housing project

Hockerton

This UK case study demonstrates that, even in a climate considerably colder than any found in Australia, homes requiring no energy from an external source can provide year round thermal comfort and a healthy environment for occupants. The case study also demonstrates how almost every recommendation in the fact sheets has been applied in a single project that was built at reasonable cost.

Building Type:	New home Lightweight construction
Climate:	Very cold, Hockerton, United Kingdom
Topics Covered	**Success Level**
Passive solar heating	Excellent
Lifestyle modification	Excellent
Rainwater harvesting	Excellent
Waste reduction	Excellent
Wastewater treatment	Excellent
Greenhouse gas reductions	Excellent
Indoor Air Quality	Excellent
Reducing transport impacts	Very Good
Renewable energy production	Excellent
Food Production	Good
HERS Rating (estimated)	★★★★★

Innovative thinking combined with sound knowledge of good home design principles can provide an economical, livable, lifestyle specific solution tailored to a cold climate.

To produce a zero-energy house requires highly skilled designers to overcome all potential obstacles. Using passive solar design principles and sufficient thermal mass it is possible to design housing that requires no heating even where sunny days are relatively few.

The brief was to design and build a terrace of five earth-sheltered zero-energy houses in the Midlands of the United Kingdom. They were designed for a co-operative comprised of families with young children.

The five houses are built into a slight south-facing slope (towards the sun in the northern hemisphere). The earth that was excavated for the construction of the houses was put back on the roof.

The houses are near the village of Hockerton, in the county of Nottinghamshire in the centre of England. The climate is colder and there are fewer hours of sunshine in Hockerton than any place in Australia.

The land was owned by a trust of the builder's family and the whole site is about 10 Hectares. The design fee was roughly 6 percent of construction cost. Each house cost about £80,000, which is comparable to the price of a conventional house of the same size in the United Kingdom, where building prices are relatively high.

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DESIGN BACKGROUND

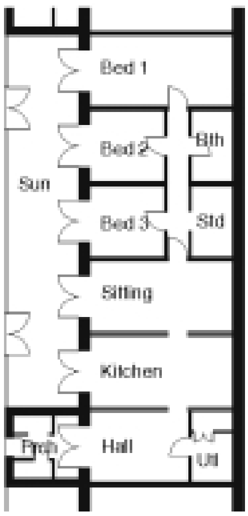
The client specifically wanted earth-sheltered houses that would be fully autonomous but offer conventional standards of space and comfort. The principal constraint was that the houses had to receive planning permission from the local Council, in spite of being outside the designated village envelope of Hockerton. This meant that permission would not normally have been granted. Several factors worked in favour of the project and resulted in the granting of planning permission.

The earth-sheltered design rendered the houses invisible from the adjoining main road and the project, a non-profit development owned by a cooperative, was a serious attempt to build a sustainable development. [See: Choosing a Site]

The principal cost constraint was that the houses should not be significantly more expensive than a conventional house in the same part of the country.

DESIGN RESPONSE

The plan was designed as a repeated series of identical structural bays. This led to very low construction costs, as all spans were the same, making the construction simple.



Each home is comprised of six bays 3 metres wide by 6 metres deep. The roof slopes from front to rear, so that on the south side (the front), the bay is 3 metres high and slopes down to about 2.3 metres high at the rear. In the front wall of each bay is a pair of full length glazed doors, with a window above, forming a large glazed opening for solar access.

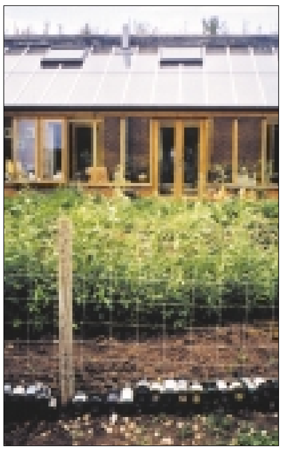
Cross Section

Orientation of the houses

The houses were arranged in a long terrace to minimise the number of "ends" (where the waterproofing details were more difficult) and to maximise the exposure to the limited winter sunshine. The long axis of the terrace was oriented as near as possible east-west to maximise the southern exposure (remember this is a northern hemisphere project). The orientation could not be due south owing to the contours of the site. The site slopes very slightly to the south. [See: Orientation]

The building envelope is clay brick for exposed exterior walls and concrete internally. This maximises thermal mass and minimises maintenance. The south-facing conservatories use timber frames and glass, and the entrance porches have slate roofs. The planned building life is several hundred years. Passive Solar Heating, Lifecycle

The double glazed roof windows allow adequate ventilation in mild UK summers. Shading of all glass and open venting would be required to achieve comfort in an Australian summer.



Thermal mass is used to carry the houses through the long winter period when there is little sun. Roof, walls and floor are concrete, around 300 mm thick. Internal, load bearing walls are also 200 mm thick concrete. The mass is "charged" during the summer and "discharged" over the winter, until about early spring, when there is sufficient solar radiation available to begin the charging process again.

The available mass is about 2.3 tonnes per square metre of floor area. This amount of thermal mass might be expected to result in very high embodied energy for the houses but research using Australian data has shown that the embodied energy of the houses is very similar to that of a brick veneer house in Melbourne. [See: Thermal Mass; Embodied Energy; Passive Design Introduction]

Ventilation for the houses is provided by opening windows in the external wall and glazed roof of the conservatory and opening windows and glazed doors between the house and the conservatory. In addition, each house has a mechanical ventilation heat recovery (mvhr) system that supplies fresh air to the living rooms and bedrooms and extracts from the kitchen and bathroom areas.

Out-going warm air passes across a heat exchanger where it gives up its heat to warm the in-coming fresh air. The in-coming air is drawn from the conservatory where it receives some solar pre-heat during daylight hours. The mvhr system is used mostly in the winter to supply fresh air with minimum thermal penalty to the house. It uses direct current motors for maximum efficiency. [See: Heating & Cooling]

The entire fabric of the house is insulated with 300 mm thick expanded polystyrene (cfc free). [See: Insulation Overview]

GLAZING AND WINDOWS

The conservatory is double glazed in walls and roof with low-emissivity glass in sustainably grown European softwood frames in the walls, and in aluminium glazing bars in the roof. The windows and doors between the house and the conservatory are of laminated European softwood, with multi-point locking. They are triple glazed, with two low-emissivity coatings and argon gas filling. In effect, between the interior of the house and the outside weather there is quintuple glazing. [See: Glazing Overview]

Electric lighting using a mixture of light sources, mostly compact fluorescent lamps (CFL) is installed in each house. Occupants chose their preferred configuration. [See: Lighting]

The houses have no heating or cooling systems, not even plug-in heaters. The indoor temperature falls to 18ºC in the winter and rises to a maximum of 23ºC in the summer. The high thermal mass means that the temperatures remain even throughout the day, with variations of less than half a degree. Changes in external temperature are not reflected inside the houses for several weeks.

The conservatories are not designed to be part of the "heated" space of the houses. Several householders have installed wood-burning stoves in their conservatories. These are used to heat the conservatory occasionally for winter parties, Christmas festivities and the like. [See: Passive Design Introduction]

Rainwater is the only water supply to the houses. It is collected from the glass roof of the conservatory for drinking water supply. For all other purposes water is collected from the site and pumped to a purpose-built reservoir pond above the houses. [See: Rainwater]

Waste water and sewage are initially treated in a septic tank. The toilets are conventional water flushed models with a low-volume flush of 3 litres. The overflow from the septic tank passes into a large pond with a series of floating rush mats with reeds (phragmites communis) growing on them.

The mats are arranged with baffles in the water that form a spiral path for the waste water flowing through, and the waste water inlet is at the centre of the spiral. The pond is at one end of a large lake constructed for the project, and overflows into this lake.

The lake was designed to attract wildlife. It now has a thriving community of plants and is frequented by many birds, insects, amphibians and native mammals.

Testing of the water quality complied with (and exceeded) the European Union standard for bathing beaches and the inhabitants of the houses use the lake for swimming. This has turned a "problem" (sewage disposal) into a visual, social and ecological amenity. [See: Wastewater Re-use]

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Hot water for each house is supplied by an air-to-water heat pump. The evaporator is at the top of the conservatory to gain the benefit of solar heating and stratification of the conservatory air.

Heated water is stored in a heavily insulated 1,500 litre plastic tank in the utility room/laundry of the house. The large tank and the high level of insulation (to minimise standing losses) means that the heat pump can be run when there is solar gain in the winter. This maximises its coefficient of performance. Showerheads and taps are relatively conventional. [See: Hot Water Service]

Electricity from the grid is the only energy received. The houses have no other source of energy. They have been using around 8 kWh per household per day.

A 6 kW Proven wind turbine is to be erected to provide all the electricity needed by the five houses. The turbine will be grid-connected so that no batteries will be needed. The erection of the wind turbine will make the Hockerton Housing Project a zero-emissions development.
[See: Energy Use Introduction; Wind Systems]

Major appliances in the houses are mostly German (Bosch, Miele and AEG). They were selected on the basis of the EU Energy/Water Efficiency Labelling Scheme.
[See: White Goods]

Site impact damage caused by construction of the houses and the lake was quite apparent, but this is now “healed”. The re-growth of the site took about a year. Several hundred native trees were planted and the lake has attracted a wide variety of wildlife.

The Project has enhanced the biodiversity of what was once a sheep paddock. Care was taken in the site design to avoid possible archaeological sites dating from the Middle Ages and the roadway to the houses was made of brick rubble so that it would be porous and allow surface water to drain through. [See: Sediment Control; Waste Minimisation; Sustainable Landscape]

Landscaping was described previously. Other aspects of the landscape design are discussed later under Food

Production. Construction waste was minimised by the modular design. No spoil from the excavations left the site as it was all used to bury the houses. Now that the houses are occupied, the tenants have a communal composting system for organic waste of all types. [See: Thermal Mass; Waste Minimisation]

Noise control in a high-mass house is very effective and it is not possible for the occupants of one house to hear the occupants of another. The houses have their backs to the busy main road, so there is no noise from that source. [See: Noise Control]

LIFESTYLE

Much of the negative environmental impact of a household comes not from the operation of the home, but from the occupants' lifestyle. Two key areas are transport and food.

Because of the longer travelling distances in Australia and the proportion of older (and less efficient) larger cars on Australian roads, emissions related to transport and food in Australia are usually higher than those in the densely populated UK.

For a household in the UK, the CO2 emissions associated with their car are likely to be equal to or greater than for running their home. The emissions associated with cooking meals for a four-person household are two to four times the emissions from the house itself.

To take account of these factors in household environmental impact, the following categories have been added to show what the residents of the Hockerton Housing Project are trying to do about these issues.

TRANSPORT

Part of the lease that the cooperative has agreed with its members is that no household may have more than one fossil-fuelled vehicle. This is an attempt to reduce the transport emissions associated with the Project.

The group share a communal four-seater Peugeot 106 electric car. They use the car for local journeys – it has a range of about 60km. This is enough to make round trips to schools, supermarkets and the nearest city, Nottingham.

The electric car will ultimately be charged from the wind turbine. The group also endeavour to share trips in their petrol cars, rather than making several individual trips in separate vehicles. In addition to the electric car the group has several human-powered vehicles (hpvs), including a "delivery van" and a number of recumbent bicycles. [See: Transport]

FOOD PRODUCTION

The Hockerton Housing Project has a large organic vegetable and fruit garden. All members work in the garden and it provides much of the food eaten. There are also poultry and pigs. The garden absorbs the compost created from the organic waste of each household. This small-scale production of food minimises the energy overhead of the residents' diet. [See: Sustainable Landscape]

EVALUATION

Strengths - what worked?

The clients appear to be very happy with their houses and their community. We think that it all works well and have had no complaints from the residents since they first moved in to the houses at the end of 1997.

Feedback from residents

"As you know, we have had a prolonged sunless period with a lot of rain that has caused the internal temperatures to drop. This is not as bad as it first seems. The maximum/minimum/ambient temperatures in our house have dropped by less than 1⁰ since Christmas [the ambient/minimum is 18⁰ today].

The fabric temperature has dropped by 1⁰ to 18⁰ during this period. The good news is that we have had two sunny days and with all the doors and windows open, we should be picking up some heat for a change. I was pleased to see the details on the embodied energy. I generally tell people that the embodied energy of the Hockerton houses is similar to a conventional masonry house. It will be good to be able to say that it is similar to a timber frame house!"

"We are all fine, despite the weather. This is our worst autumn/winter to date in the homes. A very wet/dull autumn, the wettest since records began in some parts of UK, followed by a very cold winter. Homes are still bearing up pretty well. Ours is at 17.6⁰ but some of the others are lower due to lower occupancies.

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However, it is all relative. I stayed in a youth hostel with radiators in the room. The other occupants thought it was really warm but I had to turn the radiator on full since I felt quite cold. When I got home, the house seemed so warm I had to strip down to a T-shirt. I guess the HHP homes have spoilt us rather!"

The Building Research Establishment in the UK published a report on the Project in 2000, and concluded not only that it worked, but that developers ought to make use of its principles to build better houses for the general market.

What would you do differently next time? Ideally the project would have used dry composting toilets rather than the septic tank, as this would have avoided putting sewage into water, and would have allowed the easy recovery of the "waste" as fertiliser. However, the nature of the site precluded the use of composting toilets as it was not possible (in terms of reliable waterproofing) to create the space under the house for the composting chamber.
[See: Waterless Toilets]

What would you do with more resources? There is really nothing that would have benefited from more time or money, the houses are just right. They are not large by Australian standards, but are considerably larger than the norm in the UK, where the typical three bedroom house has a total floor area of around 80 m^2.

Comparative Weather Data	Notts. UK	Melb. Aust.
Latitude	53° 05' North	37° 49' South
Annual heating degree days to 18°C	3344	1377
Annual sunshine hours	1296	2080
Monthly sunshine hours maximum	102	251
Monthly sunshine hours minimum	42	185

The table above shows a comparison between the Hockerton site and Melbourne. Note how little sunshine is received in the winter at the Nottinghamshire site compared to Melbourne.

Annual heating degree days are the number of days heating is required times the number of degrees the temperature must be raised on each day to maintain an 18ºC base during a full year. It is a guide to the amount of heating required in a given climate.

PROJECT HISTORY

The Hockerton Housing Project was the brainchild of Nick Martin, a builder in the small town of Southwell (population approximately 7,000) in Nottinghamshire. His family owned, through a trust, some land at the edge of the nearby village of Hockerton.

Nick had always dreamed of building a small settlement of earth-sheltered houses on this land, in an attempt to provide a way of living that would be less damaging to the environment. Early in the 1990s Nick met Brenda and Robert Vale, who had moved to the area to take up positions at the University of Nottingham. Brenda and Robert intended to build their own autonomous house.

The proposed house was a development of ideas they first published in their book, The Autonomous House, 1975. It turned out that this book had been a major influence on Nick's desire to build in an environmentally-friendly way.

Nick Martin won the tender to build the Vales' Autonomous House and subsequently asked them to design the five houses that became the Hockerton Housing Project. At the same time he gathered together a group of people that wanted to do more than wring their hands about the state of the environment; they wanted to try to make a significant contribution in their own lifetimes.

This group of five families steered the Project through complex ramifications of the Planning and Building Consent processes. The future residents played a major role in construction, which began in August 1996.

Nick Raynsford, Minister of Construction in the UK, officially opened the project on October 27, 1998. He arrived at the site in an electric car and later planted a tree to add to the 4,000 trees already planted at the Hockerton site to increase biodiversity and absorb CO_2 emissions generated by construction.

The Hockerton residents are perfectly normal people who wanted to make a difference. They have ended up with durable, comfortable homes that produce no carbon dioxide emissions and which cost nothing to run.

DESIGN AND CONSTRUCTION TEAM

Brenda and Robert Vale, Architects

E.J.Allott and Associates: Structural Engineers

Builders: NSM

RESIDENTS

Helena – Paediatric consultant.
Simon – Mechanical engineer.
Nick – Former medical rep - now full time HHP.
Trudi – Customer relations consultant.
Pete – Director clinical psychology.
Nick – Builder.
Sandy – Administrator HHP and P.A.
Tina – Administrator HHP and other projects.

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