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Energy buffs go to ground

Design and innovation in building rarely undergo revolutionary changes, the process is slower, more evolutionary. But, do the changes occur in the true Darwinian fashion? That is, are modern buildings really the best adaptations to fit the environment? * John Dawes discovered more of a mutation in Wales that fuses traditional methods with modern energy thinking to provide a super-efficient earth sheltered habitat

If Darwin now observed and compared all the different forms of building found in the British Isles, would he be convinced that 'natural selection' alone was responsible for development and evolution? How would he account for such a diversity of design alongside the near extinction of some traditional building forms? Could he explain why some persistent characteristics bear no relation to overall efficiency; viz, their 'fitness to survive'.

In Darwin's evolutionary thesis, the cause of variation, as he proposed, was usually won by sexual preference. In today's approach to creative building, the main controlling variable has nothing to do with emotions, but can be put down to plain, economic pressure; in other words, over-riding 'cost factors'.

Is it this weight of 'cost factors' that accounts for our wide divergence from North America say, in a growing preference for the pleasures of earth sheltered buildings (esbs)? Or, is it simply our climate? (100,000 esbs have been erected in the United States, against a handful in Britain). Perhaps inherent British conservatism to new practice and novel style, curtails indigenous enthusiasm for living inside a 'hole-in-the-ground'.

One of the major issues in the 21st Century is going to be greater conservation. How will we adapt our building form to meet inevitable fuel and material scarcities, plus the changing global climate?

Very few people have the perception to blend ancient design and modern innovation, incorporating *'new energy'* ideas sympathetically into the built environment, and in such a way that the result will be enduring and self-sustaining for several centuries. There is a long line of inheritance in traditional building method that pleases the eye and imbues a sense of function; this can be utilised.

In South Wales, one idiosyncratic pioneer thinks the time for change is now. He has faced evolutionary and economic constraints to build his long term solution into a low energy, low maintenance, high density, high quality, berm house that matches the monumental style of his existing property. Caer Llan Field Studies and Conference Centre at Lydart has been run by Peter Carpenter since 1970. It is set into the hillside in woodland above the Wye Valley, near Monmouth, now designated as an area of outstanding natural beauty. Running an old and large property, which is both a high energy consumer and maintenance intensive, convinced Peter Carpenter that all possible conservation measures are highly desirable. He also has a strong persuasion that fossil fuel depletion is criminal waste. Buildings can conserve heating energy and can be designed to extend the life of their fabric several times over. His environmentally conscious ideas were put into practice when a 'motel-like' extension was planned to cope with a growing popularity of courses being offered at the early 18th century Caer Llan house.

Increasing visitor and student numbers for conferences and courses, meant expanding the facilities to provide accommodation for up to 60 people. The 1988 extension of a unique earth sheltered berm house provided another eight study bedrooms, each with a bathroom and all heated entirely by the sun, offering "opportunity to experience 21st Century living today". Extension into the bank makes use of a steep site unsuitable for conventional building. A stone battlement fronts the building behind which a solar corridor links the rooms in line: a modular arrangement allowing further extension at the same competitive cost per sq m. The massive structure and earth banking acts as a huge thermal store.

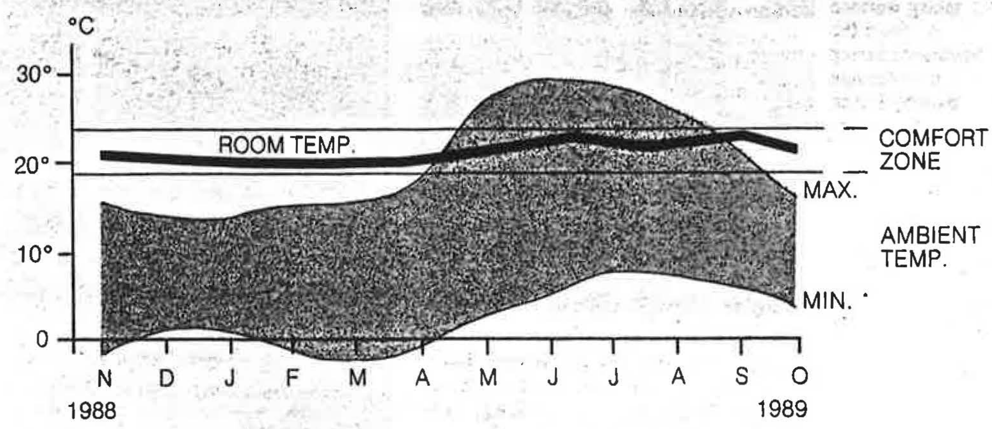
Solar energy warms the main corridor through south-west front windows. Warmed air rises through grilles into a duct and is pumped into the rooms through brick wall cavities. Air is extracted from the bathroom located at the back of each bedroom and before being exhausted to atmosphere is blown out along a flexible aluminium duct suspended inside the fresh air duct within the corridor ceiling. This configuration acts as a permanent, passive heat exchanger, recovering up to 65% of outgoing heat. In warmer weather, this same system draws upon the inherent cooling effect of the large building mass buried under a 1.5m bank of earth—hence the name 'berm' from the middle English word for bank, or ledge, in a fortification.

Stability

Temperature within the rooms remains almost constant throughout the year, without need for any supplementary heating. Since all rooms are set deep into the bank and behind the solar corridor, there can be no draughts. The h&v system constantly supplies fresh, warm or cold, air. However, this aspect could do with further development, since there is a sense of stuffiness. Also, the massive structure with its hyper-insulation seems to absorb sound, which with tightly sealed windows and well-fitted heavy doors adds to the feeling of isolation—in true, castle-like ambience. The bathroom ventilation works well, if rather noisily. Natural style of decor is wood and brick and easy to keep clean.

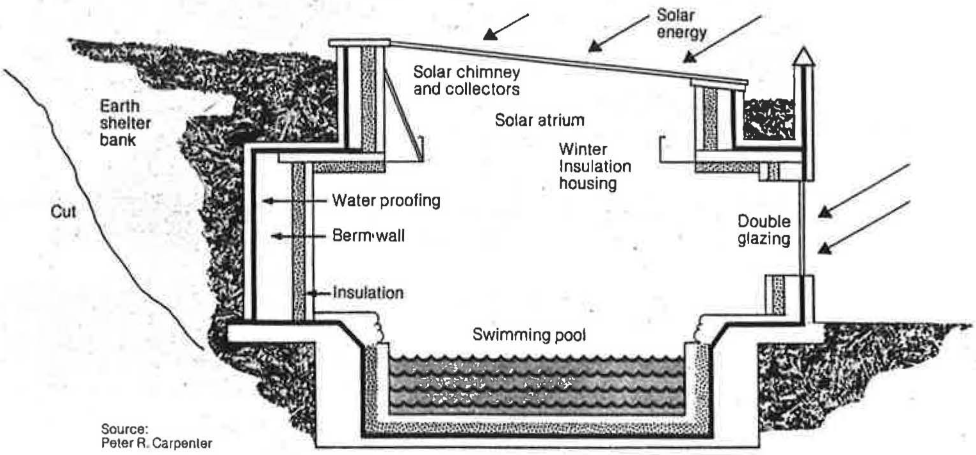
The distinct advantage in esbs, is that the design temperature can be fixed at around 20°. Temperature for a conventional house varies daily and with the seasons. By covering that house with soil, variation in ambient temperature can almost be eliminated. In Britain, soil temperature 1.5m below ground is stable at 10°C.

Diagram 1. Caer Llan Berm House temperatures (1 year)



Source: Peter R. Carpenter

Diagram 3. Caer Llan Zero Energy Swimming Pool and Solar Atrium (section)



Source: Peter R. Carpenter

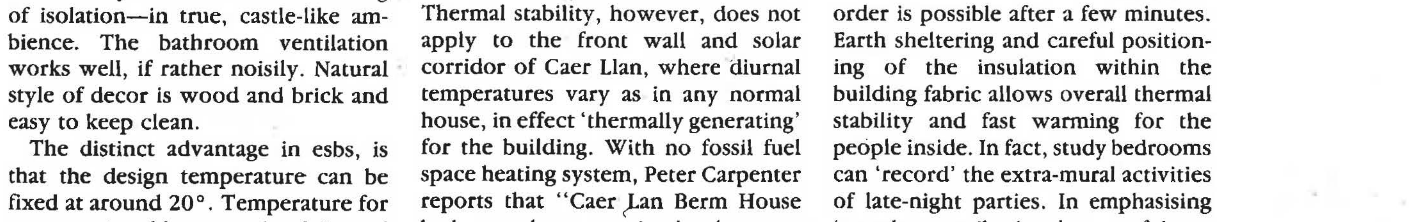
Thermal stability, however, does not apply to the front wall and solar corridor of Caer Llan, where diurnal temperatures vary as in any normal house, in effect 'thermally generating' for the building. With no fossil fuel space heating system, Peter Carpenter reports that "Caer Llan Berm House bedrooms have remained at between 22 and 23°C since April 1988, when that temperature was first achieved." The mild winter and long hot summer of 1989 account for temperatures slightly exceeding calculated predictions (see graph diagram 1).

The building is insulated with 100mm closed-cell, expanded polyurethane foam slabs (Kooltherm). Ceiling insulation is fireproofed (Nylflam) and separated from living space by an aluminium vapour barrier. Hyper-insulation allows the room temperature to respond rapidly to occupancy, such that shirtsleeve order is possible after a few minutes. Earth sheltering and careful positioning of the insulation within the building fabric allows overall thermal stability and fast warming for the people inside. In fact, study bedrooms can 'record' the extra-mural activities of late-night parties. In emphasising 'people contributions' to useful energy input, Peter Carpenter explained; "the other day, we noticed that one room felt warmer. It was found that the internal walls were above room temperature and irradiating back to the air. This situation is the exception rather than the rule, for the extra heat proved to be a legacy from 'over-occupancy' the night before".

When planning for high occupancy building such as a future conference hall, Peter Carpenter will vary insulation positions and provide for extra heat storage within the surrounding walls (see diagram 2).

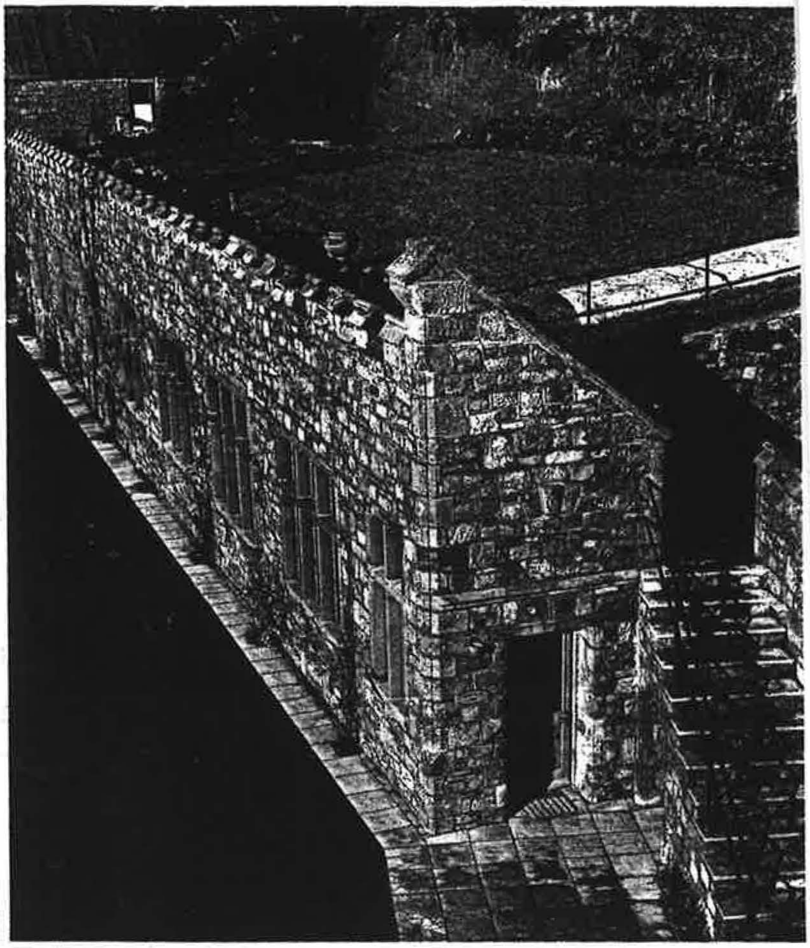
Heat store wall (source: Peter R. Carpenter)
a) Temperature gradient through a concrete berm wall.
b) c) Temperature gradients for berm walls with insulation at different positions.
d) By splitting and selecting the positions and proportions of insulation, the temperature for the bulk of the berm wall can be designed at between 20°C and 10°C to gain maximum heat storage *without* condensation.

Diagram 2. Caer Llan Conference Hall temperature gradients



a) Concrete wall
b) With insulation to inside
c) With insulation to outside
d) With split insulation to inside and to outside

The building uses solar energy by taking warmed air from the Southwest facing corridor and blowing it into the rooms



This berm house is designed to save fuel and maintenance costs and to improve land use, housing up to four visitors per study room for minimal operating cost at any time of the year. The modular row of rooms suits all manner of design requirements, from one-room starter homes to hospital wards,hotel suites and holiday units; from college blocks to craft studios, individual offices and laboratories. The philosophy is developed in a design booklet and report paper published by Caer Llan, Lydart, Monmouth, Gwent. Peter Carpenter is also organiser for the British Earth Sheltering Association; its official journal (Vol 2, NO 1, December 1989 at £2) includes latest information about Caer Llan as well as other esbs, from Mole Manor in the Costworlds to underground sportshalls and pools in Oslo.

Cost accounting

To overcome arguments that an esb is more capital intensive, Peter Carpenter adopts a careful cost accounting viewpoint. Caer Llan Berm House building cost per sq m was £330, exactly the same as conventional housing, or two-thirds that of standard hotel construction. Energy use per sq m per annum (lighting electricity and domestic hot water (dhw) oil), is 16kWh, in contrast to 125kWh for the UK low energy building target, and 275kWh for typical B&B accommodation. Swedish residential building in low energy schemes 10 years ago, were designed to 140-120kWh with reductions planned to 100-80kWh by 1990: research suggests 70-30kWh is practical.

Peter Carpenter now plans to extend upon the extension with a conference hall and zero energy swimming pool (see diagram 3), built similarly but incorporating more interesting h&v features. He intends to use solar energy tube collectors to heat swimming pool water or preheat dhw. He is considering a solar chimney (assisted by a venturi gadget to keep it going at night, and when it it windy), to reduce ventilation costs. Also, he wants to "use active solar water heating exchangers *indoors*" an idea already tried with conservatory type swimming pools. He expects "to have an atrium poking through the earth-shelter over the rest of the building". Earth sheltering will be about 1m deep with the atrium supported by Tuscan columns to give a Roman bath appearance. Conduction losses should be around 2kW with hyper-insulation for walls and floor; extra heat storage is available outside the insulation in a dry lined, vibrated concrete tank.

Ventilation will involve a vertical curtain of air arranged in a box around the perimeter of the pool, flowing from ceiling to coping, dividing high humidity poolwater from drier surrounding spaces, so saving evaporation losses. The atrium will collect waste heat and trap solar heat for recovery by heat pump operating at ˉ.1 cop. Only a few years ago, a typical public swimming pool per sq m per year, could easily consume 5000kWh; today the typical low energy commercial pool operates at around 1500kWh, and the lowest private pool at 150kWh.

It will be interesting to see where esb energy and environmental efficiency philosophies fit into the BRE/ECD Partnership ideas developed for "Green Building Rating Certification". Peter Carpenter emphasises "the whole beauty of going underground is that heat is stored at temperatures lower than the design temperature, never contributing directly to the 'warming of the house' . . . merely stopping it 'cooling so fast'. Warmth comes from the sun occupancy appliances."

21st century

There is scope to explore 21st Century energy needs with the Watt Committee who have begun their major investigations into technological responses to the Greenhouse Effect. Their conference on Technological Responses to the Greenhouse Effect at the Royal Geographical Society in London, is scheduled for the 24–25 April 1990 and will consider the options for reducing the build-up of Greenhouse gases in the atmosphere. The main emphasis will be on methods by which the energy industries can reduce CO_2 emissions. Further information is available from Geraldine Oliver, The Watt Committee on Energy, Savoy Hill House, Savoy Hill, London WC2R 0BU. □

Caer Lan Berm House philosophy is based upon lifetime costing principles involving:

- **Heavyweight construction**—the back wall set into the bank is 1m thick dense concrete incorporating vapour barrier and waterproof tanking; the reinforced concrete floor set directly onto bedrock withstands underground water pressure and the great structural weight above; the prestressed concrete roof beams carry infill, banking, concrete screed plus 1.5m earth covering.
- **Massive Insulation**—the standard of hyper-insulation and draught exclusion is similar to that used for commercial deepfreeze schemes. The cocooned building loses about 2kW in warmer conditions and 8kW in coldest winter.
- **Longlife-expectancy**—high quality materials cut maintenance costs, to exclude paint, plaster and wallpaper; tiles, beams and battens; gutters, skirting-boards or external timber . . . so spreading capital costs over hundreds rather than tens of years.
- **Passive solar energy**—the sun contributes substantially to the building's energy input; low emissivity double-glazing (Kappafloat) increases net gain in the order of 2.5 to 5.5kW over a year.
- **Balanced environment**—some heat is stored in the room walls, but most is stored in the massive concrete structures of backwall, roof and floor. Heat storage plus earth sheltering prevents rooms from cooling. Temperature stabilisation, heat distribution and recovery is operated by air circulation and ventilation—from 0.5 ac per hour flowing into each room up to 3 ac per hour vented from bathrooms when they are in use. Externally, an Old Red Standstone facade, window mullions and transoms, blend superbly with original building masonry and hillside landscape.