Q6

quickstart

Issue 6

Design for Sustainability with Plastics

Sustainable design principles for plastic building products

This is the sixth in a series of Quickstarts on Design for Sustainability (D4S) with Plastics. It provides information on D4S strategies for buildings and the potential contribution of plastic products.

The aim of the Quickstart series is to promote the design of products and services that are sustainable - that is, products and services that contribute to social progress and economic growth, as well as providing ecological benefit, throughout their life cycle. The sustainability of a product is largely locked in at the design phase, which is why D4S is so important.

The Quickstarts are written for practitioners at every stage of the plastics product chain, including designers, polymer suppliers, product manufacturers, brand owners, specifiers and recyclers. The series also supports the implementation of PACIA's Sustainability Leadership Framework (2008), which promotes a whole-of-life approach to product innovation and stewardship and the need for step-change 'transformations' in material and resource use.

The use of plastics in modern homes can offer sustainability benefits.
[House, Redhill Vic, Architect: Christopherchris Pty Ltd, Photograph: Peter Bennetts, www.peterbennetts.com]

Expanded polystyrene (EPS) pods being installed in a building slab (image supplied by Foamex)

It has been estimated that buildings account for around 25-40% of final energy consumption and between 33%-50% of commodity flows in OECD economies[1]. Water use in buildings is also significant – private residences alone account for almost 60% of urban water use in Australia[2]. Approximately 40% of all waste to landfill in Australia is from construction and demolition materials[3].

Background

Sustainable building design and selection of appropriate materials can therefore make a significant contribution to increased energy and water efficiency, and waste minimisation. The potential benefits of D4S for buildings include:

- reduced emissions of greenhouse gases;
- conservation of increasingly scarce water resources;
- reduced financial costs during construction and operation of the building; and
- increased user comfort due to more stable temperatures, more natural light and better ventilation.

These benefits are significant and wherever possible should be communicated to building designers, specifiers and end-users.

Around 26% of plastic products in Australia are used in the building and construction sector[4], and there are many opportunities for improvements and product development in this area. This is because most building products are designed and manufactured in Australia.

Design principles

Three principles of D4S were identified in Quickstart 1: triple bottom line sustainability, a life cycle approach, and step-change transformations. The implications of these in relation to plastic products in sustainable building design are highlighted in Figure 1.

Figure 1: Sustainable design principles and building products

Sustainable design principle	Implications for building products
Triple bottom line sustainability – considering the long term benefits and impacts on human health and quality of life, commercial feasibility, and the natural environment	• Plastics are used for a wide range of building products including insulation, cladding, pipes and fittings, floor coverings and furniture. • Plastic products can support sustainability strategies such as energy and water conservation which reduce the environmental impacts and running costs of a building over its life cycle.
Life cycle approach – considering the benefits and impacts of a product within the context of its total life cycle	• D4S for buildings involves the design and specification of products that minimise energy, water and waste over the life cycle of the building, i.e. during construction, occupation and demolition. • The most significant environmental impacts of a building occur during the use phase. For example, it has been estimated that the production of building materials contributes around 10% of the greenhouse emissions associated with all building types (residential and non-residential) over their entire life cycle. The remainder is primarily from the energy used in operation for heating, cooling etc[5].
Step-change transformations – developing new and innovative ways to deliver product value with significantly less environmental impact	• Plastics are being used in new and innovative construction methods, such as insulating concrete forms (ICFs) which are cost-efficient to build and help to conserve energy over the building's life.

Vinyl flooring (image supplied by Polyflor)

The embodied energy of products and materials is important, and plastics are relatively efficient to manufacture (see Quickstart 10). However, for buildings, the energy consumed during use is much more significant than the energy needed to manufacture the individual components. As a result, designers should focus on strategies that reduce energy consumption during the building's operation.

Energy efficiency

Figure 2: Winter heat losses in a typical uninsulated home[6]

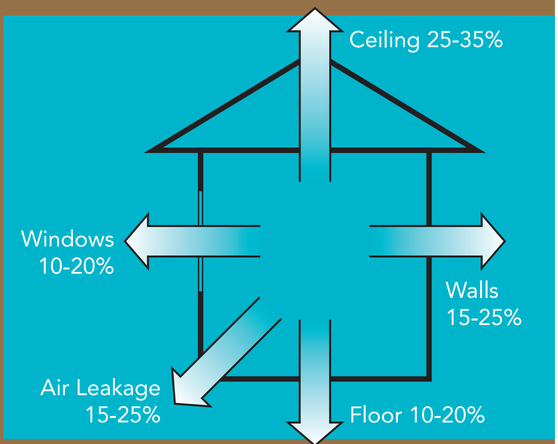


Figure 3:
Typical k and R values for building materials[7]

Material	k value	R value
Polyurethane foam	0.17	5.55
Polyvinyl chloride (PVC)	0.21	4.80
Extruded polystyrene (XPS)	0.21	4.80
Expanded polystyrene (EPS)	0.28	3.57
Glass wool	0.29	3.45
Wood	0.33	3.03
Polyethylene foam	0.43	2.33
Glass	5.00	0.20
Stainless steel	113.0	0.00885
Aluminum	960.00	0.00104

Note: The lower the k value and the higher the R value, the higher the insulating ability

Strategies to improve energy efficiency include:

- appropriate siting and orientation;
- insulating ceilings, walls and floors;
- using energy-efficient appliances;
- eliminating air gaps;
- choosing window systems and furnishings that reduce heat loss and heat gain; and
- installing solar cells or a solar hot water heater.

Plastic insulation products can contribute to energy efficiency by reducing winter heat losses and summer heat gains through better insulation. For example, in winter heat is lost through ceilings, walls, windows, floors and air leakage (Figure 2). Better insulation reduces or eliminates the need for heating in colder months and air conditioning in hotter months.

A number of plastic products are used for building insulation, including:

- Extruded polystyrene (XPS), expanded polystyrene (EPS) blocks and polyurethane (PUR) for wall and underfloor insulation;
- EPS boards sandwiched between reflective foil;
- EPS pods for use in concrete slabs; and
- Insulating Concrete Forms (ICFs) – hollow EPS or PVC panels filled with concrete.

The value of a material as an insulating product can be measured by its 'R' value, which refers to its resistance to heat flow. The higher the R value of the product, the more energy will be saved during operation. The R value is determined by the thickness of the material and its thermal conductivity, or 'k' value. Indicative k and R values for commonly used building materials are shown in Figure 3. The R value required to insulate a particular building will depend on the climate and the type of construction used.

However, materials with similar R values (which are calculated under laboratory conditions) will not necessarily show the same thermal performance when installed.

For example, ICF constructions have enhanced thermal performance for several reasons:

- continuity of insulation – no thermal breaks;
- reduced air infiltration – less air leakage; and
- thermal mass – its ability to absorb heat[8].

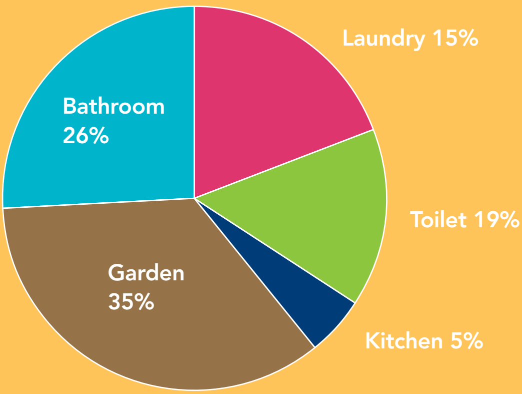
Between 10-20% of heat in a building is lost through windows. Heat loss is influenced by the type of glass, frame construction and air tightness, and single or double glazing. PVC windows have good insulating properties and can be moulded into complex profiles with excellent air seals[9].

Polyethylene modular water tanks, winner 'best new product award', designEX 2009 (image supplied by Modtanks)

The water efficiency of buildings is becoming more important due to drought in many parts of Australia, increasing population, and a predicted fall in rainfall due to global warming[10]. Water is consumed for many different purposes inside and outside the home (Figure 4), and there are many opportunities to use it more wisely.

Water efficiency

Figure 4: Water use in the home[13]



Note: These percentages will vary between geographic regions, depending on climate and water restrictions.

Strategies to improve water efficiency include:

- collecting rainwater for use in the house or garden;
- collecting and reusing greywater in the garden or for toilet flushing;
- using efficient irrigation systems to minimise water use in the garden;
- using water-efficient appliances; and
- minimising leaks from pipes and fittings.

Plastic products can support these water efficiency strategies. For example, plastics are used to manufacture tanks, pipes and fittings for rainwater and greywater systems, irrigation pipes and low-flow shower heads.

PVC and polyethylene pipes for water and sewerage can reduce the risks of leakage which are common to other materials. For example PVC pipes are less susceptible than traditional materials to tree root penetration, which can cause pipes to crack and leak, and fusion-welded joints on PE pipe networks mean that the likelihood of leaks is extremely low compared to alternative systems[11].

Polybutene (PB1) water pipes are increasingly being used to replace copper piping in commercial and domestic housing projects. The benefits of PB1 include reduced head pressure losses, elimination of water hammer, ease of installation and lower costs. An environmental impact assessment conducted on domestic water piping systems found the PB1 piping solution offered a reduced footprint compared to the traditionally used copper pipe offering[12].

Waste minimisation

Waste is generated during the construction, use and demolition phases of the building life cycle.

Construction waste

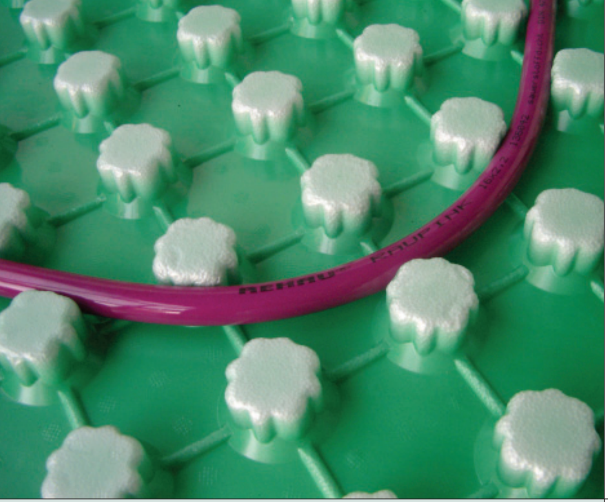
During construction, recyclable waste materials need to be separated from general waste. A code of practice has been developed for the on-site management and recycling of scrap EPS pods and EPS off-cuts. Pipe and PVC flooring off-cuts can also be recycled (see contact details on page 5).

Operational waste

Buildings need to be designed to include facilities for source separation and collection of recyclable materials such as packaging, and for compostable materials such as food waste if there is a recovery system available.

Demolition waste

A large amount of waste is generated during demolition, and recyclable materials need to be separated from general waste. Plastics only make up a small proportion of this waste (less than 1%[14]) but some materials are recyclable. These include PVC cable insulation and PVC, PB1 and HDPE pipes. Vinyl flooring is more difficult to recycle because of contamination with concrete and cement.



Expanded polystyrene (EPS) hydronic heating insulation (image supplied by Polyfoam Australia)

The Quickstart series is part of the 'Design for Sustainability with Plastics' program managed by a collaborative partnership between Sustainability Victoria and PACIA. The Quickstart series can be downloaded from www.pacia.org.au.

Regulations and Standards

The use of plastics in building products is governed by Australian Standards and the Building Code of Australia (refer to the D4S Toolbox at www.pacia.org.au).

There are also a number of environmental rating schemes for buildings. These include:

- FirstRate - the Victorian Government's mandatory 5-star energy rating scheme for new homes and renovations;
- GreenStar - voluntary rating tools to measure the potential environmental impacts of office buildings, educational institutions and retail centres at the design stage;
- Building Sustainability Index (BASIX) – a mandatory rating tool to measure potential environmental impacts of new residential buildings in NSW at the design stage;
- National Australian Built Environment Rating System (NABERS) – voluntary rating tools to measure actual environmental impacts of offices, homes, hotels and retail facilities during operation;
- Sustainable Design Scorecard – a voluntary rating tool developed by Moreland and Port Phillip City Councils for commercial and industrial buildings; and
- STEPS – a voluntary rating tool developed by Moreland and Port Phillip City Councils for residential buildings.

Publication details

Quickstart: Design for Sustainability with Plastics was prepared by Helen Lewis Research for Sustainability Victoria and the Plastics and Chemicals Industries Association (PACIA) with input and advice from practitioners and others involved in the sector.

Further information

Australian Resilient Flooring Association (information on recovery of PVC flooring off-cuts): Warren West, wwest@tpg.com.au

Building Sustainability Index (to use the on-line rating tool for new residential buildings): www.basix.nsw.gov.au/information/index.jsp

EPS Panel Group (technical information and installation advice): www.epspanelgroup.org.au/index.php

Green Building Council of Australia (GBCA) (building rating tools for office buildings, educational institutions and retail centres): www.gbca.org.au

National Australian Built Environment Rating System (NABERS) (building rating tools for offices, homes, retail): www.abgr.com.au

PACIA (to download the Quickstart series and for information on plastics recycling and sustainability): www.pacia.org.au

Plastic Industry Pipe Association of Australia (information on recycling pipes from construction and demolition): www.pipa.com.au/recycling.html

Recycling Expanded Polystyrene Australia (code of practice and recovery program for EPS building products): www.repsa.org.au/portals/0/downloads/pod.pdf

STEPS: www.morelandsteps.com.au/about.html

Sustainability Victoria (information on FirstRate; guidelines and model contract clauses to minimise construction and demolition waste): www.sustainability.vic.gov.au/www/html/1940-how-to-minimise-construction--demolition-waste.asp

Sustainable Design Scorecard: www.moreland.vic.gov.au/environment-and-waste/sustainable-building-moreland/sustainable-design-scorecard-tool.html

Your Home (to download a buyers guide, renovators guide or technical manual for residential buildings): www.yourhome.gov.au

Your Building (for articles and case studies on sustainable commercial and industrial buildings): www.yourbuilding.org/display/yb/Home

Footnotes

1 OECD 2003, *Policy brief: Environmentally sustainable buildings - challenges and policies*, Paris.

2 Senate Environment Committee 2002, *The value of water*, Commonwealth of Australia, Canberra, p.32.

3 Productivity Commission 2006, *Inquiry report: waste management*, No 38, October, Melbourne, p. 17.

4 PACIA (2000), unpublished data.

5 This figure is conservative – it would be higher for very energy-efficient buildings and if the calculation included renovations and refurbishments ('churn'). Source: RMIT University *et al. Scoping study to investigate measures for improving the environmental sustainability of building materials*, Report to Department of Environment and Heritage.

6 Sustainable Energy Authority Victoria (2001), *Insulating your home*, p.2.

7 Glacier Bay, *Transmission of heat: conduction, convection and radiation*, www.glacierbay.com/Heatprop.asp.

8 Novak, Vera (2006), 'Pushing the energy envelope with ICFs', *Modern Materials*, 4 (3), pp.12-16.

9 Reardon, Chris *et al*, *Your home technical manual*, www.yourhome.gov.au/technical/fs410.html.

10 Ross Garnaut (2008), *The Garnaut Climate Change Review*, www.garnautreview.org.au/index.htm.

11 Lu, Burn and Whittle (2000), *'Elastomeric joint performance of PVC, VC and FRC pipes'*, Polymer Engineering and Science, 40(10), pp.2217-2226;

Ambrose, Burn and DeSilva (undated), *Life cycle analysis of water networks*, http://www.pepipe.org/uploads/pdfs/Life_Cycle_Cost_Study.pdf

12 Polybutene Piping Systems Association (2006), *Successful in the past, prepared for the future.*

13 Victorian Government (2002), *21st century Melbourne: a water smart city, Strategy directions report*, p.40.

14 Golder Associates (1999), *Report on the waste profile study of Victorian landfills*, Report to the Victorian EPA, Melbourne, p.39.

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