Design Detail & Deliver Pty Ltd Trading as **ENVIROSPEC** ABN 31 088 338 532 Inc in NSW
49A Parklands Road, Mt Colah NSW 2079, Australia www.electronicblueprint.com.au
Phone: +61 2 4360 2255 Fax:+61 2 4360 2256 email envirospec@electronicblueprint.com.au

Green Specifications for Building Products – Masonry Case Study

Rod Johnston
B Tech, M Eng Sc, MICD, CP Eng, NPER, MIE Aust, RPEQ
Director: ENVIROSPEC and Electronic Blueprint,

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Scope
This paper outlines the developments in defining the sustainability features of building products, with a view to simplifying the specification process.

It deals with the potential dichotomy between simplistic ecolabels, which concentrate on "materials, manufacture, transport, construction, & demolition"; and a more comprehensive system that effectively accounts for critical "in-service" performance in addition to the above-mentioned characteristics. The dichotomy will be demonstrated by a case study for masonry products.

Background
The objective of sustainability design is to define practical methodologies for classifying building products, such that their contribution to sustainability is easily identifiable. For purposes of this paper, sustainability is taken as those properties that lead to:

- Reduction in green-house gas generation, which causes global warming;
- Reduction in the use of non-renewable resources upon which our society depends; and
- Reduction in land, water or air pollution or degradation, which alienates the use of these resources.

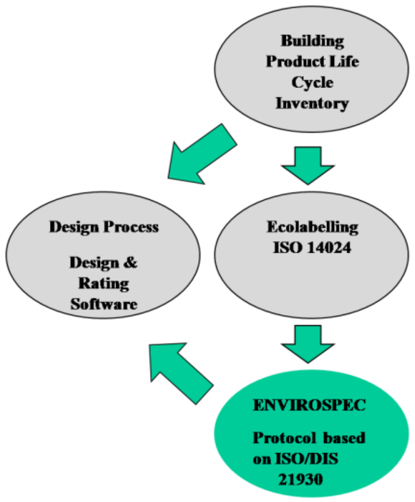
It is recognised that the comparison of comprehensive life cycle analyses, prepared for competing products, is the most equitable basis of selecting sustainable products. However, comprehensive life cycle analyses are controversial, because they involve numerous assumptions regarding the manufacture, transport, construction, demolition and re-use of the building products; <u>and</u> assumptions regarding their in-service performance in various applications.

To date, Building Regulations have concentrated on only some aspects of in-service performance (e.g. specifying levels of insulation to achieve desired energy minimisation). The process of preparing such regulations has highlighted the problems in assessing the in-service performance of various products in various applications. (e.g.Differing thermal resistance and thermal mass of various building products will contribute differently to energy minimisation in different climates and different building types.)

Part 1 – Ecolabelling Schemes

BPIC / ICIP Project
Currently the Building Products Innovation Council is collecting data for the creation of a Life Cycle Inventory (LCI). This data will be used to populate design software, enabling designers to minimise environmental impacts. Building product ecolabels may also be prepared using the LCI data, but, as noted previously, ecolabels may be too limited to provide comprehensive design information for each conceivable application, building use, climate and location.
See Fig 1. What designers required is the presentation of sustainability information

- in a technically credible format
- geared specifically for use by designers
- tailored for marketing innovative building products
- in particular applications.



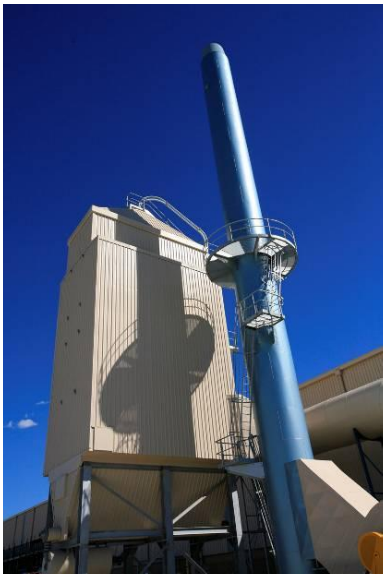


Fig 1 – Building Product Information Flow

Comprehensive Consideration of In-service Performance
The ENVIROSPEC Protocol sets out an approach for gathering and presenting realistic information, for use by designers. It draws on existing and proposed ecolabels, LCI data and the like; together with the current approach adopted by building regulators, viz. considering the special circumstances of a range of in-service performance criteria. It deals with the effects of a building product on the sustainable operation of the building into which it is built, in the context of what is both common practice and what is permissible under the Building Regulations. It provides for the collection of data for subsequent publication in;

- Environmental Declarations (life-cycle analysis and other environmental data)

- Environmental Benchmarking (the comparison of a product's life-cycle analysis and other environmental data to those of the most common acceptable alternative "benchmark construction". This may be defined as the form of building construction that is the most economic common solution permitted within the mandatory requirements of the Building Regulations and relevant Standards referrer to therein.

Scope of Building Product Declarations
Environmental Declarations and Environmental Benchmarking should account for the sustainability impacts of the manufacture, transport, construction, demolition and re-use of building products, together with their in-service performance. They should comply with ISO/DIS 21930 as described in Part 1 of the Protocol. The following extracts from ISO/DIS 21930 provide context for Environmental Declarations in accordance with Part 1 of the Protocol.

> *If possible, Type III declarations for building products should account for all life cycle stages of the product. Omissions of life cycle stages shall be justified. Where not all the necessary information is available, the PCR shall state those stages that are to be addressed and how to deal with information gaps. The declarations may be based on generic data, as defined in the PCR.*
>
> *Environmental impacts, e.g. energy and materials used, resulting from the installation of the building product in the building shall be identified and included in the report. If it is not included, because data is not available, this fact shall be stated.*

Part 2 - Case Study – Masonry Sustainability

Criteria

Fitness for Purpose

The principal requirement for any building product is that it shall satisfy any relevant Fitness for Purpose criteria. Failure of building products to achieve the intended fitness for purpose may lead to unsafe construction, unserviceable construction or other structural, mechanical or aesthetic failures. This invariably leads to re-construction or repair and the associated waste. Therefore, the purposes of sustainability are served by products that are fit for purpose.

In the case of masonry (collectively covering clay brickwork and concrete blockwork), fitness for purpose is gauged by compressive strength, flexural strength, bond strength (in conjunction with mortar) durability, imperviousness to water penetration and the like. There could be a temptation to sacrifice these properties in the cause of reducing energy consumption. However, such "shooting from the hip" could be misguided – For example, if a clay brick is purposely under-fired, its strength suffers and its ability to support a building could be significantly compromised.

Statutory Requirements

The second requirement is that building products have the requisite properties necessary to meet any relevant parts of the Building Regulations and the relevant Standards referred to therein. Fitness for purpose is often defined in regulatory requirements. Therefore, the purposes of sustainability are most often served by products that meet relevant regulatory requirements.

For masonry units, the statutory requirements are fulfilled by compliance with AS/NZS 4455 *Masonry units and segmental pavers*, for properties nominated by the designer in accordance with AS 3700 *Masonry Structures*.

Sustainability Criteria

The third requirement is that products satisfy particular Sustainability Criteria requiring an increase in sustainability over commonly used alternatives, considering:

- The contribution of the product to the overall sustainability of the building during the building life cycle; and
- The sustainability of the product in respect of its life cycle.

The Sustainability Criteria for building products shall be as follows

(a) <u>Reduction green-house gas generation</u>
The use of the product shall lead to a reduction in the greenhouse gas generation, when compared to "Benchmark Construction".

(b) <u>Reduction in the use of non-renewable resources</u>
The use of the product shall lead to a reduction in the consumption of non-renewable resources, when compared to "Benchmark Construction".

(c) <u>Reduction in land, water or air pollution or degradation</u>
The use of the product shall lead to a reduction in land, water or air pollution or degradation, when compared to "Benchmark Construction".

In some circumstances, there could be conflict between competing sustainability objectives. In such cases, the considered importance of the particular properties should be ranked in order to determine whether any particular property increases or decreases the overall sustainability. In this paper, only the first criterion (as indicated by energy use) will be considered.

Scope of Study
This study provides estimates of the embodied energy used to manufacture various Australian housing wall systems (e.g. masonry veneer, cavity masonry, single leaf masonry and timber clad walls). From this data, the savings in embodied energy to change from one system to another can be calculated, and this information is expressed as a percentage of the heating and cooling energy over the life of the house.

Limitations
This is a very preliminary study based on a limited amount of information, and will be augmented by a more comprehensive study when the BPIC/ICIP Life Cycle Inventory (LCI) data is available. It does not consider credits for reuse of materials during the final demolition. Nor does it include painting and maintenance of non-face-brick systems.

Conclusions of Study
Table 1 sets out the "saving" in embodied energy that would result from a change from the DTS (Deemed-to-Satisfy) construction of BCA Volume 2 (in each Climate Zone) for Masonry Veneer, Cavity Masonry or Single Leaf Hollow Concrete Masonry to the DTS construction for Weatherboard Cladding on Timber Frame. The "savings" are expressed as a percentage of the Heating and Cooling energy calculated using the ABCB Protocol for House Energy Rating Software Version 2005.1.

Table 1 - Embodied Energy Savings to Change from Masonry to Timber Clad Houses expressed as a percentage of the 5 Star Heating and Cooling Energy

	Masonry Veneer	Cavity Masonry	Single Leaf Concrete Masonry
1 Hot humid warm winter	2%	4%	1%
2 Warm humid summer, mild winter	7%	15%	3%
3 Hot dry summer, warm winter	5%	10%	4%
4 Hot dry, cool winter	4%	8%	3%
5 Warm temperate	6%	12%	5%
6 Mild temperate	3%	7%	3%
7 Cool temperate	3%	5%	2%
8 Alpine area	3%	6%	4%

Table 1 is based on the "5 Star" Heating and Cooling energy calculated using the ABCB Protocol. This is the optimum heating and cooling energy regime (proposed for the draft BCA 2006) and proposes very low values. Thus, the expression of embodied energy as a proportion of these values is a pessimistic result, assuming ideal performance of significantly improved building fabric. If similar data were tabulated for the more common "3 Star" requirements, the impact would have been considerably less.

The calculated values for embodied energy are considered to be very low proportions of the heating and cooling energy.

- 2% to 7% for masonry veneer.
- 4% to 15% for cavity masonry
- 1% to 5% for single leaf hollow concrete masonry.

The embodied energy values used in the study are preliminary, approximate and conservative. As manufacturing efficiencies are adopted (as discussed in the next section), these percentages will drop even further.

Total Operational Life-cycle Energy
The total operational life-cycle energy of a house, including its appliances, is much higher (7 to 8 times higher) than the heating and cooling energy. [1] If embodied energy saving were treated as a proportion of total life-cycle energy rather than of heating and cooling energy, the proportions would go from very small to insignificant. This suggests that there are far more significant savings in energy and greenhouse gas emissions to be made through controlling house operational energy (appliances etc) than by through the embodied energy of the building fabric.

Improvements
One very positive outcome of the increased discussion around reducing embodied energy is the production improvements being instituted by the major manufacturers. The following example describes some of the initiatives incorporated into a new brick manufacturing plant in Victoria.[2]

- The high-tech brick plant produces about 85 million bricks per year, sufficient for more than 12,000 typical new Melbourne homes. This leads to considerable economy of scale.
- Almost all of the clay and shale minerals extracted are useable.
- The new plant is centrally located to current and future reserves, reducing haulage costs.
- Brick kilns are fired by natural gas, and use about 30% less gas than a conventional kiln.
- Production waste has been all but eliminated. All clay and shale is crushed and placed in the mix. The few faulty units made are crushed and recycled into the mix.
- Electricity consumption has been significantly reduced, and constant operation allows the plant to maximize off-peak electricity use.
- Runoff water is captured from roofs and in quarries and stored in deep reservoirs on the site, for use in the brick-making process.
- The latest of scrubber technology, installed on the kiln stack, reduces emissions to well below legal limits.
- Electricity consumption is significantly reduced by high-efficiency variable frequency electric drives. Unlike traditional hydraulic power-pack controls, variable frequency electric drives only use the power required to do the job. This conversion from hydraulic to electric has had the added benefit of eliminating the subsequent disposal oil.
- All brick packs are plastic strapped, eliminating shrink-wrapping, metal bands and pallets.

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[1] A report commissioned by the Clay Brick and Paver Institute indicates a total Life-Cycle Energy Use of approximately 5,600 GJ (44,000 MJ/m^2 <u>floor</u> area or 56,000 MJ/m^2 <u>wall</u> area. LCA Fact Sheet *AVJ 127 Project Home - Life cycle analysis of clay brick constructions*, BHP Research.

[2] Information provided courtesy of Austral Brick.

Conclusions

- Building product ecolabelling schemes must adequately account for in-service performance for a range of applications, building uses, climates and locations.

- The embodied energy of many building products (including masonry) is often a small component of the total energy use. While important, it must be considered in the context of “Fitness for Purpose” and “Compliance with Regulatory Requirements”.

- This BPIC / ICIP project will gather a large quantity of useful data, which will permit rational calculations to be carried out.

- Building product sustainability data must be presented in a form that is clear, honest and useful to designers and specifiers.

Referenced Documents

Australian Building Codes Board, *BCA 2008 – Building Code of Australia Class 2 to Class 9 Buildings Volume One*

Australian Building Codes Board, BCA 2008 – *Building Code of Australia Class 1 and Class 10 Buildings Volume Two*

ISO 14024:1999 *Environmental labels and declarations – Type I environmental labelling – Principles and procedures*

ISO/CD2 14025:2004 Environmental labels and declarations – Type III environmental declarations

ISO/DIS 21939-2005 *Sustainability in building construction — Environmental declaration of building products*

AS 3700:2001 *Masonry structures*

AS/NZS 4455 *Masonry units and segmental pavers*

Johnston, R.K., *Comparison of Embodied Energy to Heating and Cooling Energy for Various Wall Systems of Australian Houses,* Report to Concrete Masonry Association of Australia and Think Brick Australia, Q5080803-2, 28 September 2005