CE191

Integrating renewable energy into existing housing – case studies

energy saving trust™

Contents and contact information

		Page
1	**Mixed use – Titanic Mill** Photovoltaics and a biomass CHP system are being used in the conversion of a 1911 Grade II listed, six-storey mill to residential and commercial use.	4
2	**Social housing – Braunstone Solar Streets project** Photovoltaic tiles were installed as part of the refurbishment of 45 south facing houses in a large community regeneration project.	6
3	**Social flats – Sheffield Road** A large scale communal biomass heating system now provides space and water heating to 166 refurbished flats in three separate blocks.	8
4	**Private housing – Nottingham EcoHome** A successful integration of solar thermal, biomass boiler and heat store technologies creating a hybrid system for a refurbished semi-detached house.	10

These case studies highlight some of the ways in which renewable energy technologies can be integrated into existing buildings. The benefits of combining integration with wider energy efficient refurbishment are clearly illustrated. These examples should help building designers, surveyors and consultants – in fact, anyone involved in the design and specification of dwellings – to successfully integrate renewable energy into their own projects.

Contact information

For advice and guidance regarding grants for renewable energy technologies:

- Energy Saving Trust
  www.est.org.uk/housingbuildings
- Clear Skies
  www.clear-skies.org

For further information on the technologies covered in this guide see the following websites:

- Photovoltaics
  British Photovoltaic Association
  www.pv-uk.org.uk
- Solar thermal
  Solar Trade Association
  www.solartradeassociation.org.uk
- Biomass
  NEF Renewables – logpile website
  www.greenenergy.org.uk/logpile
- British Biogen – Trade Association for the UK Bioenergy industry
  www.britishbiogen.co.uk

Acknowledgements

The Energy Saving Trust would like to thank the following individuals and organisations for their assistance in preparing these case studies:

- Ben Dodd, Environ, Leicester (Braunstone Solar Streets Project).
- Colin Kent, Kent Porter Warren Architects, Leicester (Braunstone Solar Streets Project).
- Keith Horton, Leicester Housing Association (Braunstone Solar Streets Project).
- Kate Parsons, Kirklees Environment Unit (Titanic Mill).
- John Malone, ESD Limited, Corsham (Titanic Mill).
- Dick Bradford, Barnsley Metropolitan Borough Council, Barnsley (Sheffield Road).
- Gil Schalom, MS Architects, Nottingham (Nottingham EcoHome).

Introduction

Home energy use is responsible for 27 per cent of UK carbon dioxide emissions which contribute to climate change. By following the Energy Saving Trust's best practice standards, new build and refurbished housing will be more energy efficient – reducing these emissions and saving energy, money and the environment.

Since the industrial revolution, society has become increasingly dependent on fossil fuels such as oil, coal and natural gas. These fuels have been created by natural processes and have taken millions of years to form. They are also finite resources. Burning fossil fuels to produce energy results in 'greenhouse gases' which trap solar radiation in the earth's atmosphere and cause undesirable changes in the earth's climate.

Renewable energy is derived from natural forces that are continuously at work in the earth's environment, and which are not depleted through use. Renewable energy sources produce few or no greenhouse gases. Increasing their usage will therefore contribute to reduction of emissions nationally and world-wide.

As fossil fuel resources begin to run out, security of energy supply will become increasingly important. The availability and development of different renewable technologies will increase the diversity of energy sources and contribute to security of supply.

Under the EU Renewables Directive [1], the UK has been set a target of generating 10 per cent of its total electricity demand from renewable sources by 2010. The Renewables Obligation [2] requires all electricity suppliers in England and Wales to source a proportion of their supplies from renewables.

By 2015, this proportion will be approximately 15 per cent. The Renewables Obligation Scotland [3] is the equivalent mechanism there. In Northern Ireland a similar Renewables Obligation framework has been proposed [4].

1 EU Renewables Directive (2001/77/EC), October 2002.

2 Renewables Obligation (Statutory Instrument 2002/914), April 2002.

3 Renewables Obligation Scotland (Scottish Statutory Instrument 2002/163).

4 Energy (Northern Ireland) Order 2003 (Statutory Instrument 2003/419 N.I. 6).

The Energy Saving Trust advocates a holistic approach to refurbishment and conversion in order to maximise the financial and environmental benefits. Best practice projects should prioritise the reduction of overall energy demand as this will maximise the contribution made by integrating renewable energy technologies. The case studies featured in this publication demonstrate how best practice can be implemented during energy efficient refurbishment and conversion.

Each project has its own particular physical and financial constraints that have influenced the practical potential for increasing energy efficiency. The technical specifications achieved illustrate the diverse range of strategies that can be adopted to enhance building performance. More detailed guidance regarding energy efficient refurbishment can be found in 'Energy efficient refurbishment of existing housing' (CE83/GPG155).

The renewable energy technologies featured in this publication are:

Photovoltaics (PV)
Solar panels (or arrays of panels) which convert the sun's radiation directly into electricity.

Solar hot water systems (SHW)
These employ solar collectors to capture energy from the sun which is then used to heat domestic hot water.

Biomass boilers
These boilers use plant material (biomass) in log, pellet or chip form. This is considered a renewable energy source because the amount of carbon released during combustion is absorbed again as further biomass is grown. It is important to obtain the biomass fuel from a managed source that ensures replanting takes place at a similar rate to consumption.

Biomass combined heat and power (CHP)
An energy system that uses biomass fuel to produce both heat and electricity. Overall efficiency is significantly higher than that of a conventional boiler. The heat generated during electricity production is used to meet the building's heat demand rather than being treated simply as a waste product.

The case studies describe how these technologies have been integrated into existing residential and converted buildings in the UK.

Case study 1: Titanic Mill (mixed use)

Originally designed as a textile mill, the Titanic Mill in West Yorkshire was built in 1911, but fell into disrepair. In 2004, the Lowry Renaissance Ltd refurbishment project began, aiming to turn this Grade II listed, six-storey masonry building into a carbon neutral development. The work is being done in partnership with Kirklees Metropolitan Council which is aiming to provide 5 per cent of the district's energy from renewable sources by 2005.

A total of 130 apartments are being created on the upper five floors. The ground floor will be for commercial use, with a hotel and leisure facilities planned. Enhanced thermal performance and airtightness will reduce total energy demand. With a designed airtightness of less than 1.0 air changes per hour at 50Pa, the advantages of mechanical ventilation with heat recovery can be exploited.

Large scale conversion and refurbishment work, such as this, requires careful project management. Consequently the work is being executed in three phases with completion expected in 2006.

Key technologies	Building specification		Best practice target	Performance achieved
50kWp roof-mounted PV system.	Floor	200mm mineral fibre insulation in the first floor.	0.20 – 0.25W/m²K (depending on layout)	0.20W/m²K
Biomass CHP system.	Walls	200mm mineral fibre insulation in the walls.	0.30W/m²K	0.20W/m²K
Airtight construction featuring mechanical ventilation with heat recovery.	Glazing	Double glazed, argon-fill windows with low-e coatings.	2.0W/m²K	1.5W/m²K
	Roof	300mm mineral fibre insulation in the roof.	0.16 – 0.20W/m²K	0.12W/m²K

Titanic Mill during refurbishment

Image courtesy of ESD

50kWp roof-mounted PV system
Image courtesy of ESD

Technology

By making the apartments as energy efficient as possible and using renewables to meet the (reduced) energy demand, this part of the mill will be carbon neutral – there will be no carbon emissions. The higher energy demands of the commercial areas mean that this is not possible for the whole building, although these areas will also be refurbished to a high energy efficiency standard, resulting in much reduced emissions.

The building features a roof-mounted, 50kWp PV system as well as a biomass-fuelled CHP, producing 100kW of electricity and 140kW of heat. This hybrid PV and CHP system is expected to reduce annual CO_2 emissions by approximately 400 tonnes in the residential areas and 200 tonnes in the commercial areas.

The CHP system will be commissioned as later phases are completed and create sufficient demand. In the early stages, gas boilers will meet space and water heating requirements. The gas boilers will eventually provide back-up for the CHP system during peak demand and maintenance periods.

The PV system is estimated to produce approximately 40,000kWh per year of electricity, approximately 2 per cent of the total demand. The biomass CHP system will generate approximately 700,000kWh per year, around 70 per cent of the total site demand.

Finance

EU Sun Cities funds were secured by Kirklees Metropolitan Council in partnership with sustainable energy consultants Energy for Sustainable Development Ltd. Match funding came from the Council's dedicated Renewable Energy Fund. Residents and commercial tenants will be shareholders in an energy service company.

Case study 2: Braunstone Solar Streets Project (social housing)

Located in one of the most deprived areas in the UK, Braunstone Community Association in Leicester received a £56 million New Deal for Communities grant. In conjunction with this programme, Leicester Housing Association funded refurbishment of 200 houses in the area, known as the 'Six Streets Project'. Within this, the 'Solar Streets Project' has been established by the independent environmental charity Environ. Work began in December 2003 to install PV roof tiles on 45 south facing refurbished properties and five new build houses.

Fuel poverty is an important issue to social housing providers. Installing PV technology, as part of a wider energy efficient refurbishment programme, can help alleviate this problem.

A key objective of the project was to raise awareness in the community of energy efficiency and wider environmental issues. Occupants of the houses were given information explaining how the PV systems worked and the wider issues surrounding domestic energy consumption.

The adoption of renewable energy technologies has also increased the perceived value and desirability of properties in this area. A PhD study conducted by De Montfort University during the early stages of the project found a distinct drop in the frequency of re-letting for houses fitted with PV. They estimated that 20 per cent of local authority housing stock is re-let each year. This reduced to 12 per cent in the majority of the 200 refurbished houses in the 'Six Streets Project'. However, only one of the 50 houses fitted with PV was re-let over the same period. Although based on a small sample this does suggest that fewer funds need to be committed to preparing properties for new tenants over a given period of time.

Key technologies	**Building specification**
52kWp PV polycrystalline tile system installed across 45 refurbished and 5 newbuild properties.	Part of a wider 'Decent Homes' refurbishment programme.
Occupants can monitor electricity generation.	New bathrooms, kitchens and room layouts.
Grid connected – two way metering.	Double glazed PVC-U windows installed.
Key objective was to use PV technology as an educational tool.	New gas central heating systems installed.

Installing PV tiles
Image courtesy of Environ

Technology

Between 20 and 40 PV tiles were fitted to each house. A monitor allows residents to see when the system is generating electricity, encouraging them to adjust their consumption and take advantage of the renewable energy.

Braunstone Community Association has worked closely with electricity supplier Ecotricity in developing a financially viable two-way metering system to allow the community to benefit from any excess energy generated by the PV systems. If the energy output of the PV is greater than the individual household demand, the excess is exported to the grid. Profits raised in this way are used to fund other energy efficient refurbishment projects in the Braunstone community. In total, the Braunstone Solar Streets Project is expected to produce approximately 39,000kWh of electricity a year.

Finance

Sixty-five per cent of the £450,000 total cost of the Solar Streets Project was covered by a DTI Major Photovoltaic Demonstration Programme grant. The remainder was met from the Neighbourhood Renewal Fund and the New Deal for Communities Fund.

Integrating the PV system into the refurbishment strategy where roofing replacement is required can maximise financial benefits. PV has a dual role: energy generator and roofing material. By reducing the requirement for conventional roofing materials, the savings can be offset against the capital cost of installing the PV system.

Properties after refurbishment

Image courtesy of Environ

Case study 3: Sheffield Road (social flats)

In recent years Barnsley Metropolitan Borough Council (BMBC) has been increasing its use of biomass in new and refurbished public and commercial buildings. After a successful trial at Kirk Balk Secondary School, the Council identified the Sheffield Road Flats refurbishment scheme as another suitable candidate for a communal biomass heating system.

When the 166 flats, arranged in three blocks, were refurbished, their energy efficiency was significantly improved. Heating was originally supplied by two separate coal-fired boiler houses, but it was determined that they needed to be replaced as part of the refurbishment project.

Thermal performance was improved in order to minimise energy costs for the occupants and reduce environmental impacts. Refurbishment works began with the installation of double glazed windows. In 2004 the external cavity walls were filled, roof insulation was installed and the conversion of the heating system commenced.

Prior to refurbishment, the flats had a Standard Assessment Procedure (SAP) rating in the region of 34. Following the improvements to the insulation and the glazing, together with the switch to a communal biomass system, this increased to around 92 (SAP 2001).

Key technologies
Communal biomass heating system using local wood chips.
1 x 320kW and 1 x 150kW wood chip boilers.
Smart card metering of individual tenant energy consumption.
Energy Management System – remote monitoring of performance and maintenance requirements.
Original SAP = 34 Refurbished SAP = 92.

Building specification		**Best practice target**	**Performance achieved**
Floor	Solid concrete – unchanged during refurbishment due to physical constraints.	0.20 – 0.25W/m^{2}K (depending on layout)	0.45 – 0.70W/m^{2}K (physical restrictions limited refurbishment)
Walls	65mm cavity walls filled with blown mineral fibre.	0.52W/m^{2}K	0.41W/m^{2}K
Glazing	Double glazed PVC-U windows.	2.0W/m^{2}K	2.0W/m^{2}K
Roof	Warm roof insulation profiled with an average of 75mm to provide a drainage fall to the originally un-insulated flat roof structure.	0.25W/m^{2}K	0.30W/m^{2}K (physical restrictions limited refurbishment)

Technology

The transition from the original coal heating system was phased, in order to ensure that a continuous heat supply was maintained throughout the project. The gas boiler 'back up' system was used during this initial stage. Although this is a permanent facility, it has not been required since the commissioning of the biomass plant.

The Sheffield Road blocks are managed by Berneslai Homes, the managing agent for BMBC. An energy supply contract has been agreed with the Specialist Biomass Installation Company for a local supplier of wood chips to ensure security of supply. In addition to this, an Energy Management System (EMS) allows remote monitoring of the installation. This information enables the management team to minimise supply interruption and undertake a proactive maintenance programme.

Two wood chip boilers (320kW and 150kW) now supply the space and water heating for the occupants. They used to pay a standard weekly addition to their rent for their energy. The new biomass heating system now has a pre-payment 'Smart Card' system which monitors individual usage and charges occupants accordingly.

Finance

An Energy Saving Trust Community Energy Programme development grant funded the initial biomass assessment. Further funding was then sourced from an Energy Saving Trust Community Energy Programme capital grant, a Yorkshire Single Pot Grant and the Energy Efficiency Commitment (EEC). The total system cost was approximately £1.7 million.

The 150kW biomass boiler
Image courtesy of BMBC

One of the three Sheffield Road blocks
Image courtesy of BMBC

Case study 4: Nottingham EcoHome (private housing)

Government-backed initiatives, such as Decent Homes and the New Deal for Communities, have increased the number of refurbishment projects in social housing. However, they only apply to one sector of the UK housing stock.

Refurbishment of owner-occupied homes has also been growing in recent years. The main factor driving this is the desire to increase the value of the property. However, refurbishment also presents an opportunity to improve energy performance and incorporate renewable energy technologies.

The owners of this solid-walled Victorian semi-detached house have been progressively improving it since 1998. They have improved the wall insulation; increased floor and roof insulation; and installed double and triple glazed windows. Special attention has been paid to improving airtightness and individual room ventilation with heat recovery has been added.

Key technologies
Hybrid solar thermal and biomass system.
4m^2 flat plate solar thermal panel.
14-28kW log boiler to provide space and water heating.
1,100 litre heat store.
Heat recovery units in kitchen and bathroom areas with thermostat and timer controls.
Green tariff electric off-peak immersion for high hot water demand periods.

Building specification		Best practice target	Performance achieved
Floor	100mm natural wool insulation plus 60mm wood fibreboard in suspended floor.	0.20 – 0.25W/m^{2}K (depending on layout)	0.24W/m^{2}K
	150mm EPS insulation in solid floor.		0.18W/m^{2}K
Walls	140mm EPS external wall insulation to side and rear walls.	0.30W/m^{2}K	0.23W/m^{2}K
	Double layer of 52.5mm phenolic foam plasterboard laminate internal insulation to front wall.		0.20W/m^{2}K
Glazing	Selection of PVC-U and softwood, double and triple glazed windows.	2.0W/m^{2}K	1.0 – 2.0W/m^{2}K
Roof	300-400mm cellulose insulation in flat and pitched roofs.	Pitched = 0.16 – 0.20W/m^{2}K Flat = 0.25W/m^{2}K	Pitched = 0.12W/m^{2}K Flat = 0.09W/m^{2}K

Technology

The 4m² flat plate solar thermal panel system is estimated to provide half the annual domestic hot water requirement. An automatic drain-back system eliminates any requirement for anti-freeze additives and improves the wider environmental impact of the system.

At the centre of this system are a factory-insulated 200 litre twin coil hot water cylinder and a 1,100 litre heat store. The solar panel connects to the bottom coil of the cylinder; the heat store connects to the top coil.

Integrating the heat store allows energy from a second renewable source to be integrated into the system – a 14-28kW log fired boiler. The 1,100 litre heat store effectively acts as a buffer allowing the boiler to function for prolonged periods of time at a level that maximises its efficiency. This helps minimise any disparity between the hybrid system's output and occupant requirements for space and water heating.

Finance

The solar thermal system (including a mains pressure, sealed, twin-coil hot water cylinder) cost approximately £2,500. The heat store and log boiler system cost between £7,500 and £8,000 prior to any grant funding.

There are a number of grant schemes for renewable energy technologies such as Clear Skies (until March 2006) and the DTI Low Carbon Buildings Programme. The Energy Efficiency Commitment (EEC) can help with the cost of increasing the energy performance standard of a private property.

Front elevation illustrating traditional appearance
Image courtesy of Gil Schalom

Hybrid system in basement including heat store and log boiler
Image courtesy of Gil Schalom

Further information

The Energy Saving Trust sets energy efficiency standards that go beyond building regulations for use in the design, construction and refurbishment of homes. These standards provide an integrated package of measures covering fabric, ventilation, heating, lighting and hot water systems for all aspects of new build and renovation. Free resources including best practice guides, training seminars, technical advice and online tools, are available to help meet these standards.

The following publications may also be of interest:

- Renewable energy in housing – case studies (CE28)
- Renewable energy sources for homes in urban environments (CE69)
- Renewable energy sources for homes in rural environments (CE70)
- Installing small wind-powered electricity generating systems (CE72)
- Energy efficient refurbishment of existing housing (CE83/GPG155)
- New and renewable energy technologies for existing housing (CE102)
- Post-construction testing – a professional's guide to testing housing for energy efficiency (CE128/GIL64)
- Benefits of best practice: community heating (CE13)
- Community heating: a guide (CE55)
- Community heating: Aberdeen City Council case study (CE65)
- Rural biomass community heating case study (CE91)
- Pimlico District heating undertaking (case study) (CE125)

Community Programme publications:

- Community heating for planners and developers (GPG389)

To obtain these publications or for more information, call 0845 120 7799, email bestpractice@est.org.uk or visit www.est.org.uk/housingbuildings

Energy Saving Trust, 21 Dartmouth Street, London SW1H 9BP Tel 0845 120 7799 Fax 0845 120 7789
bestpractice@est.org.uk www.est.org.uk/housingbuildings