LOOKING FURTHER THAN THE INITIAL DOLLARS

With home ownership in New Zealand changing on a 7–9 year cycle, long-term considerations may seem irrelevant to some homeowners. But taking a long-term view could have positive benefits for our health, the environment and our pockets.

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Construction decisions are generally driven by initial cost first and resource use second. But houses last a long time and need to cater for changing requirements, like young children or elderly parents. These changes and ongoing maintenance mean the cost and resource use continue throughout a building's life.

Increasing public interest in global warming, sustainability and reducing the detrimental environmental impacts of human activities requires that construction actions consider long-term performance and implications. 'Lifetime consideration' could lead to a New Zealand housing stock that is healthier, more energy and resource efficient, and cheaper to maintain.

Construction options

This concept of lifetime consideration can be explained by looking at common construction options for a simple house (the Building Industry Advisory Council (BIAC) house design with a floor area of 100 m^2) over a long period. Building Code requirements for component durability are based on ease of access after installation and are therefore not a true representation of useful life. For the best use of resources embodied in the house, it needs to be maintained for the optimum period possible – about 80–100 years in New Zealand.

Table 1 shows the three common construction types considered.

User behaviour important

Comparison of life cycle energy use (the energy used by the house over its lifetime, for construction, maintenance and to maintain 18°C internal temperature during the day) for these three construction types in Auckland is shown in Figure 1.

Light and *heavy* construction types perform similarly, although life cycle embodied energy is lower with *heavy* construction due to its lower maintenance requirement. *Superinsulated* construction has slightly higher embodied energy, due to its additional construction materials, and provides notable savings.

Although operating requirements of appliances, water heating, cooking and lighting are dependent on user behaviour, their inclusion in the life cycle energy comparisons shows their importance in lifetime performance (see Figure 2).

Greenhouse gas emissions

Floor, walls and roof constitute a major fraction of the mass of a building and could be expected to contribute extensively to life cycle energy and greenhouse gas emissions.

In the *light* and *superinsulated* construction types, however, floor construction reduced the greenhouse gas emissions by 13% and 11%, respectively. Superinsulated walls also recorded a 3% reduction in emissions. This is due to carbon locked in timber framing and other timber-based products used in the construction of these elements. *Heavy* roofs also reduced greenhouse gas emissions by 5%. *Light* and *superinsulated* roofs, however, contribute 17% and 20% respectively to the life cycle greenhouse gas.

The figures differ so much because of the emissions resulting from the use of long-run steel sheets as a roof cladding on the *light* and *superinsulated* houses. The *heavy* construction house has a roof of concrete tiles, which have much lower emissions, even allowing for the emissions associated with cement manufacture. The high value for the floor of the *heavy* construction is because of the cement content in the concrete slab.

During the useful life of the building, finishes are replaced many times and →

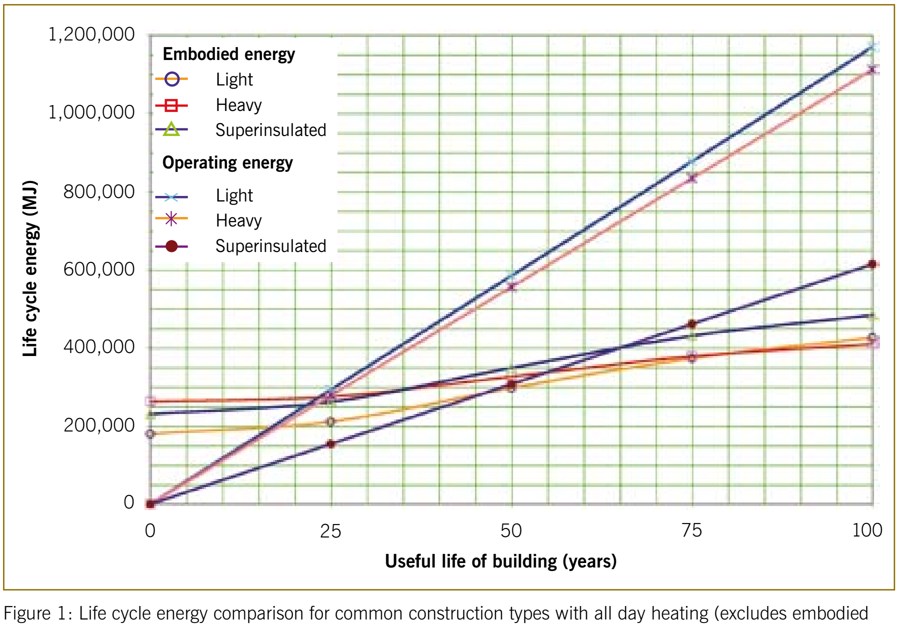

Figure 1: Life cycle energy comparison for common construction types with all day heating (excludes embodied and operating energy for appliances).

Table 1: The three common construction options considered and their R-values.

	Light construction		Heavy construction		Superinsulated	
Flooring	particleboard floor on raised framing with double-sided foil	R1.5	concrete floor slab with perimeter insulation	R1.5	particleboard floor on raised framing with 200 mm glassfibre insulation on a plywood layer	R4.4
Walls	94 mm glassfibre insulation within softwood timber wall frame	R1.9	94 mm glassfibre insulation within softwood timber wall frame	R1.8	200 mm glassfibre insulation within softwood timber wall frame	R4.4
	fibre cement external cladding and plasterboard internal lining		external brick veneer and plasterboard internal lining		fibre cement external cladding and plasterboard internal lining	
Roof and ceiling	pitched softwood truss roof with corrugated steel roofing	R1.95	pitched softwood truss roof with concrete tiles	R1.8	pitched softwood truss roof with corrugated steel roofing	R4.4
	flat plasterboard ceiling with 100 mm thick glassfibre insulation		flat plasterboard ceiling with 100 mm thick glassfibre insulation		flat plasterboard ceiling with 200 mm thick glassfibre insulation	
Windows	single-glazed aluminum windows	R0.18	single-glazed aluminum windows	R0.18	double-glazed aluminum windows	R0.33

Table 2: Life cycle greenhouse gas emission factors for a Building Industry Advisory Council standard house. (Some values are negative because of carbon locked into materials like timber.)

Building element	CO_2 emission factors (kg/m^2)					
	Light construction		Heavy construction		Superinsulated construction	
Foundation	2	1%	6	2%	2	1%
Floor	–32	–13%	61	23%	–28	–11%
Walls	7	3%	13	5%	–7	–3%
Roof	42	17%	–13	–5%	51	20%
Joinery	20	8%	20	8%	29	11%
Electrical work	14	6%	14	5%	14	5%
Plumbing	111	44%	111	42%	111	43%
Finishes	85	34%	51	19%	85	33%
Total	251	100%	262	100%	257	100%

Table 3: Life cycle cost comparison for Building Industry Advisory Council standard house.

Category	Life cycle cost (NZ$/m^2)				
	Year 0	Year 25	Year 50	Year 75	Year 100
Light construction					
Construction cost	973	1,100	1,207	1,224	1,228
Space heating energy cost	0	57	74	79	80
Total	973	1,157	1,281	1,303	1,308
Heavy construction					
Construction cost	1,177	1,292	1,374	1,395	1,397
Space heating energy cost	0	54	70	75	76
Total	1,177	1,346	1,444	1,470	1,473
Superinsulated construction					
Construction cost	1,148	1,301	1,381	1,407	1,410
Space heating energy cost	0	30	39	41	42
Total	1,148	1,331	1,420	1,448	1,452

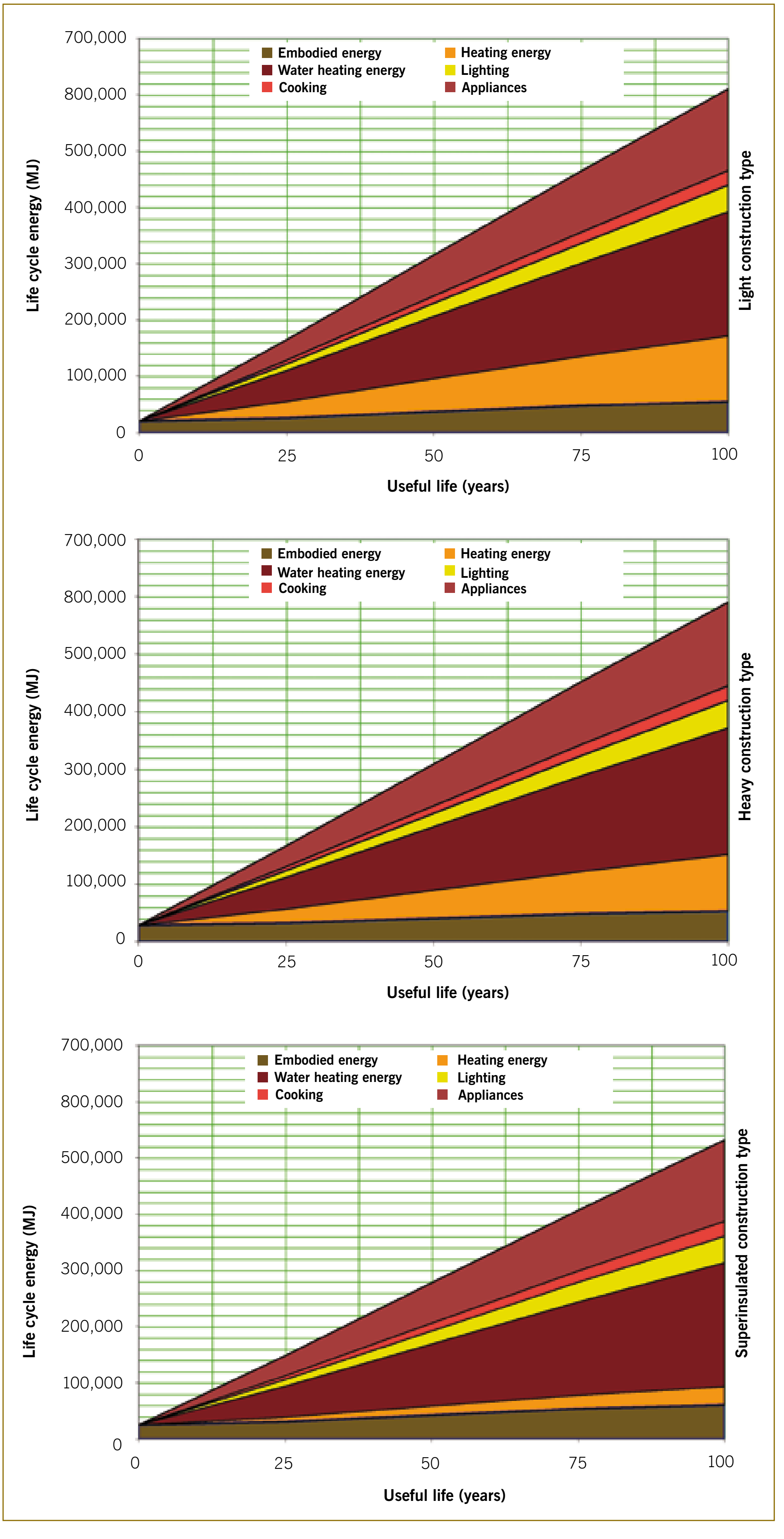

Figure 2: Life cycle energy comparison for common construction types (includes embodied and operating energy for appliances).

contribute 34%, 19% and 33% of the life cycle building greenhouse gas emissions for light, heavy and superinsulated construction types, respectively. The replacement cycle is therefore of utmost importance.

A comparison of life cycle greenhouse gas emissions for the three construction options is shown in Table 2.

Life cycle costs

Life cycle costs calculated with a 5% discount rate for the above construction types are shown in Table 3. These costs involve the building works only. Activities such as preliminaries and site works that would be similar for all constructions types are omitted. No GST is added to the initial construction cost, but 12.5% GST has been added to replacement work. Space heating energy use only is considered in terms of operating requirements. Line charges, which are applicable to all domestic electricity uses, have been omitted.

Both *heavy* and *superinsulated* constructions perform similarly. The *superinsulated* construction is approximately 11% more expensive than the *light* construction in life cycle terms, with about 18% increase in initial cost; the *heavy* construction type is 13% more expensive in life cycle terms and 21% more expensive at the initial stage.

But the use of discounted cash flows, as in this case, generally tend to focus on the initial investment rather than the continued operating cost savings which may result from the use of increased insulation.

Comparative analysis useful

Such modelling should not be used to predict the life cycle performance of a particular design, as the predicted performance will seldom be matched by the actual performance. This is because of the influence of the building's users, in the same way that the habits of different drivers affect the petrol consumption of apparently similar cars.

This type of analysis can be useful during the design stage to compare alternative designs, and assess possible improvements to a design. Naturally the earlier life cycle techniques are introduced, the easier it is to inform the design process and the greater the benefit to the final design.