GREEN ROOFS WORTH THEIR WEIGHT IN GOLD

Green roofs are slowly breaking into the New Zealand market. Some of the issues and cost benefits are discussed here.

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A 'green' roof is basically a roof planted with vegetation. There are two main types: low-profile (extensive) or high-profile (intensive). Low-profile roofs include a thin layer (50–150 mm) of planting media to support low-ground plant cover, such as herbs, grasses and mosses. Recent advances in green roof design have resulted in ultra-lightweight low-profile roofs (only 20–40 mm thick), that support shallow-growing plants such as sedums. High-profile roofs have much more soil (150 mm plus) and can support taller plants, shrubs and even small trees. All types rest on a waterproof membrane on top of the roof structure.

Figure 1 shows the basic components that make up a green roof:

- a waterproof membrane/root barrier
- an insulation layer (optional)
- a drainage layer
- soil growth medium
- plants
- a biodegradable wind blanket, such as jute, to cover new plants while their roots stabilise (optional).

Green roofs on increase

Green roofs can be used on a variety of roof types and on any property size. They are widespread in Germany and Norway, but in New Zealand their use is currently low. Few companies in New Zealand specialise in green roof design and construction, but momentum is growing for their installation, especially as energy conservation and stormwater control issues increase in importance.

Design details to consider

A green roof is an engineered structure which must address a number of critical design aspects. The following design details have been adapted from the Auckland Regional Council's 2003 Technical Publication 10 (see www.arc.govt.nz/library/l45931_2.pdf). →

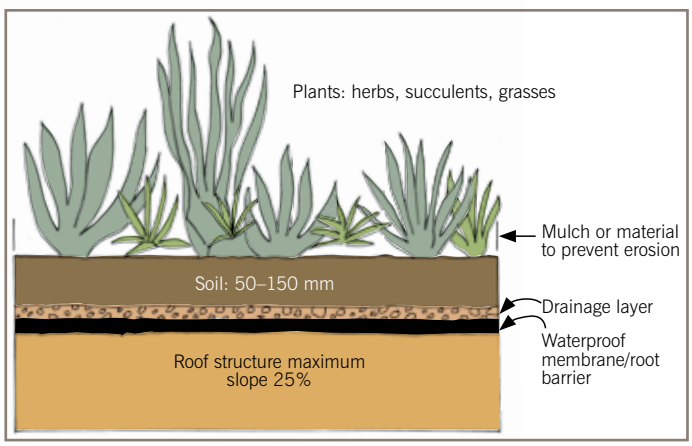

Figure 1: Diagram of a basic low-profile green roof. (From Waitakere City Council.)

Established green roof on a house in Kapiti during summer. The plants are mostly New Zealand iceplant. (Photo by John Le Harivel, Architect.)

Load bearing capacity

The load bearing capacity of the roof structure is based on the roof's saturated state. Using the German National Standard DIN 1055, the approximate saturated weight of a low-profile green roof is 60–150 kg/m^2.

Internationally, ultra-lightweight systems (35–60 kg/m^2) have been safely used on most flat roof decks designed to take bituminous or single-ply waterproofing. For high-profile roofs with saturated weights greater than 150 kg/m^2, modification of the roof system will be required to support the increased load. Consultation with a structural engineer is highly recommended.

Roof slope

Light soils and specialised water-retaining substrates make it possible to have green roofs on slopes up to 30° (some German systems even allow roof pitches of 60°). However, roofs with a slope of 20° or more do require extra measures to prevent soil slippage and erosion.

Waterproofing membrane

The waterproofing membrane must be resistant to moisture and root penetration. This layer may consist of a liquid-applied membrane or a specially designed sheet membrane system. Root resistance is achieved with a laminated upper layer or chemical deterrents in the coating. It is highly recommended that a thorough water-flood test is conducted before the other green roof layers are applied.

Drainage

Green roofs must have a drainage layer to carry excess water away and be able to store water without drying out too quickly. There are a number of ways of dealing with excess water – simple methods include a drainage layer of gravel, mineral wool or plastic applied over the entire roof area. A simple drip irrigation system, which introduces water directly to the root zone, is recommended for stopping the green roof from drying out (although most low-profile systems only need watering while the plants are being established).

Filter fabric membranes and/or wind shields can be laid or installed to hold the soil and plants in place.

Plant and substrate choice

Choose plants that have shallow root systems, good regenerative properties, are resistant to direct radiation, drought, frost and wind, and are specific to New Zealand conditions, e.g. the sand dune convolvulus *(Calystegia soldanella)* or New Zealand iceplant *(Disphyma australe)*.

Detail of the gravel gutter which has a perforated land drain laid to fall to outlets. (Photo by John Le Harivel, Architect.)

Substrate choice is important as this has a significant impact on the overall weight of the green roof. Ideally they should be lightweight with high moisture retention, e.g. a mix of expanded clay, pumice and regular garden mix. Internationally, substrate mixes may include recycled materials, such as polystyrene or recycled aggregates.

Conserves energy and controls stormwater

Green roofs offer many benefits but the two key ones are energy conservation and stormwater control.

Green roof systems provide buildings with greater thermal performance and roof insulation. This can vary seasonally and with the amount of water held within the system. Water retention can increase the amount of heat lost through the system. Therefore any efficiency gains are dependent on daily conditions.

In winter, green roofs can help reduce heat loss from buildings by providing an insulation layer. In summer, poorly protected and insulated roofs can lead to substantial overheating of spaces beneath them and the need for increased air-conditioning. A green roof not only acts as an insulation barrier, but the combination of plant processes (photosynthesis and evapotranspiration) and soil processes (evapotransmission) reduces the amount of solar energy absorbed by the roof membrane, thus leading to cooler temperatures beneath the surface.

Green roofs store rainwater in the plants and growing medium and evaporate water into the atmosphere. In summer, green roofs can retain 70–80% of rainfall and in winter they retain between 25–40%. Green roofs also reduce and delay run-off during times of heavy and prolonged rainfall, thus reducing the impact of run-off on the stormwater drainage system and the likelihood of flooding.

Installation cost estimates

The installation costs of green roofs vary depending on the roof size, type of green roof specified, plants chosen and considerations such as whether additional structural loading is required. Generally, green roof costs increase

with slope and structural loading (high-profile roofs are generally more expensive than low-profile roofs). To date, an in-depth cost-benefit analysis has not been undertaken for green roofs in New Zealand. However, the following estimation has been provided by BRANZ economist, Ian Page.

The cladding weight limit for roofs in light timber-framed houses (from NZS 3604) is 60 kg/m^2. A roof consisting of plywood substrate plus butyl sheet membrane is typically 16 kg/m^2. So using normal truss sizes in residential construction there is some 'spare' capacity to support a low-profile green roof. However, the margin of 44 kg/m^2 represents about 40 mm of soil/lightweight aggregate, which only includes ultra-lightweight models.

Specifically designed roof trusses would be required to support green roof loads above 60 kg/m^2. If flat, proprietary, parallel-chord roof trusses (supporting a plywood substrate and suitable membrane) are used, the number of trusses will need to be tripled (from 18 trusses at 1.2 m centres to 54 trusses for a 200 m^2 house). At an average cost of $300 each (10 m span, mid-support) this is an extra cost of $10,800.

For a 200 m^2 house, the lightweight growing medium required is about 30 m^3 in volume. This costs about $7,500 at approximately $250 m^3 including a drainage fabric.

The total of trusses and soil is $18,300. This excludes plants and represents about 7% of the upfront house cost. These costs may be offset by energy savings and the extended roof life, plus reductions in stormwater control and associated infrastructure costs.

Waitakere's Civic Centre

In a first for New Zealand, Waitakere City Council has installed a commercial-scale green roof on its newly constructed Civic Centre. Working with Landcare Research soil scientists and ecologists, the council designed and installed a 500 m^2 low-profile green roof specific to New Zealand conditions. Fifteen native herb, shrub and grass species were planted on a 150-mm-deep green roof in November 2005. By mid-January 2006 these had been successfully established and irrigation was stopped. The planting was completed in July 2006. The council plans to quantify the roof's performance, particularly its impact on stormwater run-off. →

Construction of the green roof at the Waitakere City Council Civic Centre.
1. The drainage cell layer is placed on the roof area.

2. The geotextile fabric is ready for the growing medium.

3. The completed roof with native plants in expanded clay planting medium. (Photos from Waitakere City Council.)

Kapiti Coast house

The Kapiti Coast house shown on the cover of this *BUILD* has a well-established green roof despite being in a very high wind zone. The roof is about 200 m^2 in total (150 m^2 of planting) with about 75 mm of organic compost originally supporting 4–5,000 plant cuttings (mostly succulents), combined with strips of turfs cut from the neighbouring paddock.

The roof construction included a primed ply substrate on rafters and purlins, waterproof membrane, polystyrene insulation spot-glued to membrane, root barrier, geo-textile filter fabric to contain 'soils', the 75 mm of organic compost, turf verges and access 'paths'. The roof slope is generally 15° with some areas up to 25°. It has a gravel gutter containing a land drain with continuous fall to water storage tanks. The overall weight is slightly higher than a concrete tile roof.

The construction provides good sound reduction, slows run-off, has different seasonal colour phases and merges with the landscape. The roof needs no maintainance, apart from occasional removal of weeds and a trim, and no watering, so looks after itself.

The owner of this house offers the following tips for others interested in a green roof:

1. Shallow roof slopes require drainage layers; steep slopes require means to contain the soil.
2. Shallow soils permit only succulent type plants; deep soils have weight issues and greatly increased structural requirements.
3. Grassed and deep-soil roofs require regular watering. Do not use grass as the main cover as it burns off in summer.
4. Use gardening rules and think about orientation-appropriate plants for each situation.
5. Access for maintenance and gutter detailing is important.

More about green roofs can be found on the websites www.livingroofs.org or www.bauder.co.uk (see 'green roofs' section). Also see www.facilitymanagement.com/articles/roofingindex.html for a comprehensive overview for building owners considering a first-time green roof installation.

COST-BENEFITS OF GREEN ROOFS

A UK cost-benefit study of three different roof systems (conventional, sedum mat and bio-diverse) provides some answers on the relative benefits of each.

A sedum mat has a base layer of polyester, hessian or porous polythene on which a 2 cm thick growing-medium layer is laid and sedum cuttings sprinkled to grow into the substrate. On maturity the sedum blanket, including the 2 cm growing medium, is harvested by rolling it up, and delivered to the site. To install as a roof the sedum blanket is rolled out onto either 5–7 cm of growing medium (standard method) or direct onto a moisture-retention blanket (ultra-lightweight method).

Bio-diverse roofs often use construction demolition material or site-recovered material on the roof. This is left to seed naturally so it can take a number of years before the brown roof becomes 'green'.

Bio-diverse shines

The study found the bio-diverse roof is the best choice as a long-term financial investment (see the table below) because it has the lowest lifetime cost (initial, maintenance and energy costs). The energy savings more than compensate for the extra costs of construction and maintenance during its lifetime. The next best roofing material is sedum mat. This takes into account a defined interest rate (also called a discount rate), which adjusts future money flows to their present value.

More information is available in 'Whole life costs & living roofs: The Springboard Centre, Bridgewater', 2005, by The Solution Organisation for Sarnafil, see www.livingroofs.org/livingpages/wholelifecosts.html.

Results from the UK cost-benefit study of roof systems.

	Conventional roof	Sedum mat	Bio-diverse
Capital cost based on 1,000 m^2	47 £/m^2	93 £/m^2	79 £/m^2
Annual maintenance costs	150 £/p.a.	600 £/p.a.	150 £/p.a.
Repair costs per annum for years 1 & 2 only	–	£2,500	£1,250
Energy savings	–	5.2 £/m^2/p.a.	5.2 £/m^2/p.a.
Net present value (net lifetime cost)	49,160	34,540	11,703