Section 4: Case Studies

18 case studies have been identified in the East Midlands – information on the following are set out below:

Albert Hall Memorial Housing, Coalville

Location	Coalville, Leicestershire
Type of Area	Suburban
Tenure	Social housing rental
Built Form	Detached bungalow
Contact Name	East Midlands Housing Association
Phone / e-mail	(01530) 839091

Summary

The development consists of seven dwellings incorporating elements of passive solar design, high levels of insulation and mechanical heat recovery ventilation. It was designed and built by the East Midlands Housing Association for older clients.

Extensive monitoring and analysis was carried out by the Energy Technology Support Unit (ETSU) as part of the project, and much of the information presented here draws on this report.

The project demonstrates how more attention and research at the design stage can enhance the benefits that may be derived from such energy saving features. It also shows how the perspectives of success or failure of a design differ between building professionals and residents.

Project Objectives

To create a high-quality flagship sheltered housing development for older people that is highly energy efficient and incorporates the principles of passive solar design.

History of Concept

The development, which was constructed in 1990, consists of seven dwellings (three two bedroom and four one bedroom bungalows) and is a memorial to a former member of the housing association, Albert Hall. The association wanted an energy efficient scheme that used electricity as its main heat source. The energy consultants decided on a highly insulated design with controlled ventilation that would meet the regional electricity company's Civic Shield 2000 standard.

The passive solar element of the design was in addition to this specification and came about as a result of the Housing Association's interest in this area.

Construction Details

Built form Detached bungalow with integral unheated sunspace. The building is orientated northeast –southwest along its longest axis.

Walls The external walls are of a cavity wall construction, with a brick outer leaf and a lightweight aerated concrete block inner leaf, separated by a 100mm cavity fully filled with mineral wool.

The wall construction is the same for the internal wall of the integral sunspace, effectively thermally isolating this area from the rest of the dwelling. The external facade of the sunspace comprises single glazed windows and doors set into laminated timber frames.

The internal partition walls are of blockwork construction.

Roof Clay tiles upon conventional sarking and trussed rafters. Insulated with 200mm of mineral wool on the loft floor.

The roof above the sunspace is mainly single glazed with toughened glass. A double glazed, Velux, opening rooflight is fitted to prevent this area from overheating during the summer.

Floors Jetplus suspended beam and slab system. 140mm thick polystyrene slabs are fitted between suspended concrete beams that span between the walls. This is covered by 18mm chipboard fitted on top of a polythene damp proof membrane.

The sunspace floor is formed from concrete paving slabs laid on sand blinding over hardcore. A damp proof membrane is installed within the blinding.

Windows With the exception of the sunspace, all external windows along with the glazed internal doors and the windows between the sunspace and the dwelling are low-emissivity, argon gas filled, double glazed units. These are set into laminated softwood frames.

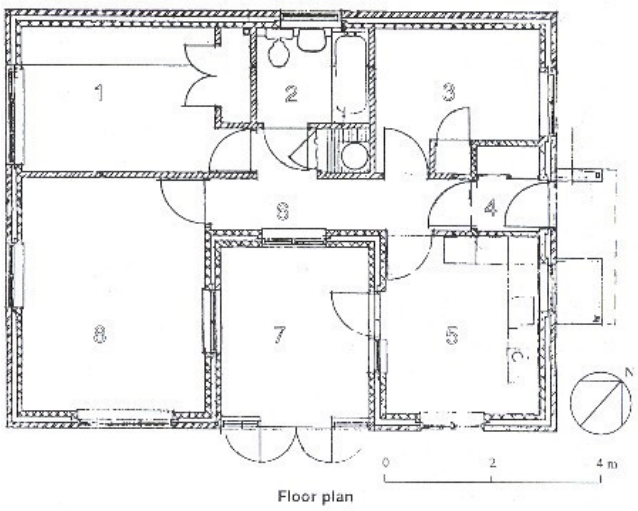


Figure 1.Internal layout of two bedroom bungalow

Key to room numbers:

1. Large bedroom
2. Bathroom
3. Small bedroom
4. Draught lobby
5. Kitchen
6. Hallway
7. Sunspace
8. Lounge

All of the dwellings are orientated northeast - southwest. The main living areas are located in the southern side of the dwelling, with the bathroom and bedrooms located on the cooler northwest side. The kitchen and sunspace face southeast, allowing them to be warmed by the sun in the morning, but preventing them from overheating in the afternoon sun.

U-Values (W/m^2.K)

Walls:	**0.3**
Internal Floor:	**0.3**
Roof:	**0.2**
Windows: (double)	**1.6**
(single)	**5.6**

Air Infiltration (ac/h)

Heat recovery sealed	**0.56**
Using heat recovery	**1.35**

Resource Conservation

Heating

The following electric heating units and controls were used in the dwelling:

Hall and living room: Creda night storage fan heaters with an output of 2.36kW and 3.56kW, respectively. A 'Meterminder' controller that matches the charge rate to the external temperature controls the night time charging. The heaters are fitted with a thermostatic control that varies the output of the two-speed fan.

Large and small bedroom: Creda 900W panel heater controlled by a thermostat, fitted with an auto-timer and a manual override switch.

Kitchen and bathroom: Creda 2kW plinth fan heater and Dimplex 1kW fan heater respectively, controlled by manual on-off switches.

Data collected during the first year of occupancy showed that the annual energy consumption for heating was 99 kWh/m^2/year [1], while domestic hot water consumed 2,307 kWh over the same year. Monitoring during the first year of use showed that 64 percent of this electricity was consumed at the off-peak rate. The same monitoring also showed that the storage heaters used 96 percent of the energy consumed for heating. The remaining 4 percent was for the kitchen fan heater. The heaters in the bedroom and bathroom were not used at all.

Monitoring also revealed that the sunspace had made only a very small contribution to offsetting the heating load. This is mainly due to the thermal isolation of this space, with highly insulated walls, high specification glazing and a separate floor reducing the opportunity for heat to move from the sunspace into the dwelling. However, the

[1] Due to the nature of the residents, who are retired older people, the heating was operated continuously throughout the day. Temperatures in all rooms were high, averaging around 25°C. As no mention was made by the residents of overheating it can only be assumed that they choose to operate the heating system at these temperatures.

largest windows in the building face southeast and southwest and admit solar thermal energy into the lounge, kitchen and large bedroom as well as the sunspace. As part of the monitoring programme, carried out by ETSU, it was calculated that the total useful thermal gains provided by these windows amounted to 1346 kWh or 12 percent of the annual heating need. This contribution was mainly made at either end of the heating season in October, April, May and June.

Lighting

The sunspace has made a significant contribution to offsetting the artificial lighting load within the dwelling. Both the manner of its integration within the building envelope and its central location in the southern half of the building allow the rooms surrounding it - the lounge, kitchen and hallway - access to large amounts of natural light. Both the kitchen and the lounge have windows that provide natural light on three sides of their construction. The window on the back-wall of the sunspace allows daylight to penetrate deep into the dwelling, illuminating the hall that would otherwise be lit only by artificial light.

Ventilation

The dwelling is ventilated using a mechanical whole-dwelling heat recovery ventilation (MHRV) system manufactured by Bahco. Warm, moist air is extracted from the bathroom and the cooker hood, and is used to preheat incoming fresh air that is then supplied to the lounge and two bedrooms. The designers wanted to keep the ventilation system independent from the sunspace and believed that using the sunspace to preheat the air offered no advantage to using outside air, and ran the risk of cooling the sunspace. The system runs continuously all year using night air in the summer to cool the building.

The natural infiltration rate of the building was calculated to be 0.56ac/h. The MHRV contributes a further 0.8ac/h bring the total to 1.36ac/h. This is enough to ensure a high quality of internal air for the residents whilst reducing the heat losses associated with conventional extraction and natural ventilation. The monitoring programme showed that the amount of heat recovered by the system contributed 778 kWh to the annual heating requirement. This showed that the system was 62 percent effective in recovering heat from the outgoing air. However, the electrical energy needed to power the system must also be taken into account when calculating the energy and financial benefits of such a system. The payback period for the installation was calculated to be 50 years, or 35 years if the system were not used during the summer period.

Transport

The development is located approximately 1½ miles from Coalville town centre and is situated on a main bus route that serves the town centre.

Social Aspects

As part of the monitoring programme, a post-occupational attitudes survey was conducted to assess the residents' feelings about the design of the dwellings. The main results are shown in Table 1 and reveal a high level of satisfaction with the design. The resident interviews revealed in particular the satisfaction that they felt with regard to the sunspace and the amount of light that it lets into the building. They also enjoyed using this space as an extension of their home during the summer months.

They learnt how to control the temperature inside the sunspace to extend their use of it during the summer months and how to use it to provide warm air to the dwelling during the spring and autumn. This area featured as the most aesthetically pleasing aspect of living in the dwelling for the residents.

Table 1. Results of post-occupation survey of residents after first year

Feature	Male Survey II	Female Survey II
The standard of thermal comfort in winter	5	5
The standard of thermal comfort in summer	4	4
The cost of heating	4	4
The fact that the house is totally electric	4	4
Effort needed to keep the home warm	4	5
Effort needed to keep the home cool	4	4
Heat distribution in the house	4	4
The quality of the air indoors	5	5
Its soundproofness from outside noises	5	5
Amount of daylight entering north rooms	5	5
Amount of daylight entering south rooms	5	5
Extent of view of outside from indoors	4	4
Its privacy from outside viewers	5	3
External appearance viewed from the south	5	4
External appearance viewed from the north	No data	3
Its internal appearances	5	5
Its internal layout and design	5	5
Its standard of construction	5	5
As a house to buy	5	5
Its general character and 'atmosphere'	5	5
Overall	5	5
key	1 = Very dissatisfied 5 = Very satisfied	

Source: ETSU, 1992

Well-Being

Health and Affordability

The high thermal performance of the building envelope, the building's orientation to maximise solar gains to the main living areas, and the efficient heating system installed should protect the residents from the effects of fuel poverty. The post-occupational attitudes survey revealed that the residents believe that the fuel costs are value for money for the comfort they experience.

The MHRV system provides adequate ventilation levels to the dwelling ensuring a continuous supply of fresh air and the removal of indoor pollution and moisture.

Economic Issues

The cost of development was £430/m^2, including the sunspace. At the time of development (1990) this was 46 per cent more expensive than a traditional dwelling without a sunspace.

Barriers and Lessons

A summary report on the dwelling was commissioned by the Department of Trade & Industry (DTI) and written by ETSU as part of the Solar Building Report programme. As part of this report, the researchers undertook computer aided modelling of the building in order to assess different design approaches and also compare the building against a reference building of standard construction. By analysing the results of this exercise, together with the data gathered as part of the monitoring programme carried out by the same group, they were able to make the following observations and recommendations:

- The building incorporated two energy saving strategies, the mechanical heat recovery ventilation (MHRV) system and the sunspace. Due to the building design they were not complementary to one another. The MHRV system is a climate exclusive strategy that benefits from a well-sealed building envelope during the winter, whereas the sunspace is a climate inclusive strategy that benefits from the controlled passage of heat across the building envelope during sunny periods. The report recommended that contradictions between various energy strategies needed to be resolved at the design stage.

- The building fabric needed to be better sealed to enhance the performance of the MHRV system.

- MHRV is not cost effective when considered purely in terms of the energy it saves.

- The primary heating system installed in the dwelling (electric storage) is too slow to respond to the solar gains entering the building and therefore negated possible energy savings. Had the sunspace not been so thermally isolated from the rest of the dwelling, it may have also led to instances of overheating. A computer model of the dwelling showed that substituting a more responsive, well controlled, wet system for the electric storage heating system would produce better energy savings than were being realised in practice.

- Due to the thermal isolation of the sunspace, the contribution that it made to offset the space heating needs of the dwelling were negligible and could not be justified in cost terms. However, 12 per cent of the space heating need was provided by solar gain, mainly due to the building's orientation, the placement of larger windows on the southern facades and the use of high specification glazing.

- The sunspace was highly valued by the residents for its amenity value, providing a seasonal living area and adding to the enjoyment of adjoining spaces because of its effect on daylighting and visual interest.

The report concluded that "The dwelling fulfilled in nearly every way the requirements of its older residents… [and used] less energy than an equivalent building of standard construction, due more to its high level of insulation and heat recovery system than to solar gain… The amount of electric heating displaced by solar gain does not justify the capital cost added to the building by the passive design. The design's inherent solar potential might be more fully realised if a more responsive heating system were installed, and if the existing solar gains to the sunspace could be ventilated to the habitable areas of the building." (ETSU, 1992)

Bibliography

ETSU: Solar Building Report: Summary Report: Albert Hall Memorial Housing. 1992. Oxfordshire. ETSU S 1163/SBS/29

Project Partners

East Midlands Housing Association
Centre for Alternative Technology
East Midlands Electricity
John Willoughby (energy consultant)

Ashton Green, Leicester

Location	Northwest of Leicester City
Type of Area	Proposed new urban extension
Tenure	Mixed private, affordable, shared ownership and social dwellings
Contact Name	Fabian Decosta, Urban Planning Unit, Environment & Development, Leicester City Council.
Phone / e-mail:	(0116) 252 7239
Web Address	www.environmentcity.org.uk

Summary

Ashton Green is a project being developed by Leicester City Council. It is still in the planning stages but is intended to be a high quality development incorporating current best practice relating to urban design and sustainable development. The entire development will eventually contain 3,500 dwellings and will be built in five phases over the next 15 – 20 years. Phase 1, with 500 dwellings on 20.28 hectares is currently at the advanced planning stage. In addition to housing, the development will also incorporate community facilities, shops and two new primary schools.

Leicester City Council wishes to deliver a sustainable development that has a clear sense of place and identity. In December 2001, the Council formally adopted a supplementary planning guidance (SPG) specifically for Ashton Green. This SPG sets out the planning, design, development guidance and requirements that the council wish to see met by any developers who become involved with the scheme. Although relating primarily to Phase 1, it is anticipated that this SPG would set the tone for the remainder of the site. The Council is the owner of the land and cannot enter into a S.106 Agreement with itself. Any desired elements that cannot be met via a planning condition will therefore be incorporated into the development agreements between the Council and the selected project partners. The success of the scheme will depend upon the project partners collaborating with one another, to share the risks and overcome the barriers that this form of development brings. At the time of writing the council is in negotiation with several potential partners.

Project Objectives

"It is intended that Ashton Green will demonstrate best practice in new housing development, in both the production of high quality in … the final layout and built form and also in sustainable development practice." *SPG Ashton Green*, Leicester City Council, December 2001.

History of Concept

The site of the proposed development was allocated for residential development in the mid-1970s and formed part of the Beaumont Leys extension of Leicester city. It is currently allocated in the Local Plan for residential development and a small local centre. It is identified as a 'Special Policy Area' in the draft replacement local plan, in recognition of the City Council's ambitions for the scheme.

Inspiration for the layout of the development and the sustainability features to be included is drawn from current government guidance and best practice as well as built examples such as Poundbury in Dorset (road layout, building and space design, etc) and the Beddington Zero Energy Development (BedZED) project in Sutton.

In 2000, planning consultants EDAW Ltd. were commissioned by the Council to develop both a master plan and a land release strategy for the site. The Council went out to tender for Phase 1 of the development and received approximately 25 expressions of interest from developers. Unfortunately, nearly all of these expressions were devoid of any reference to the energy / sustainability aims of the development, even though the importance of these issues was underlined by the Council in the tender document. The Council intends to issue a questionnaire that addresses the issues relevant to sustainable development in order to develop a shortlist of developers who have the potential to deliver such a project.

Once this shortlist has been devised, a seminar will take place with guest speakers from other similar schemes. The purpose of this is to build capacity and share experiences both to inspire the potential partners and to reassure them of the scheme's feasibility.

More successful have been the council's attempts to attract an Energy Service Company (ESCo) that can act as an energy utility to the site's commercial and residential customers. More than five suitable organisations were identified. More information concerning the energy systems is included under the *Resource Conservation* section.

Many hurdles have to be cleared before construction work can commence onsite. Amongst these is the need for the Council's cabinet members to be convinced that the benefits of the scheme will outweigh the initial loss in potential revenue from the sale of Phase 1 land. Members have so far been supportive of the ideals of the development; however they have a duty under Best Consideration to ensure that the Council achieves the maximum revenue from the sale of the land. This will create a possible point of conflict between the ideals of the planning and urban landscape departments on the one hand and the finance department on the other.

The Council commissioned a survey from the Institute of Energy and Sustainable Development (IESD) at De Montfort University to compare the difference in attitudes between developers and financiers from the private sector with those of key staff at the Council. This revealed that the private sector believed that developing the site in a more sustainable manner would lead to both increased construction costs and lower land values. The developers suggested that higher standards could only be achieved in one element of the scheme by compromising on another element.

The Council will have to be very pro-active to get their private sector partners to see the project in more long-term and holistic way. It may also have to encourage this philosophy amongst its own members when it comes to making the final decisions concerning the trade-off between the value of the land and the additional value that such a project could bring to the residents of the city.
One financial objective set by the scheme's managers, in order to alleviate this potential conflict, is to see the value of the land increase across the project build phases when Ashton Green becomes perceived as a desirable place to live by house purchasers. The Council

intends to create an agreement with its private sector partners to share this benefit in exchange for their sharing the risks and uncertainties of the earlier phases. If the first phase is successful, the Council aims to raise the sustainability standards as each of the individual phases are released.

In addition to the above issues, PPG3: *Housing*, published in March 2000, states the position of the national government with regard to new build housing. By 2008, 60 per cent of all new housing should be provided on previously developed land and through the conversion of existing buildings. Leicester City Council is currently undertaking its Urban Capacity study and is presently unable to grant permission to develop any further greenfield sites until this is completed and they can prove that they are meeting their land reuse targets. The Council's development plan has identified that there will be a need for an additional 19,000 dwellings within the city by 2015. It is extremely unlikely that this need will be met unless the City expands onto what is presently greenfield land, but the process that the council must go through to prove it necessary will delay the development of Ashton Green.

Construction and Layout

The site is a greenfield site and was used until 1964 as a repository for sewerage slurry. Two small residential developments, Glebelands (150 dwellings) and Benskins Croft (300 dwellings), already exist within the proposed area for development, and it is intended that Phase 1 will retain and link these together.

At the time of writing, individual designs for the buildings that will eventually form Ashton Green had not been undertaken. The standards to which the dwellings will be built are to some extent covered in the *Resource Conservation* section.

One of the principle challenges for the developers is to provide a central focal point, similar to the traditional market square, for the whole of the Phase 1 development. It is envisaged that most of the buildings within this area will be of three storey, terrace type construction. This will provide an adequate level enclosure to form the desired space and is referred to in the SPG as "Market Street". This area will be the epicentre of the transport system for the scheme and most of the main community services (shops, health care, community centre, etc.) will be provided here. A range of construction materials and building styles will be developed to engender a sense of place and identity for this area, as well as providing landmark buildings to aid navigation around the site.

In order to ensure that a range of shops and services can be supported within the development, a density of 30-50 dwellings per hectare is proposed for the scheme. This will allow people to have access to a range of resources without the need to travel by car. To allow the buildings to be adaptable to the changing needs of the community, the SPG calls for the design of "robust" buildings around the central area of Phase 1. The term "robust" refers to buildings whose ground floor level is adaptable, i.e. it could be used for residential accommodation in the early phase of the development and converted to commercial uses (shops, offices, bars, etc.), when the community expands as a result of new phases being released for development.

Resource Conservation

Energy

One of the principle aims of the development is that the scheme should provide low energy homes that meet the zero carbon dioxide (CO_2) emissions standard. This standard means that the housing will create zero net emissions of CO_2 on an annual basis. It therefore must meet all of its energy requirements for space and water heating, lighting, appliances, etc. from sustainable energy sources.

The city council and De Montfort University secured funding from the E.U.'s Alterner program to produce an energy strategy for the site. This showed how it was technically feasible to generate 100 percent of Ashton Green's energy needs using sustainable sources using a combination of technologies placed both on and offsite.

Energy efficiency will play an important part in meeting the zero CO_2 emissions standard in a cost-effective manner. All of the dwellings will exceed current Building Regulation construction; however the Council wishes to give developers the maximum of flexibility with regard to how they meet the zero CO_2 aim. Trade-offs between the level of energy efficiency in the buildings and the amount of sustainable energy infrastructure provided within the scheme are allowed. The Council does envisage however that it will be achieved through a combination of the following measures:

The creation of low energy demand by:

- using high levels of insulation;
- optimising dwelling orientation;
- using shelterbelts and earth forms to reduce the impact of prevailing winds;
- using low energy appliances and highly efficient heating systems.

Meeting this demand by employing sustainable energy technologies such as:

- solar domestic hot water systems;
- a biomass-powered combined heat and power (CHP) plant;
- wind turbines;
- other off-site sources.

A CHP plant will only be economically feasible with the cooperation of the manufacturing businesses on the nearby industrial estate, as it will require a constant thermal load. Low-energy domestic buildings do not provide enough demand on their own; however some of the nearby industries have a large demand for heat in their processes. The prospect of supplying this heat and electrical energy to both domestic and commercial consumers makes this an attractive proposition to potential ESCo partners.
Performance standards will also be applied to the "white-goods" within the dwellings, as these conventionally consume a significant proportion of the total domestic electrical demand. A recommendation has been made that low-energy light fittings are included throughout the scheme as standard.

Water

Best practice with regard to both water use in the home and surface runoff will be incorporated into the site. The Council requires any potential developer to investigate the feasibility of developing a sustainable urban drainage system (SUDS) to handle surface runoff from Phase 1. This system must be capable of eventual integration into the rest of the development.

It is hoped that all the dwellings will be able to achieve a water consumption rate of 30 per cent below the national average by incorporating items such as rainwater collection systems, low flush WCs, and the use of aerated tap and shower heads. Again, flexibility to design the solution is given to the developer.

Landscaping

Full surveys of the existing ecology of the site had not been undertaken at the time of writing. It is anticipated that the existing trees, hedgerows and ponds will be incorporated into the scheme and complemented with plant species appropriate to the local environment and that reflect local species.

Landscaping will be used to enhance the energy efficiency of the buildings by creating shelterbelts that will reduce the heat loss caused by winds.

Transport

The following transport measures will be incorporated into the master plan to ensure that they are delivered as an integrated part of the development:

- A high quality, high frequency bus service is specified. The specification includes the frequencies required for different times of the day, low-emission or alternative energy vehicles, minimum seating capacities and ensures access for people with disabilities.
- All dwellings within Phase 1 must be within 400m of a formal bus stop.
- These bus stops will provide seating and have the potential for connection to real time information systems.

The Council are encouraging the use of Design Bulletin 32 (residential road and footpaths – 1992) and “Places, Streets & Movement” (DETR 1998), which provide a source of good practice for the layout of the development. The main design principles that will be incorporated into Phase 1 are:

- A transport network that ensures that people, cyclists and public transport have priority over motor vehicles will be created.
- Emphasis was placed on designing for public transport at an early stage. At least 75 per cent of the site will be within 250m of a formal bus stop.
- A street network that includes restricted connectivity for motor vehicles along some streets will be used, to prevent ‘rat running’.
- All public parts of Phase 1 will be fully accessible to disabled people.
- The development will be well connected to the existing developments at Glebelands and Benskins Croft. This will allow the commercial area of Ashton Green to become a focal point for these existing communities, enhancing its economic sustainability.
- Building and space arrangements will restrict the speeds of motor vehicles to create an environment within which vehicles will travel below 20mph.
- Standard traffic calming measures such as speed bumps and chicanes will be used only as a last resort.

Social Aspects

It is hoped that a mechanism, such as the formation of a local management company, will be created through which residents can have an input into the day-to-day management of the key spaces and open places created as part of the Phase 1 development.

The chosen developer will be expected to provide funding to enable active community participation in the various stages of the development of Ashton Green, for example "Planning for Real" exercises, etc.

Community consultation exercises have been carried out with the residents of Glebelands and Benskins Croft. Initially there was resistance to the proposals, and the residents formed an action group. They have since developed a dialogue with the Local Authority's officers however, and see the value of working with the Council on the development plans to ensure that they complement their existing communities.

Communal Facilities

The Council realise that a key factor in ensuring a more sustainable form of development is the early provision of a range of shops and services that meet the immediate needs of the incoming residents, so that they do not form the habit of going elsewhere. The following developments are therefore to be included within the planning obligations for the site:

- The built form of the village centre will have to be completed following the occupation of the first 400 dwellings of the development.

- A community shop, providing convenience goods, with a floor area greater than 40m^2 must be provided. This must be open at least five hours a day following the occupation of the first 100 dwellings. It will be operated continuously for at least five years after opening.

- A single doctor's surgery and associated health facilities which:
  - must be completed after the first 250 dwellings have been occupied.
  - be capable of expansion to accommodate five doctors plus associated health facilities for the whole of the Ashton Green development.

- A community building that:
  - measures at least 500m$^{2.}$
  - is provided following the occupation of the first 300 dwellings.
  - provides for community meetings and activities, small-scale sports use and has the potential to house a local library resource.

- An increase in capacity at Glebelands Primary School for the anticipated 84 extra places needed as a result of Phase 1. This will entail the construction of an extra three classrooms and associated facilities.

- Additional nursery-age provision will be provided either at Glebelands primary school or on the proposed Market Street.

Quality of Life

Health and Affordability	Through the provision of highly energy and water efficient housing, local residents will be protected from the effects of fuel and water poverty. At least 30 per cent of the housing provided during Phase 1 will be affordable housing, in line with the adopted Local Plan. This will be delivered mainly via the provision of low cost, restricted floor space units and shared ownership units.

Accessibility	At least 20 per cent of the dwellings within Phase 1 will be accessible to disabled people.
Crime	It is the aim of the Council to see the opportunities for crime in the Phase 1 area reduced by the use of features such as designing all properties around public spaces to look out onto them. This will allow natural surveillance of the area and encourages resident activity, therefore making the area feel safer.
Other	A great deal of emphasis in the SPG is placed upon the "public realm" to ensure that this is designed to a very high standard and raises the perceived quality of the entire development. Developers are required to develop a "memorable place" that is easy to navigate due to the presence of "landmark buildings". A sense of community identity is to be created by paying careful attention to issues such as paving, planting, lighting, street furniture, signage, orientation, etc. and incorporating these into a common design theme for the whole of Phase 1.

Concept Cottages, Donnington

Location	Donnington, Lincolnshire
Type of area	Village
Tenure	Local Authority Rented
Built Form	Semi-Detached
Contact Name	South Holland District Council
Phone	01775 761 161
Visiting possible	By appointment only
Fee charged	None

Summary

Two semi-detached houses were built using factory-based, timber-framed construction methods in Sweden and then imported in completed sections to the UK for final assembly by Greenfield Way Ltd. who are based in the Midlands and specialise in this form of housing. These were the first houses to be built by South Holland District Council (SHDC) in over twelve years and are the first of their kind in the UK.

The site was chosen by the council because of its exposed position. This provided an opportunity to fully test the fabric of the buildings, the triple glazing, the heating systems and the heat recovery ventilation system. East Midlands Electricity carried out monitoring of the fuel consumption of the property on behalf of the project partners.

The houses aim to demonstrate sustainable social housing design and incorporate high levels of insulation and air tightness along with careful sourcing of components to reduce their environmental impact. The design also aims to contribute to the health of the tenants by incorporating measures such as whole house mechanical heat recovery ventilation and natural internal paints and finishes.

Project Objectives

South Holland District Council obtained funding to assess the benefits of highly insulated, low energy, timber-framed dwellings. The aim of the trial was to establish the viability of factory constructed, Swedish-style properties for the UK social housing sector.

Construction Details

Entire panel sections of the dwellings were prefabricated in factory conditions in Sweden and imported to the UK with all windows, doors and insulation already fitted. The sections were delivered to the site and lifted into place by a crane. They were then fixed together and the property was completed by a specially trained British workforce. A prefabricated bathroom ‘pod’ complete with all internal fittings including the shower and toilet was simply lifted into place. The two timber-framed houses were built in just over ten weeks, minimising the impact that the construction had on local residents.

The buildings are two-bedroom, semi-detached units of 70.63m^2 floor area. The homes are expected to last for 110 years and all materials used as part of the construction are recyclable at the end of their life.

Walls 120mm timber studs faced on the first floor with 22mm pre-strained timber cladding fixed to 13mm Bitumen impregnated fibreboard. The inner face is lined with 13mm plasterboard. The cavity is filled with 120mm rockwool insulation slabs. The ground floor walls are rendered with 30mm Heraklith board instead of the timber cladding. The partition walls between the houses are also prefabricated and are filled with 95mm of insulation to reduce acoustic transmission.

Roof Timber W-constructed trusses covered with impregnated fibreboard sarking and dressed with Decra metal tiling attached to timber battens. The floor of the loft space is insulated with 240mm rockwool insulation laid upon a reinforced glass fibre vapour barrier.

Floor The ground floor structure is a floating floor upon a concrete base. A 22mm Kährs parquet wooden floor is underlined with 70mm of Styrofoam insulation that in turn is underlined with a 0.20mm vapour barrier foil. The intermediate floor is finished with 15mm Kährs wooden flooring and includes 95mm of insulation for acoustic purposes. Tongue and grooved pine is used to finish the lobby floor.

Windows Wooden framed triple glazed units.

Waste Minimisation The nature of the Swedish based factory production system is extremely accurate and therefore reduces waste to a minimum at this stage of the process. The "Fast-Track" assembly method used on site also reduces the amount of transport movements needed to deliver all the component sections.

Additional

- Allergen-free painted surfaces.
- Simple profiled second fix timbers are used to limit the trapping of dust.

U-Values (W/m^2.K)

Walls	Ground floor	**0.19**
	First floor	**0.24**
Roof		**0.18**
Windows		**1.40**
Air Infiltration		**3.21 ac/h @ 50 Pa**

Resource Conservation

Heating There is no supply of mains gas to the site. Norwegian "Nobo" electric panel heaters are fitted throughout the properties. These are thermostatically controlled, with a programmable timer, and operate on peak-rate electricity. Due to the low heat loss rate of the properties, it was believed that storage heaters would be unsuitable and prone to causing the buildings to overheat.

Hot water is supplied from an un-vented, 125 litres, and electrically heated hot water cylinder. Monitoring undertaken by East Midlands Electricity has shown that the residents of each house consume

approximately 30 kWh per week heating water. Both properties house a family of three adults.

Lighting Low energy compact fluorescent lighting is used throughout the property.

Ventilation The property is fitted with an ADM Baxi whole-house mechanical heat recovery system. Pressure testing undertook by East Midlands Electricity of one of the units showed an air change rate of 3.21ac/h at 50Pa.

Water Conservation Aerating taps have been installed in both the bathroom and the kitchen to reduce hot and cold water demand. This results in energy saving as well as water saving as less hot water is used.

SAP / Eco-ratings The properties were rated for a SAP of 97.

Social Aspects

The residents of the properties have undergone several training sessions from both SHDC and East Midlands Electricity in order for them to fully understand the use of the heating system controls. This has had a noticeable effect in reducing the energy demand of the properties and has also led to a more appropriate control system being installed in one of the houses.

Residents took part in the monitoring process by submitting weekly meter readings to SHDC. East Midlands Electricity verified these readings with ad-hoc visits to the property. The residents have always been very helpful and positive about living in an 'experimental' property.

Well-Being

Various aspects of the project contribute towards a healthy internal living environment for the residents. These are:

- A well controlled, mechanical ventilation system with heat recovery that continuously provides fresh air to the internal space of the properties and removes stale, moist air to the outside.

- The use of allergen-free paints and finishes reduces the indoor air pollution often caused by the gassing-off of modern building finishes.

- By providing a well-insulated building fabric with a well-controlled and efficient heating system as well as providing training for residents in how to optimise the efficiency of this system, residents should be at little or no risk of suffering from the negative effects of fuel poverty.

- Features such as the hardwood floor and profiled second fix timbers limits the amount of dust traps within the property.

Costs

Each property cost £45,000 to construct. SHDC already owned the land so there was no cost for this.

The properties are designed to be low maintenance and therefore cheap to maintain. No figures validating this were available from SHDC.

Energy rating software used during the design phase of the project estimated the average annual space heating costs to be £63 per annum. The estimates for water heating were the same.
A 92-day trial conducted by the Council and East Midlands Electricity as part of their monitoring program covering December 1998 – February 1999 showed that the actual space heating costs for one property were £2.87 per week and, £5.18 per week for the other. Water heating costs for both properties were lower than originally predicted at £0.83p per week. This is some 30 per cent lower than the norm for this property and household type. The differences between the properties can be attributed to different occupancy and heating regimes adopted by the tenants. The same reason can be given for the costs being higher than predicted by the modelling software.

Additional Information

These were the first two dwellings of their type to be imported and assembled within the UK. Since their construction, the design and build company Greenfield Way Ltd. has worked in partnership with its suppliers both in Sweden and in the UK to improve the quality of its products and to adapt the overall design to complement the UK housing market.

The current products have 170mm filled cavities, use timber composite internal wall linings and incorporate specialist plumbing and rainwater materials to reduce the use of plastics used in the construction.

A formal Life Cycle Assessment (LCA) process has been adopted which investigates the impact of every component used in the buildings. The companies CONCEPT 2/3 design has achieved Local Authority National Type Approval Certificate (LANTAC) approval which assures its suitability for social housing throughout the UK.

The company now specialises in the social housing sector and has completed builds for several housing associations within the UK.

Project Partners

South Holland District Council (Project initiators and managers)
Greenfield Way Ltd (Design and build)
East Midlands Electricity (Monitoring and technical support)

The David Wilson Millennium Eco-House
School of the Built Environment, University of Nottingham

Location	University Park Campus
Type of Area	Rural
Tenure	Private Rented
Built Form	Detached
Status	Occupied, ongoing test facility
Contact Name	Professor S. B. Riffat
Phone	0115 - 951 3157
Web Address:	www.nottingham.ac.uk/sbe
Visiting Possible:	Yes, by appointment

Summary

The David Wilson Millennium Eco-House is a four bedroom detached property situated on the University Park campus of Nottingham University. It is occupied continuously by a group of researchers working at the School of the Built Environment who monitor and appraise the environmentally friendly energy features that are built into the property.

The house is of traditional construction using traditional building materials. In this way the project can provide a true appraisal of the technologies that are incorporated into it, and their relevance to the general housing stock. The design of the property is such that new technologies, techniques and building systems can be easily assimilated into the structure. They are connected to the existing systems and services, monitored and appraised by the researchers, and then removed or replaced if necessary.

The house also provides an educational resource to university students, to industry and to local schools and colleges. The university sees this as an essential role in inspiring future generations of engineers, architects and builders in the possibilities of sustainable technology.

Project Objectives

To provide a fully instrumented, occupied test house, to demonstrate and evaluate energy efficiency and sustainable energy systems, and to provide a test bed for new domestic scale systems.

Construction Details

The Eco-House is built using traditional brick and block construction techniques. It was designed deliberately to meet the 2000 Building Regulation requirements, which permits research to be carried out on novel techniques for upgrading the thermal performance of standard new build homes. The house is orientated to maximise solar gains in the winter.
It has a prominent location on the University Park campus.

Flexibility of the structure was an important design criterion for the project. The integration of a steel frame (see Figure 1) into the structure of the house means the fabric that makes up the rear of the property can be individually removed and replaced with other test materials.

The frame also provides a convenient mounting for the rapid testing of new sustainable energy systems such as solar thermal tubes and wind generators.

A solar chimney (see Figures 1 & 2) is integrated into the south facing facade. Air within the chimney is warmed by the sun and circulated into the property. The summer operation of the chimney is modified to vent warm air from inside the house and replace it with cooler air from a void beneath the concrete ground floor slab.

Monitoring sensors and data logging equipment are located throughout the property. Access for installing the required sensors and pipe and cable runs has been provided by a half basement below the ground floor slab, integrated conduit runs throughout the building and a clear span attic space.

Walls The 280mm thick external walls comprise of an outer leaf of either 103mm facing brickwork or a two coat sand cement render on 100mm thick 7N blocks. The inner leaf is 100mm thick 7N blocks and the 77mm cavity is fully filled with blown mineral fibre. The walls are lined internally with 9.5mm plasterboard.

Roof Photovoltaic tile arrays designed to produce approximately 1250 kWh of electricity per year are fitted in place of conventional concrete roof tiles on the southern facing side.

Figure 1

The steel frame in the southern half of the house, supporting two solar thermal collectors either side of the central solar chimney. Top-left is the vertical-axis wind turbine. The southern face of the roof features integrated PV tile arrays

.

Figure 2

Taken from the first floor landing, the internal upper vent of the solar chimney can be seen central. During the winter, air preheated by solar gain passes from the chimney onto the landing. During the summer, warm air from the landing is passively extracted and vented to the outside. Uppermost in the photograph is the landing lightpipe.

Floors The ground floor above the half basement consists of 150mm deep beam and block flooring finished with 16mm levelling screed, 40mm expanded polystyrene insulation and 19mm of moisture resistant grade chipboard.

Windows The double glazed units are set in wood grain finished uPVC frames.

Doors Treated softwood doors on treated softwood rebated frames.

U-Values (W/m^2.K)

Walls	**0.45**
Roof	**0.35**
Floor	**0.45**
Windows	**3.30**

Resource Conservation

The house is designed to test a wide and changing range of resource conservation technologies within its envelope. The following systems are, at the time of writing, installed within the property for tested:

Space heating Space heating for the property is provided by a variety of novel systems that include both passive and active heating methods. Passive solar gain is supplied through the south-facing facade and solar chimney. The principle behind the chimney is outlined above. Active heating includes

1. A WhisperTech microCHP unit has been supplied by Powergen so that its performance can be evaluated in a domestic building, as part of a trial program. The unit is rated to supply 8kW of heat and 1.2kW of electricity at the maximum burner firing rate. A comprehensive monitoring system has been installed alongside the unit, although no findings were available at the time of writing.

2. Two Solel, evacuated tube, solar water heating units are bolted to the steel frame on the southern facade of the building.

3. Ground couplings and a heat pump system from Clima-Gas Ltd, comprising:
   1 x vertical concentric tube at 50m depth;
   1 x vertical concentric tube at 20m depth;
   1 x vertical U-tube at 50m depth;
   1 x vertical U-tube at 20m depth;
   1 x 300m horizontal ‘slinkies’ tube just below the surface at the south side of the property;
   1 x heat pump (7kW heating, 5kW cooling, desuperheater for hot water supply).
   These three systems feed into a twin coil, 300-litre capacity thermal store, which is insulated with 50mm of spray-on insulation. The evacuated tubes and the ground source heat pump share a common heating coil within the store. These two systems are designed to meet most of the space-heating load for the building. They are disengaged at the time of writing however, as the

performance of the standalone microCHP unit is under investigation. Water drawn from the thermal store is circulated and controlled in the same manner as for a conventional wet central heating system. Domestic hot water is also drawn from the thermal store. A small contribution is made during the summer months from the heat pump desuperheater when the pump is running in cooling mode.

Lighting

Through good use of glazed elements, including external glass brick walls, the property is naturally well lit during daylight hours. Daylight is delivered deeper into the property through the use of Monodraught lightpipes (see Figure 3). These are highly reflective sealed ducts that transfer daylight from a clear dome on the rooftop to enclosed areas such as the downstairs cloakroom and the first floor landing. Low energy compact fluorescent lights (CFLs) were installed elsewhere throughout the property. These are currently being replaced by superbright LED installations from LED Lamps, which feature 80-90 percent energy savings on incandescent bulbs and a typical lifespan of 100,000 hours.

Figure 3.

External and internal views of the combined lightpipe/wind-catcher system situated on the peak of the roof.

Ventilation and Cooling

Natural ventilation is provided throughout the property via the solar chimney, the Monodraught wind-catcher installed on the roof and by occupants opening and closing windows and doors. Additional mechanical extract ventilation is provided to the kitchen and bathroom. During the summer months the operation of the ground source heat pump is reversed so that it extracts excess heat from the property and passes it into the ground outside the building. The solar chimney also passively cools the building as mentioned previously. Both of these systems have undergone testing during which they were monitored continuously by University researchers.

Energy generation

The south-facing section of the roof features Atlantis Sunslates; mono-crystalline photovoltaic tiles that replace the conventional roof covering. This integrated system has been designed to deliver approximately 1250kWh of electricity per annum; roughly one third of the building's estimated need. An inverter converts this electrical energy into conventional mains current. Any excess energy generated is stored in batteries that power the School's electric van.

A small, vertical-axis wind turbine manufactured by Windside is sited on the south-western corner of the rooftop. This provides additional power for the monitoring equipment present in the property. A larger vertical-axis wind turbine and two 1.8kWp sun-tracking photovoltaic arrays sited near to the house (see Figure 4) supplement the system,

which is further complemented from time to time by various test generation units that are bolted onto the property's frame.

Figure 4

The two sun-tracking PV arrays situated nearby the Eco-House. Inset is an image taken during the laying of the PV tiles that replace the conventional roof slates.

Water Conservation Rainwater from the roof of the house is stored in an underground tank and used by the property's residents. A processing unit located below the kitchen sink filters and purifies the water before it reaches the appliances. Filtered water is used for flushing the toilets in the house. Water receiving an additional sterilising treatment can be used for wash hand basins, washing machines, etc.

Economic Aspects

The cost of designing and building the Eco-House was approximately £200,000, not including monitoring renewable energy technology.

Source of Funding:

House construction	David Wilson Homes
Special Technology	Funding for the technology under test within the property is ongoing and delivered from various UK and European government sources, as well as industry.

Additional Information

Although there are no plans to replicate the project as a whole, it is hoped that many of the systems tested on the building over the coming years will one day become common specification for all new build and appropriate retrofit properties.

Project Partners

Nottingham University School of the Built Environment
David Wilson Homes
Maber Associates Architects

Littleover Energy Efficiency Project, Derby

Location	Hall Park Close, Littleover
Type of Area	Urban
Tenure	Social housing rental
Built Form	2-3 storey, 1-3 bed flats
Status:	Ongoing programme
Contact Name	Andy Daykin Derwent Housing Association, Technical Services
Phone / e-mail	(01332) 346 477
Visiting Possible	Only by prior arrangement
Fee Charged	No

Summary

This is a refurbishment project of 71 flats on an estate in Derby that was experiencing serious problems of fuel poverty, high tenant turnover, vandalism and was rapidly becoming a sink estate at great financial cost to the housing association.

In 1997 the Association contracted an energy consultant to develop a scheme that would provide affordable warmth to tenants, reduce tenant turnover and be cost effective with a six year payback period.

The strategy included:

- thermal dry-lining the units on their external and stairwell walls;
- reducing the capital cost of the replacement heating system by reducing the thermal load;
- insulating the ceilings of top floor flats.

These measures were delivered cost effectively by combining the energy efficiency upgrade with the standard refurbishment of the flats. The cost of the project was also offset against revenue gains from a reduction in tenancy voids. Together, these measures made the project financially feasible.

The result was a 50-60 per cent reduction in fuel costs for the tenants, and a tenant turnover rate of five per cent per year, down from 50 per cent before the works were carried out. The improvement in tenant turnover is due mainly to the improved living conditions of the flats and the improved affordability of keeping them warm.

Project Objectives

To provide affordable warmth to residents living in electrically-heated 1970s flats and reduce tenant turnover. The payback time for investment had to be kept as short as possible.

History of Concept

The Littleover estate consists of seventy one flats of one-bedroom and three-bedrooms. All units were designed in the 1970s and are heated by electricity, which resulted in tenants spending up to £25 per week on electricity bills during the winter. Consultation with the tenants revealed that most were heating only the lounge and one bedroom, and often to an

inadequate temperature. Tenant turnover was running at a rate of 50 per cent per year, and they often left the flats in a state of disrepair when they vacated. The costs of repairs, along with the lost revenue from frequent voids, meant that the estate was a financial liability to the housing association. Socially, it was becoming a 'sink' estate, with a high incidence of crime and social exclusion.

An energy consultant was employed by the housing association in 1997. He recommended that a pilot flat, which was already due for a refit of its kitchen and bathroom, be refurbished using an energy saving design that called for the external walls of the flat to be dry-lined with thermal board. This would result in less space heating being required and so lower running costs to the tenants. The refurbished flat was monitored for a year to assess its effectiveness.

The standard heating system installed in the flats up to this point had been four storage heaters and four panel heaters. These were often vandalised by the tenants when they vacated the units. The refurbished scheme achieved adequate internal temperatures using just one or two storage heaters and one panel heater. This reduced both the running costs to the tenants and the capital costs to the Housing Association. It also reduced the value of equipment that could be vandalised.

In 1999, based on the results of the first year of monitoring, Derwent Housing Association embarked on a programme to upgrade all the flats to the same specification over the next five years. The kitchen, bathroom and window replacement programme was brought forward, which made internal lining with insulation boards economically viable. Three or four flats were upgraded at the same time, which reduced unit costs. A cost analysis was undertaken, setting the void cost savings against the costs of the energy efficiency upgrade. This suggested that the measures installed would pay for themselves within six years if the void rate could be reduced to five per cent per year.

Construction Details

Built form Refurbishment of seventy one flats of one to three bedrooms on two to three storeys, originally constructed in the 1970

Roof Traditional 1970s pitched roof construction with tile over felt. The loft floor (ceiling of the top floor flats) was insulated with 250mm of mineral wool insulation.

Walls The walls are of cavity construction that was originally filled with expanded polystyrene granules. These were dry-lined using Rockwool mineral wool slab under plasterboard as part of the refurbishment scheme.

Floors The traditional concrete slab floors were maintained, as there was no economically viable method to upgrade their thermal performance within this project

Windows Double glazed units with uPVC frames.

U-Values (W/m^2.K)

Walls:	**0.30**
Floor:	**0.50**
Roof:	**0.15**
Windows:	**2.70**

Resource Conservation

Heating After refurbishment, the heating system in each flat consisted of one to two storage heaters and one panel heater. No gas is available onsite.

Lighting Dedicated low energy fittings are installed in the circulation areas of the flats. Low energy light fittings were also installed in high use areas such as hallways.

Ventilation Mechanical heat recovery ventilation is installed in all flats and set permanently to the 'trickle ventilation' mode.

An 'extracted' drying cupboard was also installed in each flat to encourage tenants not to dry their clothes over the storage heaters, thereby reducing the amount of moisture within the flat.

Resident training A tenant's user manual was developed, which explained to tenants how they could maximise their energy savings in the refurbished flats. Monitoring of the tenants attitudes to energy over the last few years has revealed an increased awareness of energy efficiency issues.

SAP / Eco-ratings The refurbishment achieved an increase in the units' SAP ratings from 42-47 to 66-91, depending on the external exposure of the individual units.

Social Aspects

The residents of all the flats were invited to a 'Show-house' open day of the pilot flat.

A tenant questionnaire has been devised to gain feedback on the project. At the time of writing, no details were available for analysis.

Economic Aspects

The cost of development for the energy efficiency measures in a three bedroom flat was £4,400. Subsidy of £10,000 was received from Powergen through the Energy Efficiency Standards of Performance scheme (ESSOP). For the total project

Monitoring revealed that total fuel costs were on average between six and eight per cent of the tenants' income after the refurbishment.

Additional Information

The project team achieved their objectives in finding a cost effective solution to some of the problems experienced by the tenants of these units. Many tenants have experienced fuel cost savings of between 50-60 per cent, and tenant turnover in the converted flats reduced to the target of five per cent per year.

The main barriers to the fulfilment of the project were:

- The cost of the works. At £4,400 per unit the cost of the new energy efficiency and heating products was very expensive. The project was able to proceed only by embedding the energy efficiency program within the maintenance department's kitchen, bathroom and window replacement programme. The other key factors in achieving financial success were a reduction in the capital costs of the heating system, by installing

a smaller system, and reducing the loss of revenue through tenancy voids. Combined, these factors gave a 5.9 year payback period for the initial investment.

- Reducing the energy costs of the units was dependent upon tenant behaviour. It was therefore essential for the Housing Association to develop an operating manual for the tenants, and to talk them through the concept of the flat and the way in which the heating and ventilation worked.

- A small minority of tenants refused to use the mechanical heat recovery ventilation system and turned it off against the advice of the housing association. Overcooling by the ventilation system was noted in some flats and the specification has since been revised. The system has been scaled down to ventilate just the bathroom, kitchen and bedroom. This has reduced the capital cost of the units and the noise problems experienced by some of the tenants.

As the project is ongoing over five years, lessons have been learned and changes have been made to the project's specification. For example, fanned storage heaters have now been introduced for improved efficiency and heat distribution.

Resident's Comments

Information from the housing association suggests that the tenant of the pilot project flat became very enthusiastic about the project. Many tenants have expressed their appreciation of the work that has been carried out, and some have given positive comments to newspaper journalists and on television programmes when the scheme has attracted media attention.

There has been resistance from some tenants however to providing the housing association access to their homes to allow the refurbishment program to take place ahead of schedule. At the time of writing, approximately 25 per cent of the flats are yet to be upgraded.

Two or three of the tenants have made complaints about the comfort levels or fuel costs of the flats, but the problems have usually been found to be more about the individual tenant's lifestyle than about the energy performance of the dwellings.

Project Partners

Derwent Housing Association
Martin Gamble (energy efficiency consultant)

Sinfin and Mapperley Energy Efficiency Projects

Location	Merlin Green, Sinfin, Derby Bennett St, Mapperley, Nottingham
Type of Area	Urban
Tenure	Housing Association
Built Form	Terrace
Contact Name	Andy Daykin Derwent Housing Association, Technical Services
Phone / e-mail	(01332) 346 477
Visiting Possible	Only by prior arrangement

Summary

This project developed five units, with the aim of demonstrating how low-energy design can be delivered for the same cost as 'standard' housing, which was being developed in parallel on the same sites. The units were three adjoining terraces at Sinfin and one pair of semi-detached dwellings at Mapperley. The dwellings were extensively monitored over a two year period and were found to provide affordable warmth to residents while costing on average just £49 more per dwelling to build than 'standard' housing.

The dwellings incorporate high levels of thermal mass through the use of dense blockwork in the wall construction. Other features of the project include mechanical heat recovery ventilation, high levels of insulation, high air-tightness, locally sourced materials, timber windows and doors and experimentation with different heating systems.

The project has led to the Housing Association revising its housing specification and onsite working practices, as well as the development of a new gas wall heater by a commercial manufacturer.

The additional build costs for the project were offset by the exclusion of gas central heating from all dwellings within the project. Total fuel costs to the residents average £307 per year, about six per cent of the average annual income of the residents.

Project Objectives

To demonstrate that energy-efficient housing can be built at a similar cost to 'standard' construction.

History of Concept

Following the success of the Littleover refurbishment project (see separate case study), an energy-efficiency design consultant was invited to look at the standard housing types being

constructed under Derwent Housing Association's development programme. It was felt that the thermal specification of the 'standard' design could be substantially improved, creating homes that were more energy efficient for the same construction budget. This would be achieved by trading the savings gained by removing the central heating system against the additional cost of the energy efficiency products. This approach was based on prior research conducted by the energy consultant.

Construction Details

Built form Terrace row of three two bed units (Sinfin) and two semi-detached two bed units (Mapperley).Both developments were on greenfield land adjacent to existing housing.

Roof Traditional pitched roof construction with the loft floor insulated using 250mm of mineral wool.

Walls Brick and dense blockwork with a 150mm cavity fully filled with batons of mineral wool insulation. High thermal mass is gained from the use of the high-density blockwork for the inner wall skin. The walls are wet-plastered internally to improve the air-tightness of the buildings.

Floors Concrete upon a 100mm expanded polystyrene slab.

Windows Timber-framed double-glazed units with a 20mm air gap. The timber frames were sourced from a local manufacturer

.

Doors Timber construction, sourced from a local manufacturer.

Internal Layout The dwellings are arranged internally so that passive solar gains can be used to offset the need for heating. The lounges are on the southern side of the units and the kitchens are on the northern side.

Construction Impact Existing hedges on the sites were retained during the development.

U-Values (W/m^2.K)

Walls:	**0.21**
Floor:	**0.25**
Roof:	**0.15**
Windows:	**2.70**

Resource Conservation

Heating The dwellings are heated by the following means:

- All units have a gas fire fitted in the lounge.
- Electric panel-heaters are fitted to the first floor landings in two dwellings. These use off-peak electricity to warm the thermal mass of the units overnight.
- A 3kW gas wall-heater is installed in one dwelling in place of the panel heater.

- An instantaneous, multi-point, gas water heater provides hot water for the dwellings.

The financial costs of the additional energy efficiency measures were offset against the savings gained by not installing a conventional gas-fired central heating system.

The Sinfin units were monitored for two years (1998 and 1999) using spot internal temperatures, air-tightness and thermal imaging techniques. It was found that the mid-terrace performed best, with an energy consumption figure of 23 percent below SAP estimates. The end terrace with the fanned gas wall-heater achieved 3 percent below SAP estimates, and the end terrace with the electric panel-heater was 20 percent over the SAP estimate. Average annual recorded running costs for the dwellings were £307 per year (gas and electricity for all uses). This equates to 6 percent of the average household income for residents in the scheme, and therefore below the 10 percent affordable warmth target. Consistent background temperatures of 20°C were recorded with the heating switched off, demonstrating the effectiveness of the thermal mass.

The monitoring results for Mapperley were not available at the time of writing.

Lighting A dedicated low-energy lighting system is installed in both the kitchen and hallway of the dwellings.

Ventilation Mechanical heat recovery systems are installed in all dwellings. A single 'through-the-wall' system is installed in the kitchen to ventilate the ground floor, and a remote controlled, ducted system is used on the first floor.

SAP / Eco-ratings Data only exists to provide ratings for the two end terrace units, which achieve a SAP of 102 (22.08 GJ/yr.) for one unit, and a SAP of 92 (24.71 GJ/yr) for the other unit.

Transport

The dwellings are located within existing housing estates that are well served by a variety of shops and local supermarkets. Public transport is available locally from both sites, with regular buses into the town centres.

Social Aspects

A handbook explaining the concept behind the houses and giving details on the efficient operation of the heating and ventilation systems is provided to all the housing association's tenant advisers, who pass this information onto the tenants. Residents took part in the monitoring of the dwellings for two years after their completion.

Communal Facilities

A new play area for the residents' children was created as part of the project.

Well-Being

Health and Affordability	The use of a highly insulated structure reduces the cost to the residents of heating the dwellings, and therefore reduces their risk of suffering from fuel poverty.
Crime	All dwellings built as part of the scheme meet the national 'Secure by Design' standard.
Adaptability	All dwellings built as part of the scheme meet with the national 'Lifetime Homes' standard.

Economic Aspects

The cost of development on average, the dwellings cost £49 more to build than the 'standard' units on the site. Funding was provided by the housing Corporation and the housing association's own resources.

Additional Information

Members of the project team made the following points concerning this project and its relevance to future projects:

- The project team had difficulty in locating appropriate gas heaters for the project. The maximum heating requirement per home is 2.5kW, and the ideal solution would therefore have been to provide 2kW of heating to each floor. At the time, no manufacturers were supplying a gas heater of this size that incorporated thermostatic control. Less effective units therefore had to be used, which had a negative effect on the SAP rating of the dwellings. A 2kW unit with thermostatic control has since developed by the project team in partnership with a manufacturer, and is being used in similar schemes as well as being commercially available.

- The initial 'warming-up' period of the large thermal mass led to higher fuel costs than anticipated during the first quarter of the year. This was due mainly to the time of arrival of the first residents, which was in December. Complaints concerning the additional fuel costs were received from the tenant whose property did not perform as well as anticipated by the SAP analysis.

- Due to the success of this scheme, the Housing Association revised their standard specification to include dense blockwork on the internal partition walls, in addition to the external walls, as a way of creating greater thermal mass. They have since incorporated this idea, in conjunction with the new gas wall heaters, into a recent scheme of flats. They encountered problems with drying out the wet plaster used on the partition walls however, and some mould growth occurred on these surfaces. The problem is believed to be due to the contractors treating wet-plaster in the same manner as dry-lining and not giving the plaster time to dry out before fixing cupboards, etc. to it.

- Problems were encountered with the mechanical heat recovery ventilation (MHRV) system. The system on the upper floor of the dwellings was overcooling, leading to an increase in the heating load. The 'through-the-wall' units fitted in the kitchen appeared to be causing the water vapour to migrate around the lower floor of the house. This initially led to MHRV systems being omitted from all future schemes, although recent projects that utilise a smaller multi-room MHRV have been more successful.

- During the monitoring period, it was found that the dwellings at Sinfin demonstrated poor envelope air-tightness. The project team have revised their onsite checks to ensure that air-tightness and the installation of insulation are checked more thoroughly during future constructions.

- The two properties in Mapperley were constructed as part of a development designed for shared ownership. No additional marketing was required to encourage buyers to purchase a share of these properties compared to standard properties within the scheme.

Project Partners

Derwent Housing Association
Martin Gamble (energy efficiency consultant)
Robinson Willey (gas appliance manufacturer)

The EcoHouse, Leicester

Location	Western Park, Leicester
Type of Area	Suburban
Tenure	Private rental and demonstration project
Built Form	Detached, 2 storey
Contact Name	Ben Dodd
Phone / e-mail	(0116) 222 0222
Website	http://www.environ.org.uk/
Visiting Possible	Yes, open to public.
Fee Charged	Voluntary charge of £2 for adults and £1 for concessions

Summary

A 'lived-in' environmentally friendly show-home that is open to the public and incorporates many of the features of environmentally sustainable construction.

Project Objectives

The EcoHouse project's objective is to demonstrate to the public that often the best option for the environment is also what's best for the people living within that environment. It aims to inspire its visitors to implement practical changes in their homes and gardens to make their lifestyles more sustainable.

History of Concept

Originally built in the 1920s as a park-keeper's cottage, Environ took control of what is now the EcoHouse and opened it to the public in 1989 after a 'green' retrofit. Ten years later, after over 100,000 people had visited the project, the EcoHouse was re-launched following the completion of an extension and refit programme.

The project is now two houses in one; the original 1920s dwelling and an extension built to 1999 best practice specification with regard to construction materials and energy saving techniques. The project provides a valuable source of information for people wishing to undertake a green retrofit of their homes, those building extensions to their homes, and those building a new home.

The design of the extension is in keeping with the original house and with other housing in the surrounding area. It was designed to be acceptable in style to as wide an audience as possible, ensuring that a majority of visitors see it as desirable.

The project team wanted to employ an architect and a firm of builders who had an interest in environmental issues but who had no real 'green' building experience. This was so that a learning element was included in the process, and to prove that it is possible to construct a low-energy dwelling without any previous expertise.

Construction Details

The original building is of standard 1920s construction, i.e. brick cavity walls, timber and slate roof, etc.

The extension, which effectively doubles the floor area of the house, is traditional in appearance, but the individual components are more novel in design. Since the EcoHouse aims to be of a demonstrative nature, as many different products as possible were used in order to test their performance and to raise public awareness of the range of products available from different manufacturers. This report does not have the scope to cover all of the products installed at the house. Rather, an overview is presented of what the project attempts to achieve. More detailed information can be obtained from visiting the house or contacting Environ directly.

Walls In keeping with the original building, the new build walls are of brick and block construction, but all the bricks used are recycled colour-damaged stock that were due to go to landfill. The interior block leaf is made from compressed power station ash. Cavities of 150mm allow extra mineral wool insulation to be inserted between the inner and outer leaves. Mineral wool does not leech the toxic fumes associated with urea-formaldehyde based insulating foams.

Roof Many of the roof tiles used were from recycled sources and the loft is insulated to a depth of 200mm with Rockwall (mineral wool).

Windows and Doors The windows and doors feature double-glazed, low-emissivity glass, with a 21mm argon filled gap. This gives better thermal performance than standard triple glazed units. All wood used in the construction was certified by the Forestry Stewardship Council (FSC), including the window frames. The windows are also fitted with insulated shutters that reduce heat loss at night and give protection from vandalism. All door finishes are metal, and all solid doors are filled with insulation to make a 'thermal sandwich'.

Other The amount of PVC used in the construction was kept to a minimum. All of the electrical cabling is PVC-free 'low smoke and fume cabling', the guttering is galvanised steel, the window frames are FSC certified timber, the heating and plumbing pipes are polypropylene, and the underground rainwater and waste pipes are made of clay.

Finishes within the house have been selected for their low environmental impact. They include nine types of environmentally friendly paint, recycled wallpaper, recycled wool carpets, carpet underlay made from recycled car tyres and rubber floor mats made from recycled aircraft tyres.

Recycled materials again feature prominently in items such as the kitchen worktops, sink splash-backs, cupboard doors, picture frames, and shop shelves that are made from recycled plastics originating from drink cartons, coffee cups and coat hangers.

Internal Layout The nature of the development is that of a visitor centre, and the internal layout is designed around this purpose. However, the project designers have still been able to simulate the effect of bringing the main living areas of the house to the south-facing side of the property. This helps to offset both the winter heating load and the lighting electrical load. Areas such as the kitchen and bathrooms are located against the north facing facade.

Impact The property's site is compact with relatively poor access. The only way construction traffic could access the site was to cross the organic vegetable garden. The topsoil from the garden, which had been created over at least ten years of organic gardening, had to be removed from the site, stored and replaced after the construction was completed, in order to avoid its compaction and degradation.

Waste produced during the development was divided between different skips (wood, metal, etc.) so that as much as possible could be recycled or reused onsite.

Resource Conservation

Heating The EcoHouse demonstrates two types of heating systems; one for the original building and another for the extension.

The original building is fitted with a gas-condensing boiler that feeds into traditional radiators controlled by Thermostatic Radiator Valves (TRVs) and with radiator foil fitted behind them. Normal controls such as room and hot water cylinder thermostats are used to maintain the correct temperatures and improve the efficiency of the system.

The extension is much more thermally efficient than the original house and does not have the heat load to require a condensing boiler. Solar water heating panels mounted on the roof of the south facing facade supplement a high-efficiency non-condensing boiler, to heat the water in a 300 litre thermal store. A heat exchange coil runs through the store and feeds into an underfloor heating system. Domestic hot water is directly drawn off from the store.

Lighting Low-energy lighting is used throughout the property, with the exception of some of the exhibition displays where its use would have been inappropriate.

Ventilation Whole-house mechanical heat recovery ventilation (MHRV) is used throughout the building to remove stale air and moisture, and replace it with fresh, preheated air. 70 percent of the heat extracted is returned to the incoming air, reducing the energy losses usually associated with ventilation systems. All ducting for the ventilation system is PVC-free.

Energy Generation Part of the south-facing roof is covered with polycrystalline photovoltaic tiles that substitute for conventional roof covering. The weatherproofing qualities of the tiles are equal to that of normal roofing materials, and a marginal economic saving is made when compared to the traditional method of installing PV arrays on top of the roof covering. Inverters convert the electrical current produced to standard household AC current. This is used by appliances within the house or exported to the national grid when a surplus is generated. When there

is a shortfall of generation, the national grid is used. The total peak output of the tiled array is 1.4kW.

Water conservation Many water-saving features are on display both in the house and in its garden.

The features within the house include: rainwater toilets linked to an 'eco-vat' water storage tank, a grey water recycling system from the bathroom and kitchen appliances, aerating heads fitted to all taps, and presence detectors fitted to the public toilet taps. A composting toilet for the use of the house residents is also provided along with a low-flow shower unit and low-water consumption appliances in the kitchen. The garden has rainwater butts for irrigation purposes and has been planted with drought resistant plants.

Recycling facilities Recycling facilities are built into the kitchen to encourage the residents to recycle glass, aluminium, paper, some plastics and organic waste.

Transport

The house is close to local bus stops and is easily reached from the centre of Leicester city. Cycle locking facilities and a car park are available onsite.

Landscaping

The third of an acre site is managed organically and integrates some principles of permaculture. The idea is to demonstrate many different techniques of maintaining a garden for people, wildlife and for growing food. A range of courses are offered each year to the public, operating from one day to a whole year (at weekends) and covering different aspects of sustainable gardening and food growing.

Examples of composting and grey water recycling (using marginal plants) and rainwater recycling are presented. Landscape plantings provide visual and acoustic barriers for the house as it is close to a major road. In addition, the planting of thorny shrub species such as quickthorn on the boundaries provides an additional security deterrent for the property, which has encountered problems in the past with vandalism.

A pond and a wetland area have been created as part of the new project. These handle the overflow from the property's grey and rainwater systems, and form part of the organic gardening strategy by providing a habitat for species that are beneficial for pest control, such as frogs.

Well-Being

Health and affordability The importance of a healthy indoor environment is recognized by the use of natural materials that do not leach solvents, formaldehyde, etc. into the air. An efficient and affordable heating and ventilation system keeps the house warm and reduces internal moisture levels. Water is made affordable to the residents by conserving and reusing water; etc.

Accessibility The EcoHouse is designed to be accessible for all and a lift can be used to reach the first floor. A disabled toilet and baby changing facilities are also available.

Adaptability A demonstration eco-home office is featured within the house, to encourage people to consider the option of adapting space for home working, and reducing the effects of their commuting upon the environment.

Crime The insulated window shutters and the thorny vegetation around the site boundary demonstrate two sustainable methods of enhancing crime protection.

Economic Aspects

The house is leased to Environ by its owners, Leicester City Council, for a 99-year period for a peppercorn rent. The development cost was in the region of £410,000. This was funded by an award of £229,000 from the National Lottery Charities Board, £120,000 from an Article 10 bid, and over £60,000 in kind from various product manufacturers and suppliers.

Approximately £213,000 was used for the building construction. The remaining funds were used to develop the interpretation elements of the project such as displays, literature, marketing, etc., and to provide a project worker.

A shop stocking environmentally friendly household products, as well as a range of books covering 'green' building issues, is located within the visitor centre. There is also a café where visitors can purchase a range of organic and Fair Trade drinks and snacks during their visit. The EcoHouse also acts as a collection point for the local organic vegetable box scheme, for which it receives a small payment.

Barriers and Lessons

The EcoHouse project manager believes that the initial objectives of this stage of the project's evolution have been met, but further objectives are constantly being set to ensure that it remains ahead of market trends.

The barriers encountered during the redevelopment phase were primarily financial. Finding a building company who could build it for the estimated price presented major problems, with the tenders being over twice that of the initial cost estimates. Errors in quantity surveyor costing meant that many of the more innovative environmental features had to be omitted in order for the project to be completed on budget. These included a living roof, a workshop for various training courses, and the building energy monitoring system to validate the project's claims. Environ have been involved as consultants on several other 'green-build' projects, and find that this is a common experience, with quantity survey estimates often being 50 to 100 per cent too low.

Obtaining a contract with the local Regional Electricity Company (REC), to sell surplus energy generated by the photovoltaic panels to the grid, was a long and complicated process. The project manager believes that this was more to do with the mindset of individuals within the REC than with any political or regulatory issues.

Project Partners

Environ

The National Lotteries Charity Board

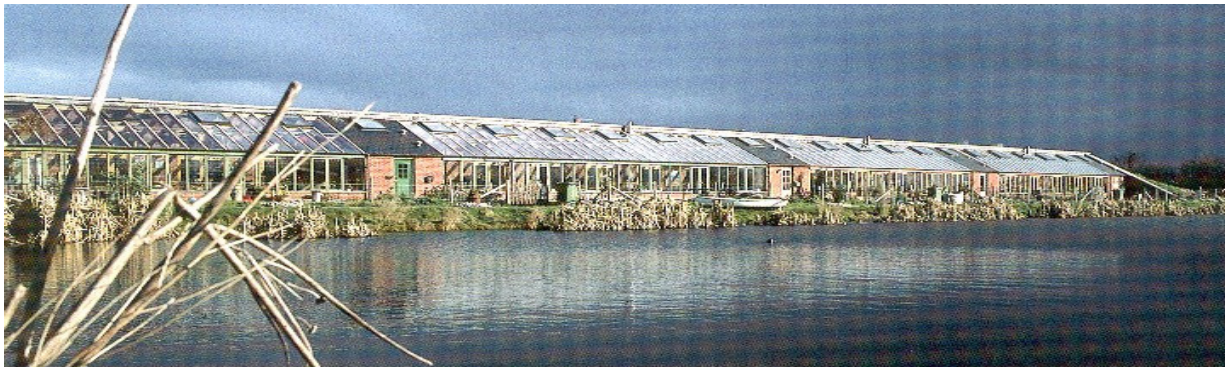
Leicester City Council

De Montfort University (Leicester)

YMD Architects (Leicester)

Various product manufacturers and installers

Hockerton Housing Project



Location	Hockerton, Nottinghamshire
Type of Area	Rural
Tenure	Owner occupied on 999 year lease
Built Form	Terrace
Status	Occupied since 1998, project development ongoing
Contact Name	Nick White
Phone / e-mail	(01636) 816 902 hhp@hockerton.demon.co.uk
Web Address	http://www.hockerton.demon.co.uk
Visiting Possible	Yes, by appointment and frequent guided tours (see website)
Fee Charged	Yes

Summary

Hockerton Housing Project (HHP) consists of a row of five terrace dwellings designed to incorporate the principles of passive solar design with the techniques of earth sheltering. The dwellings were built, to a large degree, by the residents themselves. The construction is super-insulated, with a high thermal mass, and covered on three facades with a layer of soil at least 400mm thick. This lessens the visual impact of the construction and reduces heat-loss.

The south facade is heavily glazed using high specification windows and is buffered from the outside by a timber conservatory. The conservatory acts as a solar collector, providing heating to the homes by natural convection, and heating the domestic hot water supply via an air-to-water heat pump. To provide good daylighting, all the main living rooms have windows that open onto the conservatory, which offsets the need for artificial lighting.

The project aims to develop working opportunities onsite. All residents contribute an agreed number of hour's work each year towards community purposes, such as land management, food growing and onsite cooperative business.

A communal office facility has recently been built, which will serve also as a resource centre for visitors. A number of research and networking projects are underway, through which the group hopes to stimulate more projects of this type around the country.

The following awards have been won by the project:

- A 'Major Commendation' was awarded in the Business Commitment to the Environment (BCE) Awards for 1999, in recognition of exemplary achievement in environmental activities.
- Winners of the 'Not For Profit' category of the Eurosolar UK Awards (2000), for outstanding service to the promotion of renewable energy

Project Objectives

To create one of the most energy efficient, purpose-built developments in Europe that demonstrates a zero-energy design by reducing life cycle energy to a minimum. The houses are earth covered and have passive solar heating without a space heating system. The project aims to be as autonomous as possible in terms of energy and water, and provides homes that offer financial savings in the medium to long term, with no loss of comfort or modern amenities.

History of Concept

Nick Martin, whose family owned the original 25 acre site, initiated the project by getting the group members together in 1993. As a builder, Nick had built the UK's first autonomous house at Southwell (see separate entry). During that project, he had become increasingly convinced that combining resource conserving elements with the principles of earth-sheltering was a way forward for developing even more energy-efficient housing. He hired Dr. Robert Vale to design what has since become one of the UK's most famous housing projects.

The planning application for a terrace of five dwellings was approved, subject to a S. 106 Agreement, in May 1994. This delayed construction for two years; however, the first family took occupancy in February 1998, followed by the remaining four over the course of the year.

A similar agreement was used to secure planning permission for a further two earth-sheltered properties in an adjacent field, which are approaching completion at the time of writing.

Construction Details

Built form The initial development consists of a terrace of five earth-sheltered dwellings. Two further dwellings have been constructed on an adjacent field, as well as a Sustainable Resource Centre. The site is whitefield and planning permission was only approved subject to a S. 106 Agreement.

Approach The dwellings are designed to be heated purely from passive solar gains and incidental internal gains. The structure's high thermal mass moderates the internal temperature against external variations, as heat gains are stored and released over long periods of time.

The entire building envelope is highly insulated with 300mm of Jablite expanded polystyrene surrounding the external sidewalls, roof and slab floor of the structure. Within this insulating envelope lie a 200mm thick reinforced concrete roof, a 300mm floor slab and a 450mm thick rear wall. On top of the insulating envelope is an impermeable double-layer waterproof membrane and 400mm of grassed earth.

Walls The front wall (conservatory rear wall) has a 150mm Drytherm filled cavity.

The conservatory and entrance porch act as thermal buffer zones on the exposed south facade. The design allows the conservatory to be completely isolated from the main house during winter.

Roof The soil on the roof acts as a thermal flywheel, as the temperature of the soil lags weeks behind seasonal changes in air temperature. During the summer, the winter/spring temperature soil draws heat from the structure and provides cooling. Conversely, during the winter, the summer/autumn temperature soil

lessens the temperature difference between inside and out, therefore reducing heat loss.

Floors The internal structure is kept as exposed as possible, which maximises its ability to absorb and emit heat. Carpets have an insulating effect on the floor's heat transfer capability, therefore clay tiles have been used for most of the floor coverings.

The floor slab extends three metres in front of the main living space to accommodate the conservatory floor. This is thermally broken from the house floor slab to reduce heat loss to the conservatory space during cold weather.

Windows Two layers of high specification glazing are used across the south facade. Between the bays and the conservatory, triple glazed windows with two layers of low-emissivity coating, insulated spacers and argon gas filling are used. The outer conservatory glazing is double glazed with a low-e coating. All window frames and doors are imported by Swedhouse Ltd. and are made of timber from a sustainable Swedish redwood source. There are no glazed elements on any other facade.

Internal Decoration All paints, varnishes, sealants, etc. were chosen for their low environmental impact and low toxic content to provide a healthier indoor environment.

Rainwater, Plumbing The project avoided using PVC for windows, conservatory structure and electrical wiring. Copper was used for all rainwater goods from the conservatory roof, again to avoid PVC.

Construction Impact The onsite environmental impact of the construction process was limited through the careful choice of materials and the reduction of construction waste, including packaging. The self-build nature of the construction meant that waste produced from a particular operation was often incorporated into another aspect of the project.

The concrete used was quarried locally to reduce transport energy use, and the project has planted over 4000 trees on the land to offset the CO_2 generated by the energy embodied in the construction materials. The facing bricks used on the south-facing facade were supplied by a local company that uses landfill gas (methane) to fire them.

The earth covering significantly lessens the visual impact of the houses from the surrounding roads.

Internal Layout The style of the dwellings is based on a repeated modular construction system, forming a series of bays 3 metres wide and 6 metres deep separated by 200mm concrete block walls (see Figure 1). Four of the homes have six bays each and one has seven.

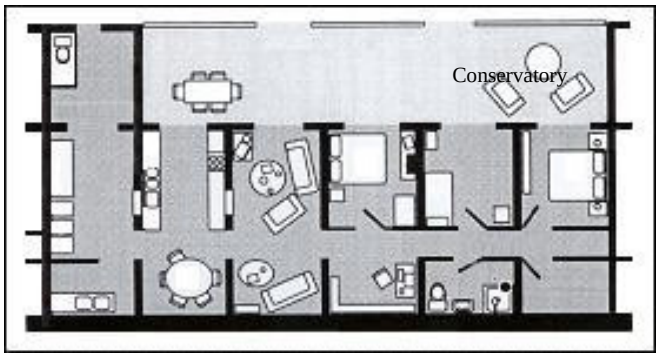


Figure 1. Internal layout of six bay dwelling. Note the use of an extended porch wall (top right) to form the conservatory sidewalls.

U-Values (W/m^2.K)
Excluding the effect of the earth covering

Rear Wall:	**0.11**
Floor:	**0.11**
Roof:	**0.11**
Windows: (Triple)	**1.15**
(Double)	**1.90**
Air Infiltration:	**0.95-1.23 m^3/h/m^2 @ 50 Pa**

Resource Conservation

Heating

Energy conservation was a primary objective of the design process, and a space heating system is not required due to the passive solar design and super-insulation. A wood stove is occasionally lit in the conservatory for aesthetic purposes rather than heating.

A Baxi air-to-water heat pump installed in each conservatory mechanically draws warm air from the sunspace. The air's heat is extracted and passed to a water-filled thermal store. This action also helps to cool and extract moisture from the conservatories, which are often used for drying clothes. The heat is stored in a hot water cylinder with a 1500litre capacity, which, when heated to its maximum, is enough for up to a week. The heat pump requires an electrical input to run, and an electrical immersion coil provides back-up for cold spells. The system's overall efficiency is dependent on the amount of heat available from the conservatory, and therefore on the solar gain.

Lighting

All the main living areas are well day lit, and compact fluorescent lights (CFLs) are used throughout.

Ventilation

Each dwelling has its own Baxi mechanical heat recovery ventilation system to provide fresh air. Air extracted from the moist areas (the kitchen, bathroom and toilets) is passed across an in-line heat exchanger before being exhausted from the building. This transfers heat from the extracted air to the incoming fresh air. The two air streams are completely separate to prevent stale air re-entering the home.

The air-tightness of the dwellings was tested in 2003 and the results showed that the mean air permeability was between 0.95 and

1.23m^3/h/m^2 at 50Pa. This is considerably lower than the UK mean of 11.48m^3/h/m^2 and the maximum level of 10m^3/h/m^2 that is specified in Part L1 of the Building Regulations.

Energy Generation

One of the project's key design objectives is to use renewable energy sources to meet the energy requirements of the development.

A Proven wind turbine with a blade diameter of 5.6m and rated at 5kW was erected in December 2001. The generator is gearbox free, which reduces the noise output. The turbine was expected to generate 12MWh of power annually. It is currently underperforming, but research and improvements are ongoing.

Planning permission has been granted for a second wind turbine from Iskra Wind Turbines, based in Nottingham. It is of a similar specification to the first.

In August 2002, a series of photovoltaic modules were incorporated onto the southern-facing facade. The modules are mounted on ballast filled consoles that sit above the conservatory glazing, on the parapet wall and at a similar angle. The ballast is 75kg of loose gravel, which ensures the modules stay fixed. Despite being a retrofit installation, it was not required to penetrate the building fabric or roof structure of the homes since the cables pass through a ventilation shaft. Ninety BP Solar 85Wp modules have been installed, giving a 7.65kWp total rating.

Excesses and shortfalls in power are compensated for by the local grid via an import / export meter.

Water Conservation

Water conservation is a major part of the project. All of the water used by the residents is both captured and treated onsite. There is no external mains water supply or sewerage treatment system.

Two rainwater collection systems are featured. The first provides the residents with drinking water. Runoff water is collected from the conservatory roof and stored in large 25m^3 underground tanks where it naturally remains cool. It is pumped on demand to the houses, passing through a 5 micron string filter to remove small debris, then through a charcoal filter to neutralise any dissolved chemicals, and is finally exposed to ultra-violet light to kill any bacteria or viruses present. When full, the rainwater tanks hold enough water to provide twenty residents with ten litres of drinking water each for 250 days.

The second system provides water for washing, bathing, toilet flushing, etc. The water for this system is collected from the turf roof of the house and the land adjoining it. This is channelled into a sump and pumped to a reservoir behind the homes. The reservoir is capable of storing up to 150m^3 of water, which is at least 100 days use for the residents. When this is pumped to the houses it passes through a sand filter to remove any suspended matter.

All the dwellings are fitted with low-flush toilets and some flow restrictors in showerheads. Showers are taken rather than baths, and

more environmentally friendly detergent alternatives are used in the washing machines.

Grey and black water is treated onsite by a combination of septic tanks and a reed bed. Once water has been treated in the reed beds, it flows into the lake that was created by the residents and is populated by fish such as carp. Much of the solid matter is removed and composted discretely onsite.

Resident Training

As it is a self-build project, the residents have trained themselves using the expertise that exists within the group. New project members are actively encouraged to share and use their know-how to benefit the group.

Recycling

The group compost all organic waste material produced on the land or in the homes. Domestic scale recycling facilities have been built into each house, and the material gathered is either reused onsite or taken in bulk to local recycling facilities. The municipal waste bins are emptied less than once a month.

Transport

The number of residents working from home at least part time is steadily increasing, therefore reducing the pollution attributable to commuting.

The project's rural location means that it is not well sited with regard to access to public transport. Hockerton, the nearest village, is not well equipped for shops or other facilities, so frequent visits to the village of Southwell, 2½ miles away, have to be made. Walking and cycling are encouraged, and part of the tenancy covenant is that each house is allowed to own only one fossil fuel powered vehicle. Car sharing and multiple purpose journeys are common.

An electric Peugeot 106 has been made available to residents using a grant from Powergen. The car has a 60km range, which is enough for round trips to schools, supermarkets and the city of Nottingham. The vehicle's batteries are charged using surplus power from the wind turbines and photovoltaic array.

As part of the demonstrative nature of the project, a number of two/three/four wheeled, human powered vehicles are used by the residents for recreation and labour.

Landscaping

Encouragement of Biodiversity

The site was originally fit only for grazing sheep and cattle. As part of the project, the residents wanted to enhance the landscape; to increase biodiversity and to provide additional resources for the dwellings.

New habitats of woodland and water have been created as part of the landscaping, which have provided habitats for local wildlife. The lake forms part of a productive aquaculture scheme, being home to many forms of fauna and flora, such as water-voles, frogs, toads, carp and numerous reeds. It attracts birds such as coot, moorhen, mallard, little grebe and tufted duck. Waders, geese, kingfisher and swans also visit on occasions.

Landscape structural Feature

The residents have observed that the houses act as a wind and noise shelter for the area between the conservatories and the lake to the south. They believe that it is the ramp shape of the earth-covered roof that produces this effect, which can also be used to protect more delicate plantings outside the conservatories.

Resource crops (food/fuel)

Food growing areas have been created to produce vegetables for the families, and livestock is grazed as part of the land management strategy and to provide wool and meat. Chickens are kept to provide eggs and manure.

Newly planted woodland of over 4,000 trees provides wood fuel for the conservatory wood stove.

Economic Aspects

The residents drew up an internal contract that obliged each household to meet the financial costs of the development up to a common stage. Each household had to separately fund their share of the work. However, each household paid a unique amount for their dwelling. An internal LET scheme offset labour contributions from capital contributions, therefore those households that contributed more in labour had to contribute less in capital, and vice versa.

The group believe that they have met their initial objective of constructing a group of autonomous, zero-CO_2 emission dwellings. The development of the project is ongoing however, and the group has received funding from various bodies to undertake research into various aspects of sustainable housing development.

An award from the Environmental Action Fund (EAF) for 2000-1 aided the development of the "Sustainable Communities" project, which promotes the group's knowledge and skills to assist other individuals and groups to develop their own sustainable community. The project includes the publication of a tool-kit that includes two publications to date, '*The Sustainable Community - A Practical Guide*' and '*Sustainable Housing Schemes in the UK - A guide with details of access'.* Along with the website content and tours and talks at HHP, the group hope to mentor fledgling groups through the various hurdles of project design, planning application, etc. to aid the development of similar projects around the country.

The group led the establishment of the Zero Emission Network (ZEN), which operated from October 2002 until April 2004, in collaboration with innovationONLINE. The aim of ZEN was to assist designers and promoters of zero emission housing projects to identify and develop markets for their products. It featured a network directory and helped establish links between the various organisations who were keen to be involved in developing zero emission housing (architects, consultants, product manufacturers, etc.). This project was funded by over £26k from Biffaward (landfill tax credits scheme) and from the Pilkington Energy Efficiency Trust.

Social Aspects

Resident involvement

The residents were completely involved with the design of their dwellings and the landscaping that surrounds them. This has led to an increase in the skill base of the residents and an increase in their confidence as individuals to take control of very important aspects of their lives.

The commitment that each resident must make to the ongoing development of the project ensures that the social cohesion of the

group is maintained beyond the major building stage. Residents are required not only to maintain the present development and its grounds but to further develop the project with regard to onsite businesses, trading products from these businesses, and to disseminate information about the project to other groups, which in itself has become a staple source of financial income.

These functions provide continual challenges to the residents, who have to develop the skills necessary to carry the project forward in line with their communally agreed and individual aspirations.

Weekly meetings are held where issues and plans are discussed and tasks are agreed. These are important as social gatherings, taking part on Friday nights, as well as to the business of the group.
Social support is provided, often on an informal basis, through shared childcare activities, car sharing, communal working and skill sharing, and through the friendships that have come about as the project has developed.

Methods of Community Engagement

It has long been an ambition of the group to better demonstrate its achievements in sustainability to the wider community. As outside interest steadily grew, it became apparent that a dedicated 'Sustainable Resource Centre' (SRC) onsite would be an effective way of involving local communities, schools and agencies in the project, and act as an added catalyst for sustainable action in the region.

A feasibility study was undertaken to better understand the needs of the target groups. It was decided that the new amenities should focus around an 'eco-barn' situated near and complimenting the homes. The SRC will feature a dedicated audio-visual room, seminar facilities and permanent exhibitions.

Communal Facilities

The main "communal" areas at the moment are the gardens and the orchards that provide vegetables and fruit to the community.

The SRC incorporates a communal office that will provide computing, e-mail and Internet facilities. This will further enhance the onsite business opportunities. Food processing, workshops, seminar and office space are also to be incorporated into the building.

Well-Being

A healthy living environment has been provided to the residents by the following factors:

- The energy efficient and water conservative design means that the residents are at no risk of suffering from either fuel or water poverty.
- The indoor thermal climate is always maintained in the comfort zone, reducing the risk of extreme temperatures exacerbating any health problems.
- A constant supply of fresh air is provided by the mechanical heat recovery ventilation systems, which maintain a low relative humidity and reduce the risk of damp related illnesses.

- The opportunities of communal working, skill sharing and mutual support, and the challenges of moving the project forward, should contribute to a sense of mental well-being to group members.

Accessibility Issues of old age and disability have not yet been addressed; mainly because none of the present members fall into these categories. The site could present a challenge to people with mobility problems, although the group has coped with both motorised and manual wheelchairs during their guided tours. It is envisaged that the situation will improve over time.

Adaptability The group is currently composed of family units and single people. However, formations such as single parents or house sharers can happily be accommodated to live and become integrated into the project.

Crime The prospect of crime is reduced by the 'stealth' nature of the project; it is not visible from the surrounding roads. The sense of community adds to the security as unknown visitors are always noticed and challenged. The residents' daily work and life routines mean that the site is never left completely unoccupied.

Economic Aspects

The Costs of development for a three-bed (171m^2) home are as follows:

Basic house construction	£51k
Conservatory	£12k
Landscaping, water systems and amenities	£ 9k
Set-up costs	£20k

The construction costs are thus approximately £450/m^2
The construction costs shown above were funded by a mixture of private investment from the residents and loans that were made available by the Co-operative Bank and later transferred into mortgages by the Ecology Building Society. One of the features of this project was the way in which these two organisations cooperated to achieve the aims of the development.

The cost of each individual household mortgage is met through a mixture of offsite employment and onsite income generating activities. The equivalent of three members fully earn their living working on the group's onsite trading projects, although most obtain some additional income through part-time onsite work. Several members have full-time employment offsite. There is no sharing of any externally gained income, but each resident gets a share of any revenue generated by co-operative business activities such as tours, sale of publications etc. A peppercorn rent of £25 per year is paid by each household to the landowner of the site in lieu of a 999-year lease.

Additional funding was provided with an award of over £11,000 from Scottish Power's Green Energy Fund for the first wind generator. Funding for the second turbine has come from the Clear Skies programme (50per cent) and Scottish Power (25per cent). The photovoltaic array was funded by £60,000 from the DTI's Domestic PV Roof Trial programme.

Two Lottery grants from the Social, Economic and Environmental Development (SEED) Programme, funded both the feasibility study (£4,799) and the construction costs (£49,619) of the Sustainable Resource Centre.

Visiting

Contact the group directly or visit the project website for details, pricing and to book a place on the regular guided tours. A fee is charged that varies depending on the nature of the visiting group.

Additional Information

The group identified two main barriers to the realisation of the project:

1. The local planning authority did not want to set any sort of precedent for a building outside village envelopes. They attached a landmark 106 agreement to the planning consent that included, amongst other things, issues around development of onsite, low-impact sustainable employment and working towards self-sufficiency. Being low-energy was not enough. The group had to demonstrate that the project would be a positive move towards sustainable development and that it would complement the Council's own policies in this area.

2. The group had difficulty in locating additional skilled labour / contractors who understood the aims of the project.

Hollies Barn, Eakring

Location	Eakring, Nottinghamshire
Type of Area	Rural
Tenure	Owner Occupied
Built Form	Detached
Status	Occupied since March 2003
Contact Name	Sam Pearce
Phone / e-mail	01623 411026 sampearce@lupus.fsworld.co.uk
Visiting possible	No

Summary

Hollies Barn is a private development that sees the refurbishment of a former Victorian barn into a large, four-bedroom dwelling. The original solid brick walls have been upgraded internally to provide a highly insulated and airtight envelope, which incorporates a high level of internally exposed thermal mass. The methodology is very similar to that employed by the Hockerton Housing Project, which to a large extent inspired the current owner to take this route. Other technologies and methods used in the development have also been chosen as a result of the influence and availability of local expertise and systems that now exist within this area of Nottinghamshire. Hockerton's earth sheltered scheme, the Vale's Autonomous House and Gusto Construction Ltd are all within easy reach and appear to be having a positive influence on other developments within the region.

The project also includes high specification glazing, rainwater harvesting and reed-bed grey water treatment, space for home-working and good accessibility features. Passive Solar Design (PSD) has been considered in the internal layout of the dwelling and the finished design will provide a high quality and contemporary home for the residents.

Project Objectives

To create a comfortable home that is CO_2 neutral in its day-to-day energy consumption and that can be used to inspire other people to do the same.

History of Concept

The owner / developer has had a long interest in alternative energy systems, low energy design, etc. After making the decision to leave London and return to the area where he grew up, he sees this barn conversion as the ideal opportunity to put his ideas into practice.

With a strong background in product design and with Nick Martin, a builder and a resident of the Hockerton Housing Project contracted as a consultant, he set about designing a virtual model of the barn conversion in order to create a large four bedroom family home that benefits from high thermal mass.

Although the building has been habitable since early in 2003, the project is ongoing, with advancements being made as the finances required become available. At the time of writing, efforts have been focused on the landscaping of the garden and pond, with the completion of the rainwater collection system due to follow.

Construction Details

Built form A detached, U-shaped, barn conversion.

Roof Clay-pantiles fixed to wooden battens upon 40mm Kingspan insulated sarking board. The space between the rafters is filled with either 100mm of rigid polystyrene, or 100mm of fibreglass. A further 40mm of insulated Kingspan plasterboard is attached to the underside of the rafters to reduce thermal bridging.

Walls The wall construction comprises 300–350mm original solid brick wall, lined internally with 150mm polystyrene sheet, and enclosed by 100mm dense concrete block (see Figure 1), to provide a large amount of thermal mass. This is then faced with wet plaster, to increase the air-tightness of the structure.

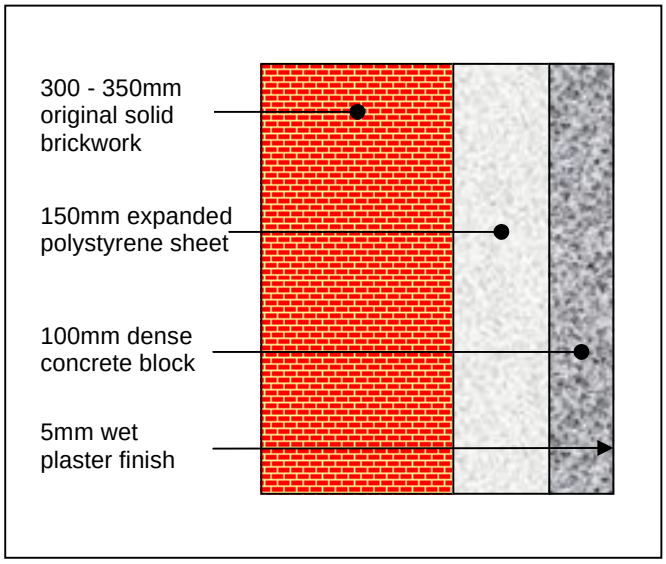


Figure 1. Cross section of wall construction

Floors A 100mm concrete slab is used to tie the walls together at ground level. On top of this is laid a 300mm EPS slab, upon which a 200–300mm concrete raft is laid, giving the internal room area a very large amount of exposed thermal mass.

Windows Bespoke double glazed units with oak timber frames, low-emissivity coated glass and a 28mm gap filled with argon gas.

Doors The doors are bespoke units made from English oak.

Rainwater Goods The owners have chosen to use galvanised steel for the guttering and downpipes. This represents an economically viable and environmentally better alternative to using PVC, and because the collected water will be used for drinking, it is healthier than iron.

Waste Minimisation During construction No 'waste' left the site during completion of the major construction works. 'Leftovers' arising from the development were either recycled on site, or traded with other builders, members of the village community, etc., for other goods or services. Three lorry loads of hardcore were taken to a recycling facility to be processed to form road surface fill material. Just one skip of rubbish has been removed to landfill in the course of the project.

Internal Layout The basic principles of passive solar design have been applied, wherever possible, to the internal layout of the dwelling. The main living area contains a large amount of south-facing glazing; and the kitchen, recycling and food storage areas are situated on the cooler northwest side of the property. The downstairs guest bedroom receives sunlight in the afternoon due to its westerly location.

U-Values (W/m^2.K)

Walls:	**0.20** (average)
Floor:	**0.16 (**average)
Roof:	**0.14**
Windows:	**1.80**
Doors:	**1.80**

Resource Conservation

Heating The heating system consists of electric panel heaters in most rooms of the dwelling. These run off a tariff that provides 10 hours of off-peak electricity throughout the day and night. No gas is available at the site. In addition, a wood burning stove has been installed in the sitting room to provide supplementary heating when required during the colder months.

Domestic hot water is provided from a mains pressure storage cylinder heated by off-peak electricity. This is a bespoke and experimental system designed by Nick Martin, of the Hockerton Housing Project, which incorporates 5 heat-exchange coils through which the mains pressure cold water is passed and heated by the hot water stored in the cylinder. The owner praises the performance of this bespoke system to date.

Lighting The lighting in all habitable areas is provided by compact fluorescent lights (CFLs).

Ventilation Individual Ventaxia heat recovery ventilation units are located in the kitchen and bathrooms of the dwelling. Due to the narrow floor plan of the structure, opening windows naturally ventilate the rest of the dwelling

.

Energy Generation The design of the refurbishment allows for the easy integration of photovoltaics at a future date. At present, their cost is prohibitive for this development.

Water Conservation Rainwater collected from the roof of the dwelling will be stored and utilised by the owners for all domestic purposes. The owners have chosen to use the FREERAIN system, when the required finance becomes available, developed by Gusto Construction in nearby Collingham (see entry on Millennium Green for further details). The household water will be filtered before use, and the drinking water will be treated by ultra-violet light to destroy any water-borne bacteria. The system has a mains water backup in the event of component / power failure or lack of rainfall.

Grey-water will be treated on site by a reed-bed system, situated on the southern side of the property, and allowed to soak away naturally. The reed-bed will also form a visual screen from the road.
Brown-water will be fed into the local sewerage system where it naturally passes into the village reed-bed and soak-away.

Recycling Facilities A dedicated area for separating and storing recyclable materials has been designed into the dwelling.

Transport

The property is situated close to a local village shop that provides day-to-day necessities. The owners of Hollies Barn both work from home and are therefore not dependent on transport for commuting. There is a regular bus service from the village to other local town and village centres.

Landscaping

The owners have created a pond and an organic vegetable patch which have already noticeably increased the biodiversity of the project site. The creation of reed-beds in future will further promote biodiversity.

Well Being

Accessibility The dwelling has level access at several points allowing for ease of entry for those people who are mobility impaired. The ground floor of the property incorporates a double bedroom and a bathroom, mainly for the use of guests, but it could also provide for residents who are not able to negotiate the stairs to the first floor facilities.

Adaptability A single step, soon after the entrance, does exist on the ground floor level, but the design allows for a ramp to be built into this should it become necessary at a future date.

Health and Affordability Both the high levels of insulation and thermal mass will reduce the possibility of the residents suffering from fuel poverty. The rainwater collection system and reed-bed sewerage system will reduce the tenants' water costs.

Economic Aspects

The cost of the conversion to date has been £295,000. An evaluation of the heating energy and utility bill savings is to be conducted once the creation of the internal buffer zones has been completed. As both owners work mainly from home the design for the refurbishment incorporated a dedicated office space. An ICT network has also been installed throughout the house, making it possible to connect to the Internet from various locations within the dwelling.

Additional Information

The owners / developers encountered the following problems when attempting to bring the project to fruition:

- The building 'industry' appeared to be very busy and it was difficult to locate the appropriate amount of labour within the desired timescales.

- Local builders were initially unenthusiastic about an 'eco-build'.

- Accessing the appropriate skills and knowledge needed for the development proved to be very difficult and the owner feels that the success of the project is mainly due to the good contacts at the Hockerton Housing Project and Newark and Sherwood District Council, which they had already established.

- A conflict arose between the properties owners and the local authority's building conservation officer over the issue of the galvanised steel guttering. The property lies within a conservation area and the local authority officer held the belief that only cast iron guttering should be used. The issue was resolved when it was made clear to the officer that the rainwater was to be used for drinking and that iron guttering could have a negative effect on the residents' health.

Lakeside Park, Sutton in Ashfield

Location	Sutton-in-Ashfield, Nottinghamshire
Type of Area	Urban
Built Form	Mixed
Status	Development in progress
Contact Name	Paul Smith Bellway Homes PLC Leicester
Phone / e-mail	0116 2727000
Website	www.bellway.co.uk/eastmids/LakesidePark/home.htm

Summary

This scheme demonstrates the ability of a local planning authority to work with a mainstream developer, to produce a scheme that is more sustainable than a traditional new-build development.

By utilising the Building Research Establishment's (BRE) EcoHomes rating system, the developer, Bellway Homes, was required to meet a defined set of national criteria that are assessed by an impartial, independent body and are quality assured. With guidance from the EcoHomes scheme assessor, a 'Very Good' rating was achieved, as had been stipulated beforehand by the Council.

Project Objectives

To develop a mixed use site consisting of 114 dwellings, a hotel, a day-nursery and a light industrial unit that meets or exceeds the Building Research Establishment Environmental Assessment Method (BREEAM) rating of 'Very Good'. After achieving this rating on this site, Sutton in Ashfield District Council is working to encourage all developments in the area to meet the same standards.

History of Concept

In a previous housing development, the Council had used its position as the planning authority and owner of the land, to secure a greater amount of public amenity space than is generally provided, doubling the amount of space from ten to twenty per cent of the gross development area.

The Council wished the focus of this new development to be on sustainability, and so a set of sustainability indicators were required to judge proposals submitted by developers in an impartial and objective manner. The decision was made to adopt the BREEAM standards for the non-domestic developments on the site and the EcoHomes rating system (the domestic version of BREEAM) for the dwellings. This standard categorises developments as Pass, Good, Very Good and Excellent. The standard that the Council decided to aim for was a 'Very Good' rating for all types of development.

B&Q, the DIY warehouse chain, were the first to accept the challenge of meeting the standard and now operate their flagship environmental store from the site. The building

incorporates many environmentally beneficial features, including photovoltaics, solar water heating and a wind generator.

The Council worked with Bellway Homes to assist them in delivering a residential development that achieves the EcoHomes rating of 'Very Good'. The developer was initially sceptical about the rating scheme and they found upgrading their standard housing specification to achieve the 'Very Good' rating difficult and time consuming. Having completed the process however, they are now very positive about the experience, and the EcoHomes 'Very Good' rating has been achieved in a similar fashion at their Earlswood development on what used to be the site of the Sherwood Colliery. Bellway Homes have also since received approaches from other housing organisations, with regard to generating further developments to a similar high standard.

Construction Details

Built form A mixture of semi-detached and detached two-storey dwellings.

Greenfield/ Brownfield The site is a former recreation sports-ground.

Construction Type The construction is brick and block insulated cavity walls, with timber rafter and tile roofs. The floors are concrete slab and the windows are double-glazed uPVC units. The U-values exceed the 2002 Part L of the Building Regulations by an average of 19 per cent, giving an average carbon dioxide emission for the development of 29.5kg/m^2/yr.

All insulation materials used in the development have an ozone depletion potential (ODP) of zero. Timber for the basic building elements came from sources that are certified by the Forestry Stewardship Council (FSC) as being from sustainable sources.

Resource Conservation

Heating Gas condensing boilers are fitted in all dwellings as standard, and meet the European Class 5 standard for NO_x emissions. The listed SEDBUK figure for the model used is 90.2 per cent.

Lighting Compact fluorescent lights (CFLs) are installed in all habitable rooms within the dwellings. All external lighting is provided by CFLs or fluorescent strip lighting.

Reasonable daylighting levels are achieved in most of the habitable rooms, which in turn helps to offset the cost of artificial lighting and its associated CO_2 emissions.

Resident Training White goods are provided as an optional extra for residents within the development. When this option is chosen, the contractor provides white goods that have an energy rating of 'A'. Alternatively, advice is given to the residents that encourages them to purchase items that have a rating of 'A'.

SAP / Eco-ratings Achieved EcoHomes rating of 'Very Good'.

Recycling Facilities Space is provided within each dwelling for three recycling bins to be installed either in the kitchen or the under-stair storage area, to encourage residents to sort and recycle their waste. Additional space is provided within the grounds of each dwelling that facilitates storage of recycled waste awaiting transport to a local recycling amenity.

Transport

The development is within a safe walking distance of nearby shops and amenities. All dwellings within the development are within 200m of a local bus stop, which operates a service into the nearby town centre at least once an hour between 07:30 and 20:00hrs.

Well-Being

Health and Affordability By providing a well-insulated structure and an efficient central heating boiler, the risk of the occupants suffering from the effects of fuel poverty has been reduced.

Economic Aspects

At the time of writing, over 50 per cent of the dwellings had been built, with many being sold in advance.

Suitable space for a home office is provided in all dwellings in the development. This provides residents the opportunity to work from home and reduce the energy they expend on commuting

Additional Information

The Council has put considerable effort into educating and influencing house builders in the local area. A survey was carried out among residents in new housing schemes within the area, as part of the planning department's 'Best Value' programme. One of the questions it asked was "would residents have been prepared to pay five to ten per cent more for their dwellings if they had contained sustainable features, particularly those that would have resulted in lower running costs?" Over 60 per cent of the respondents said they would have been prepared to pay such a premium for more sustainable features. In sharp contrast to this however, the developer has found that sustainability falls low down on their own customers' agendas, and that actual prospective homebuyers are much more concerned with the capital cost of the home and qualities such as location and aesthetics. In fact, the developer has been unable to place a premium on the homes to recoup the additional costs incurred in the project.

The UK Government's "By Design" project[2], that aims to inform local planners and architects about the benefits of improved layout in urban design, has actually proved to be much more difficult for the District Council to implement and understand than the issues of housing sustainability. The Council's planning department believes that regulation will be crucial to achieving the aims of sustainable housing at a national level.

[2] For further information see *Better places to live: by design. A companion guide to PPG 3.* The Stationary Office, London, 2001.

Barriers Encountered During the Development

Problems have been encountered with the BRE EcoHomes accreditation system. The project lost potential points because it is built on a greenfield site. The EcoHomes rating system gives higher scores to projects that are developed on brownfield sites. The District Council had very few brownfield sites at its disposal however, due to the effectiveness with which it has utilised these over the last ten years. It had no other sites available which were suitable for this type of development, and has therefore become a victim of its own success. It is felt that the rating system needs to be a little more flexible in situations such as these.

A conflict between the EcoHomes rating system and the Council's planning department came about when the Council looked at the issue of how best to deal with the surface rainwater run-off from the site in a sustainable manner. The Environment Agency wanted the surface water to run into the nearby reservoir in order to increase the flow rate of the water passing through it. A greater throughput of rainwater would help to reduce the growth of algae that was becoming a problem to the agency, and help to keep the reservoir in better condition. This was believed by all partners to be the most environmentally sustainable method, however potential points were lost with the EcoHomes rating system because the rainwater was not stored and utilised on-site.

Project Partners

Sutton in Ashfield District Council
Bellway Homes PLC

Millennium Green, Gusto Construction

Location	Collingham, Nottinghamshire
Type of Area	Village
Tenure	Owner-occupied
Built Form	Various
Contact Name	Gusto Construction Ltd.
Phone/e-mail	(01636) 894 900 mail@gustohomes.com
Visiting Possible	By prior arrangement

Summary

This was the first development of its kind in the UK. A commercial housing developer, albeit a small one, building conventionally-styled housing for the mass market that incorporates environmentally beneficial features including:

- Solar water heating
- Rainwater collection for use in toilets, washing machines and garden irrigation
- Very high thermal specification (three times the level of the UK 1995 building regulations)
- Mechanical heat recovery ventilation
- High-specification glazing
- Gas condensing boilers and intelligent boiler management systems fitted as standard
- ISDN compatible telephone and Internet connections throughout

A business centre has also been developed onsite, providing serviced office space for residents of the development who wish to work from home. The developers provide continuous support to residents who are also asked to give feedback about living in the dwellings at annual evening gatherings.

The project has been a commercial success, with all 24 dwellings that form the development being sold.

The company has won the following awards as a result of its project at Millennium Green:

- Daily Express House Builder of the Year 2000 Cert Winner
- Parcelforce Worldwide Small Business Awards, 2000
- Nottingham Environmental Business of the Year, 1999
- Nottingham Evening Post Award for Innovation, 1999
- Henry, Home Energy Rater of the Year, 1999
- Building magazine 'Entrepreneur of the Year' finalist
- Overall and category winners of the 2003 Environment Agency Water Efficiency Awards.

Project Objectives

To build high-quality environmentally friendly homes for sale on the commercial property market.

History of Concept

Gusto Construction initially commenced business as a small construction company building conventional dwellings for sale on the commercial property market. In 1998 the company purchased 3.6 acres of land in Collingham, Nottinghamshire.

The company's chief executive, Stephen Wright, wanted the organisation to change direction and had been inspired by local housing projects such as the Autonomous House in Southwell and the earth-sheltered dwellings at Hockerton, and by David Pickles, manager for energy & eco-renovation at Newark & Sherwood District Council.

Initially the group hoped to attract some subsidy from national government or from the European Union that would assist them to experiment with different building types on the site. All such applications were rejected, but the company pressed ahead with its ideals of creating more sustainable housing in a way that would be commercially viable in today's property market.

The organisation realised that it had to find a balance between the achievements of the Hockerton Housing Project and housing built to the current building standards. Thus the concept for Millennium Green was born; housing that would be built to high quality standards, incorporating many of the technologies and techniques of 'green' building, but also architecturally acceptable to the ordinary house purchaser.

Construction Details

A majority of the dwellings are detached or link-attached and are situated on what was formally a greenfield site. The site layout ensures that a majority of the dwellings have good solar access on their southern elevation. A high proportion of the glazing is installed on this elevation to enhance the contribution that solar gain makes towards heating the dwellings.

Heat loss from the individual building elements is half or less than half of that specified under the 1995 Building Regulations.

Walls The external walls are of standard brick and block construction, but with a 150mm cavity filled with Drytherm insulation. These are sited upon 350mm-wide insulating trench blocks. Internal load bearing walls are 100mm clinker block.

Roof Clay or clay-faced concrete tiles sit above a breather membrane upon a roof structure constructed from engineered timber I-beams. The roofs are insulated with 240mm Warmcel recycled cellulose insulation, which is held behind a 12.7mm foil-backed plasterboard internal lining.

Floor The ground floors of the dwellings are constructed from 100mm concrete sited upon 150mm of extruded polystyrene or 80mm polyurethane Thermo floor. This sits on top of a polythene damp proof membrane.

Windows High performance, double-glazed, timber-framed Scandinavian windows are fitted as standard. They have a low-emissivity coating and are argon gas filled. The company worked with local suppliers to achieve the supply of glazing that met their specifications.

U-Values (W/m^2.K)

Walls:	**0.20**
Floor:	**0.15**
Roof:	**0.15**
Windows:	**1.60**

Air Infiltration: **3 ac/h @ 50 Pa**

Resource Conservation

A great deal of effort has been made during the design stage to reduce the amount of non-renewable resources consumed by the dwellings during occupation. In addition to the high levels of insulation already mentioned, the following measures have been installed into each property as standard features.

Heating Condensing gas boilers are fitted in all dwellings and are coupled to an intelligent heating control system. In addition to an intelligent whole house temperature control system, all radiators are fitted with thermostatic valve controls.

Hot water is provided by a combination of these boilers and a roof-mounted solar water heating system fitted to each house. The site demonstrates a mixture of flat plate collectors and evacuated tube units. Water heated by these units is stored in a 250 litre thermal store. This system aims to offset 60% of the fossil fuel energy usually needed to heat the hot water supply.

Lighting Compact fluorescent tubes are fitted as standard throughout the dwellings, although the developer has noted that some residents have replaced these with chandeliers. A master switch by the front door allows all internal lights to be extinguished when exiting.

Ventilation A great deal of attention to detail was taken regarding air-tightness during the construction phase to reduce the heat loss due to cold air ingress through the building fabric. A positive pressure test revealed an air-change rate of 3ac/h at 50Pa.

Two ventilation options are demonstrated onsite to provide the residents with a supply of fresh air and remove moisture from the dwellings.

The first option is a whole house heat recovery ventilation system, which vents air out of the bathroom and kitchen and replaces it with fresh air, preheated by the exhaust air, into the main living areas. An efficiency of 70% reclaimed heat is claimed by the unit manufacturer.
The second option is the fitting of humidity controlled passive stack ventilation (PSV) units in the kitchen and bathroom to remove moist air

from these locations. The rest of the property is ventilated through trickle air vents fitted into the window casements. These allow the property to be ventilated to an adequate level throughout the day and night without compromising the security of the property.

Water Conservation

Every property is fitted with a rainwater recovery system that collects and stores rainwater in a collection tank to be used for flushing toilets, providing water to washing machines and for irrigating the garden.
The developers tried several 'off the shelf' systems. Each presented its own unique set of complications, which resulted in Gusto developing its own "Freerain" system that is now installed as standard. This system incorporates an underground storage tank, self-cleaning in-tank filters and a submersible pump. The system is not designed to provide drinking quality water but rather to provide water for the above purposes with minimal maintenance. Overflow water from the system passes into the local storm drains
.
The company offers three sizes of tank, with the standard unit capable of holding 3,500 litres. The filters used are cleaned whenever the unit overflows, and correct sizing of the storage tank ensures that this occurs at least three times a year.

The systems have performed well and relatively rarely run dry during periods of low rainfall. The homes' consumption of domestic mains water has been cut by roughly 50 percent.

Aerated taps and showers are also fitted as standard to reduce water consumption.

Resident Training

Resident training in the use and environmental benefits of the energy and water systems in the dwellings takes place when they move in. This aims to optimise the benefits of these systems by ensuring the residents are capable of operating them efficiently.

Recycling Facilities

Facilities are provided in the garages to encourage the residents to recycle glass, paper, cardboard, tins, aluminium, etc. No organic waste recycling facilities are provided as standard.

SAP/Eco-rating

The dwellings have been rated by a variety of recognised schemes and achieve a SAP rating of 100, an NHER of 10 and a BRE rating of Excellent.

Landscaping

A communal green has been developed in the centre of the site for the residents' use. This has been landscaped to include varieties of fruiting trees and shrubs. The stream that adjoins the northern perimeter of the site has created a protected area. Water voles have been spotted in this area and the developer has issued a leaflet informing residents about this rare and disappearing species.

Stewardship of the common areas of the site rests with the developer. This ensures that these areas are properly managed, and demonstrates the on-going commitment that the developer has in the site. This has also allowed for a more exotic landscape than would have been possible had responsibility been passed to the local authority in the conventional way.

Transport

The development is close to local shops, schools, a railway station and leisure facilities. There are no specific measures to encourage people to walk or cycle; however, charging points for electric vehicles can be provided as an option, and this has been taken up by a number of residents.

Social Aspects

As part of the developer's commitment to continuous improvement, regular feedback sessions are held with the residents to obtain information on the pros and cons of the various systems installed in the dwellings. These are also seen as essential in developing a sense of community, which is enhanced by the fact that all of the residents are living in a unique development.

Communal Facilities

A business centre has been built onsite, with the intention of providing serviced office space to residents who wish to work from home. The developer is actively seeking ways in which this centre can provide a range of services to residents. Services such as key-holding, parcel drop-off, etc. are being explored to ensure that they are useful to the community as well as financially viable.

Well-Being

Health and Affordability

The development of aspirational dwellings that can be heated and lit at an affordable cost to the residents reduces the possibility of them suffering from the negative effects of fuel poverty. The rainwater recycling system ensures that none of the residents will suffer from water poverty. The provision of a good ventilation strategy in all dwellings should reduce the occurrence of damp and mould, as well as reducing the cost of maintenance on the buildings. A pollen filter is fitted as standard on the heat recovery ventilation units.

Accessibility

Extra-wide doorways and low door thresholds on ground floor doors makes the dwellings accessible to wheelchair users. These designs pre-dated this requirement under Building Regulations.

Adaptability

All dwellings are wired for ISDN and Internet connection as standard, ensuring that all residents can access these communication technologies.

Crime

The layout of the site has incorporated good practice with regard to crime reduction and multi-point locking. Pre-wired alarm systems are fitted to all dwellings. The sense of community that the site inspires also adds to the sense of security about living there.

Economic Aspects

The developer has found that a premium of approximately ten per cent has been added to the cost of the development due to the additional features incorporated into the dwellings.
Twenty four dwellings have been built on the site and all costs were met by the developer. There have been no external subsidies for this project.

Subsequent Developments

The commercial success of Millennium Green has allowed Gusto Construction to expand on their ethos of providing homes that include many environmentally friendly technologies to the upper end of the market. Three new projects have been developed:

- The Beefield, Hawthorn Road, Lincoln is a nine house development on the outskirts of Lincoln, with a similar specification to Millennium Green. Sustainable drainage was an issue on this particular site, which led to the installation of a storm-water run-off attenuation system, to complement the rainwater harvesting system.

- West Meadows, Allington, Nr Grantham is a five house development in Allington, overlooking the Vale of Belvoir. In addition to the features of Millennium Green, all of the Allignton properties benefit from underfloor heating, supplied by the solar water-heating panels. The relatively low circulation temperature required by an underfloor heating system makes it particularly suitable for integration with solar thermal. One of the properties is also being used to pilot a, roof-integrated array of interlocking, photovoltaic tiles. The $10m^2$, southern-facing array of C21 solar tiles from Solar Century can generate up to 1kWp for the home, and feeds any surplus electricity into the national grid. As a result of the Allington development, Gusto Homes have been awarded the Sustainability Standard in the first ever Sustainable New Homes Awards.

- Gusto is also to build 9 homes in the village of Reepham, close to Lincoln, where the technologies introduced at Millennium Green will continue to be applied. A more consultative approach with local residents has been taken by Gusto during the planning stage of this development.

Additional Information

The developer encountered various regulatory problems during the development of Millennium Green. These included conflicts with the Highways Agency with regard to the design of the storm drains and resistance from the parish council with regard to setting a precedent for a different style of development.

Resistance within the industry was also encountered with trade-people being unwilling to adopt different working methods or to use different materials.

The massive shortage of skilled labour within the industry presented Gusto Construction with problems of staffing the development. The developer invested heavily in staff training and development and, through retaining these staff, a greater understanding of the technology being employed has been achieved. This has led to reduced snagging during the design stage of subsequent developments and more efficient problem resolution and maintenance once the buildings are occupied and in use.

The trade-people have become more involved with the development of the projects and feel that they have a vested interest in the success of the company. They often suggest new methods and technologies themselves. Stephen Wright, the chief executive of Gusto Construction believes that this type of approach is essential if the industry is to attract new people. He sees it as part of giving people a sense of satisfaction and pride in the industry that he feels is lacking in the UK when compared to countries such as Germany, Holland or Australia, where being a builder has a higher social status.

The developer believes that legislation must drive the construction industry towards more sustainable building methods, and cites the need for an aspirational set of Building Regulations that the industry can work to over the next ten years. “Ten years is easily enough time for this industry to change” (Stephen Wright, in interview 2001).

The success of Gusto's 'Freerain' water harvesting system has led to the formation of a spin-off company with the same name. In addition to receiving the Environment Agency 2003 Water Efficiency award, Freerain was a founding member of the UK Rainwater Harvesting Association (UK-RHA).

Beaconsfield Street, Nottingham

Location	Hyson Green, Nottingham
Type of Area	Urban
Tenure	Social Housing Rental
Built Form	Terrace
Contact Name	Nottingham Community Housing Association
Phone / e-mail	(0115) 910 4444
Web Address	www.ncha.org.uk
Visiting Possible	By arrangement only

Summary

Beaconsfield Street is a group of seven terrace dwellings providing energy efficient accommodation to single people, couples and larger households.
The project incorporates a highly insulated timber frame construction, using timber from sustainable sources, high-specification glazing, and passive stack ventilation to the kitchen and bathroom, and the use of recycled insulation materials.
The Housing Association teamed up with a local training provider, Nottingham Environmental Construction Training for All (NECTA), who employ local labour and provide training in construction trades for long-term unemployed people. This was funded by the 'New Deal for Communities' scheme.

Project Objectives

To create a group of energy efficient, 1 and 4-bed properties on an infill site in Nottingham.

Summary

Beaconsfield Street is a group of seven terrace dwellings providing energy efficient accommodation to single people, couples and larger households.

The project incorporates a highly insulated timber frame construction, using timber from sustainable sources, high-specification glazing, and passive stack ventilation to the kitchen and bathroom, and the use of recycled insulation materials.

The housing association teamed up with a local training provider, Nottingham Environmental Construction Training for All (NECTA), who employ local labour and provide training in construction trades for long-term unemployed people. This was funded by the 'New Deal for Communities' scheme.

Construction Details

Built form An 'L'-shaped, two-storey terrace development that provides three one-bedroom units and three four-bedroom units. The development took place on an urban infill site between a school and a highway.

Walls Timber frame, breathing wall construction, using Masonite 'I'-beam studs to provide a 150mm cavity that is filled with recycled cellulose (paper) slabs.

Roof Concrete tiles upon prefabricated timber trusses. The loft floor is insulated with 200mm of mineral wool.

Floors Suspended timber insulated floors.

Windows Timber framed, double-glazed units of Swedish origin incorporating a low-emissivity coating and timber from sustainable sources.

Doors Insulated timber construction.

Interior finishes To reduce the environmental impact of the interior furnishings, the association used low-solvent paints and varnishes throughout the scheme. Linoleum was used in place of vinyl floor coverings in some areas of the scheme.

Impact of Construction The soil removed for the foundations of the development remained onsite and was used to form a grassed over earth bank. This significantly reduced the amount of waste that went to landfill as a result of the development.

U-Values (W/m^2.K)

Walls:	**0.21**
Floor:	**0.35**
Roof:	**0.18**
Windows:	**2.50**
Doors:	**0.35**

Resource Conservation

Heating Each dwelling within the development is fitted with a condensing gas combination boiler controlled by a programmer, room thermostat and thermostatic radiator valves (TRVs).

Lighting Compact florescent lights (CFLs) are provided to reduce the cost and energy use of artificial lighting.

Ventilation Passive stack ventilation is used in the kitchen and bathroom. Elsewhere, standard trickle ventilation is incorporated into the window surrounds.

Resident Training It is the policy of the housing association that all residents receive training in energy awareness to help them to reduce their fuel costs.

SAP / Eco-ratings NHER = 10

Transport

The development is already within an established residential area and is close to schools, a supermarket, and public transport links, including the new Nottingham tram system.

Landscaping

Trees that were present at the site were maintained as part of the development.

Well-Being

Health and Affordability The low fuel costs incurred by the residents of this scheme will ensure that they are at a greatly reduced risk of suffering from fuel poverty.

Accessibility All units have level access to facilitate entry for people with mobility problems.

Crime All dwellings within the scheme meet the national 'Secure by Design' standard.

Additional Information

NECTA, the contractors chosen for this scheme, bid for and received European funding to provide training in various building trades to local, unemployed people. The organisation was very involved at the early stages of the project and with developing the specification. Although this is a very worthy way of working and is to be encouraged, large delays were experienced by the project due to the continuous onsite training of the workforce and the workforce's transience. Quite often the trainees would drift away from the project, leaving the project manager with the responsibility of finding and training a replacement at very short notice.

The following comments also relate to the other projects undertaken by Nottingham Community Housing Association (NCHA) featured within this publication at Garendon Road (Eco-Life), Green Lane, and the Fosse Estate.

Barriers encountered by the developers (NCHA)

The main barriers encountered by the association fall into three categories:

1. The increased financial cost of producing dwellings with a high thermal efficiency. The average premium experienced by the Housing Association for this type of construction is about five per cent per development.

2. Education of project partners and associated professionals. The project experienced delays due to the contractor's unfamiliarity with the Masonite stud system and working with wide cavities. Contractors also had to receive onsite training regarding the correct positioning and installation of the passive ventilation system, although the manufacturer very willingly and efficiently provided this.

   The housing association finds that many contractors require further education when developing projects that are not of a traditional construction nature, which can be costly in time and money.

3. Due to the increasing demand for 'green' products such as the Masonite stud wall system, delays were experienced when attempting to get quotations and purchasing such systems. This is mainly due to the few manufacturers producing them being unable to supply their increasing demand.

Project Partners

Nottingham Community Housing Association
Nottingham Environmental Construction Training for All (NECTA)

Corncroft, Green Lane, Clifton

Location	Clifton, Nottingham
Type of Area	Urban
Tenure	Social housing rental
Built Form	Semi-detached bungalows
Contact Name	Nottingham Community Housing Association.
Phone / e-mail	(0115) 910 4444
Web Address	www.ncha.org.uk

Summary

The Corncroft development is one of the largest concentrations of PV in the UK, and potentially the largest installation in social housing. It features 44 semi-detached bungalows for older persons and young, disabled residents. 22 of the dwellings incorporate photovoltaic panels on the south-facing roofs.

This £265,000 installation project was designed by Energy for Sustainable Development Ltd (ESD), who helped to secure £238,000 from the DTI's Domestic Roof Trial funding programme, launched in 2000. The project was co-funded by Powergen (£30,000). The development was built by Westleigh Homes.

A total rating of 34 kWp has been installed on the site using BP 585L mono-crystalline units attached to mounting frames from PV Systems Ltd that can accommodate up to six panels each. The frames and panels replace the tiles that would normally form the rooftop, and lead flashing provides a watertight seal.

The panels are linked to the national grid, allowing energy to be imported and exported depending on the resident's demands and the panels' supply. It has been estimated that the panels will reduce each dwelling's electricity demand by 30 per cent, saving the residents about £60 per year.

A 24 month monitoring exercise of the development has been undertaken by ESD and the results are to be made publicly available via their website.

Project Objectives

To investigate the potential of using rooftop integrated photovoltaic panels, as a means of progressing towards sustainability in community housing development.

History of Concept

Nottingham Community Housing Association operates with a core philosophy of maximising the energy efficiency and environmental sustainability of its affordable housing developments. In 2000, the housing association used their planned development at Corncroft to bid for funding from the DTI for a domestic photovoltaic field trial. This funding was secured with the help of Energy for Sustainable Development Ltd (ESD), and the project began onsite in late 2001.

Project Partners

Nottingham Community Housing Association
Energy for Sustainable Development Ltd
Powergen
Westleigh Homes

Fosse Estate, Newark

Location	Newark, Nottinghamshire
Type of Area	Urban
Tenure	Housing Association
Built Form	Terrace Bungalows
Contact Name	Nottingham Community Housing Association
Phone / e-mail	(0115) 910 4444
Web Address	www.ncha.org.uk
Visiting Possible	By prior arrangement

Summary

This project was built in 1999 on a brownfield site and incorporates high levels of thermal insulation, a covered street, level access to all properties and four units built for residents with higher needs as a result of physical disabilities.

The construction incorporates the Masonite 'I'-beam system. This is sourced from sustainable Scandinavian wood, reduces waste onsite and incorporates element recycled wood waste. This system also allows for the easy construction of wide cavities, providing for high levels of insulation, and reduces the amount of heat lost through thermal bridging via the studs when compared to traditional timber frame systems.

The dwellings are orientated to maximise solar gains and are arranged internally so that the main living areas face south.

Communal space is provided internally by the covered street, and externally by communal gardens.

Project Objectives

To create a group of energy efficient bungalows for older persons.

History of Concept

The Housing Association wished to use a covered street design to provide a communal space in which residents could socialise. This would have the additional benefit of reducing the residents' space heating energy usage, due to the street's buffering effect on the envelope of each dwelling, and its ability to store solar thermal gains. It was felt that this type of design would be particularly appropriate for older people, who generally prefer higher room temperatures and would benefit from the potentially lower fuel bills.

The buildings were designed as part of a competition to achieve weekly fuel bills of less than £1 per week. These buildings achieved this when modelled by computer software using the Standard Assessment Procedure (SAP) algorithms. From the actual fuel bills, the average energy costs for the first 38 months from the date of construction of a sample of eight properties on the site were found to be:

Gas	£1.44 per week (£74.88 per annum)
Electric	£3.80 per week (£197.60 per annum)

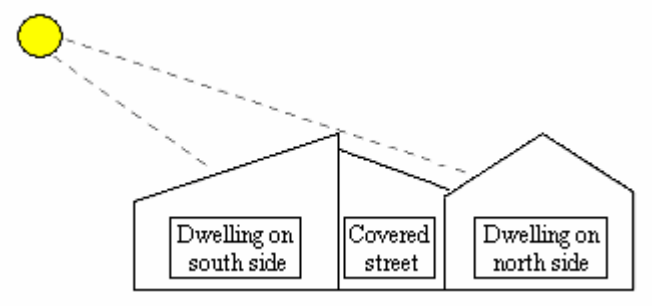


Figure 1. Showing the layout of terrace rows on either side of the .

Construction Details

Built form This was a brownfield site, formerly occupied by three 5-storey blocks of flats that were demolished. The development consists of 33 terrace dwellings arranged in five groups around the site. The largest group consists of 20 units while others contain three or four units each. The units are orientated to maximise passive solar thermal gain, thereby reducing heating costs and greenhouse gas emissions.

Figure 1 shows how the terraces are arranged on either side of a glazed covered street. The use of a mono-pitched roof on the southern dwellings provides shading to the covered street and prevents it from overheating during the summer. The covered street encloses a peripheral wall of the dwellings, thereby reducing heat loss by buffering this element from external weather conditions. In the case of the largest group of dwellings, the covered street is nearly 50 metres long and provides a valuable circulation space for the residents.

Walls Timber frame, breathing wall construction, using Masonite 'I'-beam studs to provide a 150mm cavity that is filled with recycled cellulose (paper) slabs.

Roof Concrete tiles upon prefabricated timber trusses. The loft floor is insulated with 200mm of mineral wool insulation.

Floors Timber raft floor above insulated concrete base

.

Windows uPVC double-glazed units.

Rainwater Rainwater drainage from the site is achieved by the use of soakaways.

Internal Layout The lounges are on the southern side of the dwellings, to maximise the benefits of solar thermal gains.

The windows, walls and doors facing onto the covered street are of the same construction as the external facade. This causes the covered street to be thermally isolated from the dwellings, which is important for when the external temperature falls particularly low during the winter.

Resource Conservation

Heating Each dwelling within the development is fitted with a condensing gas combination boiler controlled by a programmer, room thermostat and thermostatic radiator valves (TRVs).

Lighting Compact florescent lights (CFLs) are provided to reduce the energy use and cost of artificial lighting.

Ventilation Passive-stack ventilation is used in the kitchen and bathroom. Elsewhere, standard trickle ventilation is incorporated into the window surrounds.

Resident Training It is the policy of the Housing Association that all residents receive training in energy awareness, to help them reduce their fuel costs.

SAP / Eco-ratings NHER = 10

U-Values (W/m^2.K)

Walls:	**0.21**
Floor:	**0.35**
Roof:	**0.18**
Windows:	**2.50**
Doors:	**0.35**

Transport

The project is within an existing housing estate. There are shopping facilities nearby and good public transport links to the main town centre.

Communal Facilities

Figure 2. Covered, glazed street between two terraces

The glazed, covered street (see Figure 2) provides an area where tenants have the opportunity to engage with each another and generate a sense of community. Many of the residents have adopted the areas directly outside their homes and planted ornamental plants, contributing to the aesthetics of the scheme.
The scheme also provides a mixture of communal garden/allotment space and a private garden for each dwelling.

Well-Being

Special support and integration

Support is provided by the Housing Association to the residents of the four dwellings that are specially adapted for the needs of registered disabled persons.

Health and affordability

The low fuel costs incurred by the residents ensure that they are at a greatly reduced risk of suffering from the symptoms of fuel poverty.

Accessibility

All of the dwellings have level access from the covered street and four units have been built to accommodate residents with high disability needs.

Crime

Access to all dwellings is via a lockable entrance into the covered street. Each dwelling is then individually accessed via a conventional front door. An intercom system is provided in each dwelling to enable residents to question visitors before letting them into the covered street area. This provides the residents with a greater sense of security, as the only people who should be in the covered street are other residents or their guests.

All dwellings within the scheme meet the national 'Secure by Design' standard.

Additional Information

Details of barriers and other issues relating to NCHA's experience of developing a more sustainable form of housing are included in the entry for "Beaconsfield Street".

Garendon Road, Loughborough

Location	Loughborough
Type of Area	Urban
Tenure	Housing Association
Built Form	Terrace bungalows and semi-detached, two-storey housing
Contact Name	Nottingham Community Housing Association
Phone / e-mail	(0115) 910 4444
Web Address	www.ncha.org.uk
Visiting Possible	By arrangement only

Summary

The sustainability features of the project include estate layout and internal building arrangements that maximise passive solar gain to reduce the heating load. Rainwater harvesting and storage for use in toilet flushing is included and car parking standards are set at 50 per cent below local authority recommendations.

Project Objectives

To create a scheme of seventeen energy efficient dwellings incorporating 'Lifetime Homes' standards.

History of Concept

Nottingham Community Housing Association (NCHA) has been working with low-energy design since 1997. It was requested by Charnwood Borough Council to incorporate the methodology of low-energy design with the features of 'Lifetime Homes'.

Construction Details

Built form Seventeen dwellings have been built on this Greenfield site as a mixture of terraced bungalows for elderly clients and semi-detached family houses.

Roof Concrete tiles on prefabricated timber rafters. The loft floor is insulated with 200mm of mineral wool.

Walls Timber frame construction with 100mm of mineral wool insulation and clad with bricks.

Floors Suspended concrete ground floor with 75mm of expanded polystyrene insulation underneath.

Windows Timber framed, double-glazed units, with low-emissivity glazing.

Other The layout of the development follows the guidelines laid out in GIR027 "Passive Solar Estate Layout" published by BRECSU. The principles of this are to orientate as many houses as possible so that the elevation containing the most glazing faces within 30° of south, whilst avoiding obstructions to solar access through the windows. In addition to the layout of the housing estate, maximising the benefits of passive solar layout also requires an internal house design that places the main living areas to the south of the

dwelling. Approximately half the potential energy saving from passive solar design comes from correct estate layout and the other half from appropriate internal layout. When combined, these two design methodologies can produce energy savings of approximately 10 per cent over conventional methods at no additional cost to the developer.[3]

Resource Conservation

Heating Gas condensing-combination boilers with room thermostats, programmers and thermostatic radiator valves (TRVs).

Lighting Low-energy lighting is used throughout the development

Ventilation Humidity-controlled passive-stack ventilation is fitted in the kitchen and bathrooms of the dwellings. Standard trickle ventilation is fitted into the window frames in all other rooms.

Water Conservation Rainwater is collected from the roof, stored and used for flushing toilets. All toilets fitted in the dwellings will consume four-litres or less of water per flush.

Water butts are also provided as standard for residents to use to irrigate their gardens.

Resident Training It is the policy of Nottingham Community Housing Association for all tenants to receive training in energy efficiency awareness.

SAP / Eco-ratings NHER 10

Transport

The development is in an urban area close to schools and with easy access to public transport facilities. A cycle lane already passes next to the land where the development is situated and is linked to it. Car parking provision within the development has been reduced to 25 per cent below local authority recommended standards.

Landscaping

The cycle lane that adjoins the development site contains verges that are home to a large range of species of flora and fauna. The housing association is attempting to maintain and enhance this area during the development of the project and is working with the borough council's landscaping and wildlife departments to achieve this aim.

Well-Being

Health and Affordability The low-energy design of the dwellings in conjunction with rainwater toilets should reduce the utility costs and protect the residents from fuel and water poverty.

[3] Figures from GIR027: *Passive Solar Estate Layout*, BRECSU, London, 1997.

Crime	The homes all comply with the national 'Secure by Design' standard.
Adaptability	The dwellings all comply with the national 'Lifetime Homes' standard.

Additional Information

Details of barriers and other issues relating to NCHA's experience of developing a more sustainable form of housing are included under the entry for "Beaconsfield Street".

Project Partners

Nottingham Community Housing Association
Charnwood Borough Council

The Nottingham Eco-Home

Location	West Bridgford, Nottingham
Type of Area	Urban
Tenure	Owner Occupied
Built Form	Semi-Detached
Status	Fully Occupied
Contact Name	Gil Schalom & Penny Poyzer
Phone / e-mail	(0115) 9143893 gil@msarch.co.uk
Web Address	www.msarch.co.uk/ecohome
Visiting Possible	By appointment only
Fee Charged	Contact for details

Summary

This is an owner-led project to renovate an Edwardian semi-detached property, which was initially in very poor condition, in an environmentally friendly manner. The project is still in progress, but to date includes features such as high levels of internal insulation, rainwater harvesting, whole house composting toilets, low flush toilets, energy efficient white goods, environmentally friendly construction materials, use of recycled construction materials, solar water heating, heat recovery ventilation and a large range of environmentally benign decorative finishes.

The need for a conventional central heating system has been avoided and the dwelling is virtually CO_2 neutral in use through the purchase of electricity from a company specialising in renewable energy.

The owners have tackled the issue of housing density and converted their loft to provide additional self-contained space for lodgers. The property is currently home to 3 family members and two lodgers. This has the added positive effect of increasing the affordability of the dwelling for everyone. Transport issues have also been taken onboard and a home office has been created for one resident who works fulltime from home.

The dwelling is an expression of its owners' philosophy to minimise their impact upon the environment and to assist others to do the same. To date it has featured in numerous magazine and press articles, and local TV and radio reports. The owners have provided tours to hundreds of interested individuals and groups, and their expertise is often sought with regard to the performance of many of the products they have installed.

Project Objectives

To renovate an Edwardian semi-detached property using environmentally friendly materials, improve its sustainability in use and increase the density of its occupancy whilst providing a home that is comfortable and suitable to a modern lifestyle.

Construction Details

Built form Refurbishment of an Edwardian semi-detached property.

Walls The walls are of traditional 9-inch solid brick construction. The entire exterior of the house, except the front wall, has been clad in 6 inches of 'Sto' rigid polystyrene insulation board. This is reinforced with a glass fibre mesh and acrylic rendered to provide weather protection and a better appearance. The front wall of the dwelling has been insulated internally using two-layers of 'Knauf' dry-lining board. This comprises a 40mm layer of rigid, zero ozone depleting, phenolic foam bonded to 12.5mm of plasterboard. This approach was chosen to ensure that the appearance of the house was in keeping with neighbouring properties.

Roof Traditional Edwardian slate that has been completely overhauled, re-using the original slate wherever possible and using reclaimed slate tiles where replacement was necessary. A breather membrane was used as an alternative to sarking felt, and the roof eaves were extended over the gable wall to create an overhang that will accommodate the planned external wall insulation. The roof is insulated with 300mm of recycled cellulose insulation in the sloping sections and 400mm on the flat sections.

Floors The suspended timber ground floor has been insulated between the joists using 75-100mm thick slabs of 'Thermafleece', made from British sheep's wool, which is underdrawn using a 'Tyvek' breathing membrane, and held in place by 'Gutex' wood fibre insulation board, fastened to the underside of the joists. This reduces the amount of thermal bridging through the joists. This work was relatively easy to carry out due to the large basement that runs under the main part of the house.

The solid ground floors were excavated and replaced with 150mm concrete slabs upon 150mm Jablite polystyrene slab, insulated at the edges with 50mm polystyrene to avoid thermal bridging between the floor and the walls. The floor was then top dressed in Cornish slate.

Windows The previous owner had replaced the original wooden sash windows with double-glazed uPVC units. As the finances become available, these will be replaced with double or triple glazed units that incorporate a low-emissivity coating and gas fill.

The present external door will be replaced with a non-pressure treated softwood unit that includes Iplus glazing. Iplus uses a bismuth-based low-emissivity coating that is more thermally efficient than the conventional Pilkington low-e coating. This door will form the inner door of a draught lobby. It is hoped that the external door of the lobby will be of English Oak.

Triple-glazed 'French' windows have been installed at the rear of the dwelling. These are wooden framed, sealed units using the Iplus system, with two bismuth-based low-e coatings giving a performance about five times better than conventional double-glazing.

Rainwater All rainwater goods are made from copper, as it has better environmental performance than PVC, and because the rainwater is harvested and stored for later use. Copper has a mild disinfecting effect on water, which improves the quality of the stored rainwater.

Plumbing All replacement and new plumbing used in the dwelling is made from 100% recycled polyethylene.

Wiring All replacement wiring within the dwelling is PVC free, low smoke - low fume, rubberised sheathed cable.

Internal Decoration All paints, varnishes, floor coverings, etc. have been chosen for their low impact, with regard to the internal and global environments. The owners have chosen to experiment with as many different products as possible; including Cornish slate (in preference to more expensive Welsh slate), low volatile organic compound (low VOC) paint, mineral based paints, hardwax oil (in preference to traditional varnishes), linseed oil, borate wood preservative (in preference to pressure treated wood), zero formaldehyde MDF, etc.

U-Values (W/m^2.K)

Walls:	**0.23**
Roof:	**0.10**
Floor:	**0.21**
Windows: (double glass)	**1.20**
(triple glass)	**0.60**

Resource Conservation

Heating The heating demand was initially met using incidental heat gains provided by the residents' activities, such as washing and cooking, topped up by portable electric heaters using 'green electricity' from Unit(e). Due to the poor electrical efficiency of these heaters however, a 29kW wood-burning central heating system boiler has been installed in the cellar with the help of two grants; from the New Energy Foundation and the Clear Skies scheme. The boiler heats a super-insulated, 1100 litre drum of water and has, to date, been fuelled using softwood obtained for free from local timber merchants. Hardwood logs would burn slower and therefore permit less frequent refuelling. The water flow distribution around the house is controlled by a digital thermostat and programmable timer.

Water heating is provided by a combination of solar water heating, topped up by an electric dual immersion heater during the summer, and off-peak electricity during the winter months when the solar contribution is less. A 4m^2 flat plate collector is fitted to the south-facing roof of the dwelling. Heat from the collector is stored in a highly insulated hot water cylinder situated in the roof-space.

Lighting Compact fluorescent lights (CFLs) are used throughout the dwelling.

Ventilation Individual 'through-the-wall' heat recovery fans are provided in the kitchens and bathrooms. These are controlled by humidity sensors and have a manual override, enabling them to be turned off during the summer months, when ventilation is provided by opening windows.

Water Conservation Water use within the dwelling is reduced through a combination of rainwater harvesting and storage for use in toilets, washing machines and garden irrigation, as well as low-flush toilets (2-4 litres per flush), low flow showerheads and aerating taps. The bath is only 1.2m in

length thereby reducing the amount of water needed to fill it and the amount of space needed to accommodate it.
The dwelling also incorporates a 'whole-house' toilet composting system that separates the water from the solid waste for the dwelling's three toilets. Water from the toilets passes through an Aquatron Separator situated upon a bespoke composting chamber in the basement (see Figure 1). The separator acts as a centrifuge; separating the liquid portion of the waste, which passes into the main drain, from the solid, which falls into the compost chamber. Once inside the chamber, the solids lay on a raft composed of 150mm of plastic pellets, netting and 50mm of coir compost. Efoetida worms were introduced into the chamber to help speed up the digestion process. They also reduce the volume of the solids by 90 percent so that the chamber only needs emptying every 7 years (estimated, based on 5 adults).

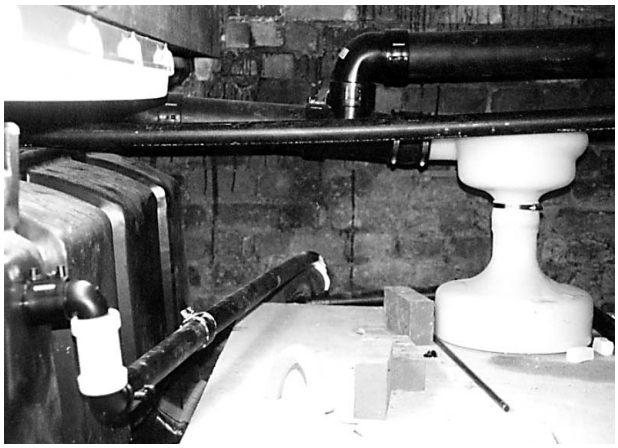


Figure 1. The bespoke composting chamber constructed from engineering brick and concrete. The white Aquatron Separator is visible on top of the chamber

A standard soil-vent pipe ventilates the chamber. The only other maintenance that the system requires is for excess liquid to be pumped out every three weeks. This is achieved through the use of a standard marine bilge pump and takes just fifteen minutes. The output can be diverted directly out to the main drain, or used as fertiliser in the garden.
Rainwater collected from the roof of the dwelling is initially filtered, again using a centrifugal separator but this time the much smaller 'WISY' units, and then stored in two 100 litre polypropylene tanks situated in the basement (see Figure 2). A sensor activates a pump when demand for water is made by turning on the outside tap, the washing machine or by flushing one of the toilets. Supply is automatically switched to the mains water system if the water level in the tanks falls too low. Water meters are fitted to both the rainwater outlet pipes and the incoming mains

Figure 2. The rainwater storage tanks in the dwelling basement.

water pipe. From these it can be seen that the system is providing approximately 25 per cent of the household's needs.

Communal Facilities

The owners rent out the top floor of the dwelling, which has been converted into a self-contained area for two lodgers. In this way the house and its facilities become shared resources for a greater number of people. This ultimately saves resources compared to the potential three households, with individual household goods, that may otherwise exist. It also contributes to diversifying the economic base of the dwelling's owners and offsets some of the costs of the renovation work.

Transport

The location of the dwelling is close to the city centre of Nottingham. Therefore its residents enjoy easy access to all of the centre's facilities, and access to public transport including a mainline station.

In keeping with the owners' philosophy, one member of the household works from home and another has a three-minute walk to their place of work.

A bike shed will be provided in the backyard of the dwelling to enable safe and convenient storage of bicycles. The residents are part of a large bike-trailer share scheme that operates in the local area. This grant-funded scheme owns over 50 trailers, of various types, for transporting children or other loads.

Landscaping

Resource Crops (food/fuel)

Although the garden belonging to the dwelling is relatively small, the owners have been growing as much of their own food as possible. There is a particular emphasis on winter salad crops and this will reduce the amount of energy expended on obtaining 'out of season' vitamins.

Well-Being

Health and Affordability

The reduced energy and water costs of the dwelling will reduce the risk of the owners suffering from the effects of fuel or water poverty. In addition, the use of relatively environmentally benign materials during

the refurbishment will result in a better indoor environment for the residents. Both these factors are further improved by the use of the mechanical heat recovery ventilation units fitted in the 'wet' rooms of the property. These will provide a constant source of fresh air to these areas, reducing the relative humidity to a point where dust mites can no longer survive.

Due to the shared nature of the house, and its proximity to local facilities, residents should find it easily affordable to live in.

Crime

The shared nature of the dwelling, and the fact that one resident works from home, means that the dwelling is almost continuously occupied. Therefore the risks of crime to the property are reduced.

Economic Aspects

The cost of the refurbishment to date is £100,000; this includes the renovation work that was necessary to the structure of the dwelling as well as the environmental features. The amount is higher than a traditional renovation, but should save the owners over £1000 per year in utility costs, as they will be paying only for the electricity required to run the appliances in the home.

One resident works from home as the co-ordinator for the local 'Eco-teams' project that works with groups of households to educate them about reducing the environmental impact of their lives.

Some members of the household actively support the Local Exchange and Trading System (LETS).

Plane Tree Court, Nottingham

Location	Nottingham City
Type of Area	Urban
Tenure	Social housing rental
Built Form	Terrace
Contact Name	Philip Wright Senior Contracts Manager, Metropolitan Housing Association
Phone / e-mail	(0845) 601 5042
Visiting Possible	By appointment only

Summary

Plane Tree Court is a group of ten bungalows for elderly people constructed using timber frame techniques and providing energy-efficient dwellings for their residents. The dwellings have been occupied since June 2002.

Apart from high levels of insulation, the main innovative feature of the development is the use of geothermal energy to provide heating and hot water to the dwellings. By working in partnership with a UK based heat-pump manufacturer, an affordable bespoke heat pump system that is capable of delivering enough heating and hot water for the residents' needs has been developed. This aspect of the project has been very successful and has been replicated in developments since undertaken by the Association. Four of the dwellings are currently being monitored by the Building Research Establishment (BRE), and the results of this are to be disseminated to the wider housing community.

The Association wished to create a sense of community within the development. They created a 'covered street', which provides a link between the dwellings and surrounds the communal gardens that are maintained by the Association. The ten terraced dwellings are set out in a U-shape, with the covered street following the internal edge of the 'U', enclosing the communal gardens on three sides.

Both of these innovations have proved popular with the residents, who enjoy the opportunities for interaction that the design offers and the lower fuel bills that the heating and construction systems deliver.

Project Objectives

To create a group of ten low-energy bungalows for older residents that creates a sense of community through the use of communal space.

History of Concept

Metropolitan Housing Association (MHA) wanted to build on the experience of other projects around the country that use communal space to create a sense of community within the development.
They also wished to trial the use of geothermal energy as the main heating source for the development. This was mainly driven by personal interest and experience of some of the Association's managers.

Construction Details

Built Form The development of ten dwellings is on a brownfield site**.** Each dwelling has two-bedrooms and is 65m^2 in size.

Walls Timber frame construction with a 147mm cavity filled with mineral wool. The outer leaf consists of a brick skin and internally the walls are lined with plasterboard.

Roof Warm roof construction that extends from the dwelling on one side to form the roof of the covered street. Motorised Velux rooflights are fitted into the roof of the covered street to provide ventilation to and prevent overheating of this area during the summer

.

Floors Suspended timber floor with 'Kingspan' phenolic foam board laid on top of the joists. The pipes for the under-floor heating system are laid on top of this and set into a 50mm screed.

Windows The windows are all uPVC units with a 20mm air gap and a single low-emissivity coating to the inner surface of the outer pane. The use of uPVC was dictated by the Association's maintenance policies; however, a review is currently underway of alternative frame types (e.g. wood) as the Association wishes to move away from the use of uPVC as its production involves no less than six of the fifteen chemicals listed by European Governments for priority elimination.

U-Values (W/m^2.K)

Walls:	**0.27**
Floor:	**0.25**
Roof:	**0.19**
Windows:	**1.70**
Doors:	**0.60**

Air Infiltration: **6.5 ac/h @ 50 Pa**

Resource Conservation

Heating A bespoke geothermal heat pump system, developed and manufactured for the Association by 'Calorex Heat Pumps', feeds an under-floor heating system and provides domestic hot water. The heat pump, which is the size of a conventional fridge, is situated in its own plant room within the bungalow. Water is pumped into a 70m borehole under the property where it is heated naturally by geothermal energy to 12°C. The heat pump extracts and upgrades this heat before storing it in a thermal store. The heat for the central heating system and the domestic hot water is drawn directly from this store.

The resident adjusts a room thermostat to set the internal building temperature to their requirements. The rest of the system is set up and managed by the Housing Association, which tries to achieve the optimum settings for each household.
The under-floor heating system uses a German 'Thermalfloor' pipe. This comprises of a layer of aluminium set between two layers of plastic. This gives the pipe extra rigidity and prevents it from kinking.

It also prevents air seeping into the pipe, a problem that may occur in more porous, plastic pipes.

Lighting Compact Fluorescent Lights (CFLs) are used throughout the development. The 'Lampholder 2000 Series' is used and prevents low-energy lights being substituted by conventional light bulbs. The system works in the same way as a conventional 'strip' fluorescent tube in that the light fitting incorporates the ballast for the lamp. The resident can replace the compact tube when necessary at a cost of less than £2 per unit. This is also the most cost effective option from the resident's point of view.

Water Conservation Dual-flush (four litre and two litre) toilets are fitted as standard to reduce water use, and showers have been fitted in the dwellings in preference to baths. The residents have not reacted negatively to this approach to water conservation.

Resident Training All residents are given basic energy efficiency information from the Housing Association that helps them to reduce their energy costs.

SAP / Eco-ratings The bungalows achieve a SAP rating of 100 and NHER rating of 10.

Transport

The development is located in an urban area close to shops and recreational facilities. A bus route passes close to the development and provides easy access to the city centre and other transport connections.

Landscaping

The landscaping of the development includes outside seating areas, a water feature and the use of bamboos and herbs to create a pleasant and low maintenance environment for the residents.

Social Aspects

Post-occupancy tenant surveys are used by the Association to gain feedback on the design. Issues that arise from these surveys are fed into the design of future projects.

Communal Facilities

Communal areas have been provided for all residents in the form of the covered street and a Japanese-style low maintenance garden. In addition, small private front gardens are also provided for each dwelling. All the external space is managed on the residents' behalf by the Housing Association.

The windowsills within the covered street have been designed to be wide enough to allow the residents the opportunity of growing their own plants inside the covered space.

Well-Being

Health and Affordability The high levels of insulation, efficient heating system and the use of low-water toilets and showers has reduced the utility costs for the residents, and therefore reduced the likelihood of them suffering from fuel poverty. CS

Accessibility	All the dwellings within the development are built to the 'Lifetime Homes' standard and have full disability access.
Communication Systems	The 'Life-Line' warden call system is fitted as standard to all dwellings in the development.
Crime	'Secure by Design' techniques were used throughout the development.

Economic Issues

The cost of development was £900,000 for a total of ten dwellings

Additional Information

One of the key features in the success of this project, and others undertaken by MHA, is the ability to form long-term partnerships with building contractors. This is largely due to the Association's implementation of the recommendations set out in the Egan report. The methodology allows developers such as MHA to share the risks and uncertainties associated with innovation with their partners.

One of the restrictive features of being a Registered Social Landlord (RSL) is having to work within the development costs set down by the Housing Corporation. There is no doubt that the increased costs of development and land acquisition, in conjunction with a Social Housing Grant (SHG) regime which seeks to deliver the lowest amount of grant possible, inhibits the ability of RSLs to be more innovative.

MHA also identified two other issues that have arisen directly from their experience with highly-insulated buildings. The first is the need to fit external doors that have a high thermal resistance. Some of the first developments undertaken by the Association using highly insulated timber frame buildings resulted in condensation, and consequently mould, forming on the door panel as this was the coolest exterior surface.

Secondly, the Association have abandoned the use of individual heat recovery fans in the kitchen due to overheating problems. This is due to the combination of a highly insulated envelope and high internal heat gains in the kitchen area. The Association now specifies standard extract fans.

Project Partners

Metropolitan Housing Trust (Owners & Designers)
Westleigh Developments Ltd. (Builders)
Powergen / Calorex (Heat-pump design)

River Crescent, Nottingham Waterside

Location:	Trent River Park, Nottingham
Type of Area:	Urban riverside regeneration
Tenure:	Mixed
Built Form:	Apartment block
Status:	Construction to start autumn 2004
Contact Name:	Trent Park Developments
Phone / e-mail:	(0115) 912 3456 tpd@rufford-hall.co.uk
Visiting Possible:	By appointment only
Fee Charged:	No

Summary

River Crescent will be an important first step towards the regeneration of the Riverside area as a major waterfront urban quarter for the city.

Trent Park Developments have proposed a 128 luxury apartment scheme that incorporates a number of well-proven eco-technologies. A solar photovoltaic roofing system and vertical axis wind turbines will generate electricity to heat and light all the communal areas. The River Trent is to be used as a heat source for a heat pump system that will provide the warm water for the complex swimming pool. Landscaped terraces will reduce the rainwater runoff from the rooftop. Most unique of the sustainable proposals however, is a fleet of compressed air powered cars that are to be provided for residents to either hire or buy. The air compressors will be powered using electricity generated by the PV roof, making this a true fleet of eco-friendly vehicles.

The proposal followed consultation with Nottingham University's School of the Built Environment and is seen by Trent Park Developments as the most effective means of illustrating how seriously they accept the responsibility of tackling both global warming and the UK's increasing dependence on imported energy. Their intention is to embrace the best of the proven eco-technologies, in a way that will make the Riverside regeneration one of real international prominence.

Project Objectives

To build a scheme of 128 luxury apartments, as part of the Riverside regeneration strategy, that incorporates many of the best and well-proven eco-technologies.

History of Concept

The success of Nottingham City's economy during recent decades has led to the transformation of many of its parts, particularly in the City Centre; however, not all parts have fared equally well. The 100 hectare Riverside area, which currently serves industrial and commercial uses, has suffered from being essentially isolated from its surrounding urban areas by the heavily trafficked roads, the rail and canal networks and the River Trent. This has led to a reduced quality and high level of vacancy in many of the existing buildings, and an environment that is very much poorer than appropriate for this potentially prestigious location.

In 1999, the British Waterways Board and Nottingham Regeneration Ltd established Nottingham Waterside Limited (NWL) as a joint venture with the aims of:

- developing a detailed masterplan and regeneration strategy to bring about the redevelopment of the Riverside area;
- formulating the strategic framework that would establish the long-term regeneration of the wider Trent River Park region.

A series of consultations with local businesses, residents and landowners were held in July 2000, with the purpose of identifying the issues of greatest importance to them, and the "*Nottingham Riverside Masterplan*" was published in March 2001.

The vision contained within the masterplan is one of a mixed-use, waterfront, urban quarter that will provide an exceptional living and working urban environment in a desirable riverside setting. One objective is to link the City Centre back to the River Trent, in a way that encourages its use as a destination for waterfront and water-based activities, as it was until the latter half of the 1900s. It is recognised that the extensive mix of residential, commercial, office and leisure facilities proposed should fit around the major land uses that the Riverside is home to at present, such as the Notts County Football Club stadium, the Lady Bay Retail Park and the Eastcroft waste-to-energy incinerator.

A number of new waterside neighbourhoods are suggested, comprising over 4,000 homes in total, each with the facilities required to support a sustainable community and with good links to its neighbours, the river front and the City Centre. One such neighbourhood will be in the Trent Basin area, which includes the existing Park Yacht Club site at the end of Trent Lane. The masterplan suggests that residential development in this area should consist predominantly of apartments at a minimum of 4 storeys high and a density of 200 units per hectare. The developers, Trent Park Developments, are hopeful that the construction of *"River Crescent"* will commence at this site in the autumn of 2004, with a 20 month build program.

Construction Details

Built form

128 luxury apartments each with 2-4 bedrooms, in a 7-storey scheme built around an in-situ concrete and lightweight steel frame.

Greenfield/Brownfield

Although River Crescent is to be on greenfield land, 70 percent of Trent Park Developments' regeneration plan for the Riverside area is on brownfield land.

Walls

The external cavity walls will consist of 102mm of facing brick, a 75mm air cavity, 50mm of Celotex insulation board, 100mm for a lightweight steel inner leaf frame, and two 12.5mm layers of Fermacell boarding for internal lining. Fermacell is a sound and thermal insulation board consisting 80 percent of gypsum recovered from desulphurisation plants and 20 percent of recycled paper.

Fermacell boarding is also to be used on the internal metal stud walls for improved insulation properties. Sound insulation is to be 100 percent above what is required in the Building Regulations.

Roof

The Corus Kalzip aluminium rooftop will contain up to 210mm of insulation to achieve the required U-value. The curved, aluminium, standing seam is to incorporate a Solar Century photovoltaic laminate for electrical energy generation.

The two uppermost floors of the scheme are to be set back from the floors below in a way that creates terraces rather than balconies. These terraces shall be landscaped using low maintenance plantings and synthetic grass.

The health centre and swimming pool is to be in a semi-basement area; offset from the main building in such a way that its rooftop can be landscaped over. This "green roof" will provide additional insulation and reduce the energy necessary to maintain the facility at the elevated temperature that it requires.

Floors

The floor between the underground car park and the ground floor of the scheme will consist of 300mm of reinforced concrete, 100mm of heavy duty, closed cell, thermal insulation, 100mm of reinforced screed, and 19mm of upper surface finish.

Upper floors will consist of reinforced concrete with 50mm of acoustic insulation.

Windows

Double glazed units featuring solar reflective glass with a low-emissivity coating and argon gas fill. The frames will be of aluminium with thermal breaks.

The terraces of the two uppermost floors will not be shaded, as the floors below are, by balconies above. Instead louvered, aluminium, brise soleil will prevent overheating of the living area.

Internal Layout

The apartments will been arranged so that the living spaces are on the southern side, to take advantage of passive solar heat gain as well as providing a view overlooking the river. The bedrooms and bathrooms of most apartments will be on the cooler, northern side.

Resource Conservation

Heating

The apartments will be heated using electric panel heaters.

Lighting

Large areas of glazing on the south facing facade of all apartments will ensure good natural lighting levels.

Energy efficient lighting and appliances will be used throughout the scheme.

Ventilation

Natural ventilation is to be used throughout the building except in the top floor penthouse suites where air conditioning units will be provided.

Energy Generation

The developers wish to demonstrate the seriousness with which they view both global warming and the UK's increasing dependence on imported energy, both of which will have the effect of rising energy prices in the years to come. A variety of sustainable systems are therefore to be integrated into the scheme to generate energy for communal use.

A flexible PV laminate roofing system from Kalzip, in association with Solar Century, will be integrated into the scheme's rooftop. It is predicted that the 47.7kWp rated array will prevent the release of approximately 17 tonnes of CO_2 each year.

Five vertical axis wind turbines from Windside will line the rooftop to give a visually striking roofscape. Each will be positioned directly above one of the glass fronted stairwells on the northern side of the building.

A heat pump system that uses coil pipes positioned in the River Tent will provide free heating for the communal health centre and swimming pool.

Research has also been conducted into the possibility of the developers running their own biomass fuelled Combined Heat and Power (CHP) plant. The plant would provide heat and power to dwellings and businesses in the development area, using locally sourced fuels such as waste wood and energy crops. The developers are confident that this aspect of the regeneration plan will progress once the end users of the generated heat and electricity are established.

Water Conservation

Rainwater is to be collected for irrigation purposes.

Recycling Facilities

Two external bin areas are designated recycling zones.

Resident Training

Written information shall be provided to the residents on the technological features within the scheme and how they are affected. In addition, there will be a 24 hour concierge service, which will be fully trained and able to instruct and assist the residents with any problems they may have.

SAP / Eco-ratings

The intention is that the scheme shall achieve an EcoHomes rating of Good.

Transport

One of the more unique sustainability features of the River Crescent scheme will be the provision of seven vehicles from French firm Moteur Developpment International (MDI), powered by compressed air and emitting nothing from the exhaust except chilled, clean air. These cars carry two onboard air compressor tanks that enable them to travel a distance of 120miles at speeds of up to 68mph before refuelling is required. Refuelling of the tanks is achieved by simply plugging the vehicle into a standard electrical power socket and a full recharge takes approximately 4 hours from empty. By running the cars off the green electricity produced by the solar roof and wind turbines, the residents will have access to a truly environmentally friendly fleet of cars that they will be able to hire or buy for their own use.

Twenty bicycles are to be provided free of charge for the residents. This will encourage recreational use of the new cycle and foot paths that the developers are creating along the riverfront to connect the development to Colwick Park and the City Centre.

Basement parking will exist for 165 cars, with approximately 10 percent of the spaces being allocated for disabled drivers. Two cycle storage areas are also to be provided as part of this scheme.

The need for commuting will be lessened by the provision onsite of a business centre, featuring a meeting room, and a health club with swimming pool.

Placement to local facilities

The masterplan repeatedly contains the aspiration of providing sustainable, mixed use neighbourhoods, with their own basic local facilities, to minimise the need for travel outside of the area.

Access to public transport

The masterplan includes a section devoted to improving public transport. River Crescent should be served by several bus services on a new road link to be created on the north side of the development. On the south side, a riverside walkway that will link the existing and proposed bridges across the River Trent will provide a safe route for pedestrians and cyclists.

In the longer term, it is planned that the Nottingham Express Transit tram system will provide a link from the Midland Train Station to the nearby Racecourse Park & Ride site. The possibility is also raised of river taxis using the Trent Basin area as a mooring point.

Landscaping

Encouragement of Biodiversity

Nottinghamshire Wildlife Trust has been consulted on the most suitable plantings for the development area. They have suggested a range of submergent plants appropriate for planting in the river, reeds and rushes for the marginals, attractive plants for the river bank, and meadows along the pathways.

Most of the trees that presently exist on the development site will be maintained and more will be planted to line the new east-west access road.

Resource crops (food/fuel) It is hoped that local and national farmers will be able to provide the bio fuel for the proposed CHP plant.

Economics

Onsite projects The development will include a business centre with a meeting room on the ground floor. This will facilitate working from home practices.

Integration with existing economy An arrangement has been made with a local bakery to supply the team during the construction phase, which should continue once the residents move in. In addition, it is hoped that agreements will be reached with local farmers to regularly supply the residents with fresh produce.

Communal Facilities

There will be a 24 hour concierge service available to all residents, on top of standard room service. The concierge will obtain information and make bookings for local events for the residents, assisting them to plan their leisure time however they can. The 24 hour presence of these employees will also provide additional security to the scheme.

Well-Being

Health and affordability By lighting the communal areas, heating the complex swimming pool and refuelling the fleet of air powered vehicles using free energy from the sustainable technologies, the developers will be able to reduce the fees charged to all the residents.

Accessibility It is intended that the scheme will provide homes suitable for middle aged persons to occupy through to old age, even if their health should deteriorate. The entire scheme is designed for full disability access, with wide doors and low thresholds throughout.

Crime The developers are working with the local police force in order to achieve the 'Secure by Design' standard.

It is intended that the scheme shall make use of radio chipped access cards for enhanced security. The cards, which the residents shall carry on their persons, will act as a key to open the security gates and doors on the development, without the residents having to physically turn a key or punch in a code. Access to the development will be automatically denied to anyone without a card, unless they are invited in by a resident via the intercom system provided every room. The use of such radio cards will also permit the automation of other manual processes, such as selecting the floor when entering the lift, or adjusting the entertainment

system to the resident's favourite settings upon entry of the apartment.

On top of the video intercom to the development gates, all apartments will have a direct call line to the concierge and security staff.

Economic Issues

This luxury scheme of 128 apartments shall have a gross development value of £40 million. It has been funded with a loan from the Royal Bank of Scotland.

The 47.7kWp rated photovoltaic array is being funded with a 40 percent grant from the DTI's Photovoltaic Demonstration Programme.

Project Partners

Trent Park Developments Ltd

Franklin Ellis Architects

Gaskell Associates, Quantity Surveyors

BWB Consulting Engineers

Hoare Lea, M&E Consultants

Taylor Woodrow Construction Ltd

Nottingham University
School of the Built Environment

Sony Professional Solutions UK

Royal Bank of Scotland

The Autonomous House, Southwell

Location	Southwell, Notts
Type of area	Rural
Tenure	Privately rented
Built Form	Detached
Contact	Robert Vale
E-mail	r.vale@auckland.ac.nz
Visiting possible	By appointment only
Fee charged	Check with contact

Summary

The autonomous house was the first of its kind in the UK. It is free from the needs of mains water and sewerage services and generates much of its own electrical energy needs onsite, using the national grid as a storage system to compensate for differences in supply and demand. The house incorporates high levels of thermal mass and insulation to offset the need for a conventional heating system. Rainwater collection, onsite sewerage treatment, photovoltaics and low energy lighting form the main elements of the building services equipment.

The house was designed and lived in by architects Dr. Brenda and Robert Vale who already had previous experience of low-energy building design and went on to design the earth-sheltered dwellings at Hockerton a few miles away. The builder of the autonomous house was Nick Martin who also constructed and now lives in the Hockerton Housing Project, which incorporates many of the lessons learned from the Autonomous House.

Project Objectives

To create an environmentally friendly four-bedroom residence that is neither exotic in appearance nor difficult to maintain.

History of Concept

The concept behind the development of the project has its roots in the writings of many authors whose work concerned utopian, socialistic, environmental and 'future technology' themes. The idea is that equity of global resources could, on some level, be achieved by harnessing the appropriate household systems technology to provide for the residents a 'sufficient' quota of warmth, water and waste disposal.

"An autonomous house has to depend on the resources that can be collected on its site, and the technology that it uses to harvest these resources needs to be simple, robust and controllable by the occupants. Only in this way will the inhabitants of the home gain that sense of control which will allow them to use their share of the Earth's resources sensibly" (Vale, 2000, p41). The house was also designed to complement the architecture of the area in which it sits and to be easily perceived as desirable by a "non-architecturally trained public" (Vale, 2000, p48).

Construction Details

The property is 15m long and 6m wide and orientated roughly north - south on its longest axis. The internal layout of the dwelling comprises of a series of four repeated bays, each spanning 3.5m of the length of the house and separated by 150mm load bearing wall. The orientation of the house was imposed by the constraints of the site upon which it stands. Whilst an orientation more in keeping with the ideals of passive solar design was possible, the designers believed that the energy saving benefits did not outweigh the benefits that the final orientation brings to 'fitting' the dwelling into the area that surrounds it. A conservatory is fitted to the west side of the dwelling and covers the external wall for three bay-lengths. The house has three real floors; a cellar, ground and first floor and a fourth mezzanine floor forming the attic, which spans the most northern bay and the two most southern bays. It does not cross the bay that contains the wood fuel heater on the ground floor.

The main living areas of the house are on the top floor with the bedrooms and bathrooms underneath. This layout takes advantage of the thermal stratification within the building, with the living areas kept slightly warmer than the sleeping and bathing areas. This strategy also provides a greater amount of natural light to the living rooms, kitchen and study / studio and avoids the overshadowing that the lower floor is exposed to from vegetation that screens the property from the adjoining busy road. Additional natural light is provided to the main areas by the use of skylights inserted into the roof.

Walls

The walls are of cavity construction with a 100mm dense concrete block inner leaf, a 250mm cavity filled with resin bonded glass fibre and a brick outer leaf. The wall ties used to join the inner and outer leaves are made of glass-reinforced plastic, which reduces thermal bridging between the elements. The bricks for the outer leaf were sourced from a supplier who uses methane gas obtained from landfill to fire their kilns, reducing the need for North Sea gas.

The cellar walls are composed of two leaves of Thermalite aerated concrete block with a 100mm cavity, which was filled with reinforced concrete and in turn tied into the reinforcing of the floor slab. The Thermalite is made from pulverised fuel ash from a nearby coal-fired power station and is therefore a recycled product. A damp-proof membrane of polyethylene reinforced with nylon mesh lines the exterior of the cellar walls to avoid water penetration. The cellar walls were not insulated as it was not designed to be heated or used for habitation. The seasonal temperature variation of the external soil was predicted to be only a few degrees around an average of 10°C, this would make the area appropriate for the siting of the water storage containers which need to be kept in a cool, dark area.

Floors

The cellar floor is a 300mm thick flat-slab of reinforced concrete. It is under-drawn by the same damp-proof membrane as used on the walls to avoid water penetration. Again, no insulation is used underneath the slab, which sits on a 50mm blinding layer of concrete. The remaining floors within the dwelling are formed of pre-stressed inverted T-beams with standard concrete blocks used to infill between them. The underside of the ground floor (cellar roof) is insulated with 50mm of spray-on cellulose insulation to reduce heat loss from the house to the unheated cellar.

Roof

The roof is pitched at an angle of 55°. The inner surface is lined with structural wooden decking which is untreated and exposed to the interior of the dwelling. This is covered with a vapour barrier, above which sits 500mm of cellulose fibre insulation followed by a breather layer (rigid bituminised fibreboard) to reduce airflow through the insulation. The roof is finished with

handmade clay pantiles, which is in keeping with housing in the surrounding area.

Windows In order to provide good internal natural lighting the house is fitted with a considerable number of windows, forming 21% of the area of the ground and first floor walls and 5.6% of the attic wall surface area. All windows are triple glazed with two low-emissivity coatings and filled with krypton gas.

Doors External doors are composite units insulated with CFC-free polyurethane and glazed to the same standards as the windows. The Velux units fitted into the roof are double-glazed with a single low-emissivity coating.

Conservatory The conservatory covers three of the four bays of the house and is on two levels. The lower floor of the conservatory shares the same floor slab as the cellar. This is used as a storage area and for growing tender plants. The upper floor is at ground level and is formed of decking placed above the lower floor. The decking does not span the entire length of the conservatory and contains two gaps approx. 2.4m in width which allow daylight from the conservatory to penetrate into the lower area. Stairs lead from the ground floor level and provide access to the under-house cellar. The roof of the conservatory is pitched at such an angle that it runs from ground floor ceiling height to just below the eaves of the first floor (see Figure 1). All glazing incorporated into the first and ground floor facades covered by the conservatory can be opened to allow the air warmed by the conservatory to circulate into the house.

Figure 1

Conservatory roof running from ground floor ceiling level to just under the roof eaves.

Perimeter ventilation is provided to the conservatory through manually controlled vents set in the 600mm brick wall that rises from the cellar level. When used in conjunction with the opening lights set into the conservatory roof, they were designed to provide enough ventilation to prevent the area from over-heating during sunny periods without compromising the security of the dwelling (see Figure 2).

Figure 2

Perimeter vents in conservatory wall at ground floor level, taken from the cellar level.

The sides and roof of the conservatory are composed of double-glazed units with a single low-emissivity coating set onto a softwood frame.

U-Values (W/m^2.K)

Walls	**0.14** (Main house external)
	0.31 (Cellar, not taking account of the surrounding soil)
Floor	**0.63** (Between house and cellar)
Roof	**0.065**
Windows	**1.1** (Main house, triple glazed)
	2.1 (Conservatory, double glazed)
Rooflights	**1.8** (Velum's figure)
Doors	**0.55**

Resource Conservation

Space heating

The levels of insulation built into the house were designed to allow the property to be heated purely from internal incidental gains (heat from people, appliances and lighting) and from passive solar gains. It was therefore unnecessary to install a central-heating system within the building. However, as a back up on particularly dull and cold days, a 4kW wood-burning stove was installed on the ground-floor hallway between the main entrance door and the stairs. This is only used for around 8 hours per week for fourteen weeks a year and is commonly fuelled by scrap or windfall wood.

Water heating

At present the water is heated by electrical energy either generated by the photovoltaic panels or imported from the National Grid. This was intended to be only a temporary measure. A heat-pump system was to be developed that extracted heat from the ventilation system and transferred it to the hot water cylinder.

Electricity

The house is fitted with low-energy lighting and appliances to reduce the electrical demand. Additional demand is incurred, however, by the use of electric pumps to pressurise the water system and a 5W fan that forms part of the sewerage system and operates continuously for 24-hours a day.

Ventilation

The house makes use of heat-recovery ventilation for the kitchen and bathrooms on an 'as necessary' basis. Otherwise, the house is

ventilated by natural leakage and trickle vents positioned above the windows.

Energy Generation A 2.16kW photovoltaic system comprising of 36 Solarex MSX-60 polycrystalline panels is fitted to a pergola in the garden and connected to the National Grid via an import/export inverter. The use of the pergola allowed the panels to be erected facing due south independent of the orientation of the main building. The pergola and the inverter have the capacity to support a further 12 panels should need or opportunity arise.

The output from the panels for the year 28th July 1994 - 28th July 1995 was recorded by a data-logger built into the inverter and showed that 1,616 kWh was generated during this period. A predicted consumption for the house, based on the first six months of recorded consumption, was 3,073 kWh of which 1,886 kWh is for water heating, leaving 1,187 kWh for all other uses[4]. The PV system would therefore have been capable of providing enough electricity for all lights, appliances, cooking, etc. on its own during this period.

Water conservation The dwelling has no mains water connection and relies purely on rainwater captured from the roof to supply all its needs. 20 ex-orange juice concentrate shipping containers that are situated within the cellar provide 30,000 litres of storage. This, at a rate of 200[5] litres per day, would provide the family with 150 days of water without the need for further rain.

Water is pumped from these tanks and initially filtered by a homemade sand filter. This is then stored in one of the twenty storage tanks and pumped on demand to a header tank located in the 'attic'. This is then fed by gravity to all the taps in the house with the exception of an extra tap positioned by the kitchen sink. Water from this tap is provided from the sand filtered storage tank but is subjected to additional filtering to ensure that it is fit to drink.

Wastewater is exported to an onsite soak-away where it leaches into the ground. As the amount of water exported is never greater than the amount of rainfall that would have naturally fallen upon the site, the local area is capable of absorbing this quantity of water.

The toilet fitted within the dwelling is a waterless composting unit. The main composting chamber of the unit is situated within the cellar. Two chutes from the two bathrooms located directly above the cellar feed into the top of the chamber. The two bathrooms are back to back on the ground floor, one is an en-suite accessible from the parents' bedroom and the other, separated from the first by a 70mm wooden partition, is for the children and guests. The two toilets are back to

[4] Figures from Vale, 2000, p226.

[5] Based on the Vale's own tests and calculations for their family of five (39ltrs/head/day). Average consumption for UK residents is 160ltrs/head/day (Vale, 2000, p178).

back within their respective bathroom, which allows their waste chutes to drop directly to the composting chamber below.

A small 5W extractor fan continuously draws air through the toilet and prevents odours from the compost chamber re-entering the property. This airflow also aids the digestion process within the chamber and carries away evaporated liquids. The products of the digestion process are used to fertilise the fruit trees and bushes in the garden.

Landscaping

Great care has been taken to fit the property into the local environment both architecturally, with respect to its effect on its neighbours' privacy, etc. and to provide as large a garden area as possible. Care was also taken to maintain the tree plantings that were already present. The house is situated behind a large hedge that was already in place. This screens the house from the noise and visual intrusion of the road that runs parallel to the property. In addition, an organic vegetable garden has been formed in one part of what is a fairly small plot.

Transport

The site was initially chosen for its convenience to local amenities. Shops, schools, recreational facilities and potential employment are all close by.

Well-Being

By eliminating the costs associated with the supply of services such a fuel and water, the autonomous house will provide affordable warmth and water to its residents. In addition, by selecting decorative finishes based on low toxicity materials and a well designed ventilation system, the house provides a healthy internal environment.

A reasonable degree of manual labour is required for the house to function correctly. This includes the chopping and storing of firewood in the cellar, transporting this to the ground floor fire, manually emptying both liquids and solids from the composting toilet situated in the cellar (60 litres of liquids every 3 - 4 weeks and about 200 litres of solids every 6 months for a family of five), etc. Older or physically disabled residents may find it difficult to negotiate the stairs to and from the cellar where most of the services are located.

Costs

The total cost of the development was £145,000. The land upon which the development is situated cost £69,000. If the whole floor area of the house, including the conservatory and the cellar are taken into account this equates to a cost of £500/m^2. Subtracting these areas and counting just the main internal living areas, the cost rises to £824/m^2.[6] All funding for the project was provided by Brenda and Robert Vale who designed and lived in the property. They also undertook the internal decoration, for which the labour costs are not included in the figures above.

Additional Information and credits

Several comments were made by the current residents with regard to the performance of some of the dwelling's features.

- The damp-proof membrane in the cellar is known to fail during bouts of heavy rainfall. This has occurred twice in the last three years leading to water penetration into the cellar.

[6] Figures from Vale, 2000, p229.

- The amount of ventilation / shading / thermal mass incorporated into the conservatory is inadequate to prevent overheating in this area. Temperatures in excess of 40°C are not uncommon during the afternoon of a summer's day even when all the vents, windows and doors are left open.
- The success of the compost toilet system is dependent on the continuous operation of the small fan that ventilates the system. If this fan fails for any reason, as it has done three times in the past three years, odours from the composting pit seep into the dwelling.

None of the problems above are insurmountable, and the residents still wish to record that the house is a very pleasant, sunny and spacious dwelling that they have enjoyed living in. They feel that it achieves its aims as an energy-efficient dwelling, with running costs much lower than previous dwellings they have rented.

Bibliography

A full and detailed account of the construction of the house, the reasons behind some of the decisions made and afterthoughts of the designers / residents several years after its completion are available in the book: "The NEW Autonomous House", written by Brenda & Robert Vale, published in 2000 by Thames & Hudson. This report has drawn extensively upon the information contained in this publication and the authors are duly recognised.

Underhill Avenue Eco-Houses

Location	Austin Estate, Derby
Type of Area	Urban
Tenure	Local authority rental
Built Form	Semi-detached
Status	Tenant occupied
Contact Name	Shaun Bennett
Phone / e-mail	(01332) 711012 Shaun.bennett@derby.gov.uk
Visiting Possible	No

Summary

Both dwellings are of highly-insulated masonry construction and incorporate different examples of heating and ventilation strategies, including gas and electric heating systems and solar water heating. Ventilation is achieved by mechanical whole-house heat recovery in one unit and passive stack ventilation in the other. The dwellings also demonstrate water conservation and rainwater harvesting techniques.

The wall construction of the dwellings differs between the ground and first floors in order to demonstrate different insulation strategies for both cavity wall and solid wall constructions. The dwellings have been used to inspire and inform both developers and residents within the city as to the financial and social benefits of energy efficiency, and they are being used in an attempt to set the standard for housing across the city.

Project Objectives

The project set out to replace existing social housing that had been damaged due to a gas explosion. In addition, Derby City Council wanted to use the opportunity to:

- Demonstrate Good Practice with regard to energy-efficient design
- Raise awareness of domestic energy efficiency across Derby
- Set the standard for cost-effective energy efficient design and encourage other housing providers to meet this standard
- Address other environmental issues such as water conservation and material use

History of Concept

The two eco-houses replace existing properties that were severely damaged by a gas explosion in July 1995. The Council took this opportunity to replace them with something out of the ordinary that demonstrated their commitment to energy efficiency, and from which other house builders and residents could learn. The properties have been tenant occupied since April 1997.

Construction Details

Built form Two semi-detached, four-bedroom dwellings.

Walls The ground floor wall (see Figure 1) consists of a brick outer leaf and 125mm Durox Supabloc 400 inner leaf, with a 50mm cavity that is filled with a Gypglas mineral wool slab. The inner leaf is lined internally with a 50mm phenolic foam backed plasterboard.

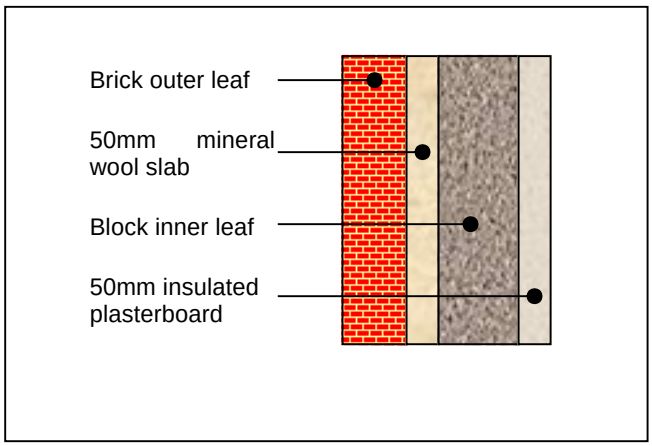


Figure 1: Construction of ground floor wall

The first floor wall (see Figure 2) construction consists of a 150mm Durox block externally insulated with a 50mm layer of Structherm phenolic foam insulation finished with a scratch texture render. The wall is internally lined with 9.5mm duplex plasterboard.

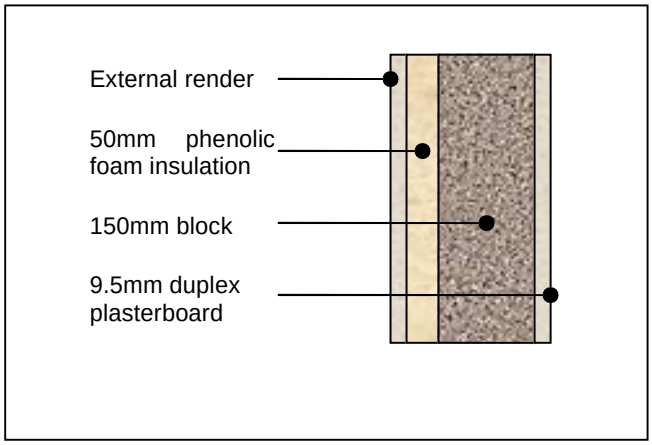


Figure 2: Construction of first floor wall

These two systems were employed to demonstrate different insulation strategies for both solid and cavity wall systems.

Roof Concrete tiles upon pre-fabricated timber roof trusses, and insulated with 250mm phenolic foam.

Floors The ground floor is comprised of concrete slab upon a polystyrene insulation slab.

Windows The windows are uPVC framed, double-glazed units with a low-emissivity coating for heat loss reduction.

Doors Fibreglass composite doors insulated with CFC-free polyurethane were fitted to reduce heat loss and ensure adequate draught-proofing, as they do not warp when exposed to varying external temperatures.

Other The damp-proof course used in the construction is made from recycled plastic, thereby reducing the amount of material going into landfill and reducing demand for virgin materials.

Linoleum was used in place of vinyl floor coverings as it has a lower impact on the environment in both its production and disposal.

Impact of Construction Local manufacturers and suppliers of materials were used wherever possible, which reduced the project's embodied energy from transportation mileage.

U-Values (W/m^2.K)

Walls:	**0.2**
Floor:	**0.2**
Roof:	**0.1**
Windows:	**2.0**

Resource Conservation

Heating Two different heating systems have been used, one in each house, to demonstrate good practice with both gas and electric heating.

One dwelling is heated by a gas condensing boiler complemented by a full controls package. This includes thermostatic radiator valves, hot water cylinder thermostat, room thermostat, programmer and a boiler management system that incorporates weather compensation. The boiler management system varies the start-up and shutdown times of the boiler in response to external weather conditions. If the weather is mild, the system will shorten the initial 'heat-up' cycle and save energy.

The other dwelling is heated by an electric 'Credanet' system. This system uses a central programmer, which allows the dwelling to be zoned, providing heat to different areas of the house at different times of day. Off-peak storage and weather compensation are incorporated into the system which, when used correctly, can be as economical as gas central heating.

Water Heating Hot water is provided by an off-peak, dual immersion heater that operates in tandem with an evacuated tube solar water heating collector. These two systems are used to heat water stored in a 210-litre insulated cylinder. In the summer months, the solar collector will provide all of the hot water requirements of the dwelling but can be topped up, if necessary, using the electric immersion system. In winter, the majority of hot water will be provided by the immersion system, using off-peak electricity. A mixing valve is installed to prevent scalding if the water temperature gets too high during the summer.

Lighting Compact fluorescent lights (CFLs) with standard fittings are used throughout the properties to reduce the amount of energy used for artificial lighting.

Ventilation Again, two different strategies were employed, one for each house. The electrically heated dwelling is fitted with whole-house mechanical heat recovery ventilation, whilst the gas heated dwelling is fitted with passive stack ventilation units in the kitchen and bathroom, and traditional trickle ventilation in the window frames of all other rooms.

Water Conservation The dwellings are fitted with a rainwater harvesting system that stores the water in a bulkhead behind the bathroom wall. The collected water

is used in the toilets. The system is backed-up automatically by a mains system in times of low rainfall. The toilets are low water-use units, requiring 6 litres per flush.

Rainwater collection butts are fitted to the outside downpipes for residents to use to irrigate the garden. A porous material made from recycled plastic was used to surface the driveways of the properties.

In addition, aerating taps are fitted in both the kitchen and the bathroom to reduce the amount of water used by the dwelling's residents.

Resident Training Residents are given training in the operation of the heating and ventilation systems.

SAP / Eco-ratings The dwellings achieve an NHER rating of 10.

Recycling Facilities Compost bins are provided to reduce the amount of organic waste going to landfill, and provide a useful resource of compost to the residents.

Transport

The houses are in an existing neighbourhood already on an established bus route.

Well-Being

Health and Affordability By reducing energy and water demand within the dwellings, the residents are protected from the negative effects of fuel and water poverty.

Adaptability Both of the dwellings meet the criteria of the national 'Lifetime Homes' standard.

Crime Both of the dwellings meet the criteria of the national 'Secure by Design' standard.

Economic Aspects

Cost of development £115,000 for two semi detached two storey dwellings

The additional construction costs came to £1,500 for each house, although this would be reduced for a larger development, due to economies of scale.

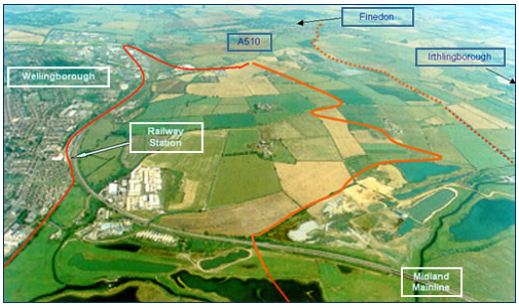
Subsidy Element of Costs Some product manufacturers offered discounts on their products to be part of the project.

The properties were constructed by the Council's Direct Labour Organisation at a higher cost than for a traditional new build. It may have been possible for an alternative contractor to have carried out the work at lower cost, but the Council felt that by using the DLO they would have greater control of the project.

Project Partners

Derby Homes Ltd.
Derby City Council
Derby City DLO

Wellingborough East Urban Extension



Location:	Wellingborough East (WEAST)
Type of Area:	Urban Extension
Tenure:	Mixed
Built Form:	Mixed
Status:	Adoption of Development Briefs
Contact Name:	Victoria Phillipson
Phone / e-mail:	(01933) 231 985 wellingborougheast@wellingborough.gov.uk

Summary

Wellingborough East is, at the time of writing, at the advanced master-planning stage. The first on-site development is due to take place in 2005 and, over the next eleven years, the project will deliver approximately 3000 new dwellings.

The total area of the site is 361 hectares. 82ha of this has been designated for housing, 110ha for employment, 14ha for community facilities, 9ha for leisure and 63ha for the town park which is located in the flood plain.

The project is a partnership between a consortium of landowners, Bovis Homes Ltd and the Council as the Community Leader. The Council has directed a lot of effort towards maintaining a successful relationship with the consortium and developer, as well as members of the existing community of Wellingborough. The aim of Council is to establish a sustainable form of development upon the site and provide valuable guidance tools for this and all future developments.

The scheme will potentially include: the provision of highly insulated dwellings, the use of reclaimed and sustainable building materials, the on-site generation of heat and electrical power, a Sustainable Urban Drainage System, and an integrated transport system with good facilities for pedestrians, cyclists and public transport. The scheme will also incorporate methodologies such as Home Zones, rainwater and grey water recycling schemes, and water conservation systems.

Project Objectives

To create a sustainable urban extension, linking into the existing town of Wellingborough in a complementary manner.

History of Concept

The Northamptonshire County Structure Plan for 1996 to 2016 was adopted in 2001. It provides a framework for a more sustainable Northamptonshire, taking account of national

and regional policies and the need to balance social, economic and environmental considerations. This Structure Plan indicates Development / Growth Objectives of 6500 dwellings and 160 hectares of employment land during the plan period. A significant proportion of both the housing and employment development is proposed in the Local Plan in Wellingborough East.

The Local Plan sets out proposals and policies for the development and use of land and buildings in the Borough. It is the starting point for all planning matters and explains what type of development will be allowed and where. It is the Council's responsibility to keep the Plan up to date, so in December 2000 it began a review to look at the housing and employment requirements for the future.

The Local Plan, which was adopted in March 2004, was guided by a sustainability appraisal that assessed, among other things, the most sustainable place for an urban extension in Wellingborough. The Wellingborough East Site has a number of benefits over the other sites assessed, which include the presence of brownfield sites and the proximity to the railway and the town centre. The railway will provide good links to London for commuters and businesses (45 minutes travel). Railtrack have recently invested in new rail sidings in Wellingborough, which could potentially attract light rail related industry to the site.

In 1999 the Council began to approach the many varied landowners on the site, which was partially identified within the Local Plan with an additional allocation provided for in the County Structure Plan. The Borough Council of Wellingborough at this time commissioned a feasibility study for the entire site and developed a vision statement.

A landowners' consortium was formed, and in 2000 BCW employed Nortoft Partnerships Ltd, who are experts in public-private partnerships, to project manage the development on their behalf. Nortoft have facilitated the link between the Council's internal Wellingborough East Project Team, the landowner consortium and the landowners' preferred developer Bovis Homes Ltd. The council are working with Bovis Homes Ltd to influence the design process in order to achieve the planning authority's objectives of a sustainable development. The council itself does not own any of the land within the designated area.

The consortium believes that the marketability of the development will increase if sustainability issues are incorporated into it, and will improve the quality of life for those living on the site. Bovis Homes Ltd has experience of working in partnership between landowners, communities and planning authorities, and has undertaken research into more sustainable methods of site development.

The local community has been actively involved in developing an illustrative masterplan to influence the developers. Many individuals and organisations have taken part in a range of consultation events including workshops, presentations, Technical Planning Events and consultation in the local shopping centre as well as an "Enquiry by Design" event, held over 3 days and facilitated by the Prince's Foundation.

The Council has committed resources, including the provision of a Project Manager, Project Co-ordinator and Project Support Staff, as well as additional staff time, into guiding the development, to enable the establishment of a more sustainable community, to which they are fully committed. The Council adopted a Supplementary Planning Guidance in April 2003 entitled "*Building Better Places: A Guide to Sustainable Development*". Along with the Local Plan, this SPG provides advice on good design and improved quality of life achieved by reducing energy usage and by the use of sustainable materials.

A Wellingborough East Development Framework SPG was adopted by the Council in November 2003. This document provides a vision and design principles for WEAST and will be used to coordinate and guide the more detailed Masterplans and individual site or building-specific Development Briefs that will be prepared in due course. At the time of writing, three draft Development Briefs were due to be adopted as SPG. The purpose of the Development Briefs is to supplement the policies of the Local Plan and guidance in the

adopted Development Framework SPG by setting out the detailed planning and urban design parameters and guidelines.

Other sustainability and development projects have been researched and best practice has been fed into the masterplanning undertaken to date. The Council also has membership of organisations such as the Prince's Foundation Urban Villages Forum and Forum for the Future to ensure that current best practice is incorporated into the master planning design.

Construction Details

Built form

Mixture.

Greenfield/Brownfield

Greenfield (part Brownfield)

Approach

Bovis Homes Ltd is researching different housing types for the development, which will take place in three phases:

- 2005 – 2006 construction of 500 dwellings.
- 2006 – 2011 construction of 1185 dwellings.
- 2011 – 2016 construction of 1190 dwellings.

It is anticipated that the dwellings built will be constructed to high standards with regard to energy efficiency, insulation and sustainable materials etc. The aim of the Borough Council is to increase the energy standards of the housing in each phase of the development and provide innovative examples of single houses to showcase new ideas, technologies and standards.

Materials

At the time of writing decisions had still to be made regarding the types of housing, the materials to be used, etc. for the first phase. The Building Better Places SPG will be used as a guide and contains direction on the selection of sustainable building materials including: the use of recycled materials, using locally sourced materials, the use of natural materials, embodied energy and certification schemes. Resource Conservation.

Energy

The Building Better Places SPG contains guidance concerning energy saving issues such as solar access, creating wind shelter, insulation use in buildings, lighting, appliances, ventilation and renewable energy. Feasibility studies have also been undertaken to assess the potential of using an onsite Biomass Combined Heat and Power (CHP) system to provide heat and power to dwellings and businesses in the development area as well as investigating the potential of solar hot water systems, photovoltaic and wind power. All of this research is being used to develop an energy saving scheme.

Water Conservation

Throughout the development a Sustainable Urban Drainage System (SUDS) will be installed. This will provide a controlled route for rainwater to return naturally to the water table within the boundaries of the site. Further research will be undertaken regarding rainwater harvesting systems and grey water recycling systems for both commercial and residential buildings. Ways to

reduce water consumption are covered in the Council's Building Better Places SPG.

Communal Facilities

Two new primary schools will be developed in the site to cater for children growing up within the development and to provide greater choice for children from Wellingborough, with a site allocated for a secondary school or other facility if required.

Research is being undertaken into the type of community facility and multi-faith centre for worship that is needed by the community of Wellingborough East.

Recycling Facilities

The existing recyclable goods roadside collection scheme that operates within Wellingborough will be extended to cover the new development. This covers all recyclable material except glass, which needs to be taken by the residents to one of the Council's local 'bring' centres. The Council is currently piloting a garden waste collection service which, if successful, will eventually be extended into the Wellingborough East area.

Feasibility Studies have also been undertaken to look at alternative ways of dealing with waste and the possible composting facilities that could be developed. Research will continue into these and other schemes such as provision of recycling bin provision in houses.

Transport

The development is close to the existing main-line railway service and its sidings; this will service both the residential and commercial communities. Local bus provision will also be extended into the site to provide a frequent and accessible bus services. The viability of these services will be increased by the development of a transport inter-change adjacent to the railway station to improve transport links into Wellingborough town centre and to other towns within the region.

The provision of dedicated routes for buses, cyclists and pedestrians is being looked at by the developers. The layout design itself will follow good-practice guidance, and will give pedestrians and cyclists priority over the car. It will also follow the 'modified' grid-pattern, rather than the cul-de-sac layout, which allows routes between places to be shorter, provides a greater choice of routes, allows for higher density and provides more flexibility in accommodating future change. The layout will also incorporate elements that 'naturally' reduce road speeds and provide schemes such as Home Zones, which will reduce the impact of private transport upon the residents.

The Council and its partners are currently engaged in an on-going discussion about the levels of parking provision within the development. Current guidance states that 1.5 spaces should be provided for each dwelling.

Landscaping

Encouragement of Biodiversity

The 63ha Town Park situated on the floodplains on the western edge of the scheme, and which will also serve the residents of Wellingborough, is the main 'green space' feature of the development; although

several more parks and green spaces are planned for the development.

Feasibility studies have been carried out, which identified the floodplain area within the development site as of relatively low ecological importance. Areas of the river further upstream do, however, have a high level of biological diversity. The aim is therefore to increase the biodiversity of the river within the development area. This will be achieved by creating the right habitats and conditions within the town park area to enable species to migrate downstream into the Wellingborough East area.

The SUDS will also increase the range of potential wildlife habitats available on the site, through the creation of swales and balancing ponds that form part of this natural rainwater handling system.

Landscape structural features

The landscape architects will 'invite' the surrounding flora and fauna into Wellingborough East by providing green areas within the development that link 'like fingers' to the surrounding countryside.

Economics

Onsite projects

'Work from Home' schemes are being investigated as part of the development, to make it easier for some residents to work at home rather than commute. Broadband internet facilities are also being considered to provide residents and businesses with high quality communications.

Integration with existing economy

The development will aim to provide both existing residents and the new community with easy access to the new facilities provided in Wellingborough East, reducing the need to travel and strengthening the local economy. The aim is for the new development to be complementary to the existing town centre and to encourage residents from both the old and new settlements to use facilities in both areas.

Social Aspects

Resident involvement

Community consultation work has been an important part of the development of Wellingborough East and the master plan for the area. This has involved the residents of the existing town, residents from the surrounding villages and relevant local and national organisations. Attendance at consultation events and responses to the questionnaires has been good.

Both Bovis Homes Ltd and the Borough Council of Wellingborough are aware of the national shortage of skilled construction workers and of the potential difficulty

that they will have in locating sufficiently skilled people to undertake the development of the site. With this in mind, they aim to develop a range of training programmes, targeted at local people with the aim of creating the skilled workforce that will be needed. This scheme will provide training and jobs to local people for the period of the development, potentially twelve years, most of whom will then be skilled enough to seek similar employment elsewhere.

Methods of community engagement

In addition to the many community consultation and information events that have taken place over the preceding years, the Council's quarterly publication The Link runs a regular feature entitled Spotlight on Wellingborough East. The publication is distributed to all homes within the Borough and aims to inform all residents about developments related to the Council's work.

Day to day management

The Community will continue to play an important role in the development of Wellingborough East through consultation and input into matters such as Section 106 negotiations. Research is also being undertaken into Community Trusts that could manage open spaces or community facilities, for example. These will be formed when there is a Community living in the Wellingborough East area to foster community spirit.

Communal Facilities

Communal facilities

The Town Park and the community centre will be amongst the new community facilities provided for residents of the area. Work is currently being undertaken to identify the other facilities that the community will need to thrive.

Well-Being

Special support and integration

The community centre will play a major role in integrating different groups of people from the original Wellingborough settlement and the new development.

Health and affordability

By building highly energy efficient homes with high thermal performance, the residents should be protected against the negative effects of fuel poverty.

Adaptability

The aim will be to make as many of the dwellings as possible adaptable to changes in the residents' lives.

Affordability

A Housing Needs Survey commissioned by the Council concluded that 27% of the new housing will

	need to be developed for lower cost ownership to meet the demand of the region. It will be a requirement for the development as a whole to provide this level of affordable housing.
Crime	The Building Better Places SPG requires all new housing developments, over 10 dwellings in size (including conversions), to provide a provisional 'Secured by Design' certificate with the planning application.

Economic Issues

Cost of development	At the time of writing the master plan and specifications for individual structures had not been finalised, therefore no costs were available.
Number of dwellings	3000 over the next eleven years.

Additional Information

The main barriers and challenges that The Borough Council of Wellingborough and their partners have faced thus far in the project include:

- Keeping the key sustainability ideas in the minds of all Stakeholders. The developers have been keen to be involved in community consultation and incorporating the issues raised in publications such as *Better by Design, Secure by Design,* the WEAST Development Framework and the three Development Briefs on the Neighbourhood Centre, Station Island and East of Eastfield Road. It has been more difficult however, to get them to take onboard issues such as waste minimisation and integrating renewable energy systems;
- A lot of time and effort is expended on keeping all the interested parties up to date with developments in the project, often involving the use of different types of media for different groups;
- Additional time is spent by Council officers in locating, assessing and applying for funding opportunities that may help to secure a more sustainable development;
- Appropriate information is not always placed within the most suitable publications to reach developers and construction companies, and so they are not always 'naturally' aware of the opportunities and issues pertaining to their particular projects.

West Beacon Energy Farm

Location:	Whittle Hill, Leicestershire
Type of Area:	Rural
Tenure:	Owner occupied
Built Form:	Detached home and farmstead
Contact Name:	Wendy Carter
Phone / e-mail:	01509 610033 wendyc@beaconenergy.co.uk
Visiting Possible:	By appointment only
Fee Charged:	No

Summary

West Beacon Farm presents a real world demonstration of how integrated renewable energy systems, combined with other sustainable practices, can form a fully functional and reliable energy network that vastly reduces dependence on fossil fuels and the nationwide distribution infrastructure. The farmstead is located on an area of approximately 20 hectares (50 acres) of outstanding rural countryside. It has been adapted with a vision of enhancing the natural ecology of the area, along with expressing a much more sustainable lifestyle than is led by the average UK citizen.

Along with being a family home, the farmstead provides local universities with a fully operational complex for research into future sustainable technologies. The technologies presently on display include various sustainable means of generating heat and electricity, hydrogen energy storage, conservation of mains water and the embodied energy it contains, and sustainable transportation.

Project Objectives

To demonstrate the effectiveness of an integrated sustainable energy generation network in providing us with independence from fossil fuels and nationwide distribution networks, as well as enhancing the natural ecology of a 20 hectare rural farmstead.

History of Concept

When the owners moved to the farmstead in 1969, the arable land was very open, with very few trees or hedgerows. Their initial desire was therefore to improve the ecology of the land, starting with the ploughing and seeding of 8 hectares of permanent natural pasture. 14,000 broadleaf and evergreen trees were later planted for natural ecology encouragement, carbon dioxide uptake and to reduce the noise from surrounding roads. The formation of a 2 million gallon lake was to follow, which has added greatly to the biodiversity of the site, as well as being a source of drinking water and energy storage for a hydro system.

The farmstead is home to Professor Tony Marmont and his family. The Professor developed an interest in sustainable energy during the 1980s when, as a pilot, he was able to visibly recognise the damage that manmade pollution was causing to the environment all around him. Combined with the growing prominence of environmental groups and the UK's reliance

on imported energy, he decided to replace the farmstead's oil fired boiler with a ground source heat pump system. Shortly after, a 4kW wind turbine and a 3kW photovoltaic array were installed to provide the electricity required to make the heat pump a totally environmentally friendly and standalone system. From this honourable beginning, the owner's interest in sustainable energy grew, along with his involvement with the relevant departments at several local universities. The Farm has become one of the world's best examples of sustainable energy utilisation.

Construction Details

Built form A 1960s detached farmhouse with 20 hectares of land.

Greenfield/Brownfield Reuse of an existing building.

Walls The original walls consisted of a brick outer leaf and concrete breeze block inner leaf with an air cavity between. When the owners decided to fill the wall cavity with blown insulation, they discovered that in many places it was filled with construction rubble and could not be drilled into.

Roof The original roof, featuring steel I-beam trusses, has been insulated between the timber rafters with 50mm of Kingspan insulation board and 50mm of plasterboard.

Windows The original timber framed double glazed units are still in place.

Resource Conservation

Heating The farmhouse is heated via a conventional wet central heating system and radiators. Rather than a standard oil or natural gas fuelled boiler however, a Biklim TOTEM Combined Heat and Power unit provides the best part of the heating requirements. This propane fuelled CHP unit is approximately 95 percent fuel efficient and is rated to generate 15kW of electricity and 38kW of heat. Although propane is a fossil fuel, it burns cleaner than standard fuels, with relatively low emissions of greenhouse gases. The unit also allows for the possibility of using gas from a biomass gasifier or hydrogen from an electric electrolyser.

Additional active heating is generated by a water sourced heat pump system. The AB Thermia system makes use of the reasonably stable temperature of the water in the lake to heat a refrigerant with a low temperature of vapourisation. The heat pump extracts and upgrades this heat before storing it in the well insulated thermal storage tank. For every unit of electricity consumed by the heat pump and compressor, about 4.5 units of useful heat are produced. At West Beacon Farm, all of the electricity required is produced by renewable sources, which makes this heat pump one of the cleanest and most efficient home heating systems possible.

A large conservatory has been added to the west end of the house, above the Engineering Plant Room and garage, and even on a cloudy day the air inside is heated by solar energy. A

system of automatic fans and shutters controls the ducted flow of this air into the main house, for passive solar heating in wintertime. The heat pump system also runs through the duct, which enhances its own heating/cooling performance.

A wood burning stove can provide supplementary heating to the lounge if required, although this is mainly for decorative purposes. The owners use fallen timber from the planted trees as fuel.

Water heating is supplied by the heat pump system and supplemented by a bank of Thermomax evacuated tube solar collectors situated on the garage roof.

Lighting

Daylight is delivered to many areas within the property using Monodraught lightpipes. These sealed and highly reflective ducts transfer daylight from a clear dome on the roof to enclosed areas such as the cloakrooms and hallways. Low energy compact fluorescent lights are used elsewhere in the property.

Ventilation

There is ducted flow of warmed air to and from the conservatory, as described above.

Energy Generation

West Beacon Farm is often described as being one of the world's best examples of sustainable energy utilisation, as it features many different renewable technologies interlinked for maximum effectiveness.

The primary generators of sustainable energy on the farmstead are two fixed pitch, stall regulated, 2-bladed wind turbines (see Figure 1). These are rated at 25kW each and were installed in 1990 at a total cost of £60,000. Over a typical year, these turbines will generate 40 to 50MWh of electricity. Their installation was followed in 1992 by the acquisition of their American manufacturers, Carter Wind Turbines Inc.

Figure 1. The two 25kW 2-bladed wind turbines. Note the man-made lake in the foreground.

The secondary generators are two photovoltaic cell arrays, rated at 3kW each. One array features 54 mono-crystalline cells from ARCO. The other array consists of 81 poly-crystalline cells from Solarex, and is 50 percent larger in area. Combined, the two arrays have been generating approximately 4.5MWh of electricity each year since their installation 20 years ago, with no apparent degradation in performance.

A further source of energy generation was presented by the creation of a lake in the grounds of the farmstead. A building constructed out of local stone sits at the bottom of an adjacent field, and houses two water turbine systems. The larger, which makes use of the 20m gross head between the turbine house and the lake, powers a 2.2kW synchronous generator. The outflow to the water turbine occurs at a flow rate of 18 litres per second, and is controlled to occur only when both the water level in the lake and the farmstead's electrical demand are sufficient. The smaller turbine is powered by the water flowing in a stream outside the building, and generates up to 850W after rainfall in the summer, and more constantly during the winter. To prevent any debris or wildlife in the stream from entering the turbine (such as trout, crayfish or snails), the water first flows over a Coanda effect water filter (see Figure 2). This filter draws water from the stream by passing it over a vertical bank of horizontal steel wires, to which water clings and flows along into a tank below. Any solid matter falls by gravity over the bank of wires and back into the stream.

Figure 2. The Coanda effect water filter.

The lake is topped up by rainfall and with water from a natural spring 50m below ground. The power to pump the water to the surface is supplied by three interlinked 1kW photovoltaic arrays (see Figure 3). The arrays make use of a novel sun tracking system to maximise their electrical generation as the sun passes overhead. This has been shown to increase their output by 61 percent. The water is pumped from below ground when the sun shines, with approximately 4000 gallons being delivered via a fountain jet each day during the summer, and 2000 gallons in the winter.

Figure 3. The interlinked, sun-tracking, 1kW photovoltaic arrays.

The electricity generated at the Farm is used in a variety of ways. Some is used to top-up a bank of series connected, lead-acid battery cells that are housed in the Engineering Plant Room. The renewable systems can be intermittent in operation due to their reliance on the correct weather conditions, and so these 60 cells serve as 200kWhr back-up on the occasions when generation falls below demand.

It is usual for the wind turbines to generate much more electricity than is required at the Farm and so the surplus has in the past been exported offsite. The majority of exported energy goes onto the national grid. Over the ten years of 1990-99, 317MWhr of wind generated power was sold to the local electricity provider, which provided an income of almost £35k. Since December 1999, after the cessation of the Non-Fossil Fuel Obligation scheme (NFFO), it has been much less cost effective to export to the local grid.

In 1996, the buildings at the neighbouring Whittle Hill Farm were restored to provide the office space required for Midlands Renewable Energy Technology Transfer (MRETT) and Beacon Energy Ltd. The restoration continues the owners' philosophy of demonstrating the benefits of sustainable energy in practice, and use about half the energy of typical UK offices. The West Beacon wind turbines have supplied all of the electrical demand of these offices since 1999.

Hydrogen

Storage A further use for the surplus energy was found when the owner chose to pioneer the use of hydrogen as an energy storage medium in the UK. The development of hydrogen storage has been heralded by many experts as being ultimately capable of bringing about a pollution free future. Hydrogen presents a method of longer-term and larger-scale energy storage than is possible by batteries, and achievable at lower cost and with a smaller footprint. It can be used as an intermediate medium that balances the intermittent electrical generation of renewable systems and the mismatched but regular pattern of demand on the grid.

Whenever there is a surplus of electrical generation, water can be split by electrolysis into its constituents, hydrogen and oxygen, with the separated gasses being stored safely in pressurised tanks. The oxygen offers a source of financial income, as it has uses in many manufacturing industries, water treatment and healthcare.

The hydrogen meanwhile can be fed into a fuel cell at times when the electrical demand exceeds generation, where it is recombined with oxygen from ambient air, generating electricity and pure hot water as a result. When a hydrogen storage system is integrated into a renewable energy network, such as at the Farm, it represents a large-scale and dependable electrical generation solution, with an abundant supply of its primary fuels (solar, wind, water) and zero CO_2 emissions. In the medium to long term, the 'Hydrogen Economy' is predicted to revolutionise our energy infrastructure, make a significant contribution towards greenhouse gas reduction, and help counter the effects of oil depletion.

The equipment installed at the Farm consists of:

- 34kW alkaline electrolyser, manufactured by Vandenborre Hydrogen Systems, which produces hydrogen from water at 25bar.
- Forty-eight storage cylinders, each of 475litre capacity (see Figure 4). These were manufactured by BOC and are filled by a compressor to a total storage capacity of 2856Nm^3 at a maximum pressure of 137bar. This represents around 4MWh of stored electricity, or three weeks of demand at the farmstead.
- There are two Proton Exchange Membrane (PEM) fuel cells currently undergoing testing at the farm. The first is manufactured by a Loughborough University spin-off company, Intelligent Energy, and is capable of generating 2kW of electricity and 2kW of heat. This heat is used for space heating, making this a form of CHP unit. A larger 5kW unit from Plug Power, supplied by SiGEN, is also under review, and it is intended that this model will also be converted into a CHP operating unit.

Figure 4. The bank of 48 hydrogen storage cylinders.

Water Conservation

The farmstead is completely disconnected from the mains water network. Supply comes instead from two natural sources. The first is a natural spring 50 metres below ground and the second is via rooftop rainwater collection. The rainwater collected in the original guttering passes through a Wisy/Coanda self-cleaning filter to remove any coarse dirt before entering the 6,000 litre underground storage tank. The water is pumped through a series of 25, 15 and finally 5 micron filters before being delivered to an intermediate tank. At this stage, the water is suitable for all needs except drinking. To purify the water further, it circulates through an

ultra-violet filter and a reverse-osmosis membrane purifier, which operates on mains pressure, before entering the home's drinking supply.

Onsite sewage treatment using septic tanks also conserves water and energy, with the resulting naturally treated nutrients being used on the farmland.

Recycling Facilities The owner is actively involved in encouraging the recycling activities of the Local Council, who supply a second refuse bin for recyclable household waste.

SAP/Eco-rating The neighbouring Whittle Hill Farm buildings were assessed by the National Energy Foundation and found to have a negative CO_2 footprint under the Energy Efficiency Accreditation Scheme.

Transport

Two electric cars were purchased during the 1990s from the USA. Both cars are powered by onboard batteries that are charged overnight from the farm's sustainable network, and require about 0.5kW of electric power per mile. The first car bought has a range of 50 miles and a top speed of 70mph. It features a photovoltaic roof and bonnet, which supplement the battery power by around 10 percent. The second car has a range of 120 miles and a top speed of 75mph, improvements made possible by using nickel metal hydride batteries.

The next development planned is to integrate a small 1-2kW fuel cell into a vehicle, which has already been shown to be technically feasible and increases performance, range and fuel economy.

Placement to local facilities The owner's business, Beacon Energy Ltd, is based at the neighbouring Whittle Hill Farm. The electric cars provide a truly sustainable means of travelling between the two properties and to nearby towns. The local village of Woodhouse Eaves is just 2km away.

Landscaping

Encouragement of Biodiversity When the land was acquired in 1969 it was arable but very open, with little protection or cultivation. One of the original aims of the owners was specifically to increase the natural ecology of the site. They began by ploughing and seeding 8 hectares of natural grassland pasture, which provided an income as hay and silage. Hedgerows were planted to divide the land and permit cattle and sheep livestock to graze freely. The grasses and hedgerows provide habitat for many rural species, such as grey and French partridges and harvest mice.

Very few trees existed on the land when bought, and so 14,000 broadleaf and evergreen trees were planted around the border for wildlife encouragement, carbon dioxide uptake and to reduce the noise pollution from surrounding roads. This was seen to have an immediate effect, with birdlife activity increasing markedly; including barn owls, great spotted and green woodpeckers, long tail tits, crossbills and kestrels. It should be noted that

the pine trees planted are gradually being replaced with local oaks and ashes.

The formation of the 2 acre lake followed the introduction of livestock and this greatly benefited the farmstead's biodiversity with a full aquaculture. As well as introducing fish, frogs, toads and many thousands of insects, the lake has brought even more birdlife to the site, including Canadian geese, ducks, coot, moorhen, little grebe and herons.

Resource crops (food/fuel)

Although the owners have ceased to farm the land themselves, both the hay production and grazing of livestock continue to this day under contract with a neighbour farmer.

Dead wood from the planted trees is used as a biomass resource in the lounge's wood burning stove.

Economics

Onsite projects

The onsite use of electricity and heat generated by the sustainable network brings immediate savings to the owners, estimated as around £3,000 per year.

The exporting of surplus energy to the local electricity provider supplied a regular stream of income that returned some of the capital costs involved. Through the 1990s, 317MWh of wind generated power was exported offsite, which brought in almost £35k.

Social Aspects

Methods of community engagement

Much of the research carried out at the Farm is in conjunction with three local universities, all of which have benefited from the owners' generosity in the past.

- The School of the Built Environment at The University of Nottingham
- The Centre for Renewable Energy Systems Technology (CREST) at Loughborough University
- The Institute of Energy and Sustainable Development (IESD) at De Montfort University

Endowments from the owner have gone towards establishing the facilities and Master Degree programmes necessary to promote the growth of sustainable technologies at home and abroad, through high quality research and demonstration projects. In 1996, the owner formed Midlands Renewable Energy Technology Transfer (MRETT), with the specific aim of facilitating links and

encouraging the transfer of sustainable technologies from universities to industry.

The Farm has been a regular focus for many open days in past years, attracting 100s of visitors annually from industry worldwide and local school groups.

Economic Issues

Cost of development

An evaluation of the capital costs involved in developing the sustainable network was made in December 1999. At the time, it came to over £250k.

Number of dwellings

One working farmstead.

Source of Funding

The primary source of funding for the various renewable energy systems in operation at the Farm came from the sale in 1992 of the family business, Carters Gold Medal Soft Drink Co. The sale made possible the acquisition of Carter Wind Turbines Inc, the American manufacturer of the two turbines erected at the Farm, and operator of a 10 turbine wind farm near Carlisle. The wind farm was sold to Cumbria Wind Farms Ltd, by which time Beacon Energy had been established as a company in its own right, with the aim of persuading home builders, architects, and industry figures in general of the benefits and practicality of renewable energy and sustainability.

Additional Information

The owners have encountered the following problems while bringing the projects to fruition:

- In 1992, the owners had to defend the wind turbines against the local District Council. The Council were arguing for their dismantling on the grounds that the area is designated as one of 'particularly attractive countryside' in the statutory County Structure Plan and is therefore afforded special protection. With the assistance of Leicestershire Friends of the Earth, the owners succeeded in making their case and the turbines continue to generate free electricity to this day; however, the owners incurred disruption and substantial legal fees in the process.
- The cessation of the Non-Fossil Fuel Obligation scheme (NFFO) and the introduction of the New Electricity Trading Arrangements scheme (NETA) largely influenced the owner's decision to cease supplying the national grid with the surplus electricity generated by the turbines. The NETA requirement for power producers to predict the output for every half hour in advance, and to buy any shortfall at premium prices, made most forms of embedded renewable generation economically unfeasible, as the output literally depends on the weather.