Achieving Factor 5 improvements in Typical Australian House[1]

This case study presents the findings of a theoretical assessment of potential, significantly reduced, energy requirements for standard homes in Queensland, Australia. The project, using commonly available and generally off-the-shelf technologies, has demonstrated that the operational impacts of a home can be reduced by more than Factor 5 without any substantial redesign of the home. This improvement is achieved on typical homes of the type currently being constructed on new residential housing development sites in South-East Queensland. Importantly, these sustainability changes are affordable, with additional capital cost approximately paid back by savings on power use. The project, undertaken by GreenMode and RMIT, is one of a group carried out through an alliance between the Queensland Environmental Protection Agency and developer, Delfin Lend Lease.[i] The project modelled the performance of 35 standard homes that are approved and/or constructed at Springfield Lakes Ipswich, near Brisbane. The 35 standard home designs were chosen as a representative sample of actual 'typical' home construction. A set of sustainability changes (including efficient appliances, construction materials and design variations - orientation, shading) were then theoretically applied to the designs and the impact, on each home, assessed. These changes are summarised in Table 1.

Table 1: Sustainability changes made to homes, key modifications for sustainable homes.

Focus Area	Elements
Space Heating and Cooling	Best of two orientations for home.
	Double glazing and automated window shading.
	Insulation (equivalent to r4 roof and r2.5 walls) and heat reflective paint.
	Roof and room ventilation, ceiling fans and sealable kitchen and bathroom extractor fans.
	6 star air conditioning
Domestic Hot Water	Gas boost Solar Hot Water.
Appliances (including refrigeration)	High efficiency appliances in home – an average of a 3 star improvement in all home appliances.
Lighting	Energy efficient lighting
Renewable Onsite Energy	1kW Solar PV system.
Home construction	NRG Greenboard style wall construction.
	60% concrete recycling rate at end of building life.

The project used the concept of an Ecological Footprint (EF) to guide the investigation into the energy and material related impacts of a household. The method included an assessment of the life-cycle impacts of the home, both in construction and operation, assuming that it would remain in operation. The EF is considered to be a 'real world' measure of sustainability, expressing the environmental requirements of homes as the amount of productive land needed to supply all the

[1] This case study has been developed by Simon Divecha (GreenMode), Lynn Whitfield (Queensland Environmental Protection Agency), Rob Ball (Lend Lease) and Andrew Carre (Centre For Design RMIT) in 2009 on invitation from the Authors to compliment the work in '*Factor 5: Transforming the Global Economy through 80% Improvements in Resource Productivity*'.

resources and, absorb all waste, from the home. This land use concept can be understood by a wide variety of stakeholders and used to promote the benefits of sustainable housing.

EF is assessed in accordance with Wackernagel *et al*[ii]. Life-cycle carbon dioxide equivalent emissions are converted into land use requirements.[iii] Factors, to convert home resource demand or waste production, normalise each of the land use types.[iv] When the relevant comparison is Australian, yield factors adjust Australian land usages to global land usages – e.g. for the actual land occupied by the house.[v] Data for a house's energy consumption is taken from actual home plans,[vi] construction material quantities,[vii] manufacturer data,[viii] energy use data,[ix] emission factors,[x] previous related studies,[xi] Data on Queensland EF[xii] and, home heating and cooling requirements - thermal efficiency.[xiii] Thermal efficiency is assessed using 'FirstRate 5' software generating a Building Code of Australia star rating plus energy demand. House thermal performance changes with orientation and the best north and south or east and west orientation is chosen as the basis for the sustainable home. This allows for home placement in the better of two directions and overcomes standard objections to optimising the home's orientation. The homes are two types – cement slab on ground (CSOG) and elevated homes. 'SimaPro' (Life Cycle Assessment software) calculated the construction and maintenance footprint of a CSOG and elevated home in seven variations (standard or sustainable with different roof and wall types to fit the full home range). The sustainability changes have a significant impact on a home's footprint. The changes result in the average Ecological Footprint, from the ongoing daily use of new homes, being reduced to less than one fifth of the standard homes' footprint (Figure 1).

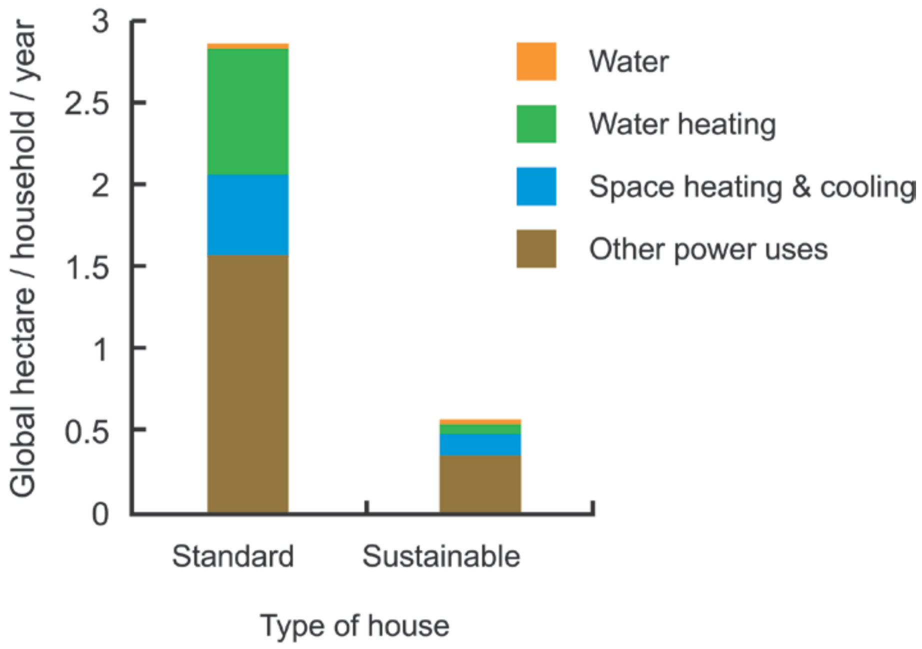

Figure 1: House Footprint Results - Average across 35 typical project home designs

Sustainable housing is often regarded as imposing a significant cost premium on the home. Consequently, the indicative price of the sustainability changes, for a typical 165m^2 house, was assessed. The capital cost of such changes may be offset by a reduction in the power and operating costs of the house. This depends on a number of factors, such as the mortgage rate (assuming extra lending to finance the changes), cost of power (especially given current price increases and the future impact of carbon trading in Australia), solar PV feed in tariff plus other government solar subsidies and, the scale to which these sustainability changes are implemented (driving efficiencies of supply). For these homes, if the sustainability changes are financed with a 20 year mortgage, the increase in mortgage repayments is similar to the reduced power costs.

An important consideration is the impact of materials required for making a home more sustainable. Consequently, the project also looked at the footprint from the home's physical structure (construction and maintenance). This becomes only marginally larger as the home is enhanced to achieve better results.

The significant changes between a *standard* home and a *sustainable* home are:

- *Space Heating and Cooling - thermal performance* - The cooling and heating loads of the modelled sustainable homes are significantly reduced through insulation, appropriate orientation, shading, and, allowing for the cooling of a home using fans (in addition to air conditioning). Some sustainable homes achieved almost a 9 star thermal efficiency rating, with an average of 7.1 stars. CSOG homes performed better than elevated homes. The average star rating of a CSOG sustainable home was 7.7 with elevated homes averaging 6 stars. Sustainable homes showed an average increase of 3.1 stars.
- *Space Heating and Cooling - air conditioning* – While the homes are easier to cool and heat (as a result of the above changes) it is still assumed that air conditioning is fitted. Six star efficiency air conditioners are used in the sustainable homes.
- *Appliances, Lighting and Refrigeration* – A significant proportion of the standard home's energy use is related to lights and appliances (such as fridges, TVs). This category would dominate the footprint of a sustainable home if it was not addressed. The sustainable home uses highly energy efficient lighting and assumes the equivalent of a 3 star improvement in all appliances used in the home.
- *Domestic Hot Water* – a gas boosted solar hot water system is fitted to each sustainable home.
- *Renewable Onsite Energy* – a 1kW solar power system is added to each home. The Queensland Feed in Tariff, combined with Australian Government subsidy makes it attractive for homeowners to purchase such a system

The sustainable outcomes achieved by implementing changes on the standard home designs are very significant. The options chosen are effective, affordable and, in most cases, readily available off the shelf options for existing home designs. These simple options have achieved major improvements in the sustainability of project homes and, importantly, do so without a substantial redesign.

Key results from this project show that:

- Sustainable homes achieve a five to six fold reduction in Ecological Footprint without any significant increases in the construction and maintenance.
- Large sustainability gains come from areas such as solar hot water and improvements in home heating and cooling. The results also highlight the importance of addressing other power uses in the home (white and brown goods) as well as the effectiveness of solar.
- Home heating and cooling needs are reduced very significantly through the efficiency measures applied to the home. The gains from some of these measures, such as orientation, shading, and insulation come at little to no net extra cost.

These sustainability changes are indicative of what can be achieved. It will be possible to obtain similar results with a different mix of sustainability criteria and technologies. Nevertheless, these significant improvements - within the boundaries of current house design and costs - show that Queensland Factor 5 housing should have broad appeal.

Notes:

[i] Delfin Lend Lease is the lead business unit on this project for parent company Lend Lease

[ii] Wackernagel, M., C. Monfreda, et al. (2005) National Footprint and Bio-capacity Accounts 2005: The underlying calculation method. Oakland, Global Footprint Network.

[iii] Wackernagel, M., C. Monfreda, et al. (2005) National Footprint and Bio-capacity Accounts 2005: The underlying calculation method. Oakland, Global Footprint Network.

[iv] EPA Victoria (2005) EPA Ecological Footprint Calculators: Technical Background Paper. Melbourne; and Wackernagel, M., C. Monfreda, et al. (2005) National Footprint and Bio-capacity Accounts 2005: The underlying calculation method. Oakland, Global Footprint Network.

[v] EPA Victoria (2005) EPA Ecological Footprint Calculators: Technical Background Paper, Melbourne

[vi] Delfin Lend Lease (Gibson. G.), (2008) Assessment of homes in Springfield Lakes, pers. com 19/2/2008.

[vii] Lawson, W. (1996) Building materials, energy and the environment: towards ecologically sustainable development, Red Hill, Royal Australian Institute of Architects.

[viii] Zanoni. R., (2008) NRG Greenboard Wall Cladding, Sunhoods and Blades specifications, email 4/7/08. NRG Building Systems Pty. Ltd.

[ix] Commonwealth of Australia (2006) 2006 Census QuickStats: Brisbane; Housing statistics, Australian Bureau of Statistics, Australian Government; Commonwealth of Australia (2008a) Energy Use In The Australian Residential Sector 1986 – 2020 Department of the Environment, Water, Heritage and the Arts, Australian Government; Commonwealth of Australia (2008b) Appliance Energy Ratings – www.energyrating.gov.au, accessed 3/7/2008; Queensland Government (2004) Regulatory Impact Statement, Proposed amendments to building and plumbing regulations to improve sustainability of new housing, Queensland Government, December 2004.

[x] Commonwealth of Australia. (2008c) National Greenhouse Accounts (NGA) Factors, January 2008. Department of Climate Change, Australian Government.

[xi] Divecha. S., Muffet. L., Grant. T., (2008) Mawson Lakes Footprint Report, GreenMode, Strategic Matters and RMIT.

[xii] Wood. R., Wiedmann. T., Barrett. J., Lenzen. M., (2007) The Footprint of Consumption in Queensland, The Centre for Integrated Sustainability Analysis at The University of Sydney and the Stockholm Environment Institute at the University of York.

[xiii] Harrison, W., (2008) 280 FirstRate 5 Reports, Home Energy Rating, QBears.