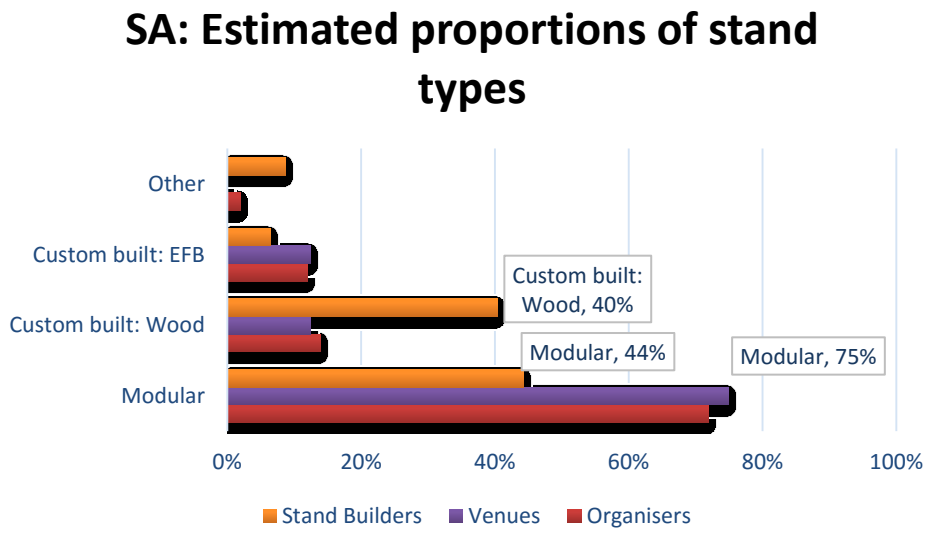


Figure 5 Estimated proportions of stand types used

For the most part, event venues, organisers and stand builders agree that modular stands are used most often. It is interesting to note however that venues and event organisers estimate that two-thirds of stands are already modular while stand builders estimate that only 44% are modular. Stand builders also indicate that 40% of their stands are custom-built, while it is estimated at much less by event venues and organisers.

There's a mismatch between the types of stands event organisers and venues think are being used and what stand builders report using

Internationally, stand builders report that 37% of the stands they construct annually are modular re-usable systems and only 54% are custom wood-based stands, with the remaining 8% made up of combinations between custom modular and bespoke elements. As in South Africa, the events organisers indicated that they thought a higher proportion of stands are modular and a lower proportion is custom made.

This may indicate an important mismatch between what event organisers think is being used and what stand builders actually use, highlighting the potential need of for event managers to improve on the type of waste management services they offer.

8.3.2 Five-year trend in types of stands

Participants had to indicate the trend in the last five years of the types of stand most often used. None of the three respondent categories indicated a decreasing trend in either 1) modular stands, 2) custom made wood-based stands or 3) custom made Engineered Fibre Board (EFB) stands. While event organisers and venues indicated an increase in custom-built EFB stands, stand builders highlighted an increase in wood-based custom-built stands. Other trends identified included a trend towards Fabric stands, increased use of plants and green walls, disposable, hybrid and portable stands.

Internationally, stand builders report a decline in wood-based stand and more emphasis on mixed custom and modular designs using materials other than wood.

In contrast, the international participants noted a clear and sharp decline in the use of custom-made wood stands, while more than 50% of participants indicated that modular stands and custom-made stand of EB is on the increase.

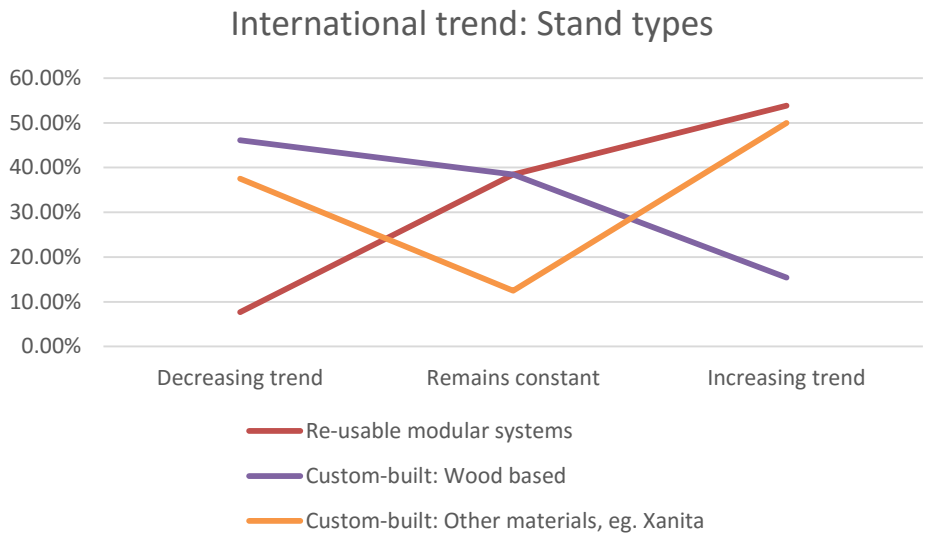


Figure 6 International trends in the types of stand used

The increase in re-usable and other custom-built materials point toward less waste at exhibition sites.

8.4 Waste management in South Africa

Participants indicated waste management and proportions placing wood waste in context of all exhibition waste dealt with. The types of waste vary considerably for event organisers, the waste types dealt with by event venues and waste generated by stand builders at their own premises. In this section the waste proportions, differences in attendee and exhibition waste and designated management agents for these types of waste is explored in more detail.

8.4.1 Waste proportions in South Africa

Waste proportions at the premises of the participants were estimated. This provides some insight into the types of waste dealt with by each stakeholder group. By far, food makes up

The best place to deal with wood waste is at the stand builder's premises

the largest portion (42%) of waste dealt with by venues; cardboard make up 29% of the waste dealt with by event organisers; wood is the most important waste product dealt with by stand builders, constituting 37% of all their waste.

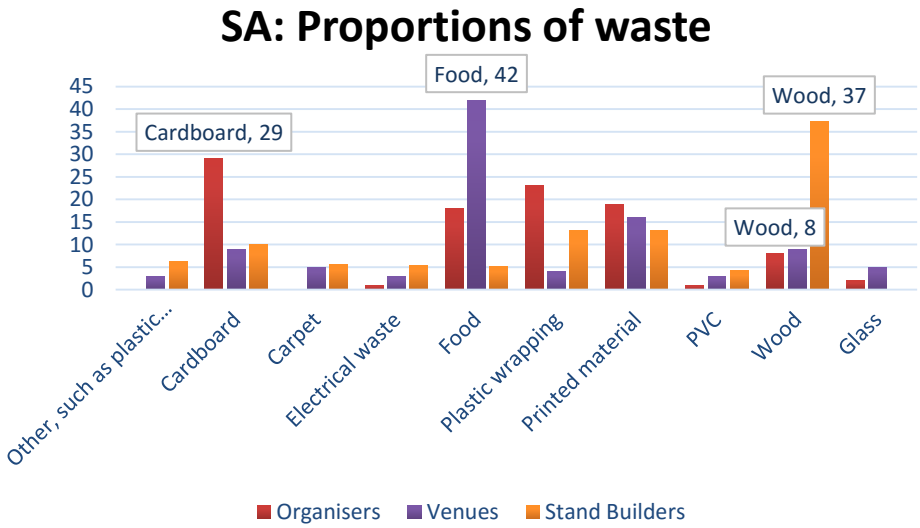


Figure 7 Proportions of waste in the South African exhibition industry

Wood waste therefore does not make up a large portion of the waste dealt with by event organisers, and only make up a small part of the waste dealt with by venues. Wood waste, however, makes up the bulk of the waste dealt with by stand building contractors.

8.4.2 Attendee waste vs exhibition waste in South Africa

Event organisers and venues were requested to indicate their waste management approach regarding attendee waste and exhibition waste. Most organisers indicated that they advocate waste minimisation practices to attendees and clients; that waste management is handled by and charged for by the venue; and that they ensure they use venues with a clear waste management policy. Only 3 organisers however indicated that they monitor waste and only one indicated that the officially report on waste.

Similarly, all venues indicated that they monitor waste, and that they ensure that waste is recycled. However only 3 venues out of the 7 included in this assessment indicated that they officially report on both attendee and exhibition waste.

8.4.3 Responsibility for waste management

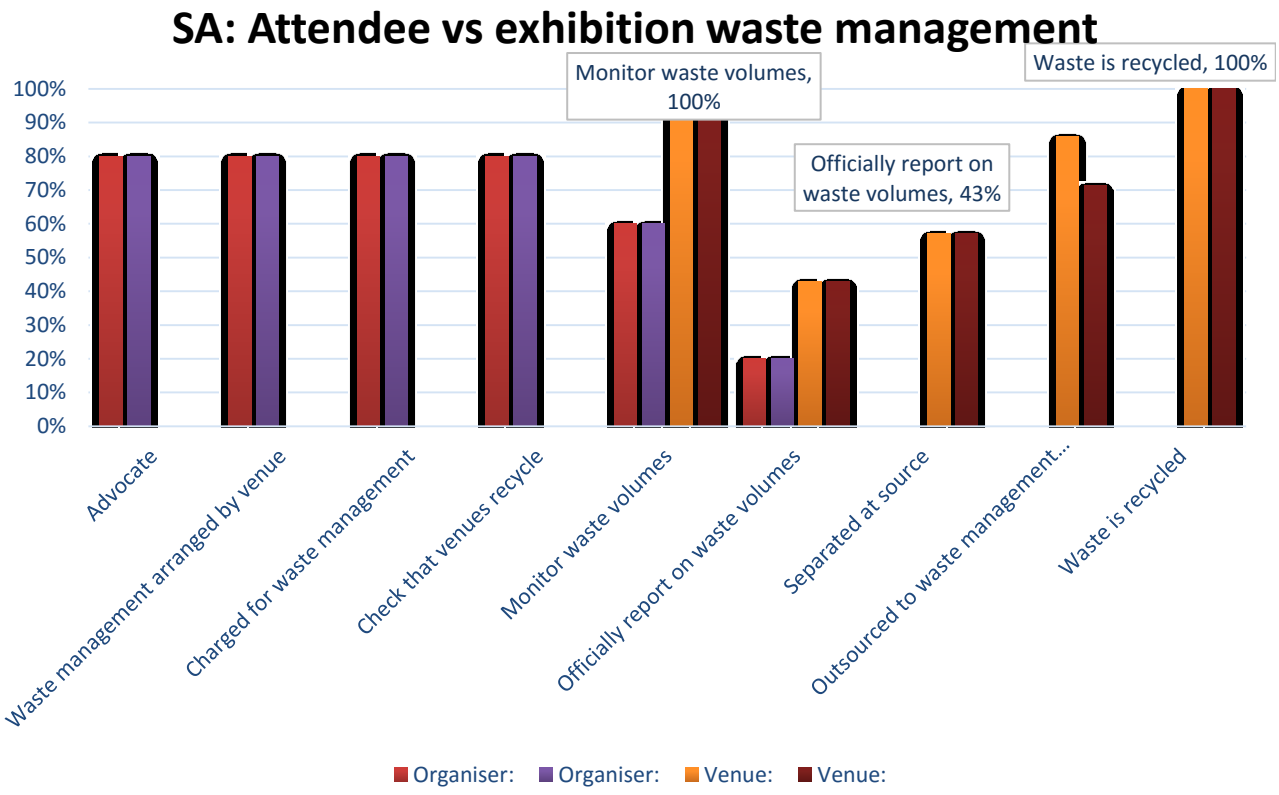
Figure 8 Attendee versus exhibition waste management in South Africa

In most instances event organisers and venues outsource their waste management for recyclable as well as non-recyclable and food/organic waste. From Figure 8 it is indicated that all three stakeholder categories and most waste types make use of waste management companies to deal with waste and separation of waste.

Figure 9 Waste management responsibility according to South African participants

8.5 Wood waste management

In this section, the focus is more on wood waste. One of the objectives of this study was to



understand more about the volume and practices in managing wood waste by the stakeholder groups.

8.5.1 Wood material consumption hierarchy in South Africa

Stand builders were requested to indicate the types of materials used to construct stands. They indicated the following in order of most frequently used, to least used.

Table 9 Building materials used to construct stands in order of frequency

1	MDF
2	Chipboard
3	Plywood
4	Softwood – like pine
5	OSB
6	Hardboard
7	EFB
8	Hardwood – like Mahogany

Other materials used to construct exhibition stands which need to be addressed as part of the waste management include standard correx boards, thicker commissioned correx boards (not available on the market), Perspex, Metals and PVC.

8.5.1.1 Monitoring wood waste

None of the event organisers reported measuring wood waste volumes specifically.

Two venues reported measuring wood waste, however both state that they do not separate untreated from treated wood. One discards the wood waste along with other municipal waste and the other use a private waste management company. Both companies state that they do not know the waste management company's wood waste recycling practices.

Very few monitor wood waste volumes

Indications from the one venue is that 50% of wood waste is clean untreated wood representing approximately 500 kilograms of wood per month while treated and mixed wood waste make up around 35% of the bulk and represents about 300 kilograms of wood per month at this venue.

As stand builders deal with wood more frequently, they were asked specific questions about their wood waste management practices and were able to provide much more detail. Of the 12 stand building companies who answered this specific question, half state that they dispose their wood using municipal waste systems, only 4 monitor their waste wood and none officially report on their wood waste volumes.

Figure 10 Stand builders' wood waste management practices

Stand building companies indicated that the main type of wood waste they deal with include mixed wood types such as MDF and Chipboard, wood treated with paint, glue and varnish as well as CCA treated pine and some untreated wood.

Discarding practices depend on the company rather than the type of material that is disposed with some companies making use of waste management companies and others discarding their waste wood into the municipal waste system.

8.5.1.2 Waste volumes

Only three (3) stand building companies indicated their wood waste volumes (Table 9-2).

Table 10 Wood waste volumes

Type of wood	Companies	% of all wood waste per month	Estimated weight in kgs per month
Clean wood – no treatment	Company 1	5%	500kg
	Company 2		
	Company 3	80%	300kg
Treated wood - paint, varnish, glue and fixings	Company 1	70%	2000 kg
	Company 2	75%	2500kg
	Company 3		
Saw-dust, chips, strands, bark	Company 1	5%	200kg

	Company 2	10%	200kg
	Company 3		
Mixed processed wood, MDF/Chipboard	Company 1	20%	1000kg
	Company 2	10%	1200kg
	Company 3	10%	50kg
CCA-impregnated wood	Company 1		
	Company 2	5%	200kg
	Company 3		
Other	Company 3	10%	50kg

No generalisations can be made from three participants, however it is clear that the majority of waste wood is either clean, or treated with a smaller portion being MDF, chipboard and the like.

8.5.1.3 Responsibility

Two companies reported that they do not know how the wood is dealt with by their waste management company while two companies indicated that they re-use virgin wood and MDF and chipboard, while sawdust, chips, strands and bark as well as treated wood are sent to landfill.

8.5.1.4 Strategies to manage wood waste

Strategies employed by stand building companies to limit and manage wood waste are discussed in this section. Out of the 12 participants that responded to this question, more than 80% of participants indicated that they "always" or "most of the time" design with re-use in mind and almost 80% said that they advise clients to design for re-use. Strategies commonly employed include limiting waste, refurbishing used stands and designing stand to be dismantled without damage (in each instance 17% said "always" and 50% said "most of the time").

In most instances stands are used more than once with only 2 participants stating that they use stands only once "almost half the time", the rest tend to use stands more often although it does sometimes happen that stands are used only once, 75% (9) reported that it happens "sometimes" and 17% (3) said it "never" happens.

Selling refurbished stands might not be viewed as "acceptable and desirable" by clients

Interestingly although more than 60% indicated that they refurbish their stands, 42% stated that the "Never" sell refurbished stands and a further 50% said they sell refurbished stands only "Sometimes".

This may be an indication of social perception issues where it is still not desirable to sell off refurbished stands.

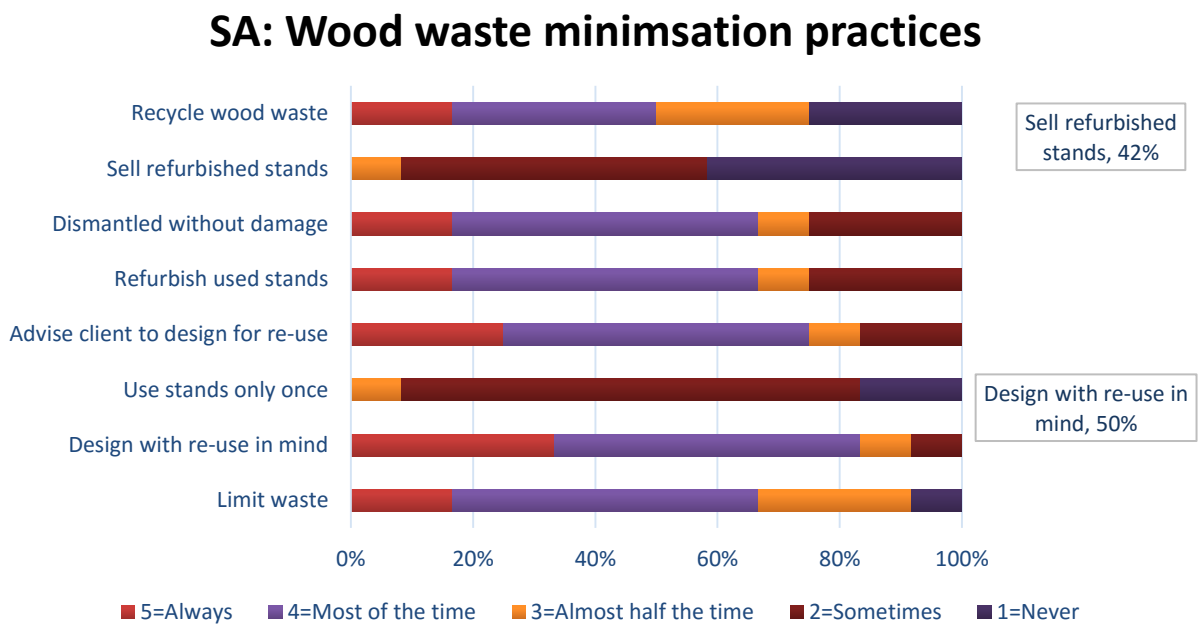


Figure 11 Wood waste minimisation practices

Internationally, more participants agreed that they sell refurbished stands, design with re-use in mind and advise clients on the benefits of designing for re-use.

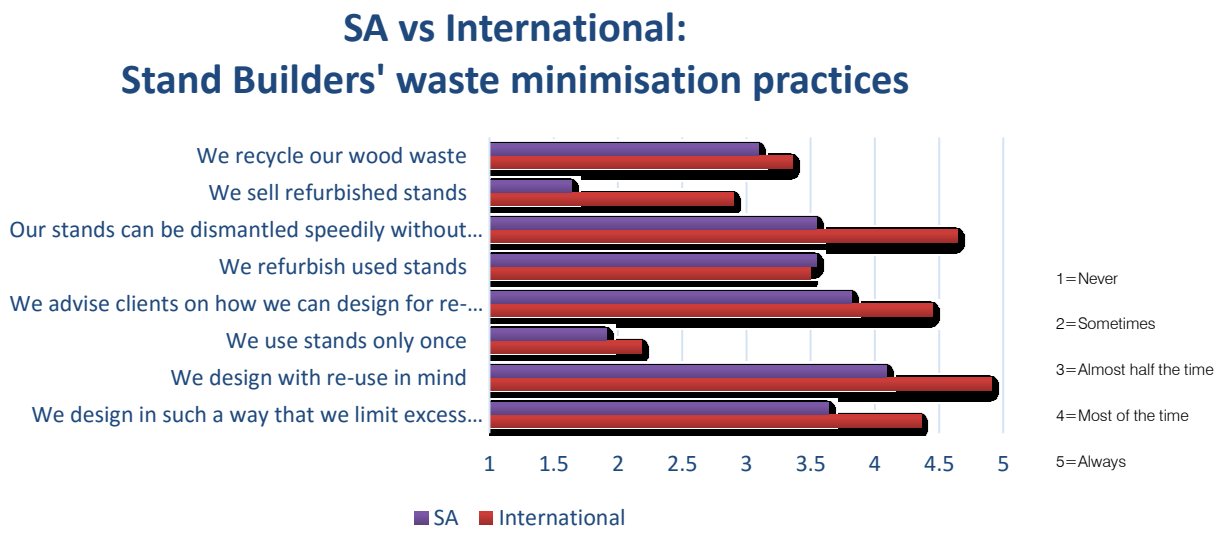


Figure 12 Waste minimisation practices in South Africa and abroad

8.6 Wood management strategies

8.6.1 Client interactions

Only one out of five event organisers reported that they encourage wood waste minimisation practices - during job inception they advocate not building custom sets. Even though none of the event organisers reported having specific processes in place to effectively minimise wood

waste, one organiser provides guidance on disposal and re-use of exhibition stands in their exhibitor manual which contains a specific green exhibition section. This event organiser discusses waste and wood reduction strategies during planning meetings and also provides people on-site during break-down to assist with the waste management.

Three out of six venues on the other hand reported encouraging wood waste minimisation practices, either by avoiding cost or more pro-actively by utilising the ISO 14001 waste management system at their venue, although none reported having specific wood waste minimisation processes in place. Two of the larger venues reported advising clients of their waste management strategies; separating waste into recyclable, non-recyclable, compostable and hazardous waste; and then "committing the balance to landfill". Neither elaborated on how they manage wood waste. One venue reported making clients aware of their environmental impact and the impact on cost should their exhibition stand end up in the skip, however they do not specifically talk about re-using exhibition stands.

Stand builders are the most involved in advocating wood waste minimisation practices with eight out of the twelve indicating that minimisation starts in the factory where staff are educated and encouraged to use resources efficiently, re-using offcuts, and planning effectively to limit waste by keeping board sizes in mind during the design stage. For stand builders the impact of effective use of materials is closely linked to their profit margins, supporting their motivation for effective management. Cost effectiveness also provides the platform in which monitoring of waste is done.

All but one of the participating stand builders reported that they offer advice, guidance and/or assistance to customers in re-using their stands, assisting in the financial planning and storing options of the commissioned stand.

Comparing the waste minimisation and management practices employed both internationally and locally the following is clear:

Both the South African and International participants indicated the same proportions of stand building companies who try to minimise wood waste and those who don't; with 73% of participants both here and abroad stating that they do attempt to minimise wood waste.

Figure 13 Wood minimisation practices

Internationally more stand building companies have procedures and processes in place to enable minimisation of wood waste, internationally 45%, locally 36%.

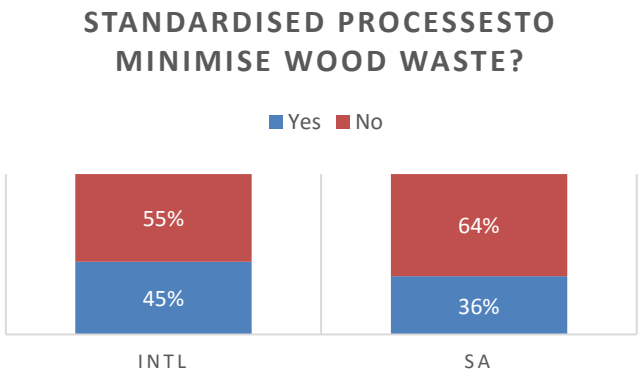


Figure 14 Standardised processes

All South African stand building companies reported that they receive customer queries to assist with recycling of their used stands, compared to 64% internationally.

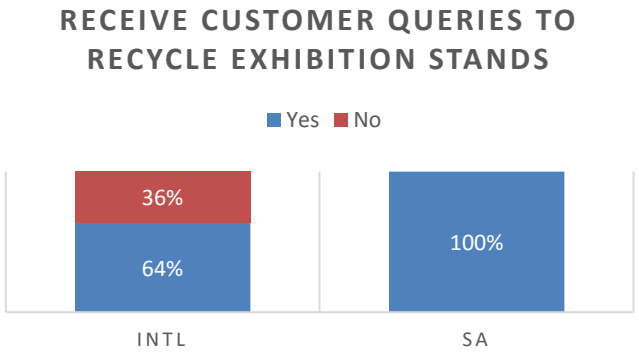


Figure 15 Customer requests for assistance

Again 64% of international participants indicated that they advise customers on how to minimise their exhibition waste, while in South Africa 90% of participants indicated that they do.

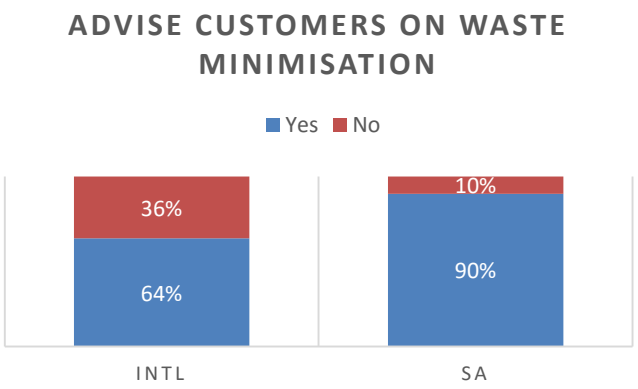


Figure 16 Customer advice on waste minimisation

Internationally, less than 30% of participants indicated that they receive guidance and advice from their waste management partners on recycling wood waste while no participants reported getting any help from waste management partners in South Africa.

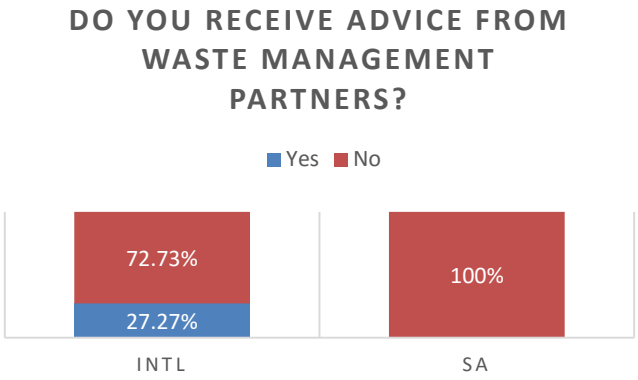


Figure 17 Advice from waste management partners

In some instances, customers request assistance as one stand builder commented "Sometimes [our clients request assistance]. We design and manage the entire exhibition process including storage, maintenance, reconstruction. We actively encourage clients to re-use."

Both locally and internationally, guidance from waste management companies on the management of wood waste is

Interestingly none of the stand builders reported receiving any information or advice on how to limit wood waste from their waste management partners. This highlights an opportunity.

8.6.2 Future of wood waste management

Seventy three percent (73%) of stand builders indicate that their top management would be supportive in the development of policies to manage wood waste, however, not all agree that managing wood waste is becoming increasingly important and even fewer have any policies in place or are planning wood waste management policies soon.

Figure 20 Event organisers' wood waste management sentiments

Figure 19 Venues' wood waste management sentiments

Figure 18 South African event organisers' wood waste management

Stand builders also seem unsure whether wood waste will in fact increase in future. For venues, the sentiment is also that top management would support specific wood waste management policies, however they also doubt that wood waste would increase in future, or the wood waste would become an increasingly important issue to manage.

Again, as was the case for the stand builders and venues, the event organiser participants indicated that they are entirely unconvinced that wood waste will increase in future and again, although top management would support limiting wood waste, very few are planning to invest in wood waste management in future.

Fewer international counterparts indicated that they have policies in place to manage wood waste compared to South African participants and fewer are planning on investing in wood waste management in the coming years. Interestingly international participants don't think wood waste in the exhibition industry will increase in the coming years. This is in line with the trend indicated earlier that wood-based exhibition stands are on a declining trend overseas.

8.7 Challenges in wood waste management

Challenges faced differ substantially between the various stakeholders. Organisers for instance feel that waste management is not really within their ambit of management, with statements like, it is *"not on our radar"* and *"not under our control".* Clients may also insist on using unsustainable practices, to which organisers feel 'forced' to comply or risk losing the client.

Venues commented that strategic management of waste is not their main concern, and especially where large venues are regarded as state entities and serviced by municipal waste management, there might be room for improvement. Other challenges highlighted was that *"client budgets don't allow for re-cycling"* and *"up-cycling is not considered*", emphasising the caveat between rising cost of landfill and the lack of options considered.

Figure 21 SA vs International sentiment on wood waste management

Stand builders said their challenges specifically centre around the *"status quo on stands"* in the industry, *"clients insisting on specific products"* and the hard work it takes to convince clients to try alternatives. South African corporate companies as well as Asian companies have been identified as being *"especially closed to the idea of re-usable exhibits".*

The 'status quo' is a real barrier

"Lack of knowledge" and *"lack of support on these issues in industry*" further hamper improved wood waste management for stand builders. A final concern is that *"waste sites don't accept wood"* and *"waste management costs are too high".*

Faced with high waste management costs, confusion on how to implement practical and cost-effective waste management plans and clients requesting the status quo, wood waste management has a long way to go. Figure 22 below indicates the most pressing issues highlighted by South African companies, while figure 23 indicate the important obstacles highlighted by the international participants.

Figure 22 Obstacles for South African companies

International participants indicated that the short dismantling time available after a show presents a big problem in ensuring waste is dealt with in a responsible manner. One respondent highlighted that the labour needed to dismantle and sort the re-usable from waste material is too expensive and not worth the effort.

Figure 23 Obstacles for international companies

Similar issues as those identified in South Africa were highlighted emphasising the lack of knowledge on how to recycle wood, but also the lack of options or knowledge of options for recycling/reusing wood waste. In contrast to South African participants, international participants indicated that the linking with the correct partners and using creativity could

successfully resolve some of the problems regarding wood waste management in the exhibition industry.

8.8 Information sources on sustainability in the exhibition industry in South Africa

Organisers mentioned that they look for information about sustainability in the industry on the internet, using the EGF website, contacting local waste management companies, and taking the lead on desired behaviour from venues.

On the other hand, venues look to municipalities on guidance for dealing with wood waste, as well as to the websites of private waste management companies and international case studies of well-known industry players such as the Hilton Worldwide.

Stand builders who deal with wood waste more often deal with waste management and recycling companies to find solutions, use trade magazines and talk to colleagues about their strategies they employ. Industry partners abroad also provide guidance.

Figure 14: Sustainability in the exhibition industry data sources

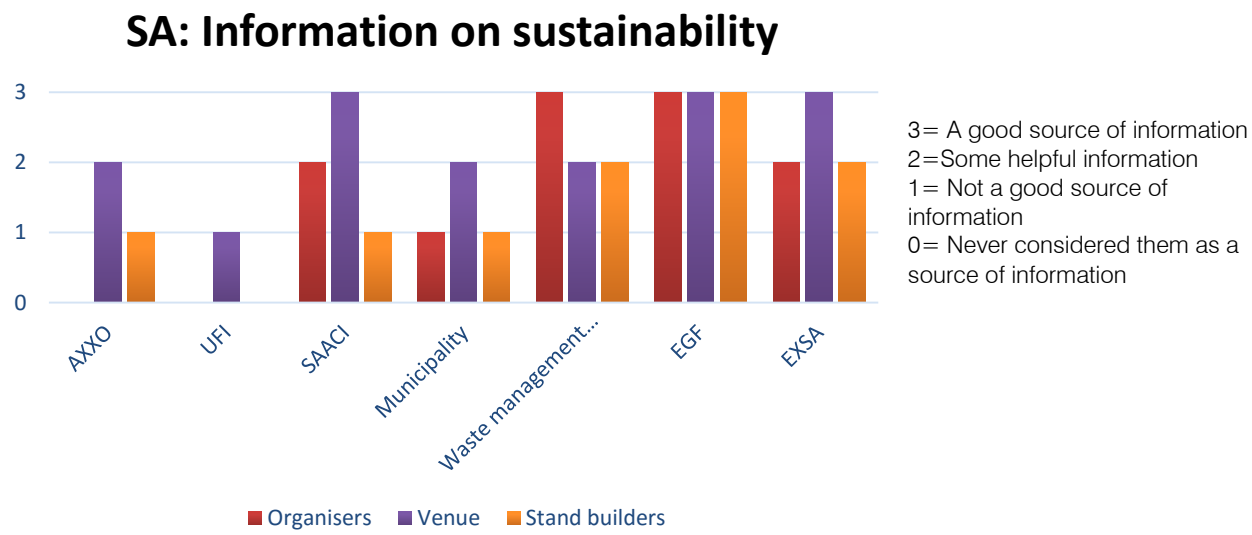


Figure 24 Sources of information in the South African Exhibition industry

It is interesting to note that the EGF is the only role player in the industry that is considered a good source of information on wood waste management by all three stakeholder groups. EXSA and SAACI are both trusted by venues to provide helpful information on wood waste management, while event organisers tend to rely more on waste management companies for information on wood waste management.

International participants state that they most often rely on their waste management company for advice on managing wood waste; the second most used source of information is the internet.

9 Conclusion

Venues and organisers noted an increasing trend of engineered fibre board stands in use, however this is not reflected in the results from the stand building contractors' responses. Other trends include an increased used of fabric stands, plants and green walls, disposable, hybrid and portable stands.

Venues and event organisers reported that 75% of the stands used at their events or venues are modular and re-usable, while only 44% of stand building contractors state that they use modular or re-usable stands, and 40% say they use custom-built wood-based stands. This discrepancy could be a part of the reason why venues and event organisers feel that wood waste is not a great concern. In terms of waste proportions, stand building contractors are mainly affected by wood waste with 37% of their waste consisting of wood. The main building materials used to construct wood-based custom stands are MDF and chipboard.

Very few companies monitor their wood waste. While 33% of stand builders state that they monitor the waste, none reported on waste volumes officially. It is suggested that waste audits be conducted to achieve a more realistic assessment of wood waste quantities. The researcher team is aware that such an audit may be invasive and extremely costly.

Wood waste is not perceived to become a big problem in future and although top management would support waste minimisation initiatives, most participants do not believe wood waste to be a great concern, now or in the future.

Challenges in wood waste management, as have been identified in the international sphere focus around the needs of the client, who, in many instances, insist on unsustainable exhibition stands and are difficult to move away from the "status quo" in the industry. Lack of knowledge on managing wood waste and the lack of the necessary systems to support effective wood waste management are also problems.

The EGF is the most important source of information on sustainability in the South African exhibition industry with SAACI and EXSA also proving useful specifically for the Venues.

10 Limitations of this study

10.1 Multiple stakeholder focus

The study had a multi-stakeholder approach focusing on input from various industry players including event organisers and event venues' perceptions on wood waste management. In several instances event organisers communicated to the research team that as event organisers they have very little input to give on waste management practices as it is beyond the scope of their normal work. We therefore specifically thank those who participated.

10.2 Perceptions on waste

It was beyond the scope of this research to conduct a waste audit, and therefore waste estimates were asked from participants. Waste estimates can be particularly vulnerable to social acceptability bias wherein participants report lower estimated totals to appear more socially responsible. Even if the approach of waste audits is used, the potential is that only

companies who already feel their waste management practices are ‘above board’ will permit researchers to visit their site for a waste audit.

10.3 Timing of international study

The international segment of this study was poorly timed and therefore had to be postponed to September due to the summer season in the northern hemisphere.

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13 Appendix A: International stand builder strategies – Secondary data		
Company name	Strategies employed	Source:
Expomobilia	Everything is built to last. Environmentally certified suppliers Local suppliers minimise distances travelled Print and canvas items from recyclable and biodegradable stamoids Eco-fleeces and wood-block floorings Light fittings are LED Optimised logistics through proximity to event and Euro 5 engines, which currently have the lowest harmful substance emission levels, are used as transport.	https://www.expomobilia.com/en-US/Ueber-uns/Nachhaltigkeit.aspx
Apex Stand Design Specialists	Re-usable stands Built to last Custom-built modular elements that can be re-used Modular means: ease of transport Modular means: lighter weight Modular means: cheaper storage Flexibility and customisability	https://www.marketingdonut.co.uk/exhibitions-and-events/exhibiting/the-green-guide-to-exhibiting.
Green Guide SG	Choose a long-lasting modular stand. Re-use bespoke elements. Lay fibre-mixed carpets that can be recycled and turned into wheelie bins and plant pots. Or put down carpet tiles that can be re-used. Choose other materials, such as plastics and cardboard, that can be recycled. Use timber from well-managed forests (with Forest Stewarding Council approval). Install low wattage lighting or LED energy efficient lighting. Use organic compound-free adhesives. Look for “green” water-based paints. Don’t produce printed marketing materials - email your brochure to potential clients or use scannable QR codes. Promote your green credentials and spread the word about sustainability.	Green guide
Think Sustainability	Careful selection of materials Choosing the materials that have lower embodied carbon, lower toxicity and recyclability whilst maintaining the characteristics of the traditional materials, which make them so successful to work with. Hiring equipment Much equipment can be hired to save you money as well as reducing environmental impact. From furniture to AV equipment, we treat this the same as sourcing any material – looking at the environmental credentials	http://www.think-sustainability.co.uk/sustainable-exhibition-stands

	of the item, including energy saving opportunities. Reusable elements Reusability is a concept that even the most bespoke built exhibition stand can embrace. We don't need to limit creativity. Travel & waste management Having the processes and supply chain management to ensure we reduce travel and waste where possible. Carbon calculation & offsetting When you've reduced the environmental impact of the exhibition stand as much as is feasible, there is still going to be a remaining impact. We offer clients the option of calculating the remaining carbon emissions of the stand and offsetting these.	
Design Rock	• We specify durable sustainable materials from renewable and recyclable resource streams • We use and specify energy efficient technologies • Our holistic approach ensures end-results that are environmentally, economically and socially sustainable • Our designs are inherently simple, flexible and streamlined • All of our designs make optimum use of natural daylight • We create spaces that are free from chemicals and pollutants • Our design supply-chain supports local environmentally responsible suppliers and local economies	https://www.designrock.com/blog/exhibit-green
Clarity!	Follow our Sustainable 7! 1 Keep it simple Sustainability can't be an after-thought. It has to be integral to the design process right from concept stage. Is each component valid? Ask for a design that uses as few materials & components as possible - less is definitely more! Simplicity delivers greater focus & impact. 2 Design to last Re-use is key. So components need to be constructed using durable materials to prolong lifespan. You also want your exhibition stand to be modular so that components can be reconfigured for use at a number of events - both green & cost-effective. And when you no longer need your stand? Why not look for other companies or associations in your locality, such as schools or colleges, who would happily give your stand a new lease of life? 3 Materials of choice Request a stand built from recycled plastics, FSC & reclaimed timber or rapidly renewable materials such as bamboo, hemp & straw. Another option is FSC & formaldehyde-free MDF, manufactured using 100% recycled or recovered wood fibres. Reduce or do away with vast quantities of printed marketing brochures &	Newton at al (2014)

	leaflets, but for any necessary printing & graphics make sure that vegetable-based inks are specified and printed on to highest percentage recycled material, whether paper, plastic or fabric. 4 Time to switch Lighting is an energy hog! Select energy-efficient LED lights however and you can reduce the amount of power your stand consumes by as much as 90 percent! 5 Detox Opt for organic paint, varnishes & adhesives or ones that are low or no-VOC (Volatile Organic Compounds). For floor finishes try bamboo (check resins), cork, sisal or even recycled rubber - all are comparatively harmless set against traditional carpeting. 6 Lose weight! Transport is another good reason for adhering to the eco ethic that less is more. Lowering the weight and size of stand components that need to be transported will have a huge impact on reducing carbon footprint - & cost you less to boot. 7 Stay local Have your green exhibition stand components manufactured & stored close to the show sites, wherever possible. Not only will this enable you to reduce the need for shipping, saving on cost & CO2 emissions, but it allows you to boost local economies. A final thought... When we talk about sustainability, we mean social & economic sustainability as well as environmental. If you follow green design principles & develop green practices, then the social & economic sustainability follows? They're intrinsically linked.	

13 Appendix B: International wood waste classification systems

Waste classification in various countries are presented below and can be largely grouped into four main categories; virgin wood, treated wood, mixed wood and toxic wood.

	Description	*Wood waste classification*			
		Norwegian NS 9431 (2011)	*UK*	*Australia*	*South Africa*
Clean wood	Building materials and packaging without surface treatment; Or Virgin timber including trees, branches, wood-shavings and saw dust, shavings and off cuts from sawmills, wood working or timber manufacturing plants before virgin timber is treated.	1141 Clean wood	Grade A Visibly clean non-hazardous waste wood	Grade A Untreated timber commonly used in furniture and framing for houses and are considered high quality or Green waste	Construction and Demolition waste (GW30) or Green waste
Treated wood	Demolition wood, transport packaging treated with paint, varnish or chemicals which does not count as hazardous waste	1142 Treated wood	Grade B Non-hazardous waste wood: Chipboard and medium density fibreboard		
Mixed wood	Untreated, unpainted, and unstained engineered wood products like plywood, laminated veneer lumber (LVL), glued laminated lumber, particleboard and medium density fibreboard (MDF), finger-jointed timber.	1149 Mixed processed wood	Grade C Non-hazardous waste wood	Grade B Untreated, unpainted, and unstained engineered wood products like plywood, laminated veneer lumber (LVL), glued laminated lumber, particleboard and medium density fibreboard (MDF), finger-jointed timber.	
Toxic wood	Treated wood with hazardous chemicals	7098 CCA-impregnated wood 7154 Creosote impregnated wood	Grade D Waste wood		Hazardous waste HW09 – Organic waste containing halogen or sulphur; OR Hazardous Waste HW11 – Organic waste without sulphur or halogen
Source:		Tellnes (2016)	Environment Agency 2017 in the UK	https://www.famitchell.com.au/can-old-plywood-be-recycled	National Waste Management Strategy (2010).

14 Appendix C: Specific contact details

- Please find the contact details of the various companies below; as provided by GreenCape

Cape Furniture Manufacturers is the company that re-used the treated wood from previous events;
Contact Name: Riana Galanos
Company Name: Cape Furniture
Tel: 0219817132
Email: capefurniture@yahoo.com
In the meeting I mentioned that Meganika is busy working on a gasification solution for a furniture manufacturer. Once successful they would like to utilise the technology for all treated wood applications.
Gerard van Harmelen
gerard.van.harmelen@meganika.com
083 407 5862
The lady at the CDI who I contact when i have waste streams I want to divert is;
Lisa Parkes
lisa.parkes@thecdi.org.za
The contact for UCT School of Architecture can be found below.
John Coetzee
Workshop manager
john.coetzee@uct.ac.za
You can also chat to the Gauteng Industrial Symbiosis Program (GISP) and the Kwazulu-Natal Industrial Symbiosis Program (KISP)
Henry Nuwarinda
HNuwarinda@csir.co.za
+27 (12) 841 2359