Energy Efficiency Best Practice in Housing

Innovative social housing

Alpine Close, Maidenhead, Berkshire

ENERGY EFFICIENCY™
SAVE ENERGY MONEY ENVIRONMENT

Introduction

This case study looks at a recent example of innovative social housing – Alpine Close in Maidenhead, Berkshire. It examines the environmental, design and construction aspects of the project. Most importantly it shares the lessons learnt - providing information and inspiration to housing associations, local authorities and designers.

It should be noted that the scheme was built before the 2002 changes to the Building Regulations in England and Wales - and the raising of the maximum SAP rating from 100 to 120. INTEGER schemes continue to exceed current Building Regulations and aim to fit comfortably within Energy Efficiency Best Practice in Housing's (EEBPH) Best Practice Specification. For more on this, see Summary Specifications for Energy Efficiency in New Dwellings.

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Housing solutions

In 1998 Housing Solutions approached Bree Day Partnership, pioneering architects of INTEGER and INTEGER Architects, with a site for a scheme in Maidenhead. Their brief was for the development to incorporate as many INTEGER elements as possible that would give maximum benefit to the future occupants.

The scheme is on a brownfield site in the centre of Maidenhead. It was originally a car park with concrete garages, the majority of which were no longer in use. The site is ideally located for housing, being only five minutes walk from a railway station and ten minutes walk from the town centre.

INTEGER project background

INTEGER is an action research project aiming to deliver better performance and value in mainstream housing. Formed in 1996, it has since developed, demonstrated and implemented a wide-ranging agenda for innovation in the housing field. INTEGER's ethos is based on the principles of intelligent and green design.

www.integerproject.co.uk

Development scheme

Housing Solutions in-house design team had already produced a scheme plan of 26 dwellings and 48 parking spaces laid out on the site with limited consideration for orientation.

Bree Day Partnership then produced new plans which took account of the optimum orientation for solar gain. This layout increased the number of dwellings to 27 whilst reducing parking spaces to 22.

This final design gave six two-bed houses, two three-bed houses and 19 one-bed flats. The design incorporated many innovative environmental features in which low energy use, and therefore low bills for tenants, was a central theme. These are detailed in the table opposite.

The scheme was jointly funded by the Royal Borough of Windsor and Maidenhead and the Housing Corporation. Work on site began in 1999 and development was completed in September 2001.

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Key features of the scheme	
Brownfield site	Existing garages demolished, crushed on site and used as hardcore under paths and vehicle areas. Car park tarmac surface removed and the sub base recycled as hardcore under paths.
Foundation sub structure	Pre-cast concrete ground floor slabs spanning from party wall to party wall, with no intermediate foundations.
Timber frame with pre-fitted windows	Timber frames incorporating factory fitted double glazed low-emissivity coated windows.
Insulation	Stud timber frame wall panels, factory insulated with recycled cellulose insulation. Ceiling level recycled cellulose insulation.
Prefab pods and service core	Prefabricated pre-plumbed pod of bathroom and section of kitchen installed around a vertical service core in flats.
Materials	Low maintenance sustainable timber from managed sources for cladding and windows.
Roof	Low maintenance green sedum roof.
Passive stack ventilation	Whole house passive stack ventilation (PSV) system.
Photovoltaic (PV) panels	Grid-connected PV panels provide electricity to the houses and the top floor flats.
Passive solar design	Optimum orientation and configuration of houses with south west elevation glazed solar space off living room.
Centralised boiler system for flats	Gas condensing boilers as central source of heat for flats.
Solar water heating	3.3m^2 solar hot water panel on each house.
Low energy lighting	Dedicated low energy lighting to all internal areas.
Day lighting	Sun pipes used to allow natural day lighting into internal staircases in houses
Rain water harvesting	Rainwater from the roofs collected then stored in an underground chamber and used as required for irrigation of landscaping.
Grey water system	Bath and wash-hand basin water treated, stored and re-used to flush toilets.
Remote utility metering	Photovoltaic panels (PV), mains electricity, water and gas are all monitored remotely via extensive data cabling.
Security	Door entry integrated with existing telephone and television systems.
Entertainment	Pre-wired structured cabling system for voice, data, and entertainment services.

Costs

The scheme was jointly funded by the Royal Borough of Windsor and Maidenhead and the Housing Corporation.

Total costs were approximately £2.4 million.

A further breakdown of the cost of innovative features is shown in the table below. To help meet some of these additional costs, Housing Solutions were able to secure DTI funding from the 100 Roofs PV Domestic Field Trial and the SMART Metering Programme. You'll find more information on current grant schemes on the back page.

Table of innovation costs

Building elements	Total approximate costs including all supply and fixing
Kitchen/ bathroom / airing cupboard/ central service riser pods (15 flats)	£97,000
PV system (8 houses, 7 top floor flats)	£150,000
SHW system (8 houses)	£18,000
Passive stack ventilation vents (all 27 units)	£22,000
Grey water system (all 27 units)	£46,000
Remote monitoring (all 27 units)	£35,000

The contract

The scheme embraced high levels of innovation, both in features and partnership. To maximise the innovative potential, and for all parties to benefit, the type of contract was an important issue. A Partnering Contract was preferred, but PPC 2000 was still in discussion; therefore a standard JCT98 Contract with Quantities was used, but with a Partnering ethos applied.

Following a post-completion analysis it was agreed that it would have been better to use a two-stage tender with the Partnering Contract. This would enable the sub-contractor to have valuable design input at stage one, when the design is being worked up. Stage two would then allow for firming up of the fixed price.

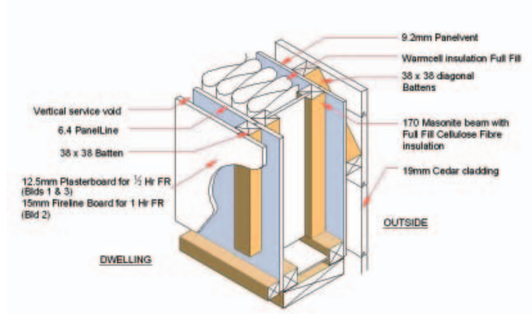
Construction

Timber frame

Timber frame was the selected method of construction as it was perceived by INTEGER to be sustainable and inherently thermally efficient. Also, prefabricated elements would reduce site time.

The timber frame was a 170mm engineered timber I-beam, which was filled with recycled cellulose insulation. I-beams offer additional thermal benefits as they prevent cold bridging.

All the ground floors were v313 chipboard on 50mm rigid insulation on a sand base. The upper floors of the flats were 30mm dry flooring, 22mm OSB (oriented strand board) on engineered timber joists with 100mm glass fibre quilt between joists for sound insulation. The ventilated roof spaces have 250mm recycled cellulose insulation fully covering the ceiling joists.



U-values of the houses and flats were well in excess of Building Regulations at the time. These are shown in the table below.

	U-values (W/m^2K)	Building Regulation requirements at time
Roof	0.2	0.25
Exposed external walls	0.2	0.45
Windows	2.16	3.0
Ground floor	0.35	0.45

Running costs

SAP ratings

The SAP ratings on this development ranged from 90–100 (this scheme was built prior to the raising of the maximum SAP rating from 100 to 120).

Dwelling type	No. of dwellings	SAP rating	Annual total predicted heating and hot water cost
one-bed flat	19	100	£97 ground floor flat
two-bed house (mid terrace)	4	92	£184
two-bed house (end terrace)	2	96	£181
three-bed house (end terrace)	1	90	£209
three-bed house (mid terrace)	1	100	£197

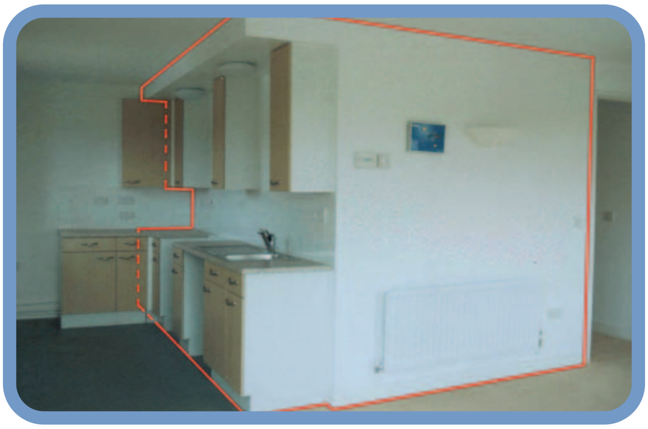
Bills

Gas provides all of the heating and hot water needs; cooking is electric. The annual gas bill for the one-bed flats is currently £55 all-inclusive. This is less than you would expect because Housing Solutions buy gas at a commercial rate through a block contract covering this scheme and some 20 sheltered schemes.

Prefabricated pods

For prefabrication to be cost-effective, multiples of the same unit need to be produced. There also needs to be a high concentration of services in the units, making bathrooms and kitchens ideal. In this scheme, plans for the 19 flats were amended at the design stage to enable repetition of the bathroom and part of the kitchen. The kitchen was also altered so that all the mains services were located on the wall between the kitchen and the bathroom. This gave rise to a combined bathroom and kitchen open-ended pod i.e. a complete bathroom with kitchen units already attached to one external pod end wall. A central service core was also included. Prefabricated pods were not considered cost effective for the houses because of the smaller numbers of units.

Using the pods saved estimated costs of £1,000 per flat. A combined pod system did work, but leaving the kitchen end of the pod open made it vulnerable to damage, giving rise to issues of responsibility for damage during storage, transportation and installation. It was also considered preferable to leave off the external linings in future pods, allowing access for site trades and allowing a better finish to be achieved. The central service core was a success, although lessons were learned about making clear the division of responsibility between prefabrication plumbers and electricians and their equivalents on site.



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Cedar cladding

The dwellings were clad in Western Red Cedar. This is a low maintenance material requiring no preservative treatment. It contains natural oils and can be left without painting or varnishing for a natural look. It does change colour to a more subtle silver shade and this should be considered when specifying, and explained to clients.

In this scheme the external cladding alternated between vertical and horizontal orientation to give each tenant in the flats a visible exterior boundary. This variation of orientation does mean high levels of wastage; it was recommended that this should only be carried out in future if there is an overriding rationale for doing so, rather than for purely aesthetic reasons.

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'Living' green roof

Another low maintenance feature was the 'green' roof. The roof is planted with chives, saxifrage and sedum, which are all tough flowering alpines with short roots. Pre-mixed and grown, the roof is simply rolled out - just like turfing a lawn - over a base. The roof offers extra protection to the waterproofing layer and can extend the roof's lifetime by a factor of up to four. The plants are able to survive in periods of drought without extra attention.

The roof will require annual maintenance, which is carried out by the suppliers until it is established. The waterproofing system is guaranteed for 20 years.

Passive stack ventilation extracts and light pipes were easily incorporated into the gently sloping green roof - whilst the steeper rear up-stand allowed for easy integration of the photovoltaic and solar water panels.

Building services

Heating and hot water

Solar Hot Water system (SHW)
3.3m2 SHW panels were provided for each house. As there was insufficient space on the roofs of the flats for both PV and SHW panels, the PV potential was maximised instead.

The SHW panels have an efficiency rating of 80% and an expected average output of 1.126 kW/hour in the summer and 0.926 kW/hour in the winter.

Each SHW panel is connected via a pressurised circuit into a copper double feed pre-insulated 160 litre storage cylinder with double primary coil for solar and boiler water heating.

The life expectancy of these SHW panels is in excess of 25 years, with a five year guarantee.

Boilers
Two gas condensing boilers are the centralised source of heat for the flats. Each flat is individually heat metered to ensure that individual bills reflect actual usage. The houses have individual gas boilers for heating and secondary hot water.

Heating is controlled by a two-channel time programmer, external and room thermostats and TRV's.

Electricity and lighting

PV Panels
Photovoltaic panels provide a proportion of electrical power to the eight houses and the seven top-floor flats. The panels were not connected up to all the flats as it was felt more appropriate to provide a significant amount of power to the top floor flats, rather than a lesser amount to all 19 flats. The panels were grid connected via Scottish and Southern Energy to enable tenants to sell back any surplus electricity generated.

The PV arrays have performed well over the two years since their installation, although their actual output remains lower than anticipated due to the predictive software slightly over-estimating.

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Light pipes
The transparent domes visible in the picture are light pipes. They are a natural and efficient way to provide light to windowless or dark internal spaces, so reducing the use of electric lighting.

The sealed tube of air within the pipe also limits heat loss and solar gain. Manufacturers claim a U-value of 0.6W/m2K for units similar to those installed here. In this scheme light pipes were used to light the hallways in the houses.

PV Specification	
Cost	£110,000 for the solar power systems (including panels, BOS (balance of system) and monitoring equipment) panels for 15 homes (eight houses and seven top floor flats); £20,000 for electrical work; £8,000 for roofing work. Total costs were approx £140,000
Funding	Part of the DTI 100 roofs domestic field trial and the DTI SMART metering programme
System size	Each home has a power of between 1kWp and 1.8kWp totalling 20kWp. Predicted to generate 15 -16MWh per annum
Installation	Complete installation took an average of one day per home and was carried out by the main contractor's electrical and roofing contractors, with appropriate training and supervision from the PV supplier
CO^2 saved	6 - 7 tonnes per annum
Maintenance	Maintenance and monitoring can be carried out remotely via a dial-up connection to each inverter
Life expectancy	Panel life expectancy is greater than 30 years. Manufacturer's warranty on panels specified covers 20 years
Predicted energy output (kWh/kWp/yr)	Varies from 692 to 794 per dwelling
Actual energy output (kWh/kWp/yr)	Varies from 702 to 743 per dwelling

Ventilation

Ventilation extract terminals for the whole house passive stack ventilation system can be seen in the picture opposite. This system uses the natural stack effect to remove moisture-laden air from kitchens and bathrooms, replacing it with fresh air via a controlled flow into the building. This is aided by the two-storey solar spaces on the houses.

Grey water recycling

Grey water systems can significantly reduce tenants' water and sewage bills. The systems in this scheme use water from showers, baths and wash-hand basins to flush the toilets. Water from the kitchen and washing machine was thought to contain too much debris and detergent to be treated and used on site.

Each house had an individual grey water system. For the flats there were several communal grey water systems, with the flats being linked vertically. This caused a problem with the location of - and responsibility for - the disinfectant unit within the flats. In this case the system provider redesigned their system to include an external brominator for ease of maintenance. This proved to be less than ideal. They learned from the experience and subsequent installations and have replaced the brominator with a chemical chamber built into the sump chamber within the external treatment tank. This enables disinfectant tablets to be dropped into the tank which is accessed simply by opening the manhole cover.

Locating of communal treatment tanks is a maintenance issue that needs to be considered by the housing association / local authority when specifying shared grey water systems.

Another issue encountered was the lack of information available on the grey water system at the beginning of the project. As recycled grey water has a different chemical composition to ordinary water, copper and copper alloy pipes cannot be used. This caused a problem when several pods had already been fitted out with inappropriate pipes and these had to be replaced.

Dwelling type	Average annual metered water consumption (m3)	Typical annual water consumption
one-bed flats	40	108
two-bed houses	121	140
three-bed houses	95	160

Rainwater harvesting

The initial stages of heavy rain are absorbed by the sedum roof, preventing surges in the local authority's surface water drainage system. Surplus rainwater beyond the roof's capacity is collected and stored in two underground tanks - and used to irrigate the landscaping.

Remote monitoring

Remote monitoring enables the building services systems and fuel consumption to be checked and diagnosed remotely by Housing Solutions. This reduces unnecessary visits and checks on site, and minimises maintenance costs. In this scheme remote monitoring of the PV panels, SHW panels, mains gas, mains electricity and mains water was incorporated.

Remote monitoring of the electricity did cause some problems because the local electricity distribution company would not accept a remote monitoring meter. In the end two meters had to be connected - one for remote monitoring and the other for the electricity company. This waste of resource was an issue that needs to be resolved in future projects.

The future for INTEGER

INTEGER aims to be at the forefront of construction innovation; to be a role model in the field of sustainable developments - not a follower. As the building regulations within the UK tighten, INTEGER will be in front - proving that the boundaries can be even tighter. INTEGER's future specification also aims to fall comfortably within the EEBPH Best Practice Specification (see back page for more information).

Having proven the ability to transform the design and performance of new housing, the next priority for the INTEGER action research programme is to ensure that this improvement is delivered in the large-scale housing projects being planned throughout the UK. To achieve this, INTEGER is actively engaged in the performance specification and the delivery of a number of mainstream housing projects, which form a key element of the Government's Sustainable Communities programme.

To achieve truly Sustainable Communities - in terms of the triple bottom line of environmental, social and economic sustainability - requires the integrated implementation of innovation strategies for housing regeneration, community involvement, and education. INTEGER is now working to show how this can be achieved successfully through a series of demonstration and pilot projects.

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Further reading

Energy Efficiency Best Practice in Housing documents

Energy Efficiency in New Housing – Summary of Specifications for England, Wales and Scotland (CE12)

Renewable Energy in Housing – Case Studies (CE28)

Energy Efficient Housing Association Schemes

The Hockerton Housing Project – design lessons for developers and clients (CE15)

BedZED – Beddington Zero Energy Development, Sutton

References

1) The Building Regulations 2000, Approved Document L1, Conservation of fuel and power in dwellings

Current funding opportunities

The Department of Trade and Industry's £20 million first phase of the major photovoltaic (PV) demonstration programme is now running. Substantial grants are available towards the installation of solar electricity equipment for householders, businesses and social housing groups.

For more information visit www.est.org.uk/solar/

For more detail on grants for solar water heating and other renewable technologies in England, Wales and Northern Ireland, see www.clear-skies.org

For information on the sister scheme in Scotland visit www.est.org.uk/schri

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Gramm Environmental Ltd – Rainwater harvesting / grey water recycling systems

Housing Solutions (Peter Ware)

Monodraught – Light pipes

Passivent – Passive stack ventilation

solarcentury – PV panels

Energy Efficiency Best Practice in Housing

Helpline: 0845 120 7799
Fax: 0845 120 7789
Email: bestpractice@est.co.uk
Web: www.est.org.uk/bestpractice

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