SUST.
THE LIGHTHOUSE ON SUSTAINABILITY

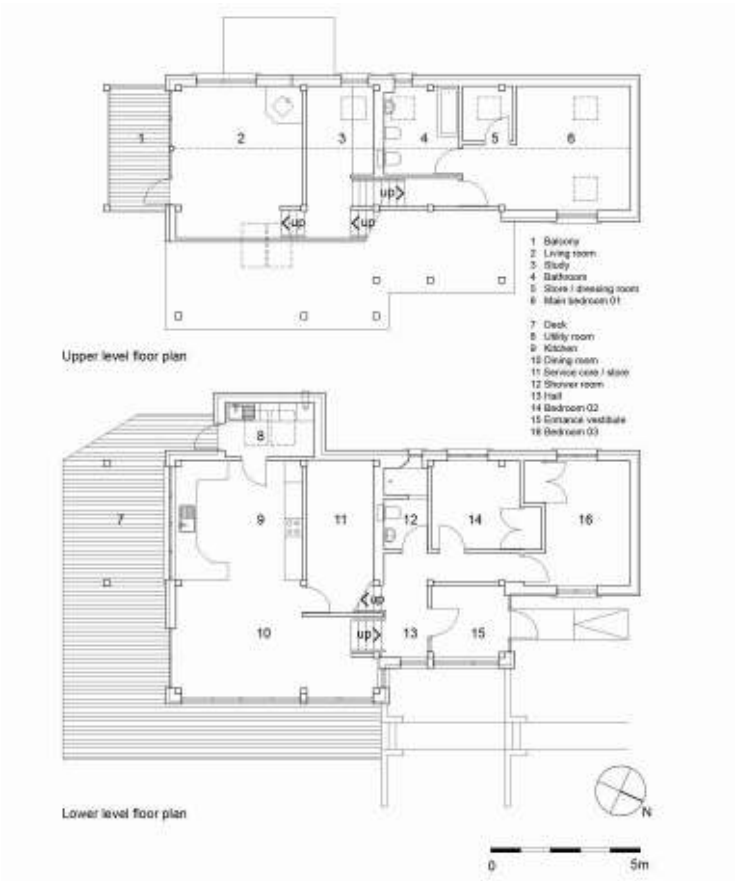
Case Study

General Details

Name of Project	Paton House + Garage  Exterior and interior of Paton House, by Neil Sutherland Architects
Location	Near Montrose, Angus
Choice of Site (Greenfield/ Brownfield etc)	Greenfield site, sold off as a serviced plot by a developer, in grounds of former house.
Client	Private
Design Team	Neil Sutherland, Architect; Colin Henderson, Architect; Scott Reid, Architectural Assistant. All of **Neil Sutherland Architects** Clachandreggy, Torbreck, Inverness, IV2 6DJ | T: 01463 709993 | F: 01463 709515 | W: http://www.organicbuildings.com Award* The project has recently been awarded the Montrose Society Civic Award 2006.
Consultants	Structural engineers **A F Cruden Associates** 24 Bank Street, Inverness | T: 01463 719200
Contractors	For manufacture, supply and construction of timber post and beam frame: **Sutherland Architecture Ltd** Clachandreggy, Torbreck, Inverness, IV2 6DJ | T: 01463 709993 For general construction works: **Steve Warren Joiner | Builder | Maintenance Contractor** 69 Ferry Street, Montrose, DD10 8BZ | T: 01674 677185
Project Value	£249,000 for the house, complete, including fittings and finishes. £16,000 for the garage. These costs exclude the land purchase, professional fees and any VAT applied.

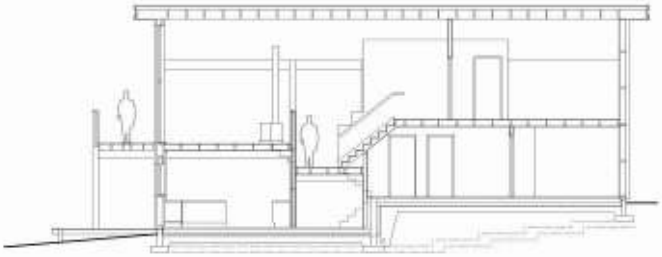
Floor Area	170m^2 for the house (£237,000), with 60m^2 of external works, structures and decking (not including garage) (£12,000).
Cost per sq m	£1,400 per sq m on house construction
Grant Funding/ Support (specialist input/ non-standard design features)	Early in the project, the practice along with the client investigated making an application to the Scottish Community and Householder Renewables Initiative (SCHRI). However to comply with the conditions of the grant, all the components had to come from a particular source, with an approved contractor to install them. In investigating the alternatives, surprisingly it worked out better to go independently, and cost less to install the panels without grant assistance. No application was therefore made.
Procurement Route	Neil Sutherland Architects (NSA) provided traditional architectural services, for the full project. However the practice was also associated with a design and build element; specifically for the design, manufacture, supply and erection of the load bearing Douglas Fir post and beam frame. This was carried out through Sutherland Architecture Ltd, NSA's related construction company. For all other general construction works (from foundations to completion), Steve Warren operated as the main contractor, with appointed subcontractors. This was a negotiated agreement with the client, with remuneration phased in tandem with completion of agreed stages of work. One other thing of note is that in this project, and common to most of NSA's projects, the practice were commissioned to source and supply to site the majority of the materials, (specifically the timber, all timber products, all technological components, insulation, etc) thus guaranteeing that the ecological specification proposed could be delivered.
Start Date	March 2004
Completion Date	November 2005

Project Details

General Introduction to Project	A new family house (plus garage cum workshop) for a husband and wife, who are jointly involved in the running of a specialist manufacturing business. With their personal and working lives so closely intertwined, the building had to respond to their need for a degree of 'home working' (a trait of 21st Century living) whilst giving them an inherent flexibility on the domestic side to live in the house for an intended 'lifetime'.  The building occupies a sloping site, within the grounds of a former country house; immediately overlooking Montrose, with the coast a mere three to four miles beyond. To the East, big skies, associated with the comparatively flat and open (North) East coast of Scotland are captured in the house, in addition to a welcome Southerly aspect (aiding passive and active solar collection). The views to the West and North are more restricted owing to the close proximity of the existing and established shelter belt of trees in the former grounds of the 'big house', plus the built up neighbouring community and it's school beyond. This is particularly reflected in the South West elevation of the house, whereby comparatively smaller apertures have been incorporated.

South West Elevation

North East Elevation

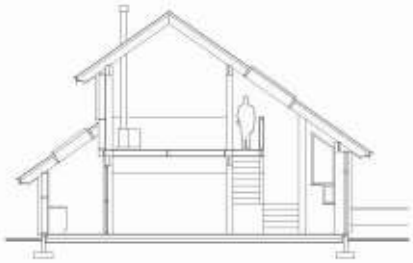


Long Section through house (South East to North West)

0 5m

North West Elevation

South East Elevation



Cross Section (South West to North East) through principal living spaces

0 5m

New house under construction in grounds of former country house. Design accommodates and retains mature trees and landscape.

Architecturally, the house incorporates one level change on the ground floor, which directly responds to the context of the sloping site. In use, one drops down through the house from the entrance and cellular rooms to experience a predominantly East and South facing open plan kitchen and dining area at a slightly lower level. This level change brings additional volume, in part to the ground floor (specifically the dining area), but more so to the living spaces above plus the areas (the study, galleries and staircases) which link the lower and upper floors. These strategic moves in design terms, have generated a greater sense of space in the principal and public 'rooms' or areas, bringing contrast with the cellular rooms (bedrooms and bathrooms) to the North and West of the house. Externally a series of decks and balconies from these principal living spaces (some of which benefit from the cover of the large overhanging roof), further extend these internal rooms, and diminish the boundaries between the inside and outside of the house.

	In construction, the house celebrates the use of timber throughout. The structure of the house is primarily an indigenous and untreated Douglas Fir post and beam load bearing frame, with external softwood wall panels. The house is well insulated, beneath the floor slab, and in the walls and roof. Externally the house is clad in Larch, and finished with a slate roof. Solar energy contributes to the heating of the house in two ways; passively through the extensive glazing to the East, South (and West), and stored in the high thermal mass of the concrete floor slab; and actively in the solar panels to the roof, which connect to the domestic hot water tank.
Sustainable Design Features (see note 1)	**Decreasing the amount of operational Carbon Dioxide produced by the building** Neil Sutherland Architects (NSA) employed a number of passive and active energy saving measures in the design of the Paton House, aimed at reducing the amount of operational CO_2 in the building, and in line with their general practice. PASSIVE SOLAR GAIN + MAXIMISING NATURAL DAYLIGHTING At a very basic level, considering and maximising opportunities offered by the site and orientation was key to contributing to an energy efficient design (amongst other measures). Here the house straddles a gentle South East facing slope, and is designed to be long in both plan and elevation to the East and West, and in contrast, slender in plan to the North and South elevations, but with the section increasing in height to the South East through utilising and maximising the slope. The resultant restricted (or contained) North facing elevation has very few openings, enabling a higher level of insulation to be achieved, where it is most needed. In contrast the East and South (plus West) elevations are extensively glazed to maximise passive solar gain. This area of glazing coupled with the relative slenderness of the plan, generally 7.4m and reducing to 4m across the width of the building, allows penetration of natural daylight to the core. However any potential overheating of the building, owing to this extensive area of glazing, is combated by the large overhanging roofs. This allows winter sun deep into the building, where it is welcomed, but restricts the summer rays from fully entering and overheating the building. However, the overhanging roof was also designed with other objectives in mind; it is mainly in place to provide protection to the external timber cladding, and to give overhead shelter to the occupants who now use the spaces (decks and balconies) beneath it.  The interior of the house benefits greatly from passive solar gain and natural daylight.

PASSIVE VENTILATION

Every habitable room within the dwelling benefits not only from natural daylight but also (again through the extensive glazing) from passive and cross ventilation; achieved through simply opening windows. Again the long slender plan, gives rise to this, in that all rooms connect directly to the outside and can be naturally ventilated.

ACTIVE SOLAR + HEATING

Common with all of NSA projects, large or small, a dedicated service core (either an area or a room) is found within the heart of the building. Located here are the 'organs' of the building (hot water tanks, controls, etc) from which services can be run or components connected in, both vertically or horizontally, with relative ease, and from which the whole property can be controlled. In the Paton House this zone occupies a generous floor area of $12m^2$, with a reduced but acceptable ceiling height of just short of 2m, carved out of the site section on the lowest level of the house (and adjacent to the kitchen).

The South West elevation accommodates the solar panels and flue for stove; both are located vertically above the service core, which is housed on the lowest floor level.

Whilst the Paton House is connected to mains delivered services for power, both in terms of electricity and gas, NSA persuaded the client on the value of an active solar system, which contributes to the heating of domestic hot water, and reduces dependency on these utilities. This is now in place and operational.

Given the reduced height in the service zone, a large but low tank to store domestic hot water was prefabricated and installed on site. NSA treated the hot water tank as a 'large battery' or thermal store to the house 'dumping' hot water collected from the active solar system into it, and releasing this again when needed to provide (domestic) hot water.

With regard to the more general heating of the house (beyond the passive solar system, or the gas fired boiler which can feed the same) a wood fuel stove is located at the heart of the living space to provide or top up background heat. In certain projects, NSA have increased the capacity or number of stove(s) to heat the hot water and provide a higher level of background heat, in place of a conventional boiler. However, in this particular project owing to the clients' preference (given the availability of mains delivered services and without a ready supply of wood fuel on site,) NSA has not.

IMPROVING INSULATION + AIR TIGHTNESS

NSA are concerned with improving insulation levels within buildings, and in the Paton House as with other projects, are delivering a specification which meets and (slightly) improves on current building regulations (in terms of thermal performance). The house has 200mm of insulation in the walls, 220mm of insulation in the roof, both of which are hemp

quilt, plus 100mm of rigid polystyrene insulation under the floor slab. In specifying insulation, the practice has elected to move away from the more hazardous or highly manufactured insulations, favouring less toxic and breathable alternatives (using Warmcel and now hemp in recent projects including the Paton House, for the walls and roof). However, in using these more natural insulation materials in preference to products like mineral wool, to simply achieve the current performance requirements of the building regulations, significantly higher budgets need to be allocated to this part of the construction. Therefore, the higher cost now anticipated if specifying these natural insulation products (for a number of well documented reasons and outwith the practice's control), has to be balanced out by the quantity of the material specified. Clearly for NSA the wish to use these alternative insulations (on health grounds) has been at the expense of further improving on the thermal performance of the building, where a greater level of insulation may also be desirable. There is clearly a fine balance to be struck, and an area where important environmental decisions (producing a healthy building or increasing the thermal performance), are being weighed up against each other, owing to cost, when clearly in an ideal world neither would be compromised.

Timber structure prior to installation of insulation | Hemp insulation in place within the roof.

The air tightness of the building is an area of construction which NSA will devote some resources to over the forthcoming projects, to further improve the performance of their buildings. This will be done primarily through revisiting and rethinking some of the technical detailing, in tandem with running more checks on the contractor's actions on site, particularly with regard to sealing up the building at critical junctions, etc. SEDA has recently issued guidelines to promote improvements in this area of construction, and these are worth consultation.

Reducing embodied Carbon Dioxide
The Paton House, exemplifies a building which promotes the reduction of embodied energy through three main areas.

USE OF NATURAL + RENEWABLE RESOURCES
Natural materials are predominant throughout the specification of the house. Timber accounts for the material which is most extensively used, along with other materials like hemp for insulation, slates for the roof, etc. Given the quantity of the timber (from structural timbers through to skirting boards), alongside other products like the hemp, a significant quantity of the building's materials are from renewable resources, and used in a less processed or manufactured state. (See section on *Choice of Materials* for full analysis of the timber used in the house design).

LOCALLY SOURCED MATERIALS + REDUCING TRANSPORTATION TO SITE

NSA take responsibility for the supply of many materials to site, focusing heavily on the sourcing of timber, which is predominant in the practice's architecture. As such the practice can ensure that a high proportion of these materials are locally sourced and principally from the Highlands. This accounts for all of the timber used in the construction of the house with the exception of the window frames, plus some of the timber by-products, such as Oriented Strand Board for sheathing, etc. Beyond this other materials and components are specified from manufacturers in the UK, and only a few are brought in from manufacturers in Northern or Central Europe (such as the Hunton Board, used in the external wall construction which comes in from Norway).

ELEMENTS OF PREFABRICATION + REDUCTION OF WASTE IN DESIGN AND MANUFACTURE

In the work of NSA the design and construction processes are closely linked, given the practice's design and construction capabilities, working in partnership with the related construction organisation. This has enabled elements of prefabrication to take place in their projects in general, and accounts for a reduction of processing and waste in the construction of the house. This is best exemplified in the supply and erection of the post and beam frame, whereby the timber (in this case Douglas Fir) was sourced from a Highland sawmill (with a specific quantity selected after the production of detailed construction drawings thus reducing waste at source). This raw material was then handled by the construction company (Sutherland Architecture Ltd) in consultation with the architectural practice, to produce the structural members (posts and beams) and their connections. On completion the frame was partially assembled in the yard, to ensure accuracy and ease of fit, disassembled and taken directly to the site. This aids a 'right first time approach', reduces time spent on site, and avoids additional work being necessitated through errors being made.

Primary structure with post and beam frame.

Choice of Materials (see note 2)	As an architectural practice, and given that NSA are also involved first hand in construction, a strong policy has been developed for material selection, specification, detailing and construction. NSA try, wherever possible, to use local, healthy (benign), natural, renewable and durable materials, with low embodied energy (in extraction, manufacture and transportation), and aim to make the construction breathable, where possible. TIMBER For environmental reasons, and also because of NSA's wider architectural interests, the practice extensively favours and uses untreated Scottish timbers in all projects; and this is clearly demonstrated in the Paton House. For this project the use of timber is found in six main areas of the house construction as follows: 1. In the primary structural frame and panels; using Scottish Douglas Fir (untreated) for the post and beam frame, Scottish Larch (untreated) for the sole plate, Scottish Spruce (untreated) for external wall framing, etc. 2. In the internal wall framing; using Scottish Spruce (untreated) for the framing, plus wood panel products, etc. 3. For external cladding; using Scottish Larch (untreated) for boards and battens, etc. 4. For balconies and decking; using Scottish Douglas Fir (untreated) for the post and beam frame, Scottish Larch (untreated) for the boards, etc. 5. For manufactured joinery components; specifically Nordan timber windows, and more locally manufactured internal doors (Norbuild, Forres). 6. For internal finishes and fit-out; using Scottish Larch (untreated) floorboards throughout much of the house (Cromartie Sawmill, Strathpeffer), etc.

A universal use of timber from start to finish in the house.

NSA have eliminated the need for heavy chemical timber treatments from the practice's specification and construction, through educating themselves, and also contractors on each and every job, plus supplying the timber directly where possible. NSA are rigorous with timber selection, mainly choosing timbers which have an inherent durability appropriate to the application in which they will be used. This is coupled with careful design and detailing, generally aiming to keep the timber as dry as possible, and where needed allowing replacement over the building's lifetime to be made. That said NSA have applied some (non chemical) treatments, to certain timbers in the house, in the form of oils and waxes etc, simply to finish or further protect them.

Untreated external cladding; out of contact with the ground and protected overhead by roof.

	OTHER MATERIALS Of the main and remaining materials used in the construction of the house, NSA specified a number of other 'natural' products from plant and mineral sources. These are in the form of hemp insulation (imported from Germany) for the walls and roof, slates (imported from Spain) for the roof finish plus areas of floor finish, and travertine (imported from Turkey) for the floor finish in the wet areas of the house. With the hemp, for example, aside from the comparable levels (relative to other insulations) achieved by using this product, it was also exceedingly safe and easily handled by the contractor; eradicating the need for protective clothing, masks, etc. We also believe it will prove to be less 'dusty' for the inhabitants (now that the house is in use) than other 'natural' insulations we have trialed in the past (e.g. warmcel), given that it takes the form of a bound or quilted product. TECHNOLOGY + COMPONENTS Contrasting to NSA's 'low technology' approach to timber specification and other natural materials within the house, the practice also embrace the use of a small selection of engineered or manufactured components which enhance the overall performance of the building. These are sourced as far afield as Central or Northern Europe, as have been the case in the Paton House. In the fenestration this takes the form of manufactured timber frame windows, fitted with 'low e' double glazed units; the glazing being in line with current building regulations. To provide domestic hot water, tap into a renewable resource, and reduce the clients' dependency on their mains fed gas supply, NSA have also installed solar panels connected to a large hot water cylinder.
Maintenance Issues (see note 3)	DOCUMENTATION On completion of the project, a full set of 'as built' drawings, were given over to the client; and this contains a detailed specification of the house. With larger or commercial jobs, which fall under the *CDM Regulations: Health and Safety*, NSA have been involved with the preparation of full manuals, but with the practice's domestic projects to date have not. If NSA become involved in speculative house design, which is highly likely in the near future, they will likely have to review this policy, as they would be distanced from the end user. However at present, as with the Paton House, the practice remains in close contact with the client who is also the occupant, and would seek to resolve or advise on any maintenance issues as they arise. The greatest problem that NSA confront in the production of a maintenance manual (and by no means exclusive to this project) is associated with specialist kit or components for installing or operating the heating systems and other 'smart' technology in the building. The individual components of these complex kits currently tend to be imported from manufacturers in Central Europe, even if the suppliers or companies who may put together a hybrid of these parts exist in Scotland or the UK. There are now a few trusted companies or suppliers of these kits, whom NSA have consulted over recent years, and whilst these companies can comprehensively guide the practice on installation or operation and field most queries that may arise from electrical or plumbing subcontractors during construction, on the occasions when the practice has requested the associated operational manuals some have been supplied in another

	language (German being common). When this occurs the practice have requested a translation from the source or have had to commission translations from others; but this can be both time consuming and costly, and sometimes without much success, or at least with a 'watering' down of the detailed content. TIMBER + MAINTENANCE NSA are constantly challenging the perception that timber in construction is a poor material choice, delivering a second rate building and leading to maintenance issues. The practice has a full working knowledge of timber and celebrates the language of the material in their buildings. The practice can confidently specify timber having considered, developed and refined construction details for the use of timber in architecture in parallel with understanding the properties and limitations (structure, durability, etc) of the species of timber proposed. To this end, when carefully selected, with a level of durability appropriate to the application, and detailed accordingly, timber in architecture should also last a lifetime.
Architect's Perspective (see note 4)	GREEN DESIGN APPROACH NSA are a small practice (five in total), led by three principals (all architects), who have come together having gained experience in architecture, ecology and environment, land use management, forestry and timber, technology and resources, innovative technical detailing and construction, and have all worked across business and academia; in all contributing to and undertaking education, practice and research. NSA continue to influence and be influenced by all three (practice, education and research). Over time in practice, NSA has narrowed down the field of work which the company undertakes, and has focused (almost) exclusively on the understanding of how to use timber in construction, to produce environmentally accountable, healthy and joyful buildings. The portfolio reflects this position. As such, although NSA do initiate a number of projects, the practice tends to have clients approach directly with a brief, a budget (but not always a site) and the knowledge of the company's ethos. This was the case with the Paton House; and with this particular project the client had acquired a site with outline planning permission beforehand.  Owing to NSA's stance and where the practice wish to focus efforts, they have also openly walked away from work, or redirected enquiries, if people have approached not knowing what they specialise in, and are clearly at odds with their

	interests or motivation. To operate in this way is not always easy (and has been financially testing, at times, with little security) but NSA have now reached a position where they have a steady stream of work for the present and an optimistic outlook for the future. Although NSA operate in a niche market position, what was perhaps seen as 'avant garde' fifteen years ago when the practice started, is now much more acceptable and mainstream, and is likely destined to become even more so given recent and extreme rises in energy costs / oil prices etc. The motivation for it all, is that at core NSA believe that they are producing good and interesting timber buildings, greatly enjoyed by their clients, constantly challenging but leaving the practice's collective 'environmental consciences' clear. Furthermore, because of their direct link to construction (through the sister company), they have a firm grasp of construction costs, and can deliver a building in full. This approach, with all aspects taken into consideration, means that NSA are not comprised environmentally. TOOLS, TECHNIQUES + GUIDANCE USED BY THE PRACTICE Of course it is one thing to believe that you are doing the right thing, and another to put it to the test. NSA do have a 'long lead' into a number of architectural projects; not specifically with one-off domestic projects, like the Paton House, but often on any project of greater size or value than this. Where possible, the practice will try to persuade a client to identify a small budget early on, to carry out some investigation prior to a commission in the form of initial exploratory, feasibility or research work. This usually delivers a better product in the long run, and pays for some thinking time and research at the outset; essential if you are working in this field. NSA also use this time to find any funding sources which the client may benefit from, for example grant assistance for energy saving measures. In terms of the production of both hard and soft data on the buildings, to date NSA have produced 'Environmental Design Statements' to accompany recent planning applications to the Highland Council (not yet compulsory, but likely to become so), run SAP rating tests on all the projects to satisfying Building Control, and had independent testing by BRE carried out on one of the projects. NSA also maintain an exceedingly up to date specialist library, relating to developments in timber, building and the environment, and through research and feasibility work this resource and knowledge within the practice is constantly refreshed. Neil Sutherland also acts in an advisory role to the Highland Forestry Forum and other bodies, on all matters related to timber and building. Through this work he frequently delivers seminars, contributes to and attends industry based events.
Any other relevant information	Early feedback from the client indicates that they have not drawn down on their gas supply, for heating (of the house or water) since mid to late Spring 2006; thermally the house appears to be performing well. They are also pleased to report that they had a 'comfortable' first Winter in the house; experiencing good levels of passive solar gain, and finding the house free from draughts, etc.

	With hindsight, the client wishes they had given consideration to higher capital investment in solar panels, etc, from the outset. This would have been with a view to becoming entirely unplugged from mains fed gas, for heating and hot water. They note that their own knowledge of renewables was limited, at the time; and as such so was their confidence in alternative energy systems. Now having experienced the benefits they bring first hand, they have indicated that they may review their current specification (particularly in terms of the number of solar panels) and increase the capacity in the future.
Conclusions + Lessons Learnt (see note 5)	Having now reflected on the project in full, NSA would look to concentrate their efforts in the following areas for forthcoming projects and works: INCREASED INSULATION Since completing this project, energy prices for mains delivered power (electrical and gas) took a sudden and rapid rise early in 2006 by 25%. As such it may become easier to persuade clients of the value of an increased capital investment associated with 'super-insulating' the building at the outset, with a view to dramatically reducing running costs thereafter, and positively contributing to a reduction in life-cycle costs overall. However if increased thicknesses of insulation are to be accommodated in the structure, then the practice need to rethink and revisit technical details, to accommodate the insulation efficiently to retain a degree of 'lightness' in construction and aesthetic terms. IMPROVING AIR TIGHTNESS As insulation increases, any ventilation losses have greater effect. Consequently NSA seek to further improve the air tightness of their buildings, and will investigate mechanical heat recovery systems. This may be more applicable to larger and more commercial jobs, and has to be balanced out with aiming to have the building work as passively as possible. INCORPORATING WATER SAVING DEVICES A number of past projects by NSA have incorporated a turf roof specification and rain water soaks away at source, effectively reducing the run off. However with the Paton House, or more urban projects, where a turf roof may not be desirable, and slates or profiled sheeting are favoured, rainwater collection or harvesting should likely be incorporated in the design. Internally in the specification, and particularly with domestic projects, the practice seeks to find the balance between enabling clients to make aesthetic choices over some of the sanitary fittings, and advising on the value of water saving devices, for example, reduced flow showerheads. RENEWABLES NSA is currently focusing heavily on renewables plus the implication of 'unplugging' buildings, with the practice undertaking research and feasibility studies in this area. The practice believes that this may be the key to unlock future developments and enable projects to proceed, without being at the expense of the environment. Author: Julie Macrae, Architect | Neil Sutherland Architects.