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BULLETIN

LOW-IMPACT HOMES

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- Low-impact construction provides a better use of resources and a better experience for the occupants of a house.

- The processes start with site selection and continue to deconstruction and salvage.

- This bulletin gives an overview of the key elements and benefits of low-impact construction, and replaces Bulletin 446 *Sustainable construction.*

1.0 INTRODUCTION

1.0.1 Low-impact construction for new dwellings:

- minimises use of non-renewable resources while using renewable resources to their best advantage over the building's lifetime
- adopts technologies and processes for local conditions
- reduces construction and in-use waste
- is resilient to adverse conditions and changes in use.

1.0.2 Low-impact construction is a process involving building owners, designers and builders from site selection, design and specification and construction, through to occupancy, maintenance, deconstruction and salvage.

1.0.3 This approach to building provides a better quality of life for building occupants over a building's lifetime.

1.0.4 Analysis of typical costs of low-impact construction shows that costs may be slightly higher than a standard building, but life-cycle savings of more than 10 times this amount can be achieved – for example, through lower energy usage.

1.0.5 House size is related to resource use – the larger the house, the more resources needed to build it and keep it 'fit for purpose' during its lifetime. A well planned 3-bedroom house with garage can be achieved within 150 m^2 or less.

1.0.6 Benefits of adopting low-impact construction practices include:

- reduced lifetime costs
- reduced maintenance
- ability to respond to change in the homeowner's circumstances
- better occupant health and productivity
- potential for independence from utilities
- adding value to the building stock.

1.0.7 This bulletin gives an overview of the key elements and benefits of low-impact design and construction. It replaces Bulletin 446 *Sustainable Construction.*

2.0 SITE SELECTION

2.0.1 Site selection is important, as it influences:

- thermal comfort
- transport costs
- connections with the community
- energy use
- micro-renewable energy generation
- durability of the construction materials
- psychological wellbeing of occupants
- carbon impact.

2.0.2 In greenfield subdivisions, the aim should be to orient streets so that the majority of the sections have an east-west axis to maximise the north-facing aspect for sun access. They should be wide enough to allow well sized north-facing outdoor living spaces to provide warm, sunny outdoor areas that are not shaded in winter by neighbouring buildings, foliage and landforms (see SNZ HB 44:2001 *Subdivision for People and the Environment*).

2.0.3 Check sites for solar access. Sun should be available for at least 75% of the daytime all year round. Several online and smartphone-based tools can quickly and accurately determine the amount of solar incidence on a site. Some account for just the geographic shading while others include shading from artificial objects and nearby foliage. Check the zoning of adjacent sites, especially if vacant, to determine the potential for future shading. Planning rules have recession planes that limit the building envelope, which can be used to work out the permitted development on adjacent sites and the potential shading.

2.0.4 NIWA's SolarView (http://solarview.niwa.co.nz) provides quantitative solar access information but only accounts for geographic features. If the site is shaded for more than approximately 40% of the time (compared to a clear site in the same region), this has significant implications for the thermal performance of the house. Ideally, total shading – including foliage and nearby buildings – should be less than 20%.

2.0.5 Determine the walkability from a site to key utilities and local transportation links using the free online tool Walk Score (www.walkscore.com). Scores range from 0–100 (a walkable site has a score of 50 or more).

3.0 DESIGN AND SPECIFICATION

3.1 CLIMATE-RESPONSIVE DESIGN

3.1.1 The cornerstone of low-impact construction is climate-responsive building design – working in unison with the local climate, building planning/orientation and construction material properties to ensure high levels of year-round comfort and indoor air quality.

3.1.2 Effective climate-responsive design can give high levels of comfort/indoor air quality while using minimal (or no) purchased energy for heating, cooling or ventilation.

3.1.3 The majority of glazing should face north to collect solar energy. Shade north glazing to prevent summer overheating. Glazing that faces east, west or south should be smaller and is mainly to meet daylight/view requirements. A good target for non-north glazing is around 3% or less of the home's total floor area.

3.1.4 With exposed concrete floors and good solar access, north-facing windows should be 10–15% of the home's total floor area. For timber floors, the north-facing windows should be closer to 10% of the total floor area to reduce the possibility of overheating.

3.1.5 If solar access is poor, north-facing windows should be less than 8% of the home's total floor area, with the other window orientations being considerably smaller.

3.1.6 All living areas and, ideally, bedrooms should have a northern aspect. The garage and service spaces (bathrooms, laundry) should be on the south side of the house.

3.1.7 Good ventilation is critical, especially in lighter weight homes with large glazed areas. Many new homes overheat in summer because they can't be ventilated naturally but securely or lack summer shading of north glazing. High-level windows that can be left open during the day, narrow louvres on the side of windows or trickle ventilators allow secure ventilation. Side opening casements are better at pulling breezes into a house and reducing overheating.

3.2 INSULATION

3.2.1 An R-value is the measure of a material's insulation value – the higher the figure, the better it insulates. Poorly installed insulation significantly reduces performance.

3.2.2 The construction R-value is the combination of the R-values of the individual components, less the effect of any thermal bridging of the framing. The construction R-value is usually less than that of the insulation material. The higher the specified construction R-value, the more important thermal bridging becomes.

3.2.3 The design should target the construction R-values shown in Table 1.

3.3 THERMAL MASS

3.3.1 Heavyweight building materials, such as poured concrete, concrete block, and adobe (and its derivatives) provide thermal mass by absorbing and storing the sun's heat during the day and releasing it slowly as the indoor temperature falls at night.

3.3.2 Thermal mass should:

- receive direct sunlight in the colder seasons yet be completely shaded in the warmer seasons
- be a darker colour with a lower colour reflectivity, allowing more energy to be absorbed
- preferably be visually appealing (such as polished concrete or finished with ceramic tiles)
- be large enough to heat the adjacent space(s)
- be contained within a well insulated envelope that can be easily ventilated
- be part of an integrated solar design, so it is proportioned correctly
- not be carpeted or covered with vinyl if it is a floor.

3.3.3 Having a household space with a northern aspect that has an exposed (that is, not covered by carpet or furnishings) and insulated concrete floor slab adjacent to substantial north-facing glazing will ensure the internal climate of the house remains comfortable throughout the year.

3.4 ASSESSMENT AND RATING TOOLS

3.4.1 To understand the thermal inter-relationship between the building aspects and material properties, a purpose-built thermal simulation/assessment tool should be used as this is the only way to check the design properly. Examples of these tools are Sefaira, AccuRate NZ, Passive House Planning Package (PHPP), and SUNREL. There are consultants who can provide thermal assessments for a fee. Assessments are best carried out at the sketch design stage.

3.4.2 A comprehensive, national, voluntary residential rating tool called Homestar™ evaluates the environmental attributes of stand-alone homes in terms of energy, health and comfort, water, waste and more. Homestar rates homes on a 1–10 scale, with a 10 being a home with a very high level of environmental sustainability. The average new home scores around a 3. A formal Homestar rating can be obtained via an onsite assessment performed by an independent Homestar assessor.

TABLE 1: CONSTRUCTION R-VALUES

Building element	Climate zone 1 (Northland and Auckland)	Climate zone 2 (all regions not included in zones 1 and 3)	Climate zone 3 (volcanic plateau and all South Island	Notes
Roofing/ceiling	R-3.9	R-4.5	R-5.0	Downlights should be IC-F rated as these can be covered by insulation in their thermal envelope.
Walls – low mass	R-2.2	R-2.86	R-3.5	Low-mass or medium-mass construction.
Walls – high mass	R-2.4			For high-mass construction (e.g. concrete floors and walls). Insulation for concrete walls should be located on the outside for better performance.
Windows	R-0.4	R-0.47	R-0.53	R-0.4 equates to thermally broken aluminium frames with low-emissivity (low-E) double glazing.
Floor – concrete	R-1.9			Fully insulated concrete slab that has a continuous horizontal under-pad insulation with edge insulation.
Floor – timber	R-3.0	R-4.0	R-5.0	

3.5 APPLIANCES

3.5.1 The efficiency of the major energy-intensive appliances has long-term implications on the environmental impact of the house.

3.5.2 The biggest benefit is gained by addressing those appliances that use the most energy – hot water heating accounts for approximately one-third of energy use, space heating just less than one-third and refrigeration about 12%. The environmental impact of appliances reflects their rated efficiency, fuel type, set-up and usage patterns.

3.5.3 The environmental impact of hot water supply can be reduced by:

- selecting the highest-efficiency system
- specifying water-efficient showerheads (which have flow rates ≤ 9 litres/minute)
- minimising hot water pipe runs by grouping the service areas
- insulating pipework from the cylinder
- fuelling the system using a low-carbon source (such as a wetback) or a renewable-based booster (such as solar thermal or photovoltaic) or a heat pump water heater.

3.5.4 The environmental impact of space heating can be reduced by:

- ensuring that the design is based around well integrated passive solar principles so that supplementary space heating is minimised
- choosing an efficient wood burner, pellet burner or heat pump.

3.5.5 With refrigerators, a new energy-efficient Energy Star-labelled model is a wise investment, as significant gains have been made in their performance. To compare energy efficiencies, see www.energyrating.gov.au. Ensure that the fridge and freezer are located out of the sunlight and have enough of an air gap to circulate warm air away from the compressor.

3.5.6 Artificial lighting should be based around energy-efficient (compact) fluorescent or high-quality LED technologies. Look for Energy Star-awarded products.

3.6 ON-SITE RENEWABLE ELECTRICITY GENERATION

3.6.1 Specifying on-site generation of electricity from renewable sources will lower impact.

3.6.2 Photovoltaic units can provide significant energy benefits to most homes with north-facing roofs while being reliable, silent and low maintenance. Their lifetime price per unit energy delivered compared to other forms of renewables gives them a considerable advantage for most situations.

3.6.3 Before committing to photovoltaics, carefully examine the site for shading, aspect and the amount of energy that can be generated. Photovoltaics are most cost-effective in off-grid situations where there is a high cost to connect to the grid or in grid-tied systems where the occupants are home during the day so they can use the electricity generated, offsetting their higher per unit purchase cost.

3.7 RAINWATER COLLECTION

3.7.1 The average New Zealand household uses about 160 litres of water per day per person – less than 2% is used for drinking. This water has to be collected, treated and then pumped to the site where it is used. Rainwater collection for household use is a simple way to make better use of an important resource.

3.7.2 There are two main types of rainwater systems – when a rainwater tank provides non-potable water for the garden, toilet flushing and clothes washing, and when rainwater is used for potable household water supply. Many councils now encourage rainwater tanks for non-potable water supply.

3.7.3 For potable water, the risks to health of roof-collected rainwater can be minimised by sensible preventative measures during design and maintenance as outlined in *Drinking-water Standards for New Zealand 2005 (revised 2008)* issued by the Ministry of Health:

- Roofing materials, fixings, flashings and paints that don't contain lead, chromium or cadmium (check with manufacturer).
- Roofing and guttering that is kept clean.
- A first-flush diverter and leaf guard.
- A rainwater tank with a draw-off that is about 100 mm below the water surface.
- UV or filtered treatment of the household supply.

3.7.4 Rainwater tank sizing is related to household needs, regional rainfall statistics and the collection/roof area. There are online tools and smartphone applications that can help.

3.7.5 In areas with year-round rain, if rainwater is collected for all uses, a 5,000 litre storage tank will provide a good proportion of water use. In areas with dry summers, a much larger tank will be required. If rainwater is collected only for gardening usage, installing either a rain barrel (generally about 240 litres) or a small rainwater tank (500 litres) is sufficient for places with year-round rainfall. Otherwise, 1,000–2,000 litres is recommended.

3.8 INDOOR MOISTURE MANAGEMENT

3.8.1 Designing to manage indoor moisture is important to prolong material life and also the health of the occupants. Moisture management starts with occupants minimising moisture generation and then extracting any moisture generated at source.

3.8.2 To minimise potential moisture:

- fully enclose showers
- specify flues for gas heating
- specify overflows for all sinks, basins, baths and wet rooms
- provide localised extract ventilation adjacent to the moisture source and vent to the outside for kitchens,

bathrooms and clothes dryers – locate bathroom extracts close to the shower, and rangehoods should cover all hobs and be powerful enough to remove the steam
- for suspended floors on damp sites and where subfloor ventilation is limited, specify a polythene ground cover.

4.0 CONSTRUCTION

4.0.1 During site development and construction, retain significant vegetation, recycle topsoil to keep nutrients on site and minimise soil and silt run-off.

4.0.2 Controlling sediment run-off, which is a significant water pollutant, can be done by preventing water from eroding the soil in the first place or by trapping the sediment before it leaves the site. Methods of avoiding erosion include:
- run-off diversion channels
- contour drains and/or earth bunds (embankment)
- silt fences
- hay bales
- vegetation buffer strips
- sediment ponds.

4.0.3 Concrete and paint washwater can be a problem in new construction. Where concrete is acid etched to expose the surface, the run-off must not enter the stormwater.

4.1 MATERIAL SELECTION

4.1.1 Material selection is an important environmental consideration for low-impact construction but less so than climate-responsive design. The most comprehensive and accepted systems internationally are based on life-cycle assessment (LCA) techniques using formalised, verifiable, transparent assessment systems, although application in New Zealand is currently at an early stage of development.

4.1.2 Environmental product declarations (EPDs) report verified environmental data of products based on life-cycle assessment using a formalised methodology. Ask a supplier or manufacturer if they can supply an EPD.

4.1.3 Currently, the most useful, independent resource for comparing New Zealand building products is the ecolabelling body Environmental Choice. It uses a cut-down version of LCA to determine where the biggest impacts occur. Manufacturers who have significantly reduced their impacts in these areas can apply for an ecolabel for their product.

4.1.4 A range of construction materials have been awarded Environmental Choice labels (floor coverings, plasterboard, paints, long-run steel products, ready-mix concrete and thermal insulation). When investigating and comparing construction products, use the Materials section of the BRANZ website www.level.org.nz.

4.1.5 For those products that fall outside the Environmental Choice labelling, use an eco-hierarchy tool designed to assist designers to prioritise relevant environmental issues using an eight-step process. See www.level.org.nz then Material Use>Life Cycle Assessment>Eco-hierarchy Tool. It is research based and is useful when no other independent resources are available.

4.2 REDUCING WASTE

4.2.1 The construction industry is responsible for nearly a third of all wastes in New Zealand landfills. Around 40% of these landfill wastes come from residential construction.

4.2.2 All those responsible for the building of a new home have an obligation to minimise construction wastes where practical as it reduces the financial cost in the material purchase, storage, handling and waste disposal as well as reducing the demand for additional costly landfill development and maintenance. Detailed information on minimising construction waste can be found online at REBRI – www.rebri.org.nz.

5.0 HOUSE OCCUPATION

5.1 MAINTENANCE

5.1.1 Regular maintenance maximises product and system durability while benefiting the utility and appearance of a house.

5.1.2 Keeping a maintenance diary will mean better planning and easier identification of work that needs to be done before it becomes a major issue. The diary should include what was done and by whom. Appliance warranties can be stored with it.

5.1.3 Designers and builders can create a maintenance manual using www.maintainingmyhome.org.nz. Homeowners should be encouraged to undertake the tasks listed in Table 2.

TABLE 2: REGULAR PREVENTATIVE TASKS

Tasks	Period between maintenance or replacement
Wash down roof and walls	6–12 months
Clean gutters	6 months
Check roof	12 months
Check subfloor	12 months
Check exterior walls	12 months
Clean chimney	12 months
Check function of battery smoke detectors	6 months
Check emergency first aid/food kit/water	12 months
Check photovoltaic panels (cleanliness)	6 months
Check solar hot water system (panels, glass, pipe insulation, temperature probes)	6 months
Check heat pump system (pipes, pipe insulation)	6 months
Check rainwater collection system	6 months

5.2 RESOURCE USE BY OCCUPANTS

5.2.1 Designers and builders should advise occupants that the way they run the house can make a significant contribution to its environmental impact. This is especially significant for larger energy users such as space heaters.

5.2.2 Homeowners with solid fuel burners should be encouraged to use only well seasoned firewood with less than 25% moisture and make sure it is stored in a dry space. They should not use driftwood or treated or painted timber as they emit toxic fumes when burnt and can damage the flue. Lastly, they should avoid using the damper mechanism as this greatly increases emission levels. All new burners should be low-emission models – the Ministry for the Environment lists those that are compliant.

5.2.3 For users of heat pumps, the filter will need replacing or cleaning periodically. The heat pump instruction manual will have details.

5.2.4 The 'measure to better manage' principle applies to houses. To determine how resource-hungry a working household is and what utility it provides, a check on only a few indicators is encouraged. Total energy use, water and indoor temperatures are the most useful indicators. By periodically reading the energy/water meters and investing in a wireless weather station with a recording capability, sufficient information will be provided.

5.2.5 Table 3 sets out some upper maximum resource use limits corresponding to healthy indoor environment targets. These figures should be easily achievable anywhere in New Zealand, given a well designed house and sensible user behaviour.

5.2.6 Effectively managing daily wastes is important. For kitchen wastes, there should be space to separate into three bins: general recyclables, decomposables/organics and one for landfill. Hazardous wastes should only be stored in a secure (lockable) outside space, such as a garden shed or garage. Ideally, most household rubbish is organic and comes mainly from the kitchen and can be composted.

6.0 DECONSTRUCTION/SALVAGE

6.0.1 There are often very good opportunities to salvage construction material and household items for reuse in new houses from other houses that have reached the end of their lives.

6.0.2 To maximise recovered items that can be diverted from the landfill/cleanfill, a plan should be implemented. A good plan will:

- detail an inventory of building material and household items that have the potential to be sourced from demolition/deconstruction sites
- ensure that a realistic time is scheduled for collection
- ensure items are either delivered just in time or suitable storage is available
- brief all associated services to ensure that they are aware of any changes from standard practice.

6.0.3 Types of building materials than can often be recovered/recycled for use in new homes include tongue and groove flooring, timber doors, larger cleanspan timber framing materials for structural work (provided they have been verified by engineers) and steel framing (in some cases).

6.0.4 Types of building items than can often be recovered/recycled include ceramic whiteware (baths and basins) and joinery in good condition that can be easily removed whole and on-sold.

6.0.5 Talk to your local recycling agents, but also consult the yellow pages, REBRI recycling directory, www.wikiwastenz.com, BRANZ Level series and BRANZ *Building Basics: Minimising Waste*.

7.0 KEY RESOURCES

Eco Design Advisors
Eco Design Advisors can be consulted in council areas where they are available. These are independent experts who provide up to 2 hours of tailored, free advice for a particular project. Contact your local council for booking details or www.ecodesignadvisor.org.nz.

TABLE 3: INDICATIVE RESOURCE USE AND CONDITIONS PROVIDED

Resource use		**Condition provided**
Maximum energy use (kWh/yr)	Maximum water use (litres per person/day)	Key indoor climate indicators
Climate zone 1: Auckland/Northland New homes: 5,800 kWh/yr	125 litres	Average temperature: Living rooms 5–11pm in winter >18°C Bedrooms 11pm–7am in winter >16°C Average relative humidity: Living rooms 5–11pm in winter 40–70% Bedrooms 11pm–7am in winter 40–70%
Climate zone 2: All remaining regions not in zones 1 and 3 New homes: 6,300 kWh/yr		
Climate zone 3: All of the South Island and the Volcanic Plateau New homes: 7,300 kWh/yr		

Source: www.beaconpathway.co.nz/being-homesmart

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- www.level.org.nz
- www.rebri.org.nz
- *Building Basics: Minimising Waste*
- Bulletin 478 *Rainwater collection for domestic use*.

OTHER

- Homestar™ Home User Guide www.homestar.org.nz
- Smarter Homes www.smarterhomes.org.nz
- Energy Efficiency and Conservation Authority www.eeca.govt.nz
- NIWA's online SolarView tool http://solarview.niwa.co.nz
- Walkscore www.walkscore.com
- *Drinking-water Standards for New Zealand 2005 (revised 2008)* www.health.govt.nz/publication/drinking-water-standards-new-zealand-2005-revised-2008-0
- SNZ HB 44:2001 *Subdivision for People and the Environment* – free download from www.standards.co.nz

Cover photo: Beacon Pathway's Waitakere NOW Home®.
Photo: Craig Robertson Photography

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