SustainCo
Sustainable Energy for Rural Communities

Tŷ Unnos

Home-grown timber in construction

Evaluating
TY UNNOS MODULAR™

April 2014

Evaluating TY UNNOS MODULAR™

BACKGROUND

Coed Cymru was set up in 1985 as an all-Wales initiative to promote sustainable woodland management and the use of locally grown timber. It is a partnership of public, private, academic and third sector bodies working through the charity Coed Cymru Cyf.

'Improve the Supply Chain for Low value Welsh Timber' is a Coed Cymru project that is funded through the Rural Development Plan for Wales 2007-2013 which is funded by the Welsh Government and the European Agricultural Fund for Rural Development.

The **Severn Wye Energy Agency** (Severn Wye EA) set up in 1999, is an independent charity and not-for-profit company which aims to promote sustainable energy and affordable warmth through partnership, awareness-raising, innovation and strategic action. In 2012 it became a partner in the **SUSTAINCO** project which is co-funded by the European Union under the Intelligent Energy Europe Programme (Contract No. IEE/11/847). The project aims to raise awareness of and support the development of low energy building projects, with special emphasis on rural areas of the seven European countries participating in the project. It aims to increase the visibility of front-runners, for both new-build and renovation, with the aim of capacity- and confidence-building in the public sector.

In 2013 Severn Wye EA chose the **TY UNNOS MODULAR™** affordable houses, built for the North Wales housing association Cymdeithas Tai Clwyd, at Glan Gors, Dolwyddelan as one of five developments to be case-studied as part of 'SustianCo'. The project aims to promote good practice in rural locations, in readiness for the European 'Energy Performance Building Directive' (EBPD) for 'Near Zero Energy Buildings' (NZEBs).

The 'Glan Gors' case study brings together information from Elements Europe Ltd, CymdeithasTai Clwyd, Severn Wye EA, Coed Cymru and the post occupancy evaluation (POE) work by the RDP SCE scheme. This verifiable data has provided proof that these houses built from home-grown timber are extremely efficient and are outperforming their Environmental Performance Certificates.

Housing from Home-grown Timber

In 2006/7 a partnership consisting of the Welsh School of Architecture, University of Wales Bangor and Coed Cymru undertook a brief study, funded by the Countryside Council for Wales, to establish the feasibility of producing efficient, social housing using home-grown softwood.

The study led to a report that proposed a radical departure from current practice; a whole house construction system of engineered home grown timber components.

This would lead to a stronger supply chain involving growers, sawmillers, manufacturers and construction professionals who would bring the raw material from forest to a useful end product in Wales. Jobs and training opportunities would follow as the manufacturing processes are designed to be within the capabilities of a standard joinery workshop, easily adaptable for a range of equipment and skills.

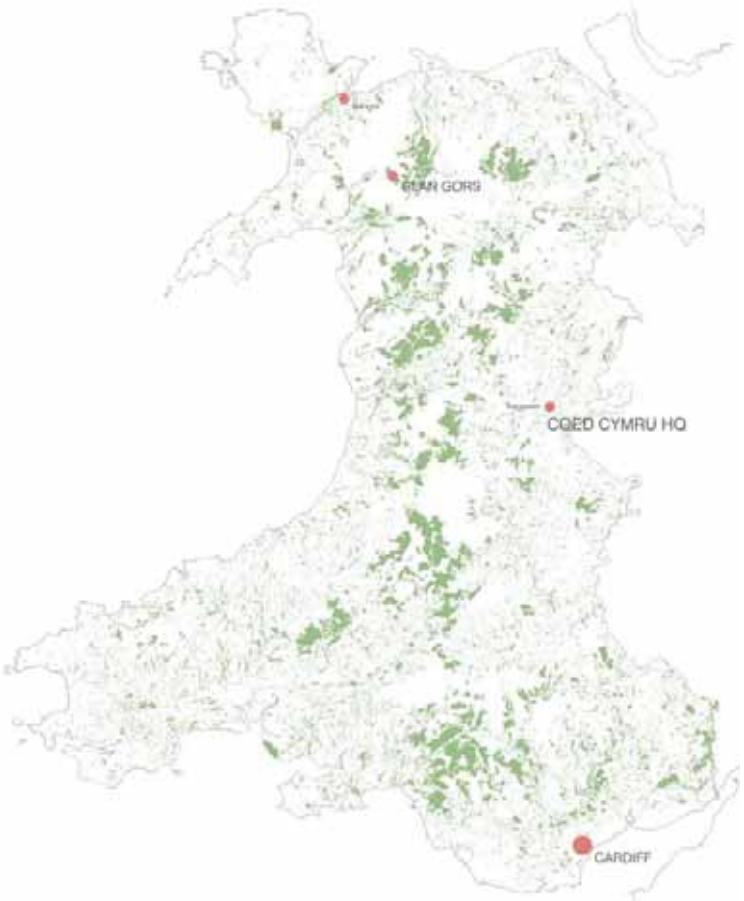
USING WELSH TIMBER

Wales has 150,000 hectares of coniferous plantations, producing one million tonnes of softwood per annum 70% of this is Sitka spruce.

In 2007 all of the modern timber frame manufacturers in Wales (and the UK) used imported softwoods due to greater stability and strength of slower grown material. Welsh spruce grows -

- much faster
- producing timber of lower density
- with heavier branching and larger knots.

Although Welsh spruce has poorer structural properties than imported softwoods, it is its tendency to twist during drying that timber frame manufacturers cite as their reason for not using it. It was recognised that simple substitution with home-grown softwood was not possible. If a system was to be adopted generally it would need to stabilise the main structural components and eliminate the need for conventional trussed rafters.



DEVELOPING THE SYSTEM

Collaborative working

The proposals attracted great interest from industry and work began to prototype, test, and develop components in collaboration with a number of partners from the academic, public and private sectors. This new way of working necessitated a level of commitment, co-operation and communication skills previously unseen in the Welsh Timber Sector.

The Name

The System was named 'Tŷ Unnos' literally translated as "a house in one night" from the tradition of erecting a house overnight on vacant land and claiming it as a home. The name was chosen to convey a fast and adaptable building system making use of local material and local labour.

The Timber

Home-grown Sitka Spruce, Douglas Fir, and possibly Hemlock or Larch, graded to structural strength class - C16.

The Components

The system comprises of two simply assembled engineered timber components; a hollow box section beam and a ladder beam. When combined with frame connectors and infill panels, the engineered components form an innovative whole building construction system. It is a virtue of this system that all the insulation can be incorporated within the walls/floor/roof, with the ladder trusses and hollow beams allowing for very efficient use of blown cellulose insulation eg Warmcel® 500.

Intellectual Property Rights 'Open Source'

All Coed Cymru's work is put into the public domain as 'open source' information available for all to use. The base level of technical information can be used by businesses to develop their own system, which they can protect and brand– eg. TY UNNOS MODULAR™ as developed by Elements Europe Ltd.

Stringent Testing and Certification

The design team followed the Eurocodes convention in prototyping and testing components with the box beams receiving their European Technical Approval in 2012. A number of technical information sheets have been produced. Component manufacturers can obtain their component certification through the TRADA Q Mark.

TY UNNOS MODULAR™

First affordable housing built in 2010

The first company to take advantage of the Tŷ Unnos open source work was Elements Europe Ltd, part of the JR. Pickstock group of companies. Taking the components it developed them into TYUNNOS MODULAR™ a fully certified volumetric system, where buildings leave the factory fully finished and fitted. Cymdeithas Tai Clwyd working with the rural housing enabler and Conwy Borough Council chose to use TY UNNOS MODULAR™, in their delivery of four, three bedroom affordable houses in Dowyddelan. The tenants moved in in January 2011.

Post Occupancy Monitoring

Few published work on POE in domestic dwellings exist but it is not a new subject. Royal Institute of British Architects in its plan of works for design team operation (1963) included a Stage M – Feedback, in which Architects were to return to the buildings to review what they had done but by 1973 this was omitted from 'Architect's Appointment'. Without a monitoring or feedback program how do we know if our buildings are performing as they were designed to. Coed Cymru has an ongoing monitoring program at Glan Gors. Some of the data is reported in the attached case study.

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September 2013

Glan Gors
case study

Glan Gors is a development of four semi-detached properties made up of two Ty Unnos modular system buildings, built to meet local housing needs. It is 40 years since the last social houses were built in the village of Dolwyddelan.

The homes were constructed for, and owned by, Cymdeithas Tai Clwyd, a social housing landlord. Each is factory-made from locally grown timber and consists of two modules, an upper and ground floor, with roof section. This development was designed to meet the Code for Sustainable Homes Level 4 standard.

Co-funded by the Intelligent Energy Europe Programme of the European Union

CYMDEITHAS TAI CLWYD

COED CYMRU

asiantaeth ynni SevernWye energy agency

elements europe

JR.PICKSTOCK LTD. DEVELOPERS & CONTRACTORS

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Glan Gors

GENERAL

Name: Glan Gors

Owner: Cymdeithas Tai Clwyd

Designer: J Ross Developments, Oswestry

New/retrofit: New

Use: Social housing

Location: Dolwyddelan, Conwy, Wales

Climate: Oceanic (Köppen Climate Classification)

Heated area: 68m^2

Investment cost: £505,000 | £126,250 per house (€611,050 | €152,762 per house) | £1,096/m^2 (€1,327/m^2) (gross)

Awards: Ty Unnos system: The Cardiff University Innovation Prize; Chartered Institute of Building International Prize for Architecture; Innovawood Laureate; and the TRADA 75th Anniversary Award.

DESIGN

Approach: To build highly energy efficient affordable homes to near Passivhaus design using home grown timber where possible to fit into the surrounding environment.

Construction typology: New build, modular home-grown timber frame construction on light steel frame cassette and concrete trench footings, highly insulated with Warmcel ® 500. Clad in slate, render and timber.

U-value walls: 0.17 W/m^{2}K

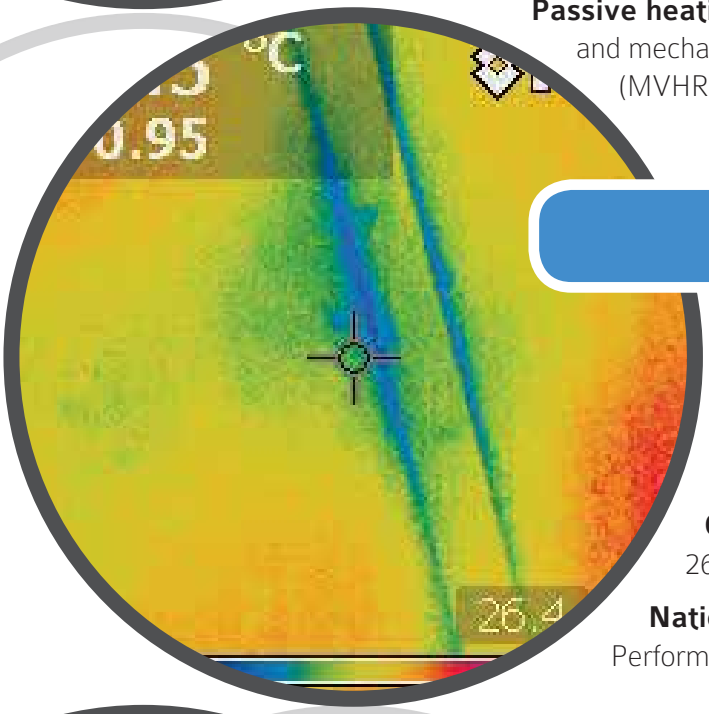
U-value roof: 0.13 W/m^{2}K

U-value floor: 0.17 W/m^{2}K

U-value windows: 1.8 W/m^{2}K

Passive cooling strategies: None.

Passive heating strategies: Insulation, triple glazing, and mechanical ventilation heat recovery system (MVHR).



ENERGY

Primary energy need: 9.202 kWh/yr | 107 kWh/m^2/yr (gross) (EPC simulation)

Final energy consumption: 6,860 kWh/yr (gross) | 60.18 kWh/m^2/yr

CO_2 annual emissions: 3,056 kg $C0_2$/yr | 26.8 kg $C0_2$/m^2/yr (gross)

National energy certification level: Energy Performance Certificate rated – 'B' (81)

RENEWABLE ENERGY

Sources: Solar thermal

Solar thermal installed power: 3.62 kW

Annual renewable energy generation: 3,120 kWh/yr (estimated)

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GENERAL

Glan Gors

Name: 1 - 4 Glan Gors

Use: Residential

Users: Local people

Completion year: 2010

New / retrofit: New build to meet local housing needs

Type of ownership: Owned by Cymdeithas Tai Clwyd for affordable local rental (social housing)

Building / community: There are two buildings, each consisting of two, two-storey semi-detached houses. Rectangular in shape with accessible pitched roof.

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GENERAL

Building description: First build in the UK of the Ty Unnos Modular system, to provide low-cost, local needs housing.

This development was designed to meet the Code for Sustainable Homes level 4, each semi-detached dwelling consists of two modules – a ground and upper floor with a roof section.

Using home-grown timber and local manufacturers, the modules are factory built in a quality controlled environment. Fully fitted and finished internally with bathroom, kitchen, windows and doors, wired and plumbed before transportation to site.

The modules are lifted into position by crane from flat-bed lorry onto a preformed foundation with roofing sections completing the building. Four secure and weather tight houses are assembled in a matter of hours. External finishes, service connection, solar thermal and landscaping are typically completed in six to eight weeks.

BUILDING

Area and volume (per dwelling):

Net floor area: 87m^2

Gross floor area: 114m^2

Heated area: 68m^2

Cooled area: 0m^2

Façade area: 118m^2

Glazed area: 19m^2

Floor height: 2.4m

Net total volume: 208m^3

What is special? Housing constructed from home-grown timber. A feasibility study commissioned in 2006 looked at the possibility of building homes using home grown Sitka spruce, the most readily available softwood resource in Wales. A simple substitution of imported material commonly used for timber frame systems was not deemed possible, due to the greater stability and superior strength of slow grown softwoods available from drier, cooler climates.

The study therefore proposed a radical departure from current practice in the form of a whole house construction system of engineered home grown timber components. The proposals attracted great interest from all aspects of the industry and a multi-disciplinary team of experts formed to prototype, test, and develop home grown timber components in combination with a number of commercial partners.

The Ty Unnos system is comprised of two simply assembled engineered timber components; a hollow box section beam and a small section ladder beam. The components were prototyped by the design team and then tested by The Timber Research and Development Association (TRADA), the internationally recognized centre of excellence on the specification and use of timber and wood product. The box beam can be used as a load bearing element and can span up to 4.8 metres. The ladder beam can be used as a floor joist with spans up to 3 metres and as a non-load bearing wall stud.

Elements Europe were the first company to take advantage of the Ty Unnos open source work – working with Coed Cymru and BM TRADA (Timber Research

BUILDING CONT.

and Development Association), Elements developed its own commercial model Ty Unnos modular which is fully Q-marked and NHBC (National House Building Council) compliant. BM TRADA Q-Mark is regarded as one of the most rigorous certification processes available for construction products. Like other certification schemes, BM TRADA Q-Mark is recognised by controlling authorities, home warranty providers such as the NHBC and is used by world-class construction companies and manufacturers.

With Snowdonia National Park strict planning laws and the Welsh Governments rules for the social housing grant it took Cymdeithas Tai Clwyd, Dolwyddelan Community Council, Conwy and Denbighshire's Rural Housing Enabler, Conwy Borough County Council, Forestry Commission Wales, Snowdonia National Park, Coed Cymru and the Welsh Government working closely together to enable the houses to be designed, planning permission obtained and the houses built.

Forestry Commission Wales released the 1.5 acre of land which it previously managed on behalf of the Welsh Assembly Government, in order that Cymdeithas Tai Clwyd could develop these affordable homes to meet local people's needs – the first social housing to be built in the village for over 40 years.

LOCATION

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Location: Dolwyddelan, Conwy, Wales LL25 0WA

Population: 427 (2001 census)

Site: A sloping, wet, greenfield site previously covered by coniferous forest, on the edge of a forward-looking village in Snowdonia National Park. The village has a railway station and good bus links, a community centre, junior school, public house, hotel, shop and a good number of businesses.

Local resources: A local hydro-electric scheme is currently being considered.

CLIMATE

Climate description

Oceanic (Köppen Climate Classification)

Heating degree days: 2,400–2,800 (1971–2000)

Cooling degree days: 5–10 (1971–2000)

Yearly sunshine hours: 1,200–1,300 (1981-2010)

Mean annual temp: 6°C (1981-2010)

Rainfall: 2,612.2mm (1981-2010)

Source: www.metoffice.gov.uk - from local weather station.

Microclimate: Open aspect, good for solar and possibly for wind power generation.

ACTORS & AWARDS

Owner: Cymdeithas Tai Clwyd.

Established in 1974 as a charitable housing association to assist local people to obtain comfortable homes at a reasonable cost, Cymdeithas Tai Clwyd achieve this by providing rented accommodation as well as assisting people to buy a property. In this development they currently have four properties rented to local families.

Designer: J Ross Developments, Oswestry, Shropshire, England

Construction company: Contractor – J R Pickstock Ltd., Oswestry, Shropshire, England; Offsite Manufacturer – Elements Europe Ltd., Oswestry, Shropshire, England.

Supporting actors: Coed Cymru (developing housing from home-grown timber); Forestry Commission Wales (released the land); PYC Insulation (Warmcel ® 500).

Actors' impressions: Cymdeithas Tai Clwyd's Development Manager, Bryn Davies said: "It was exciting to see a semi-detached house formed on the site within daylight hours. It's a far cry from conventional building work, with all the planning and construction work having taken place within the compound of a clean factory space.

ACTORS & AWARDS CONT.

Kitchen units, bathroom suites, radiators, tiles, and even the plastering work have all been fitted and completed within the 'pods' before leaving the factory in Oswestry.

It's an affordable process, requiring many weeks less input on site at Dolwyddelan from varied tradesmen. We were pleased to be part of this Ty Unnos innovative building method, especially as the sitka spruce timber (coniferous evergreen trees) used on the project was grown, processed and developed in Wales."

Llion Derbyshire, Area Land Agent for Forestry Commission Wales said: "We were delighted to see a second site of land previously managed by Forestry Commission Wales developed for affordable housing. The houses, set on a on a 1.5 acre of open land within Snowdonia National Park, were built to a high standard in a sustainable manner making the householders living experience much greener. In this part of the world, using the natural environment to assist with reducing the carbon footprint is an ideal solution. The transformation of the land is clear to see, and we are delighted to be part of the process working on behalf of the Welsh Government."

Gwyn Roberts, the Dolwyddelan Community Council Clerk, explains: "It's nearly 40 years since the last council built houses was developed at the village. Without this project there would be no hope for local residents to rent or buy here in Dolwyddelan. The village is a tranquil, idyllic place with stunning views and great outdoor leisure activities on our doorstep. This type of village has seen house prices soar, so we need to congratulate the Welsh Government for appointing Rural Housing Enablers across Wales who are able to work with us and Conwy County Borough Council in getting projects like this off the ground."

Awards: The Ty Unnos research project's success was recognised by Cardiff University Innovation Prize, Chartered Institute of Building International Prize for Architecture, Innovawood Laureate and the TRADA 75th Anniversary Award.

COSTS & FINANCING

Building and renewable energy systems investment:

Total (including all fees): The cost of this development £505,000 (€ 611,050), was secured jointly from the Welsh Assembly Government's Social Housing Grant and Cymdeithas Tai Clwyd.

The cost of each property was £126,250 (€152,762), with solar thermal units costing £1,300 (€1,573) before installation.

Construction cost: £1,096/m^2 (€ 1,327/m^2) (gross)

Financing scheme: Cymdeithas Tai Clwyd

Public aid: Welsh Assembly Government Social Housing Fund

IMPLEMENTATION

Implementation process: The development team inherited house plans which had to be adapted to suit the system. This was the first time the factory had produced timber frame housing – the run was not streamlined. Unforeseen road closure and escort services added £10,000 to the cost of the development.

The site was difficult to work adding cost to the project. Groundworks included moving an existing electric main, divert ditches, extensive new drainage, new culverts and a 200m pipe for foul water. It took time and skill to manoeuvre the 4.8m x 10.68m modular units across the narrow bridge onto the site.

If there was a next time: Improvements to the manufacturing system are ongoing. The process, components and build have since been streamlined and have been proven on a subsequent build.

GENERAL

USERS

User behaviour: Has not yet been tested

User feedback: Has not yet been tested

COMMISSIONING

Energy commissioning: There was an early problem with elevated kWh usage, which was identified as a voltage problem and fixed. There is no formal energy monitoring as tenants are responsible for procuring their own energy deals.

Gap: No gaps with respect to the housing, however, some additional unforeseen works were required, such as moving overhead power lines and building a water culvert outside and adjacent to the front the development because of the high levels of run-off since the deforestation of the surrounding land.

Heating comfort: Coed Cymru have just begun data-logging internal and external temperatures in one property. (September 2013)

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DESIGN
Glan Gors

DESIGN APPROACH

Approach: To build highly energy efficient affordable homes to near Passivhaus design using home grown timber where possible, that fit naturally into their surroundings. For an overview on how this was done, watch this short movie on YouTube about Ty Unnos (6:44): **tinyurl.com/oyhpj95**.

In a village that had seen no new social housing in 40 years, to build 'local needs' housing, with high levels of insulation, coupled with a heat recovery system and solar thermal panels leading to low running costs.

Goals: To meet Code for Sustainable Homes level 4

Design methodology: To build to Code for Sustainable Homes level 4, meeting full Design Quality Requirements and Lifetime Homes requirements as standard. Prefabricated 4.8m wide modules to be built in a quality controlled factory environment utilising a skilled efficient workforce. To minimize waste, costs and on-site work while maintaining quality throughout. For an overview on how the Ty Unnos modular 'volumetric' system is constructed, watch this short movie on YouTube (3:17): **tinyurl.com/noqqtv5**

Motivation: Deliver low-cost high performance housing using home-grown C16 timber.

Key points: The weather-tight prefabricated units were fully fitted and finished internally, including windows and doors prior to transportation. The units took 4.5 hours to install from the lorry onto the site. No cracking, settlement or other defects have been observed.

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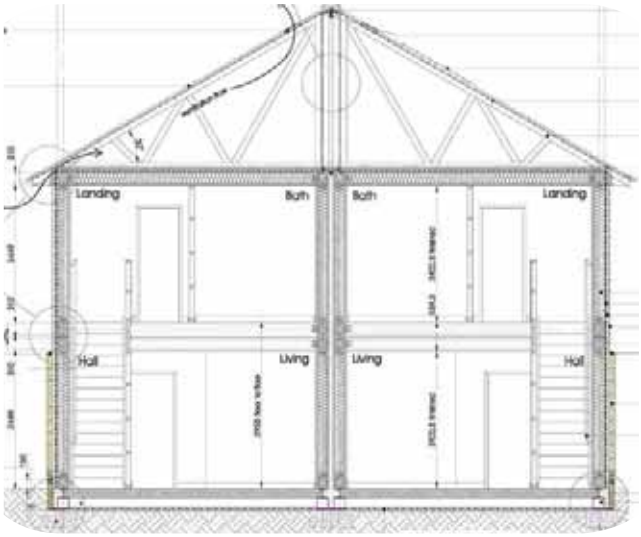

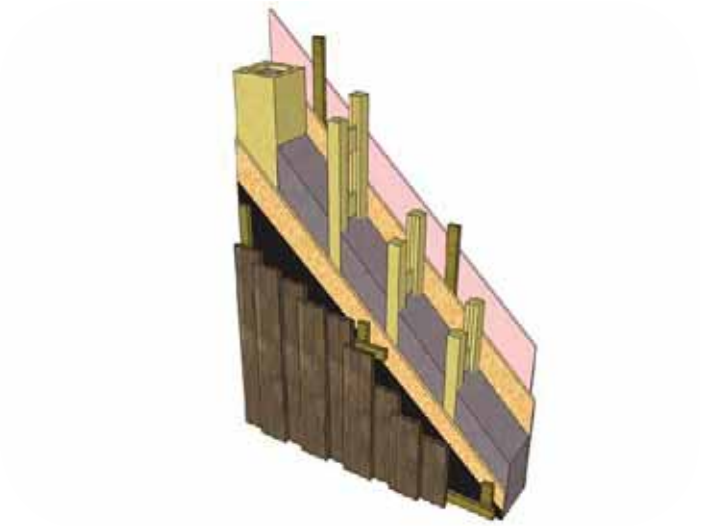

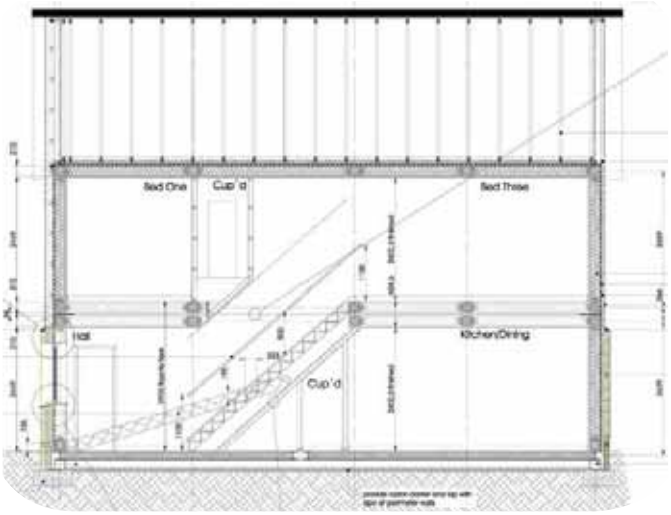

CONSTRUCTION

Construction typology: New build, modular home-grown timber frame construction on light steel frame cassette and concrete trench footings, highly insulated. Clad in slate, render and timber.

Daylighting: There were no special considerations made for daylighting as the plan was already fixed for the architects and developers.

DETAILS

Facade: Ty Unnos timber framed with OSB racking and slate/ timber cladding to road frontage. Render and timber cladding to side and rear. Internally OSB with plaster board taped and jointed. Insulated with Warmcel ® 500 (recycled paper).

U-value 0.17 W/m^{2}K (2006 regulations min 0.35 W/m^{2}K)

Roof: Timber truss, felt, batten, brace with natural slate.

U-value 0.13 W/m^{2}K (2006 regulations min 0.25 W/m^{2}K)

Ground floor: Ty Unnos box beam with Ty Unnos ladder joists and OSB sheathing on light steel frame cassette and concrete trench footings.

U-value 0.17 W/m^{2}K (2006 regulations min 0.25 W/m^{2}K)

Windows: Painted-FSC (Forest Stewardship Council) softwood triple glazed Jeld Wen low-e krypton.

U-value 1.8 W/m2K (2006 regulations min 2.2 W/m^{2}K)

Thermal bridges: The Ty Unnos system by virtue of its hollow sections, ladder joists and trusses is designed to maximise insulation and minimise thermal bridging.

Thermal inertia: None, as these building rely on high levels of Warmcel ® 500 insulation and very high levels of airtightness.

PASSIVE STRATEGIES

Passive heating: Insulation, triple glazing and Mechanical Ventilation Heat Recovery system (MVHR)

Passive cooling: None

DESIGN

AIR QUALITY

Ventilation type: Natural with mechanical where required (kitchen/bathroom/WC's)

Design rate: Minimum standard is 10.0m^3/(hr/m^2)

Air tightness: Tested as @50pa: 2.9m^3 / (hr/m^2)

Ventilation system: Hybrid –trickle vents and MVHR Envirovent whole house system with a manual boost. (89% efficiency rating)

Moisture movement: Mechanical ventilation with heat recovery. Vapour barriers built into structure to control interstitial condensation.

ENVIRONMENT

Water: Low water usage fixtures – Showerhead 9 litre/min; Taps 4 litre/min; Toilet low flush 6/4 litre. Water butt plumbed into rainwater downpipes.

Waste: On-site – recycling storage units built in

INNOVATIONS

Technology: Solar thermal panels for hot water. Low energy lighting. Mechanical heat recovery/ventilation system. Minimum thermal bridging.

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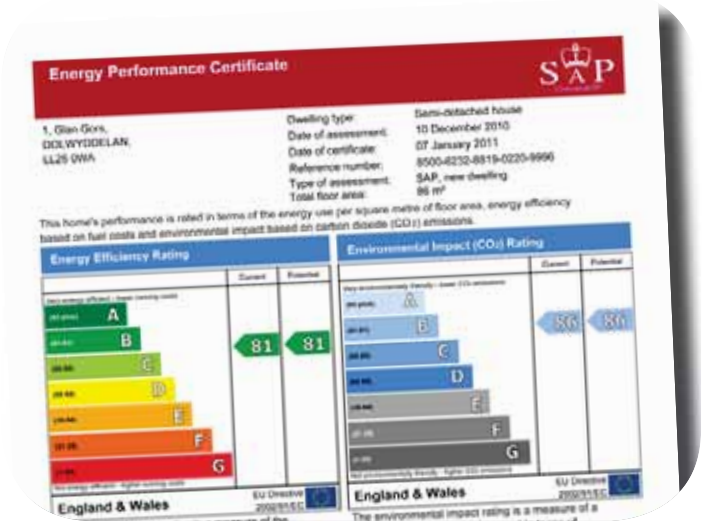
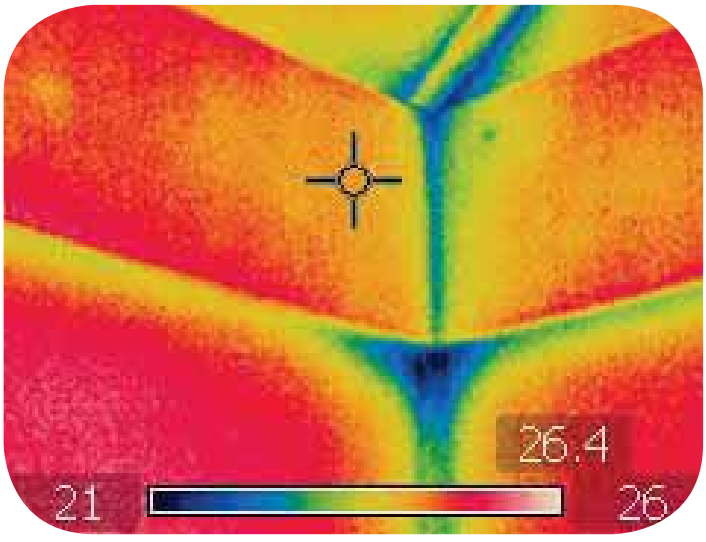
ENERGY
Glan Gors





ENERGY INDICATORS

Primary energy need (per dwelling for heating, hot water and lighting):

9,202 kWh/yr (Energy Performance Certificate simulation)

107 kWh/m²/yr (EPC simulation)

Final energy consumption (per dwelling and including appliances and external devices):

6,860 kWh/yr

60.18 kWh/m²/yr (gross)

CO_2 annual emissions:

3,056 kg CO_2/yr

26.81 kg CO_2 /m²/yr (gross)

Conversion factor FE-PE: FE-PE electricity: 2.5 (Source: Digest of UK Energy Statistics - (Dukes) 2013)

Renewable energy production: Solar thermal - 3,120 kWh/yr (estimated)

Renewable energy sources coverage: 34%

National energy certification level:

Energy Performance Certificate (EPC): 'B' (81)

Environmental Impact (CO_2) rating 'B' (86)

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ENERGY

ENERGY DEMAND

Heating demand: 31.95 kWh/m²/yr (EPC simulation)

Cooling demand: None

Domestic hot water demand: 24.04 kWh/m²/y (EPC simulation)

Lighting demand: 8.22 kWh/m²/yr (EPC simulation) | 1.32 kWh/m²/yr (gross) (survey and estimated use calculation)

Total electricity demand:

6,860 kWh/yr (gross) (actual/measured over three years occupation)

60.18 kWh/m²/yr (actual/measured over three years occupation)

ENERGY SYSTEMS

Heating system: MVHR system with small thermostatically and time-controlled electric convection room heaters as backup. Mechanical ventilation heat recovery, or MVHR, provides fresh air and improved climate control, while also saving energy by reducing heating (and cooling) requirements.

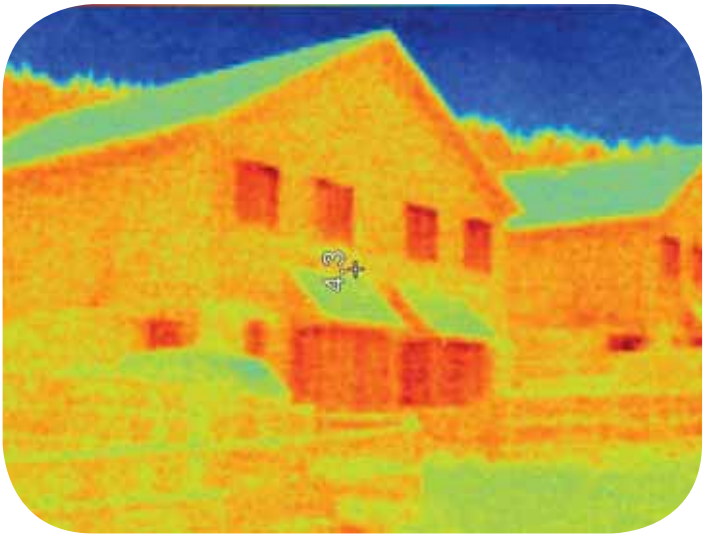
Domestic hot water generation: Solar thermal with two 3kW electric immersion heaters for back up.

Energy storage: 210 litre unvented direct cylinder

Energy management system: MVHR system automated controls. Visual display for solar thermal system.

Control and automation: Heat recovery and ventilation system, programmable and automatic. Programmer and appliance thermostats.

ENERGY



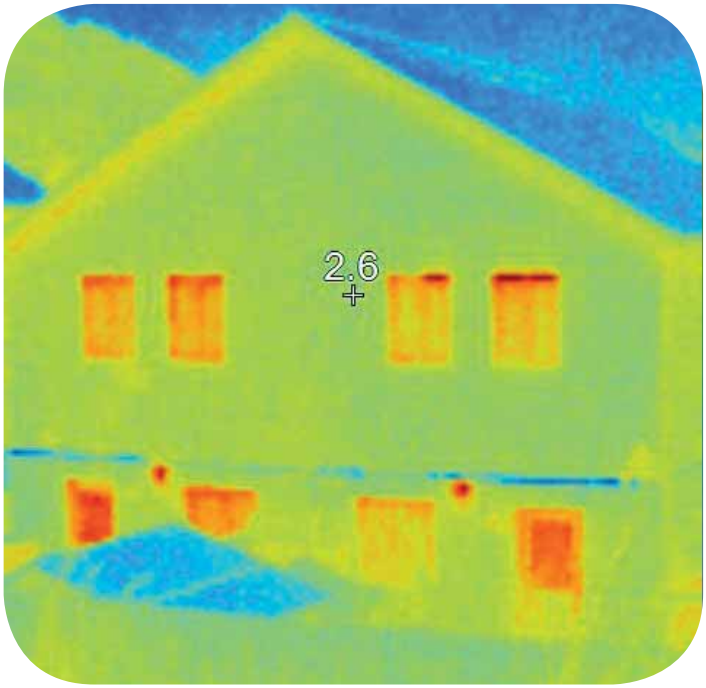
LIGHTING

Lighting: 12 x 15W GLS Compact Fluorescent Lamps

Total consumption: 150 kWh/yr | 1.32 kWh/m^2/yr (gross) (estimated).

COMFORT

Temperature set point (heating): Controlled automaticity by MHVR and thermostats and electric wall heaters.



COST

Electricity: Estimated at £823 (€996) per year using 6860 kWh @12p/kWh (€0.145/kWh)

Total energy consumption per dwelling for both primary energy (heating, hot water and lighting) and all internal appliances and external devices.

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CYMDEITHAS TAI CLWYD

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elements europe

JR.PICKSTOCK LTD. DEVELOPERS & CONTRACTORS

RENEWABLE ENERGY

Glan Gors

RENEWABLE ENERGY SOURCES (RES)

Renewable energy sources: Solar thermal

Total RES generation: 3,120 kWh/yr (estimated)

RES cost: £1,300 (€1,573) for materials | £359/kW (€435/kW)

SOLAR THERMAL

Installed power: 3.62 kW

Annual generation: 3,120 kWh/yr (estimated)

Cost: £1,300 for materials | £359/kW (€1,573 | €435/kW)

Panels area: 5.2m^2

System: RM Solar flat plate solar thermal system integrated into roof on south elevation feeding into a 210 litre Santon Premier Plus Solar, unvented, direct solar thermal hot water storage tank with RM Solar digital solar display unit.