Sustainability consideration in the Australian International Design Awards

Dr Stephen Clune
Centre for Design at RMIT, Melbourne, Australia

Dr Mariano Ramirez
University of New South Wales, Sydney, Australia

This paper investigates the engagement (or lack thereof) of manufacturing, engineering and product design industries towards sustainability. This was achieved by completing a content analysis of the award winners in the Australian International Design Awards (AIDA) against an independent set of Design for Sustainability (DfS) criteria established by the authors. Particular focus was given to the 2010 recipients of the Australian International Design Award™ and the Australian International Design Mark™ and the claims made in their product descriptions and key features and benefits statements. The paper reflects on the criteria used by the AIDA to assess the awards, elaborates on the positive elements of sustainable design presented, and suggests directions that the industry may utilise in order to strengthen its capacity to achieve sustainable outcomes.

Context

The Australian International Design Awards (AIDA) has been rewarding excellence in product design and innovation in the Australian marketplace for over 50 years. These industry-acclaimed accolades are presented to a number of products each year, either as an Australian International Design Award™ in recognition of design excellence and indicating superior design and investment in innovation; or as an Australian International Design Mark™ in recognition of good design and indicating quality, value and reliability in the marketplace.

The AIDA assessment criteria include innovation, visual and emotional appeal, functionality, quality, manufacture, and human factors. In 2007, a criterion on environmental sustainability has been added, questioning the need for the product, its long-lasting qualities, efficiency in use of water, materials and energy, as well as compliance with environmental best practice. In the same year, AIDA instituted a special Award for Excellence in Sustainable Design. To qualify for this award, the product must evidence that: it serves a real need; its design has been driven by a primary concern for sustainability; it is an outstanding achievement in, and a creative application of, sustainable design principles; and its manufacturer has embraced responsible business practices.

Certainly the recognition of ecologically sustainable design within the AIDA should be celebrated as a positive move in the right direction. However this paper steps back and attempts to address the impact that the award winning designs would have if they proliferated, by asking the question: how does this design contribute to a sustainable society, economy or ecology?

Several metrics exist in an attempt to quantify environmental sustainability targets ever since the Club of Rome reported in 1972 that economic growth was using up resources at a rate which can no longer be sustained by the planet (Meadows, et al., 1972). Since then Factor 4 (Von Weizsäcker, et al., 1997), Factor 10 (Schmidt-Bleek, 1999), and Factor 20 (Vergragt, 1999; Weaver, et al., 2000) have been proposed. These factors, which refer to a 4-fold, 10-fold or 20-fold increase in efficiency, suggest a substantial targeted reduction in resource use in the order from 75% to 90% to 95%. More recently an emphasis has shifted to carbon dioxide equivalent (CO_2e) reduction: calculated scenarios show that a reduction of 85% of current levels in global emissions is necessary in 2050 to mitigate the risks of climate change (IPCC, 2007).

The purpose of our paper is to locate the current position of the Australian industrial design community, and question what the response of designers could be if the above targets are considered. Clune (2009) suggested that if industrial designers are to pursue design for sustainability (DfS), a shift is required to reconcile a sound interpretation of unsustainability with technical design strategies and tools; postulating that "how you define is how you design".

Vezzoli (2003) argues that 'the design activity itself needs to be redefined in order to positively and effectively contribute to the radical change required by the transition towards a sustainable society'. By default, such changes challenge the product-centric approach that is conventional to the industrial design discipline. Various tools and strategies have been proposed by design researchers to challenge designers into considering the change agency of design and their role in creating a more sustainable society. The higher forms of innovation imply a more influential consequence of design activity than do those at the technical end of the spectrum.

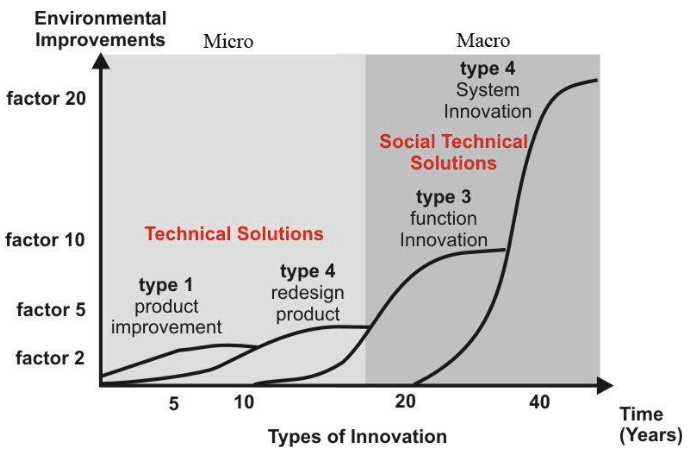
Methodology

The study examined the entries of the winners of the 2010 Australian International Design Award™ and Australian International Design Mark™, as they appeared on the www.designawards.com.au website. Information about the designs, images, and the claims of manufacturers and designers in the entry forms were copied into a relational database management system. Content analysis, using a coding protocol (Table 1), was used to evaluate the winning entries against the three theoretical tools below for locating and analysing their DfS potential.

1. the 'hierarchy of eco-innovation' by Brezet (1997) which describes four types or step-levels of innovative approaches that could enable design solutions with a high sustaining potential, as illustrated in Figure 1. These types are namely: product improvement, product redesign, function innovation and systems innovation. Product improvements only make minor changes for pollution prevention and environmental care, without changing the product or manufacturing technology. Product redesign goes further by developing or replacing components, materials, distribution, recycling or energy efficiency, although the product concept remains almost intact. Function innovation seeks alternative ways of fulfilling the function with greater environmental benefit. System innovation replaces the status quo with a completely overhauled and less environmentally impacting system. Function and systems innovation can potentially achieve Factor 10 to 20 targets of resource efficiency; they promote an important shift from conventional industrial design, in which technical solutions dominate, to the design of solutions which are far more cognizant of the complexities of context and usage.

Figure 1: Four types of sustainable innovation

Source: Brezet (1997)



2. the DfS ‘school of thought’ derived from a combination of the “how you define is how you design” framework (Clune, 2009) and the social, technical and socio-technical schools of thought by Robinson (2004). In this view, sustainability can be addressed through scientific development (‘technical’ approach) or through a cultural change in shared values and everyday behaviour (‘social’ approach).
3. the ‘scale of resource reduction’ in relation to the Factor 10 and 20 proposed targets. These factors emphasize that radical approaches to sustainability may be required, which technical sustainability alone has a limited chance of bringing into being.

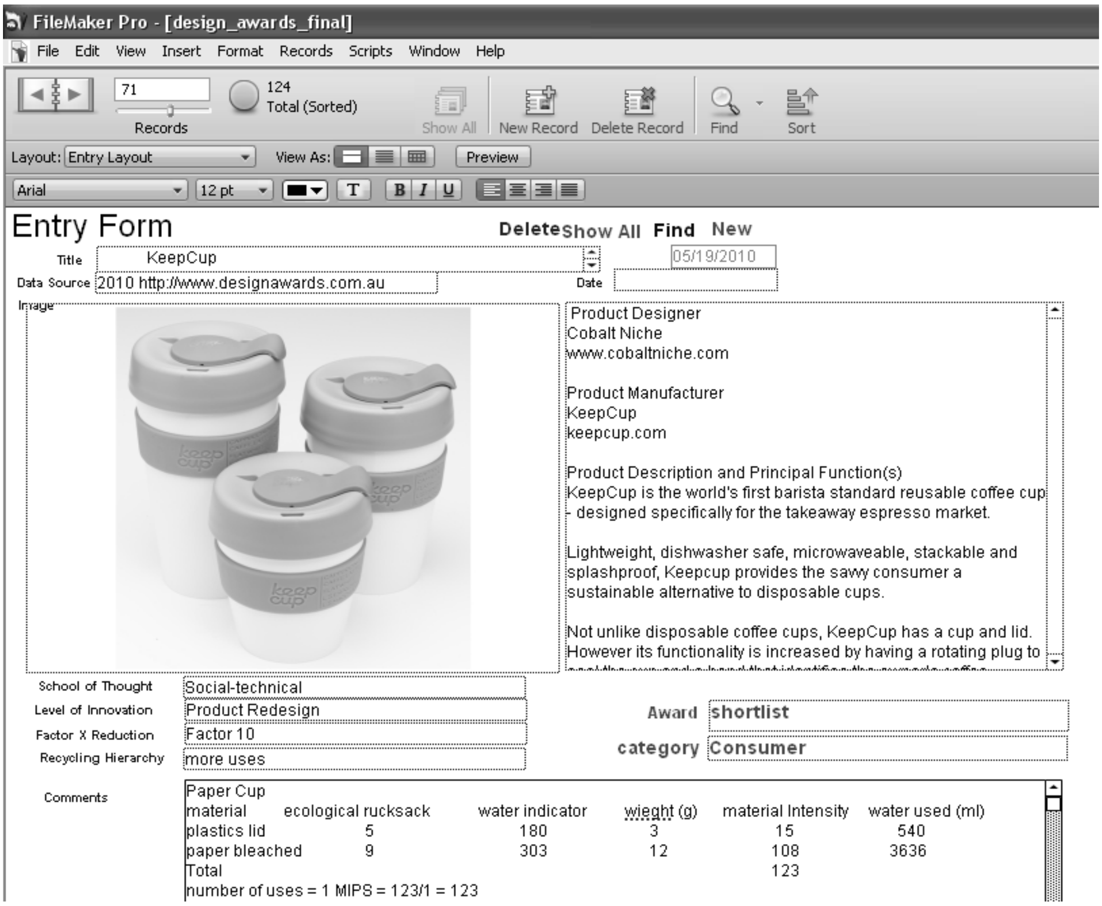
Individually the DfS assessments as revealed by these tools may be judged to be not so significant in their capability to bring about solutions of high sustaining potential; however if the school of thought and level of innovation approaches are combined then the relationship between products and their sustaining potential can increase quite significantly.

An example of the coding protocol in use in the database entry form is shown in Figure 2. All 37 winners of the 2010 Australian International Design Award™, 59 recipients of the 2010 Australian International Design Mark™ and a sample of 53 short listed products were evaluated using this process. The breakdown of product categories examined is shown in Figure 3.

Table 1: Protocol for coding of AIDA winning designs

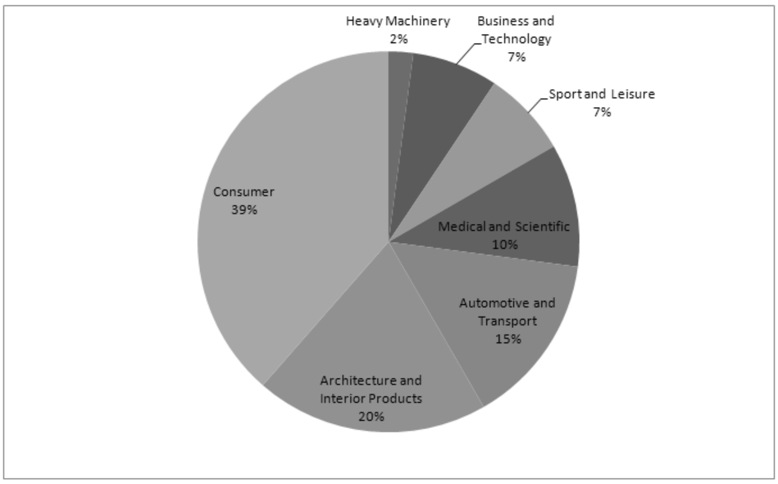
Questions	Coding
School of thought	
Does the product ask the end user to alter their behaviour in any way?	No = technical
Does it ask the end user to alter their behaviour in any way?	Yes = social or social technical
Does it incorporate technical design to facilitate the behavioural change?	Yes = product asks consumers to change behaviours
Type of innovation	
Does it incorporate product-based incremental improvement to minimise the impact upon the environment?	Yes = product improvement
Does it incorporate product redesign based on DfS principles?	Yes = product redesign
Does it question the function of the existing product or practice, and attempt to meet that function in an alternative way?	Yes = functional innovation
Does it question the function of the existing product or practice, and attempt to meet that function in an alternative way?	Yes = functional innovation
Does it propose a revision in how the function is met through dematerialising existing requirements such as transport or labour?	Yes = systems innovation
Factor X reduction	
Using a quick MIPS Formula, assume the best case scenario: Quick MIPS formula = The potential fold reduction of resources afforded by the conceptual design scenario (explain working), x the potential fold increase in use life afforded by the conceptual design scenario (explain working).	Negative factor if negative MIPS = 0-2 MIPS = 2 MIPS = 4 MIPS = 10
Recycling hierarchy	
AVOID > Dematerialise the product; Eliminate product or practice	
REDUCE > Minimise physical amount of material used; Use alternate material with lower ecological rucksack; Reduce throughput of materials over lifecycle; Designed for longer life	
REUSE > Designed from re-used materials; Designed for re-use (more uses); Designed for more users; Front of pipe solutions	Yes = encourage more users per service
RECYCLE > Designed from recycled materials; Designed for recycling	No = material selection leads to landfill; cannot be recycled
REGENERATE > Restores natural environment; Restores social interaction amongst people	

Figure 2: Sample entry in database for evaluating AIDA winning designs



It should be noted that the parameters used in this paper to evaluate the sustaining potential, eco-innovation and scale of resource reduction of the product entries are different to the sustainability criteria required by the AIDA of all entries and winners, mentioned in the beginning of this paper.

Figure 3: Categories of examined Design Award and Design Mark winners



Results and Analysis

The evaluations of the AIDA entries and winners displayed the following results with regards to the category factor X reduction (Table 2). The majority of designs were classified to have a relatively small impact in their ability to reduce resources, as 50% (n=75) had either a negative impact or provided no improvement over their predecessors form an ecological perspective. 26% (n=39) offered a 25% resource reduction or less. This contrasts starkly to the levels of reduction required by the DfS theory of 90% or factor 10. Only 13.4% (n=26) had the capacity to reduce resources greater than 50% (Factor 2 and above), of which only 4% (n=6) met the 90% reductions (Factor 10). Note the N/A results applied to products which were ambiguous to assign metrics for.

Table 2: Frequency of Factor X reduction

Factor X reduction	Frequency	Percent
Negative factor – 0	34	22.7%
No Improvement	41	27.3%
Factor 0–2 (less than 25% resource reduction)	39	26.0%
Factor 2 (50% resource reduction)	16	10.7%
Factor 4 (75% resource reduction)	4	2.7%
Factor 10 (90% resource reduction)	6	4.0%
N/A	10	6.7%
Total	150	100

The frequencies of the type of innovation (Table 3) showed that 86% (n=129) of the AIDA winning designs were product orientated (58% being 'product improvement' and 28% being 'product redesign'). Only 14% (n=21) of the designs could be classified as 'functional innovation' where the designers had questioned the function of a product and attempted to meet that function in alternative ways. None offered designs solution that would be classified as systems innovation.

Table 3: Frequency of Innovation Type

Brezet's Type of Innovation	Frequency	Percent
Product improvement	87	58%
Product redesign	42	28%
Functional innovation	21	14.%
Systems innovation	0	0%
Total	150	100%

With regards to the DfS school of thought (Table 4), the great majority (85.8%, n=115) of AIDA winning designs can be classified as technical. Only a minority (14%, n=19) presented social-technical solutions. An excellent example of a significant social-technical innovation is an internet-enabled vital signs monitor installed at home for patients with chronic disease conditions; this won a Design Award™.

Table 4: Frequency of DfS School of Thought

DfS school of thought	Frequency	Percent
Technical	128	85.3%
Social-technical	22	14.7%
Social	0	0.0%
Total	150	100

The majority of entrants (n=86) had no identified strategy for end-of-life optimization and from the authors experience have a high probability of being disposed of in landfill. Apart from disposal, the second most popular identified strategy was that of recycling. Again some products were ambiguous and couldn't be assigned metrics, thus the N/A.

Table 5: Frequency of End-Of-Life Strategy

End-of-Life Optimization	Frequency	Percent
Avoid	0	0.0%
Reduce	16	10.5%
Reuse	9	5.9%
Recycle	28	18.3%
Dispose	86	56.2%
N/A	14	9.2%
Total	153	100.0%

The results from the evaluations of the AIDA winning designs match other empirical studies that highlight that industrial design practice and education is dominated by product improvement and redesign. Halila and Hörte's (2006) study of 150 award-winning eco-innovations in Sweden identified that 75% of eco-innovation occurs in what Brezet (1997) classifies as "product improvement' and 'product redesign', and suggest that, in order to achieve greater reductions in resource use, exploration of 'systems innovation' and 'scientific breakthrough' would be desirable.

Brezet's schema also raises questions about the practical and disciplinary contexts of industrial design. If industrial designers are to offer functional innovations they may have to form different sorts of relationships with new clients who are more open to collaborative problem solving and innovation with a high sustaining potential.

Discussion

The overall snapshot of the Australian product design industry from the sustainability analysis above appears bleak; there is a large gap between what the literature supporting sustainability is advocating and what is actually occurring. The following section attempts to provide explanation for the results, discussing the increase in material intensity and the dominant environmental strategies used by designers.

Ratcheting of Material Intensity

An observation from completing the analysis is that the incremental increase in functionality of the products tends to lead to an incremental increase in the material intensity of the product, an inconspicuous ratcheting of 'quality'. Televisions, fridges, wine coolers and barbeques all appear larger with more functions available. This has also been matched by trends of stainless steel appliances, which dominated much of the consumer section. Stainless steel has a higher material intensity in comparison to plastic materials used in small kitchen appliances; in terms of lifecycle impacts, stainless steel has an ecological rucksack 3.6x greater than ABS (Lettenmeier, et al., 2009), the typical plastic used for appliance housings. Thus if the material in the AIDA entry offers no improvement in performance value then the products are classified as having a negative impact or no improvement.

Recycling

As noted earlier, the majority of products did not have an outlined strategy for end-of-life optimization. Of those specifying a strategy, recycling was the most popular approach. Claims of recycled content and potential recyclability, not only of the product but also of the packaging, abound among claims to satisfy the environmental criteria of the awards. For instance, one task light that won a Design Award™ claimed that the product is "constructed primarily of eco-friendly aluminum and plastic… up to 81% recycled content… 99% recyclable… ships in 70% recycled packaging".

The Green Marketing Guidelines (ACCC, 2008), referring to the Australian Trade Practices Act 1974, and AS/NZS 14021:2000 Australian/New Zealand Standard for Environmental Labels and Declarations caution Australian businesses from making environmental claims that may be false, misleading or deceptive to consumers. Specifically, unqualified claims of being "recyclable" breaches the Act and don't comply with the Standard if collection or drop-off facilities for recycling the product or packaging are not conveniently available to a reasonable proportion of purchasers and users of the product in its area of sale (AS/NZS, 2000). The same applies if the product is not recyclable in Australia or if recycling facilities are very few or exist only as pilot plants (ACCC, 2008). Moreover, a product that whose "recycled content" does not come from post-consumer waste should be qualified with such words as "materials reclaimed from manufacturing" to avoid being misleading (ACCC, 2008).). Pre-consumer material diverted from a manufacturing waste stream can be claimed as "recycled content", provided it doesn't include rework, regrind, or scrap that can be reclaimed within the same process that generated it (AS/NZS, 2000).

Theoretically, any waste material can be recycled (Ayres, 1999), but in practice the cost of processing and sorting mixed waste into different material fractions can become so prohibitive that most materials do not get salvaged from the solid waste stream that ends up in landfill. Therefore, claims of "99% recyclable" are meaningless unless the products are designed for optimized disassembly with minimum expenditure of time, effort and infrastructure, and unless a recycling program is actually in place to facilitate recovery from end-users. For instance, take-back and trade-in programs for mobile phones, batteries, car tires, laser toners, some appliances ensure that these products can be recycled in the most efficient manner and without contamination from household garbage.

Among the Design Award™ winners, an emergency exit sign was designed for disassembly to aid recycling; it was manufactured from only two types of plastic and uses clip-together assembly instead of mechanical fasteners. Therefore the product's claims for easy recyclability are justified since the design facilitates cost-effective processing at its end of life.

Reuse

The literature suggests that reuse is environmentally preferable to recycling; unlike recycling that requires breaking down the disposed items into raw materials for manufacturing into new items, reusing the intact item can be a less energy intensive alternative.

One of the Design Mark™ recipients was a reusable connector and hinge system that enables the creative construction of objects and spaces from found materials. The constructed objects that result from this facilitation are typical of craft activities and certainly not "designerly", but the system successfully accomplishes its aim of inspiring people to see new value in the things around them, particularly by reusing and giving a second life to discarded packaging materials. We see the recognition of this approach by the AIDA as unprecedented and encouraging industrial designers to rethink how product development efforts could be redirected towards promoting a culture of reuse rather than consumption of brand new products.

Another AIDA entry which fostered a reuse culture was a reusable barista-standard coffee cup. It provides the habitual takeaway espresso customer a sustainable alternative to disposable paper cups. Manufacturing efficiency is also promoted by having a one-size lid, band and plug that fits into three sizes of reusable cups. Our calculations suggest that this product cup only needs to be reused five times before it achieves the breakeven point in material intensity as paper cups. If the cup is used 44 times it has diverted ecological resources by a Factor 10, and raised awareness of our disposable society. In spite of being a world-first and demonstrating qualities of good design, innovation, value and sustainability, this product was only shortlisted in the AIDA and did not win awards.

Efficiency

Several AIDA entries claimed efficiency in their consumption of energy, water or fuel. Again the ACCC (2008) cautions that energy efficiency claims should be quantified by comparison to objective benchmarks or rating schemes. The Australian Government websites for comparing energy and fuel consumption of appliances and vehicles (www.energyrating.gov.au and www.greenvehicleguide.gov.au) facilitate this benchmarking, although not all appliance and vehicle models can be found.

One AIDA entry was claiming to have a radical breakthrough in cooling technology, with "previously unheard of" energy efficiencies. This product is not available for comparison on the energy rating website, and therefore its power inputs, outputs and lifetime energy cost cannot be benchmarked against the 2½ or 3-star rated air-conditioning systems in the market.

In the automotive category, the average fuel consumption of the AIDA vehicles was 9.3L/100km and an overall greenhouse and air pollution rating of 12/20 (note: 20/20 is the best possible rating). After benchmarking at www.greenvehicleguide.gov.au with the most comparable representative vehicle (medium sized 5-seat hatchback), which only used 6.2L/100km and had an overall rating of 16/20, we find that the AIDA entrants were in fact 32% more fuel inefficient and scored 33% lower in greenhouse and air pollution ratings than similar ones in the market.

Compliance

Meeting eco-labelling requirements on top of the relevant safety and performance standards indicates that a product exhibits qualities of an environmentally sound design. Receiving an award for design excellence or good design further confirms that such the environmental credential of such products is recognized. The manufacturer of a Design Mark™ ottoman stool acknowledged the flooding of greenwash claims in the furniture industry, so it highlighted its independently-verified environmental certificates from the Forestry Stewardship Council, the Green Building Council Australia and Good Environmental Choice Australia.

AIDA Environmental Sustainability Criteria

The first criterion for the environmental sustainability assessment of AIDA entries is: 'Is there a need for the product?' This is the most fundamental question to ask from a sustainability perspective. The question is also the most loaded if one strips 'need' back to the fundamental human needs (Maslow, 1943; Max-Neef, 1992). The ratcheting of automobile size saw four 4WDs as AIDA finalists, along with three sports cars and two sedans. Such finalists offer far more beyond the basic "need" of transport. The model Manzini & Jégou (2003) present in their 'scenarios of everyday life' is to visualise how the needs of society may be realised in a sustainable way and one potential model for designers to follow.

The second criterion questions: "Is the product long lasting?" This must be viewed in a context specific scenario, as it may not be desirable in some technologically obsolescent product ranges such as refrigerators, cars and televisions. Morelli (2001) suggested that if the greatest impact is within the use phase, then overtly long lasting products may be detrimental, as gains in efficiency outweigh the production stage of making a new more efficient product. Design for upgradeability may then be a more relevant strategy.

The third test is a logical one: "Is the design water, material and/or energy efficient?" However the question must be asked to what degree efficiency is judged. The results indicate that against the steep calls for material and energy efficiency such as Factor 10 (Schmidt-Bleek, 1999), the majority of finalists are not efficient. In the automotive category, the most efficient AIDA finalist ranked 77th (in the top 4%) out of all new vehicles sold, and five of the vehicles did not make the top 400 of the 1851 cars benchmarked on www.greenvehicleguide.gov.au. The results indicate that efficiency may not be measured against class leading products, or that it is not given a high priority.

Further, the focus on efficiency as a sustainable strategy is difficult. On one hand it is clearly desirable and part of any improvement model incorporates elements of efficiency; on the other hand the "rebound effect" attached to efficiency is problematic. For example the electronic industry increases the capacity of processors on average by 41% each year, yet an increase in consumption has reduced the effects of the gains. Consumption continues to outstrip the efficiency improvements, leaving the net consumption levels largely unchanged. This is what Manzini (2002) refers to as "rebound effect": most products are substantially more efficient than their previous counterparts however the sheer growth in consumption has outstripped any of the efficiency gain.

A more radical design approach to that of efficiency would be Fry's (2009) design-led redirective practice, where a low material intense activity is advocated to replace a high material one. One AIDA entry rematerialised a traditional baby carrying sling, potentially replacing a stroller, but was not even shortlisted.

Criteria four: "Does the product comply with environmental best practice?" One would hope all entrants would satisfy this. Why would manufacturers release products onto the market that do not comply? Justifying the environmental credentials of a product by suggesting it is "RoHS compliant" and "heavy metals free" is interesting, as it is a standard requirement for sale in an international context.

Of the four criteria, "design for need" is the most fundamental from an environmental sustainability perspective. It brings to the fore an uncomfortable conversation that the Australian design community needs to have, to think through design's contribution in a society with greatly reduced material flows.

With respect to the remaining criteria it may be possible for an award to satisfy the criteria and not contribute to a significant reduction in resource throughput required for a more sustainable society.

AIDA Sustainable Design Excellence Award

The decision from 2007 onwards to include an Award for Excellence in Sustainable Design represents a commitment from the Australian design industry to move towards sustainability. This has been awarded four times; we briefly reflect one each year's winner.

The 2009 winner was Electrolux's 'Refrigeration Collection', offering a Factor 2 reduction in energy across the life of their refrigerator in comparison to a 10 year old fridge. The 2008 winner, 'Slide Connect G2' by Legrand, was a world-first emergency lighting and exit sign system using a single, high brightness, long-life LED that uses a Factor 4 less power in the use phase. Of all awardees the 2007 winner, Caroma's 'H2Zero Cube Urinal' offers a Factor 10 solution by eliminating water and chemical use across the entire life of the product. This innovation presents a solution of the scale required of sustainability, moving from efficient use of resources to eliminating resource use (water).

The 2010 winner 'Enviromesh' replaced steel reinforcement in concrete with a lightweight plastic alternative, thus enabling the eradication of concrete cancer and leading to longer concrete life. In particular, it had "broad-ranging environmental benefits, smart choice of materials and cost savings for the building industry... significant advances in product life extension, durability and materials efficiency, while minimising embodied energy in manufacture" (AIDA, 2010). While the saving between plastic and steel reinforcement is notable and the ability to extend concretes useful life is positive, if viewed as a system, Portland cement has by far the largest impact in concrete production. It uses a significant amount of heat energy to produce, and also generates carbon dioxide as a chemical reaction in the production process. The overall reduction in embodied energy of concrete would be minimal from the Enviromesh reinforcement. A more important point is that sustainability must be viewed holistically, and as part of a system. This leads to the final point of the paper, which is the apparent lack of system innovations amongst AIDA entries.

Systems innovation takes into account the broader production and consumption process, including the physical and institutional contexts, the use of the product by the end user and the product artefact, i.e. the entire system (Brezet, et al., 2001). Product service systems would be classified as 'systems innovation'. There is a capacity for this type of designing within Australia. For example Melbourne recently installed a bike sharing scheme and car sharing schemes have been in operation in Australian capital cities for some time.

Conclusion

The results would indicate that at present the Australian design industry is attempting to engage in sustainability, which is a relatively new ballgame for designers. However it would be desirable for the AIDA to encourage a higher engagement in the metrics surrounding how design may contribute to a move towards a more sustainable environment. Of course, Australia is not alone in the product-focused nature of design awards (Halila & Hörte, 2006; Sung, et al., 2009). This paper should be viewed as contributing to the learning process required of the design industry. As Manzini (2003) states the move towards sustainability will be "a complex social learning process: a sequence of events and experiences thanks to which, progressively, amid mistakes and contradictions as always it happens in any learning process – human beings will learn to live in a sustainable way".

Bibliography

ACCC. (2008). *Green marketing and the Trade Practices Act*. Canberra: Australian Competition and Consumer Commission.

AIDA. (2010). *Environmentally-friendly concrete reinforcing product takes out sustainable design award (media release)*. Sydney: Australian International Design Awards | Standards Australia.

AS/NZS. (2000). *AS/NZS ISO 14021:2000 Australian/New Zealand Standard™: Environmental labels and declarations: self-declared environmental claims (Type II environmental labelling)*. Sydney + Wellington: Standards Australia + Standards New Zealand.

Ayres, R. U. (1999). The second law, the fourth law, recycling and limits to growth. *Ecological Economics, 29*(3), 473-483.

Brezet, J. C. (1997). Dynamics in ecodesign practice. *UNEP Industry and Environment, 20*(1-2), 21-24.

Brezet, J. C., Diehl, J. C., & Silvester, S. (2001). *From ecodesign of products to sustainable systems design: Delft's experiences*. Paper presented at the EcoDesign'01: 2nd International Symposium on Environmentally Conscious Design and Inverse Manufacturing. Tokyo: Union of Eco Designers.

Clune, S. J. (2009). *Developing sustainable literacy in industrial design education: a three year action research project enabling industrial design students to design for sustainability: PhD dissertation*. Sydney: University of Western Sydney.

Fry, T. (2009). *Design Futuring: Sustainability, Ethics and New Practice*. Oxford: Berg Publishing.

Halila, F., & Hörte, S.-Å. (2006). Innovations that combine environmental and business aspects. *International Journal of Innovation and Sustainable Development, 1*(4), 371-388.

IPCC. (2007). Summary for policymakers. In B. Metz, et al. (Eds.), *Climate Change 2007: Mitigation: Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

Lettenmeier, M., et al. (2009). *Resource productivity in 7 steps: how to develop eco-innovative products and services and improve their material footprint*. Döppersberg: Wuppertal Institute for Climate, Environment and Energy.

Manzini, E. (2002). Context-based wellbeing and the concept of regenerative solution: a conceptual framework for scenario building and sustainable solutions development. *Journal of Sustainable Product Design, 2*(3-4), 141-148.

Manzini, E. (2003). Scenarios of sustainable wellbeing. *Design Philosophy Papers, 1*(1).

Manzini, E., & Jégou, F. (2003). *Sustainable everyday: scenarios of urban life*. Milano: Edizioni Ambiente.

Maslow, A. H. (1943). A Theory of Human Motivation. *Psychological Review,*(50).

Max-Neef, M. (1992). Development and human needs. In P. Ekins & M. A. Max-Neef (Eds.), *Real-life economics: understanding wealth creation*. London: Routledge.

Meadows, D. H., et al. (1972). *The limits to growth: a report for the Club of Rome's project on the predicament of mankind*. New York: Universe Books.

Morelli, N. (2001). Technical innovation and resource efficiency: a model for Australian household appliances. *Journal of Sustainable Product Design, 1*(1), 3-17.

Robinson, J. (2004). Squaring the circle? Some thoughts on the idea of sustainable development. *Ecological Economics, 48*(2004), 369-384.

Schmidt-Bleek, F. (1999). *The Factor 10/MIPS-concept: bridging ecological, economic, and social dimensions with sustainability indicators*. Tokyo/Berlin: United Nations University | Zero Emissions Forum.

Sung, W. O., Chung, K. W., & Nam, K. Y. (2009). Reflections on design excellence through international product design award schemes. *The Design Journal, 12*(2), 171-194.

Vergragt, P. J. (1999). *Leap-frogging to sustainable households*. Paper presented at the GIN1999: 8th International Conference of the Greening of Industry Network. Chapel Hill NC: University of North Carolina.

Vezzoli, C. A. (2003). A new generation of designers: perspectives for education and training in the field of sustainable design: experiences and projects at the Politecnico di Milano University. *Journal of Cleaner Production, 11*(1), 1-9.

Von Weizsäcker, E., Lovins, A. B., & Lovins, L. H. (1997). *Factor four: halving wealth, doubling resource use*. London: Earthscan.

Weaver, P., et al. (2000). *Sustainable technology development*. Sheffield: Greenleaf.