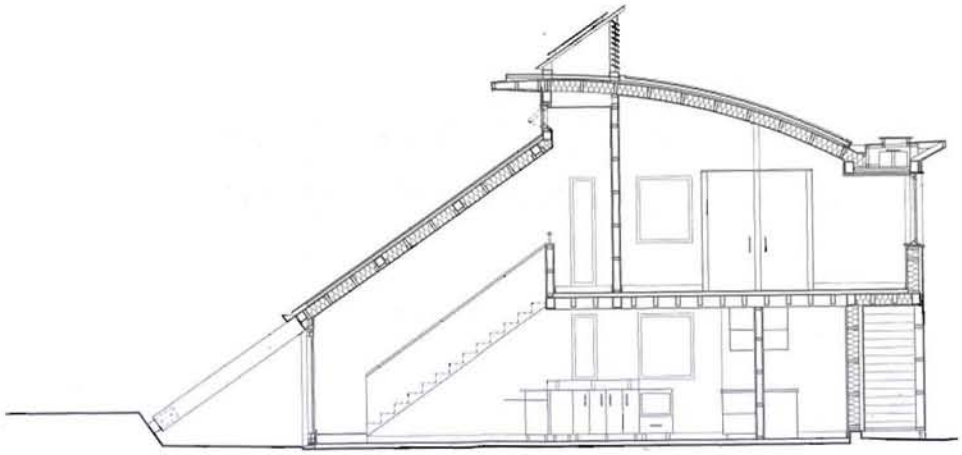
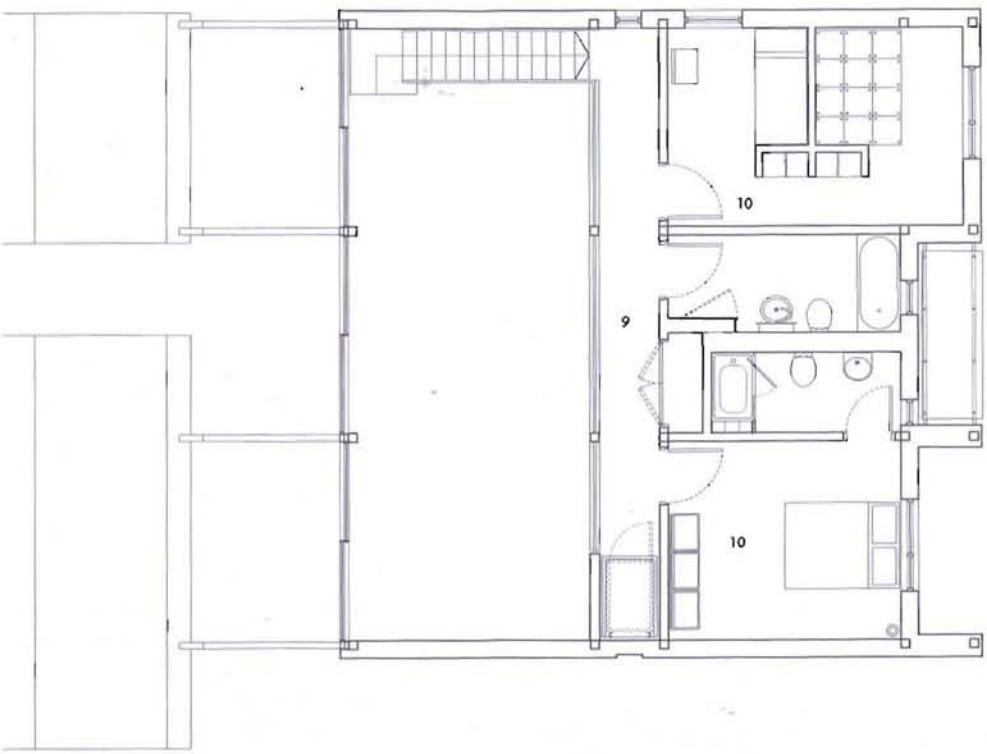
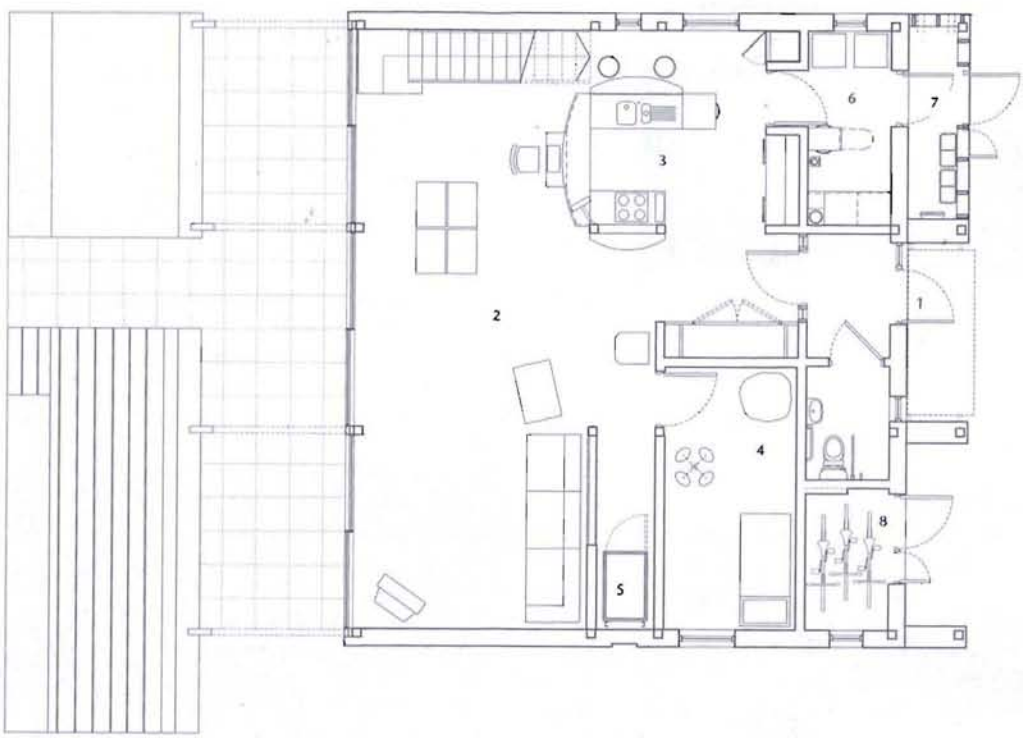




Plans *1 Entrance, 2 living/dining, 3 kitchen area, 4 study bedroom, 5 lift, 6 utility, 7 recycling, 8 store, 9 gallery, 10 bedrooms.*



House for the Future

Domestic architecture is characterised by the struggle between rooms and space. Rooms are necessary for specific functions whereas space is needed for social exchange. The history of the house has certain underlying symmetries; private and public functions are generally in balance and reflected by the structural and spatial order on the lower floor being replicated by the pattern above. In this sense the house is a mirror of the society it serves; walls not only contain functions, they serve to cement wider cultural or social values. Any 'house of the future' needs to question these assumptions.

Since the industrial revolution the house has become a largely standardised unit, repeated both horizontally and vertically. Countless builders and their architects gave physical form to a society where social and functional order was contained by loadbearing walls. Only rarely were houses an exercise in space as against rooms; where domestic volumes were as fluid as the family structures they housed. In this sense twentieth-century domestic architecture was fundamentally different from other building types where the frame was a dominant element.

The House for the Future designed by Jestico & Whiles at St Fagans near Cardiff explores the alternative tradition in domestic architecture of the framed house. There are of course many precedents for this but few which combine the flexibility of framing with the demands of sustainability.

The plan of the house appears conventional until compared with the section. The 100 square metre ground floor is twice the area of the upper floor and is distinctly open in character. There is the minimum of enclosing walls and, where the structural frame is necessary, it is pared down. This gives the lower floor a spacious character quite different to that above.

The section shows how the different areas are resolved: it is as if two separate houses had been pushed together. Each 'house' has its own roof shape, its own method of construction and its own architectural personality. Where the two join there is a service zone at right angles to the entrance axis which

Jestico & Whiles have built a house at the Museum of Welsh Life that provides a new benchmark for sustainable housing. Critique by Brian Edwards. Photos: Charlotte Wood.

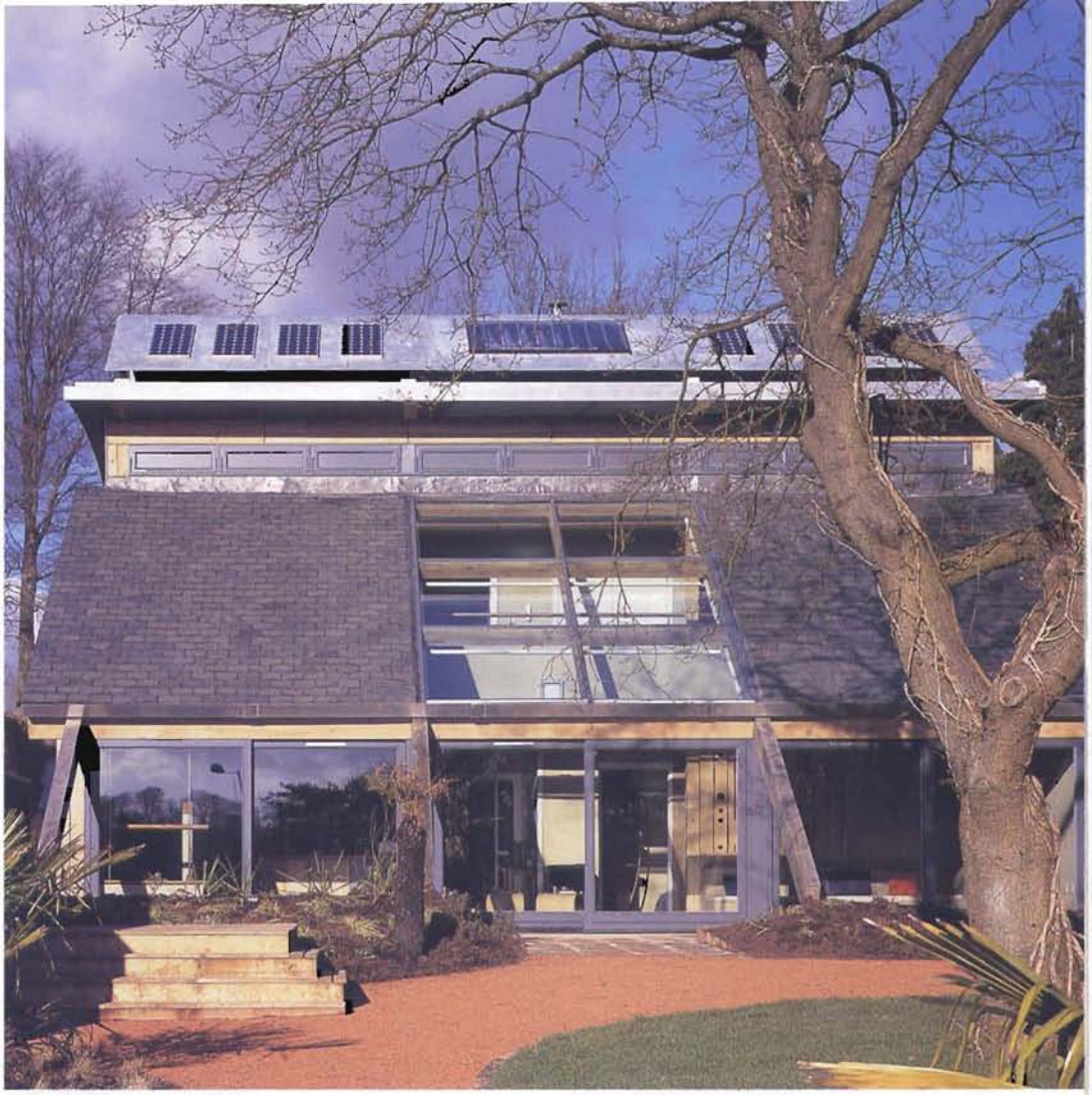
handles both physical movement and the alternative technologies of the house. Here are the solar panels, the stack-effect vents and the computer-operated clerestory windows, all positioned above a gallery which joins a disabled lift to the top of the stairs. Conceptually the two 'houses' do not join – they overlap by about a metre – and it is this zone which is the key to the design.

On one side, to the south, is a double-height living room while to the north are two storeys with bedrooms and bathrooms. The section in some respects recalls Cole Thompson's Integer house at Watford (AT96) but here the double-height space is integrated into the house as the living room, with roof glazing to the central bay only. What both houses display is a debt to the green office – open-plan solar heated spaces to one side of a central service area with bespoke accommodation on the other. This exploration of a non-domestic typology opens up many fertile avenues – not least the potential economy of frame construction, selective thermal capacity and differential orientation.

Three structural bays divide the house into tidy 3.6 metre wide dimensional units. These allow the house to be timber-framed, using not small-scaled softwood construction but heroic post-and-lintel construction in green oak. The effect is at times more medieval than futuristic, especially when seen in conjunction with the natural clay plastering. But when the oak framing is set against the large glazed aluminium panels of the giant rooflight which bisects the house, the effect is daringly contemporary. The glazing to the central bay creates a wide sunlit 'corridor' through the house at right angles to the service zone. The interior experience is given tension and drama by the drawing together of the sun angle with the east/west movement axis. The resulting ambiguity is welcome in a house otherwise notable for its rational order.

If the House for the Future appears to look back as much as it looks forward, this is partly the result of a brief which required a response to 'Welsh culture and climate'. While in no way nostalgic, the design does make more than a passing reference to the local vernacular. This is hardly surprising given the location at the Museum of Welsh Life and the requirement that sustainability should be broadly addressed. As a result the house taps into geothermal energy sources, uses rainwater, has a mini-garage for storing bicycles and recharging an electric car, employs healthy building technologies, exploits local sourcing of materials and uses recycled aggregates, sheep's wool insulation and sound insulation based upon reconstituted car tyres. Sadly much of this is invisible – a pity in a building that is also a museum exhibit.

As a prototype, the house offers a



Above *The south front is topped by solar water heating and photovoltaic panels.*

Below *The open-plan living/dining/cooking area with staircase to the upper gallery leading to the bedrooms.*

wide range of potential applications. The plan allows for linear applications and subdivision into single-bay or double-bay units. It can readily make an urban terrace, a suburban semi or a detached house. What it cannot adapt to is additional storeys – the section is too dependant upon the solar aperture to allow for multi-storey configurations.

The oak, slate and textured plaster are reminiscent of the arts and crafts movement. In this respect the house continues the rational tradition of Voysey, combining a love of natural texture and uncluttered space with new sustainable technologies. Built at a modest cost of £120,000 (about £800 per square metre) by volume housebuilder Redrow Homes there are ideas here we can afford. The question is not whether society would like to live like this, but whether the planet can survive without house-builders employing these ideas.

Left *Living and kitchen areas.*
Below *With its blind gable walls, the House for the Future concept is viable in terrace form.*
Opposite *Gallery, stair detail and bathroom.*

Heinz Richardson and Jude Harris of Jestico + Whiles Architects write:
The competition-winning design for a House for the Future, sponsored and built by Redrow Homes at the Museum of Welsh Life in south Wales, was officially opened on 1 March 2001 (St David's Day). The house forms part of the museum's collection of over 40 buildings brought from various parts of Wales and re-erected to form live outdoor exhibits. The design was subject to an international competition organised by the National Museums and Galleries of Wales in collaboration with BBC Wales, who filmed a family 'test driving' the house for a week in December 2000.

The design for the House for the Future embraces sustainability and flexibility as key determinants of form. The house provides a model for future housing, capable of reproduction and repetition in a multitude of configurations, in many different locations. It has been conceived both as offering a rural or suburban model on greenfield sites with detached units, or a higher density terrace, more appropriate to urban brownfield sites.

The modular layout provides a simple structure designed to enclose flexible space, which can be adapted over time to suit changing

lifestyle and circumstance. The house eschews high-energy technology and embraces appropriate sustainable technologies incorporated within a contemporary design.

The house has been designed to make no net contribution to carbon dioxide emissions. It is highly insulated, with heating supplied by a ground-source heat pump and a wood pellet heater as well as passive solar gain. An active solar (water heating) and photovoltaic unit mounted at ridge level contribute to the building's power and hot water demands.

All materials were selected with consideration for low embodied energy. Calculations by ECD Energy & Environment have shown an embodied energy 18 per cent lower than a typical house. It was a major aspiration for the project to ensure that all timber should be sourced from renewable sustainable sources of homegrown timber, preferably those within Wales and from companies that are committed to the objectives of sustainable forest management, ie FSC/WWF certified.

The structure of the house consists of a post-and-beam timber frame prefabricated with locally grown oak. This is one of the most sustainable materials available, releasing only 41kg/m³ of carbon dioxide into the atmosphere and serving as a long term carbon 'store' through the natural process of photosynthesis. The four timber frames were prefabricated off-site and craned into position to form the three structural bays, each 3600mm apart. The posts are 175mm x 150mm sections of solid green oak and the primary beams spanning north to south are 250mm deep. The 300mm deep-curved roof beams (on a 15m radius) were formed from naturally curving oak trees.

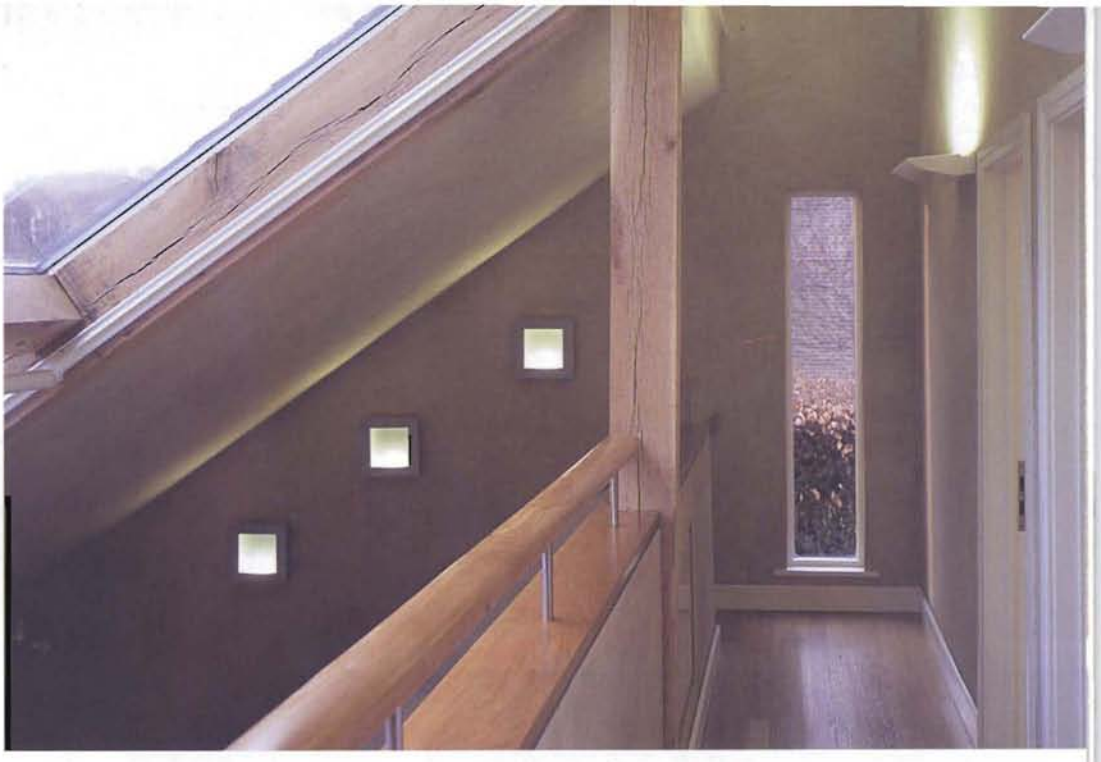
A super-insulated wall of timber studwork made from homegrown Douglas fir 'wraps' around three sides of the building, allowing maximum flexibility for window and door openings. This is faced externally with lime render and Welsh oak boarding. The void between the timbers is filled with 200mm of sheep's wool insulation, giving a U-value of 0.16W/m²K. There are no known or expected adverse health effects associated with wool insulation.

The external walls and roofs have all been designed using the principle of the 'breathing wall', a method which relies on selecting materials of different vapour resistivity, to control the passage of moisture through the wall, and so prevent condensation.

Secondary timber battens fixed to the outside sarking board provide a ventilated cavity and a base for the lime render covering and timber rainscreen cladding. The sarking board is manufactured using wood chips, selected wood waste and forest thinnings that would otherwise be burnt or wasted. It is more vapour permeable than most types of sheathing and sarking board, which reduces the risk of interstitial condensation and facilitates breathability.

The external wall is clad internally with clay board sheets which were used instead of gypsum based plasterboard. The clay board is a combination of clay, reed and hessian, and offers excellent thermal and vapour diffusion capacity. The board absorbs moisture and odours and acts as an effective sound insulator.

The Welsh oak cladding is left untreated, as are the exposed elements of the green oak structural frame. The softwood lining to the soffits has been treated and finished with a high-performance water-borne paint. The limewash used to finish the external render is a traditional paint made using high calcium (fat) lime. It sets when exposed to carbon dioxide in the air. It is naturally white and becomes more opaque as it dries.



The curved north roof contains 200mm of cellulose fibre insulation, blown between the deep timber rafters that span between the primary structural beams. This gives a construction U-value of 0.17W/m²K. Sheets of bitumen impregnated fibre board are nailed on top of the rafters to provide additional racking resistance to the structural frame. The standing seam roof made from recycled aluminium is fixed directly onto the sarking board and through into the timber rafters below. The aluminium pans of the roofing system have been overlaid with sedum plants to create a lightweight green roof. This approach to 'greening' the roof was chosen as a more cost-effective and environmentally responsible solution than turf roofs, which are often very heavy. The NatureRoof comprises a drainage board which sits directly onto the standing seam aluminium roof surface, allowing excess water to drain away whilst retaining sufficient water for plant growth, with a filter fleece to prevent silting-up of the drainage board.

The inclined south roof consists of 300mm deep oak beams which span all the way to the ground and create the three structural bays. Two of the roof bays are opaque, and have been finished with recycled natural slate. Again 200mm of cellulose fibre insulation has been inserted between the 200mm rafters. The remaining roof bay is fully glazed with fixed double glazed panels with a low-e coating that are set onto patent glazing sections.

All the windows and doors are made from timber and contain high performance double-glazing with a low-e coating and argon gas fill for increased thermal performance. These window frames are considered to be far superior in both environmental and aesthetic terms to pvc and metal alternatives. The windows were factory-finished in a fully automatic painting plant which applies the paint electrostatically, ensuring a uniform surface. The timber is pine heartwood, which comes from the hardest part

of the trunk and offers the most resistance to rot and fungus attack.

Internally, flexibility is provided by non-loadbearing timber studwork partitions. The insulated concrete ground slab, which contains recycled aggregate, provides useful thermal mass to regulate the passive solar gain. Additional thermal mass is provided by earth block partitions on the ground floor, which were manufactured on site using clay fill found on the site.

Planning of the internal living space is kept fluid to respond to the needs of the residents both now and in the future. Open living and daytime spaces are located to the south, while more private and enclosed cellular spaces are located on the northern side of the dwelling. The modular approach to the design of the house allows the possibility for a number of variations to the base model according to spatial needs, a desire for flexibility and available finance. The simple shell structure can be increasingly colonised or cellularised as the circumstances of the residents alter with time and economics. The house can be either a 'loft on the ground' or more cellularised to suit larger family life. The number of bedrooms can vary from one to five in various modular configurations, with the option of a 'granny flat', teenagers' den or sub-let apartment as required. The section also allows the house to be repeated to make a terrace.

The house has been designed to be 'affordable' and within the reach of the average house-buying budget (£120,000 excluding the site). Whilst this might seem a high figure for a single house in Wales it has taken account of the innovative nature of the house, its use as a public exhibit and a prototype for future forms of housing in Wales.

Above The north-facing entrance front; rainwater run-off from the sedum roof is collected in tanks within the projecting eaves for use in toilet flushing. Extensive glazing to the south elevation reveals the internal arrangement.

Above right The white lime render of the recessed entrance porch contrasts with the timber rainscreen cladding of the north elevation.

The house relies on a strategy of sensible energy use, assisted by passive technologies that are supported by easy-to-use control systems. It has been designed to be interactive with both its occupants and visitors, with provision for maximum user control. When solar gain is insufficient, space heating can be supplemented by the ground-source heat pump and at the highest peaks of demand a pellet wood burning stove can further heat the space.

Roof-mounted solar collectors are able to provide water heating for most of the year. Electricity generated by an integral photovoltaic array (800W) meets some of the family's electricity demand (calculated as equivalent to running the electric lighting). The intention is for the house to become self-sufficient in electricity as energy-generating technologies become more affordable. In the early design stages the possibility of generating wind power at the domestic scale was investigated and the first competition submission included a proposal for a ridge-mounted wind turbine. While the costs associated with prototyping a machine of this nature were outside the limited budget, the architects remain convinced of the potential for wind generation on individual buildings.

Space heating is supplied to the house by an electric ground-source heat pump fed from a 35m bore hole. A heat pump works like a conventional refrigerator, but instead of taking unwanted heat from food and releasing it through cooling fins, it takes heat from the ground and releases it as useful warmth in the house. This system was chosen as there was no mains gas available to the site and the heat pump is powered by electricity from renewable sources, which would equate to zero carbon dioxide emissions. In the medium term this is achieved by purchasing electricity through Green Tariffs, which offer renewably generated electricity at a premium rate. The system installed in this house is 315 per cent efficient, ie each unit of electricity delivered can produce 3.15 units of heat. High levels of insulation and high performance glazing throughout help to minimise heat loss from the building, thus minimising the need for artificial heat input.

Rainwater falling on the north-facing roof is collected in the oversized eaves gutter, which can store more than 700 litres of water at high level. This can then be fed by gravity for various functions, including toilet flushing and the washing machine. This water is mechanically filtered to remove particles and is used for all 'non contact' requirements in the house. The house will collect an average of 155 litres per day, equivalent to about 25 per cent of the average annual family water consumption.

The water actually used in the house is kept to a minimum. The baths include an upright shower, which is a more efficient use of water. All wash handbasins have been fitted with mixer taps with an aerated 'mousser' device, which give the impression of more water being dispensed, and thus cut consumption. The dual-flush wc installed in the main bathroom is heralded as one of the most water-efficient

flush toilets available for use with normal gravity sewers. A double button mounted above the toilet pan selects full or part flush and is factory set to deliver two or four litres. The toilet areas have stale air extracted through the toilet seat – a small and efficient 12V fan contained within the service riser is activated by passive infra red detection and exhausts the air to outside.

In building the house, recycled construction and demolition waste was used for the hardcore layer under the ground slab and also in the recycled aggregates used to form the concrete foundations and slab. Other recycled materials included aluminium flashings and natural slates, while the cellulose fibre insulation is also recycled.

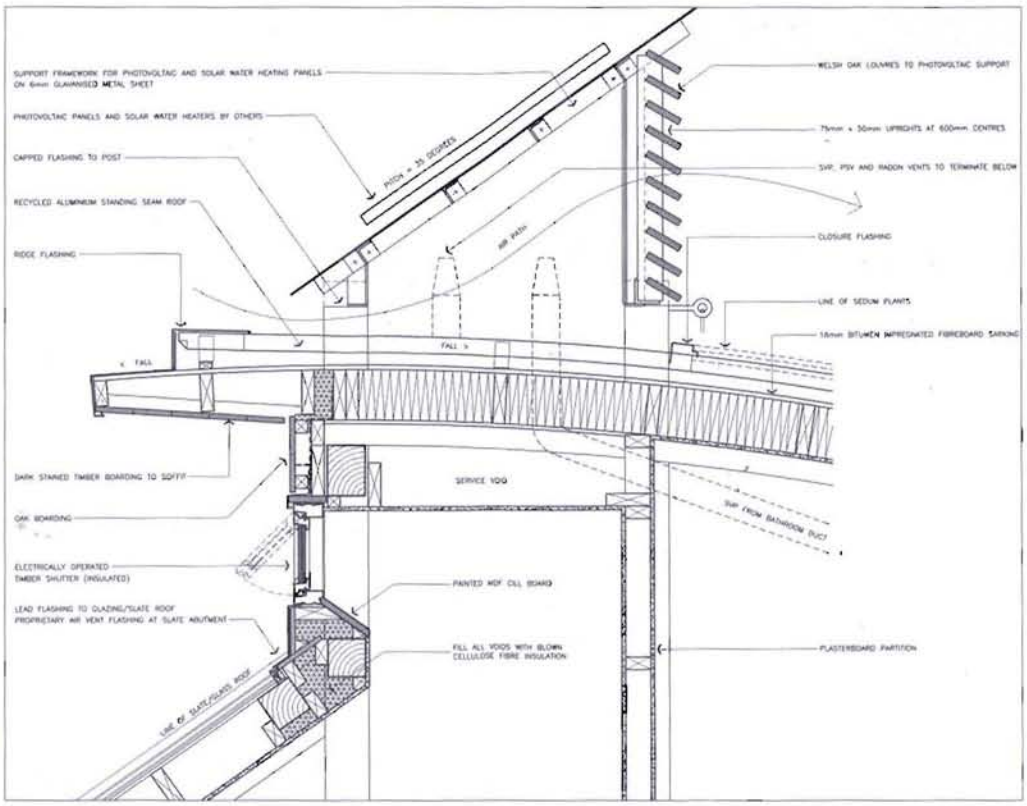
Recycling by the inhabitants is also encouraged by a dedicated recycling area. This space, which is semi-external and well ventilated to outside air, also provides a secure holding area for deliveries ordered by internet. Segregating containers are provided in the kitchen and the recycling area to assist with recycling.

Project team
Architect: Jestico + Whiles; project team: Heinz Richardson, Jude Harris, Andy Piles; energy: ECD Energy & Environment; structure: Barton Engineers; furniture: Designs from the Attic; landscape: Richards Moorehead & Laing; project manager: Davis Langdon & Everest; contractor/sponsor: Redrow Homes (South Wales); other sponsors: BBC Wales, United Welsh Housing Association, DCA Consultants; client: National Museums & Galleries of Wales.

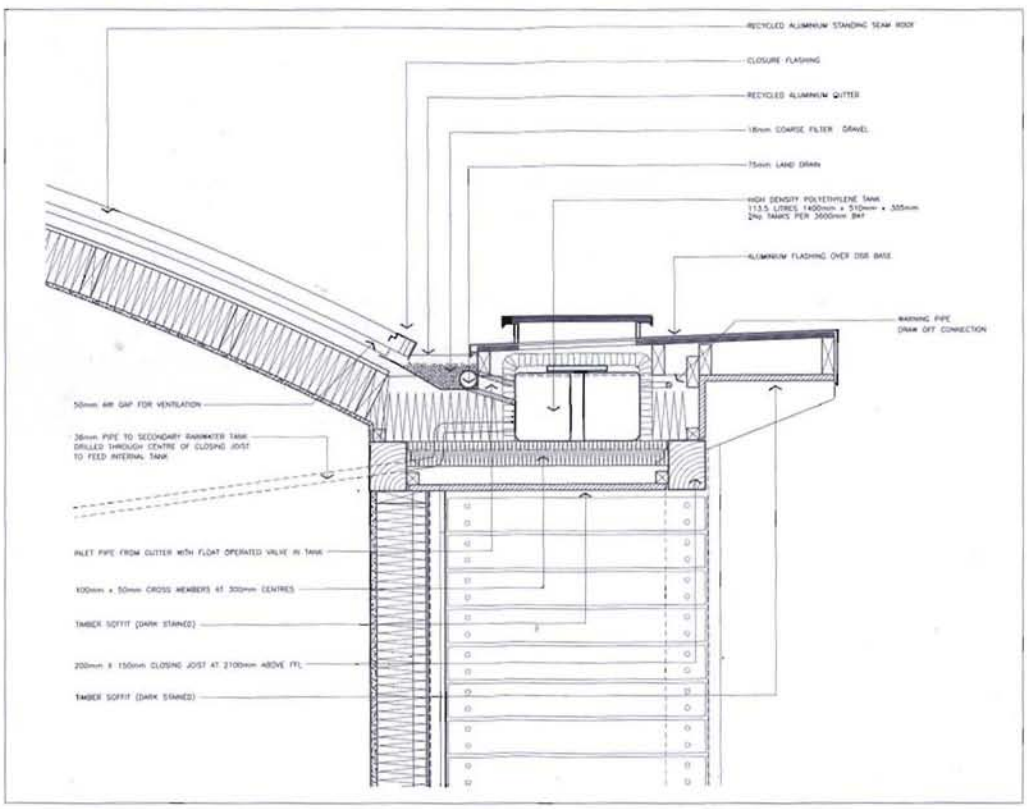
Selected subcontractors and suppliers
Photovoltaic panels: BP Solar/PV Systems; Welsh Radnor sheep's wool insulation: British Wool Marketing Board; Kalzip Nature Roof: Corus; solar water panel: Filsol/Solar Sense; motorised blind: Guthrie Douglas; internal rainwater storage: HEWA; heat pump: Markus Energi; clayboard: Natural Building Technologies; kitchen: Paula Rosa; rainwater tanks: Polytank; Welsh oak cladding: Quality Hardwoods; windows, doors: Rationel; lime render: Ty Mawr Lime; ventilated toilet seat: Ventalu; wood pellet heater: Welsh Biofuels; appliances: AEG; riven finish slate: Alfred McAlpine Slate; ironmongery: Allgood; radiators: Bisque; timber floor sealer: Bonakemi; coir mat, lino, sisal: Bob Jude Flooring; plasterboard: British Gypsum; radiators, towel rail: Caradon Plumbing Solutions; design, fabrication and installation of oak frame: Carpenter Oak & Woodland; ceramic tiles: Ceramiks; lighting: Delta Light, Genesis Lighting, gfc Lighting, Into Lighting Design; low flush toilets: Elemental Solutions; insect mesh: Expamet; sarking board: Fillcrete; sanitaryware, shower: Ideal Standard; homegrown softwood: Jewson; patent glazing: Lonsdale Metal Co; aluminium gutters, downpipes, flashings: Metal Fabrication Co; precast cills: NBS Pennine; glass roof and canopy: Pilkington Processing and Merchanting; cellular glass insulation: Pittsburgh Corning; limewash: Rose of Jericho; Tyvek membrane: Sheffield Insulation; controls: Smarta Systems; recycled rubber floor insulation: Sound Service; oak staircase, handrails, flooring: Stairway Joinery; lift: Stannah Lifts; external timber stain: Valtti Specialist Coatings; internal doors: Vicaima; polybutylene plumbing: Wavin; smooth finish slate: Wincilate; roof glazing, glass canopy: Alan Hone Assocs; heat pump bore holes: Apex Drilling & Grouting; nature roof: Blackdown Horticultural Consultants; recycled aggregate ground slab and drainage: Brandwells Construction; electrical installation: Connect Electrical Services; painting and decorating: G&S Decorite; landscape: Gerald Davies; PV array: Helios Fabrications; slate tile installation: High Vogue; wool insulation installation: Miller Pattison; cellulose fibre insulation installation: Pen-y-Coed Construction; plumbing and heating: Talesouth; screed, plaster and render: WK Plasterers; Membrain latex sink: Clive Scott; low-flush toilets: Elemental Solutions; recycled aggregates: Hanson Aggregates; structural Welsh oak: Mick Jones Timber; wood pellet heater: Welsh Biofuels.

Further information
- www.nmgw.ac.uk
- www.jesticowhiles.co.uk
- www.ecde.co.uk
- A book on the House for the Future is published by the Museum of Wales, price £15 (contact Mari Gordon tel 029 205 73248).

• *Brian Edwards is professor of architecture at the University of Huddersfield and co-author of Sustainable Housing: Principles and Practice.*



Above *Detail section through the photovoltaic array, roof junctions and automatic ventilation panel.*
Below *Eaves gutter detail showing the integrated tank for greywater recycling.*



Below *Typical cross section through the north-facing green roof.*