The IAQ performance of interior finishing products and the role of LCA

Naalamkai Ampofo-Anti, Senior Researcher, CSIR

1.0 Introduction

The environmental rating and certification of products is a voluntary, market-based response by industry and business to the consumer's perceptions of the importance of the environment. On the one hand, environmental product certification enables customers, be they government, professionals or the general public, to make environmentally aware choices and influence how products are produced. On the other hand, it is very profitable for business. Most importantly, product-related environmental information differentiates "green" products from conventional products, increasing the market share of the "green" products, fuelling innovation, and thereby driving processes and products in a more sustainable direction.

Societal concerns for environmental protection and conservation, which emerged in the 1970s, is said to be the root of product-related environmental claims (Johnson 2003). Environmental labels and declarations initially attracted consumers who were looking for ways to reduce adverse environmental impacts through their purchasing decisions. The proliferation of unsupported claims however caused a great deal of confusion – without consensus on what represents an environmentally preferable product[1], consumers could not decide on the merits of one environmental claim over another.

The concern with credibility and impartiality led to the creation of public and private bodies providing environmental product certification. For instance, the Blue Angel, launched by the German government in 1977, is the world's first environmental product certification (eco-labelling) programme. The desire for objective information also necessitated a comprehensive environmental audit covering all supply chain activity, hence a gradual acceptance of a life cycle perspective as the preferred methodology for standardisation of environmental product certification.

2.0 Interior finishing products and IAQ performance

Building rating and certification tools such as Leadership in Energy and Environmental Design (LEED) (USA) and Green Star (Australia) aim to provide the construction sector with a framework within which to put the concept of sustainable construction into effective practice. Building rating tools recognise and make provision for addressing the adverse environmental impacts of buildings on both the external and internal environment. The progress made towards the mitigation of external environmental burdens, for instance, energy use, is commendable. High performing "green" buildings may consume only 25% of the energy required by an equivalent conventional building. However, there is a lack of information on how the improvements made in one focus area affects the other.

When it comes to rating the environmental performance of interior finishing products[2], there is no consensus on "green" building products, thus "green" guidelines are applied without resolution of the inherent conflicts. The pursuit of energy efficiency in buildings justifies tighter building envelopes. However, the drastic reduction in air exchange rates facilitates the build up of indoor air pollutants, in particular, Volatile Organic Compounds (VOCs), semi- Volatile Organic Compounds (SVOCs) and particulate matter (dust). A growing body of scientific evidence suggests that the air within buildings can be more seriously polluted than the outdoor air (USEPA 2008); and that concentrations of VOCs may be up to ten times higher indoors than outdoors (SEDA 2007). Formaldehyde, which is a VOC, has been shown to cause cancer in animals and may cause cancer in humans. High VOC concentrations have been conclusively linked to sick building syndrome (SBS) complaints. Other research findings suggest that people spend up to 90% of their time indoors (SEDA 2007). Thus for most people, health risks due

[1] **An environmentally preferable product** is a product (or a service) which causes less stress on the environment when compared with a competing product which serves the same purpose. This comparison may consider the cradle-to-grave environmental burdens of the product.

[2] **Interior finishing products** are building products such as carpets, tiles, paints, varnishes and ceiling panels inclusive of their integral backing, adhesives or grout; and fixed furniture and fittings such as kitchen cupboards and workstations.

to exposure to indoor air pollutants may be greater than that associated with exposure to outdoor air pollutants.

Similarly, interior finishing products may be rated and certified in consideration of low embodied energy whereas embodied toxicity, which could be an issue at any stage of the material life cycle, is overlooked, for instance:

- Wood is a bio-based material which is ordinarily harmless to the environment. However, wood treated with copper chromium arsenate (CCA) to prevent its decay is extremely hazardous to human and ecological health. CCA is a Persistent and Bio-accumulative Toxicant (PBT)[3] associated with birth defects, neurological damage, and numerous other illnesses (ref). Burning CCA wood releases arsenic and chromium into the environment where they enter the food chain. Disposal by landfill results in the leaching of arsenate into groundwater (HBN 2000).
- Poly Vinyl Chloride (PVC) flooring is inherently toxic (Lent et al. 2009). PVC is however included in the United States (US) Resilient Floor Covering Institute (RFCI) FloorScore certified products approved by LEED and Green Star (Australia) for use in "green" buildings.

Although there are other indoor pollutant sources, for instance, heating, ventilation and air conditioning (HVAC) systems, interior finishing products are a major source, releasing air contaminants more or less continuously throughout the use phase of buildings. The indoor air quality (IAQ) performance of an interior finishing product refers to the contribution of the product to the quality of the air inside a building, as represented by concentrations of chemical toxins which affect the health and well-being of the occupants. Such relatively long term exposure to low doses of chemical pollutants can result in moderate to serious systemic harm that does not reverse itself when an occupant leaves a building - this constitutes the most important potential exposure in respect of human health (Hodgson & Alevantis 2004).

In the last decade, the environmental management of products has gone through a paradigm shift from prescriptive, piecemeal approaches towards science-based systems approaches. The new approaches stress pollution prevention and chain-of-custody. There is a corresponding shift in consumer demand towards "radical transparency" (Walsh 2009) that is, full disclosure of product ingredients, thus unsubstantiated claims are increasingly viewed with suspicion of "greenwash". The building and construction sector is not immune to these trends in the global sustainable development agenda – for instance, as compared to LEED, the more recent Green Globes (North America) certifies buildings in consideration of life cycle environmental impacts. Currently, few debate the need for the rating and certification of interior finishing products to be more performance-oriented, where performance is defined in terms of the life cycle human health effects[4].

3.0 LCA – the science-based tool

Life Cycle Assessment (LCA) is a science-based tool which is designed to measure the environmental performance of a product over its full life cycle, often referred to as cradle-to-grave or cradle-to-cradle analysis. Environmental performance is generally measured in terms of a wide range of potential environmental impacts associated with the production, use, maintenance and disposal of the product in question. The assessment criteria applied in an LCA include but are not limited to contributions to depletion of non-renewable resources (energy, materials and water); acidification; climate change, and other toxic releases to air, land and water. By its nature, LCA describes the whole supply chain and all technologies behind the life cycle of a product or service. This approach provides a systematic opportunity to anticipate problems and their solutions all along the life cycle.

As a basis for determining the environmental sustainability or "greenness" of a product, LCA has strong support internationally. At the 2002 World Summit on Sustainable Development (WSSD), World Ministers for the environment endorsed the Johannesburg Plan of Implementation (JPI) which calls for

[3] **Persistent and bio-accumulative toxicants (PBTs)** are chemicals which resist breaking down into more benign substances and tend to accumulate in increasingly higher concentrations as they get passed up the food chain to humans. PBTs have been targeted for elimination by international treaty; and some are subject to action by international, regional and national bodies.

[4] **Health effects** are the physical responses of building occupants to the presence of indoor air pollutants.

environmental policy applications of LCA together with “consumer information tools”, that is, environmental product certification, to rapidly advance the cause of sustainable development. The United Nations Environment Programme and the Society of Environmental Toxicology and Chemistry Life Cycle Initiative (UNEP/SETAC LCI) was launched in 2002 to put the JPI into effective practice through dissemination of the environmental management tools Life Cycle Thinking (LCT); Life Cycle Management (LCM); and Life Cycle Assessment (LCA).

At regional level, the LCA concept is the analytical backbone of the European Union’s (EU) Integrated Product Policy (IPP) which provides a holistic framework for various environmental management tools including Green Procurement; Cleaner Production (CP); Design for Environment (DfE); environmental product certification programmes; and Extended Producer Responsibility (EPR).

The use of LCA as a measure of the environmental performance of whole buildings and building products[5] has also grown considerably in the last decade. LCA-based, building-specific tools include ATHENA (North America), BEES (USA), ENVEST (UK) and Eco-Quantum (Netherlands). The focus of currently available LCA methodologies is however global and regional environmental impacts. LCA is generally not extended to assess localised human health effects (Jönsson 2000). The IAQ performance of interior finishing products is therefore not addressed by these tools. Pending the development of appropriate impact categories, the application of LCA in the context of the indoor environment is limited to rating and certifying the environmental preferability of interior finishing products.

4.0 LCA and environmental product certification standards

As a step towards harmonising diverse and often confusing product-related environmental claims, the International Organisation for Standardisation developed its 14020 series of standards *Environmental Labels and Declarations*. LCA forms the basis for two out of three distinct types of labels and declarations developed under the ISO 14020 Series, namely*, Type I Environmental Labelling; Type II Self-Declared Environmental Claims*; and *Type III Environmental Declarations*. The overall objective of the ISO 14020 Series is to (ISO TC 207 2000):

- Communicate verifiable and accurate information - which is not misleading in anyway - on the environmental aspects of products and services;
- Encourage the demand and supply of those products and services that cause less stress on the environment: and
- Stimulate the potential for market-driven continuous environmental improvement.

4.1 ISO 14024: Type I Environmental Labelling

A Type I label is commonly known as an eco-label and its use is voluntary. A Type I label conveys business-to-consumer information in the form of a symbol or seal of approval which is easily identified by consumers, for instance, Germany’s “Blue Angel” or the Nordic Eco-labelling Board’s “Swan”. ISO 14024 provides for a mechanism by which a third party, such a private company, sanctions the use of a label indicating the overall environmental preferability of a product within a specific product category. Important requirements to be met in appraising a product for Type I certification include the use of multiple assessment criteria derived from Life Cycle Thinking (LCT); and definition of product categories.

4.2 ISO 14021: Type II Self-declared Environmental Claims

A Type II label conveys business-to-consumer information in the form of a statement, symbol or graphics, displayed on a product, on product packaging, in product literature or in advertisements. A self-declared claim is concerned with only one environmental attribute of a product and is not subject to third part verification. To assure the validity of a self-declared claim, the methodology underpinning a claim needs to be scientifically sound. There is however no requirement to apply LCA in any of its forms. Energy Star is the most well-known example of a Type II label.

4.3 ISO 14025: Type III Environmental Declarations

A Type III label is also known as an Environmental Product Declaration (EPD). An EPD is issued on a voluntary basis and conveys business-to-business information, in the form of a report card which provides detailed product environmental information, akin to the nutritional label on food products. The

[5] **Building products** are goods or services used during the life cycle of a building and include building materials (e.g. cement, brick) components (e.g. doors, geysers) and elements (e.g. roof structure)

use of an EPD in business-to-consumer communication is however not precluded. Unlike a Type I label, an EPD provides information for comparative purposes, to enable the information user to make informed comparisons between products fulfilling the same function. Therefore, an EPD does not confirm or deny the environmental preferability of a product. The data behind an EPD is obtained from quantitative LCA, conducted in terms of the ISO 14040 Series on LCA methodology. EPDs are subject to the administration of an independent EPD programme operator; verification by a third party; and development and use of product category rules (PCR).

There is a keen interest and rapid growth in the use of EPDs in the built environment, namely;

- A number of EPD Programmes with a building-related focus have emerged in recent years, for instance, BEES (USA), BRE (UK), BVD (Sweden), RTS (Finland), and MRPI (Netherlands).
- In 2005 the European Committee for Standardisation (CEN) initiated standardisation in the field of integrated environmental performance of buildings. The work includes a range of EPDs for buildings and construction works.
- To complement ISO 14025, which is a generic standard, a building-specific standard, namely, ISO 21930 *Sustainability in building construction – environmental declaration of building products* was published by the ISO in 2007.
- In 2008, Scientific Certification Systems (SCS), a US-based environmental certification company, released a draft Type III standard on building product certification for public comment (SCS 2008). *SCS-002-2008 Type III life-cycle impact profile declarations for materials, products, services and systems* is likely to become a US national standard for the environmental certification of building products, subordinating existing Types I and II labels such as FloorScore and Green Label Plus.

5.0 Integrating environmental product certification standards into green building rating tools

The leading brands in building rating and certification systems do recognise the shortcomings of the “green” material selection framework. They are taking steps to align newer versions of the rating tools with the science-based environmental product certification standards which have become the norm internationally. The strategies adopted by Green Star (Australia) and LEED (USA) to promote the specification of certified building products were investigated.

Green Star’s (Australia) Indoor Environmental Quality (IEQ) prerequisites in respect of low-emitting materials awards credits for specification which avoids hazardous materials (asbestos, lead and polychlorinated biphenyls (PCBs)[6]; avoids formaldehyde content engineered wood products; and meets 95% of TVOC limits in respect of paints; adhesives and sealants; wall and ceiling coverings; flooring systems; and fixed furniture and fittings. The US CRI’s Green Label Plus (Type I label) is cited as a measure of low-VOC carpet.

LEED’s IEQ prerequisites in respect of low-emitting building products awards credits for specification which avoids urea-formaldehyde content engineered wood and agrifibre products; meets low-VOC requirements in respect of adhesives and sealants; paints and coatings; and flooring systems. Various Type I labels, namely, Green Seal, FloorScore and Green Label Plus are cited as measures of environmental preferability in respect of paints and coatings, hard surface flooring and carpet respectively. LEED additionally awards credits for the development and implementation of an IAQ management plan during construction and prior to building occupation. The IAQ management plan entails sequencing, pre-conditioning and flush out periods aimed at minimising concentrations of indoor air pollutants.

The requirements set by Green Star (Australia) and LEED bring some of the most current research to bear on the impact of building product emissions on human health problems. However, a range of IAQ performance issues remain inadequately addressed, amongst others:

- When non-industrial air is tested, 50-300 specific VOCs are indentified (Jönsson 2000). Section 01350, which is the testing protocol behind most of the US Types I and II labels, can identify and test only 80 VOCs (Lent 2009).

---

[6] **Polychlorinated biphenyls (PCBs)** are man-made, bio-accumulative toxicants. In 2001, PCBs were banned internationally through the Stockholm Convention on Persistent Organic Pollutants (POPs). Due to their nature however, PCBs are still present in the food chain and may be present in some building products such adhesives, oil-based paint and floor finishes.

- There is as yet no scientific basis on which to establish limit values for TVOCs thus credit prerequisites around TVOCs has limited value (Jönsson 2000, Lent 2009).
- In its current form, Section 01350 is intended for office applications but the protocol is now applied on a "one size fits all" basis to all building types (Lent 2009).

The specification strategies of both Green Star (Australia) and LEED are not sufficient to deal with the long-term emissions associated with interior finishing products.

6.0 Conclusion

Building rating and certification systems recognise the human health effects of interior finishing products. The rating tools promote specification strategies which facilitate the avoidance; or alternatively, the minimisation of occupant exposure to the known chemical emissions and hazardous content of interior finishing products.

However, key constraints remain for interior product specifiers, namely:

- Green building practices are typically applied without resolution of the inherent conflicts between and among such practices. The outcome of the CIWMB study is a case in point.
- There is a general lack of factual information to guide the choice of environmentally preferable interior finishes.

The trend towards integrating environmentally certified products into the "green" building rating tools therefore represents a step in the right direction. LEED (USA) and Green Star (Australia) have already taken steps in this direction by incorporating requirements to specify Green Label Plus carpets (Type I label); Green Label carpet (Type II); and FloorScore hard flooring (Type I).

The Type I label has significant support – there are more than 30 national, eco-labelling programmes in operation internationally. There is however very limited coverage of building products. Type II labels are widely applied in North America but subject to limited growth in the EU. The outcomes of building product-related research however suggests that the IAQ performance of a Type II labelled building product may be no better than that of a standard product. When it comes to the indoor environment, the heightened awareness of consumers around the actual IAQ performance of products used indoors, for instance, household cleaning products, is driving environmental product certification programmes towards "radical transparency". The rapid growth in building-specific EPD (Type III) programmes reflects this trend; and also suggests that despite the inability of LCA to directly assess product toxicity, the LCA concept will continue to play a central role in managing the life cycle emissions impacts of interior finishing products.

Regardless of the labelling type, much remains to be done to assure consumers that interior finishing products are not contributing to building-related human health effects such as SBS. In particular, environmental product certification programmes need to be expanded to address life cycle emissions impacts of all VOCs and SVOCs associated with the non-industrial indoor climate. A comprehensive material screening strategy is needed to exclude inherently toxic building products. For instance, PVC-content building products deserve to be placed on the same list as building products which contain asbestos, formaldehyde or lead.

7.0 References

CIWMB, 2003. *Building Material Emissions Study*, Available at: http://www.ciwmb.ca.gov/Publications/.

EDCMAG, 2009. LEED 2009 Cites FloorScore certification as indicator of indoor air quality . Available at: http://www.edcmag.com/copyright/BNP_GUID_9-5-2006.

HBN, 2000. Healthy Buildings Mission Statement. Available at: www.greenaction.org/healthybuildings/missionstatement.shtml .

Hodgson, A. & Alevantis, L., 2004. *Testing of Building Products for Emissions of*

Volatile Organic Compounds: Practical Time Point for Assessing Potential Chronic Health Impacts, California Department of Health Services.

ISO TC 207, 2000. ISO/SANS 14020: 2000 Environmental labels and declarations – general principles.

Johnson, P., 2003. International ecolabelling developments and the global ecolabelling network. . Available at: www.geca.org.au/.../International%20Ecolabelling%20Developments%20-%20Petar%20Johnson.pdf.

Jönsson, Å., 2000. Is it feasible to address indoor climate issues in LCA? *Environmental Impact Assessment Review*, 20(2), 241-259.

Lent, T., 2009. Improving Indoor Air Quality with the California 01350 Specification. Available at: www.healthybuilding.net/healthcare/CHPS_1350_summary.pdf.

Lent, T., Silas, J. & Vallette, J., 2009. Resilient Flooring & Chemical Hazards a comparative analysis of vinyl and other alternatives for health care.

RFCI, 2004. What products are certified and how you know. Available at: http://www.rfci.com/int_FS-ProdCert.html

SCS, 2008. SCS-002-2008, Draft Standard for Comment. Type III Life-Cycle Impact Profile Declarations for Materials, Products, Services and Systems. Available at: www.scscertified.com/lcs/docs/SCS_002_0808_FR.pdf.

SEDA, 2007. *Design and Detailing for Toxic Chemical Reduction in Buildings: the issues*, Available at: seda.uk.net/dfcrb/ch3.htm.

USEPA, 2008. The Inside Story: A Guide to Indoor Air Quality. Available at: http://www.epa.gov/iaq/pubs/insidest.html.

Walsh, B., 2009. The Coming Age of Radical Transparency. Available at: www.healthybuilding.net/news/091022radical_transparency.html .