Gilmour’s Close: Edinburgh World Heritage Site Low Carbon refurbishment

By Andy Jack, Assist Architects

Hillcrest Housing Association and Assist Architects beat off stiff competition to win Inside Housing’s most sustainable social housing refurbishment project of the year. The greenest social housing organisations in the UK were honoured at a glittering awards ceremony in London in November 2009, hosted by Jon Snow, Channel 4 news anchorman and organised by Inside Housing magazine and its sister-publication Footprint.

John Mulloy, Hillcrest Group Chief Executive commented that “We have a strong focus on sustainability so we are delighted to be recognised in this way. This is the second award Gilmour’s Close has won this year specifically focusing on the energy efficiency aspects of the development.

“With Gilmour’s Close being a listed building in a world heritage site, the refit and the rehabilitation of the development faced particular difficulties. This project specifically tackled the difficult task of refurbishing an existing building to minimise CO2 emissions and dependency on non-renewable energy. We are very proud of the end result and are pleased to be able to offer affordable housing in one of Edinburgh’s most picturesque and vibrant areas.”

The tenants in the 17 affordable homes benefit from various innovative energy efficiency features through reduced energy costs and a reduction in their carbon footprint.

Amongst the most notable of these sustainable design features is the installation of a ground source heat pump which delivers heating and pre-heated water to all of the apartments. The only energy used by Ground Source Heat Pump systems is electricity to power the pumps. Sunspaces are featured within twelve of the flats which utilise passive solar gain, re-circulating warmed air within each flat.

The complete rear elevation showing the tower and new sunspaces

Andy Jack of Assist Architects commented that “With Gilmour’s Close, we set out to meet the challenge of addressing emission reductions in existing housing stock. The process was only made possible through key partnership working – Hillcrest HA, Energy Savings Trust, Historic Scotland, Communities Scotland, specialist suppliers and the design team. We were delighted to be applauded at the official opening by the Leader of City of Edinburgh Council, Councillor Jenny Dawe, as an exemplar in partnership working.

“Gilmour’s Close signals the way forward in achieving sustainable social housing and how it is possible to meet the challenging targets set for the reduction of green house gas emissions.”

The judges included some very distinguished experts including Robert Napier the Chairman of the Homes and Communities Agency; Neil May, Managing Director of Good Homes Alliance; Jon Lovell, Head of Sustainability at Drivers Jonas; Simon Mcwhirter, the Head of Campaigns at WWF Homes and Alan Yates, Director of Regeneration at Accord Housing Association.

Client: Hillcrest Housing Association
Design Team: David Adamson and Partners (QS), Clark Contracts (contractor), Waterman Group (structural engineers), Faber Maunsell (service engineers)

Project description

The project entailed refurbishment of two 19th century tenement closes to provide 17 energy efficient new flats for social housing with 10 of these providing specialist accommodation for vulnerable young people. It was the final phase of redevelopment of the Caste Trades Hostel in the centre of the city's World Heritage site.

The project specifically tackles the difficult task of refurbishing an existing building to minimise CO_2 emissions and dependency on non-renewable energy. To achieve this, Assist specified a ground source heat pump (GSHP), with 70m vertical bores drilled into the bedrock to provide onsite renewable energy for hot water and space heating. We also designed south facing sunspaces for passive solar gain, combined with a positive input heat recovery system to minimise the requirements for a non-renewable energy source. Finally, enhanced insulation was wrapped inside the existing stone fabric and secondary glazing added to the existing sash & case windows to minimise heat loss.

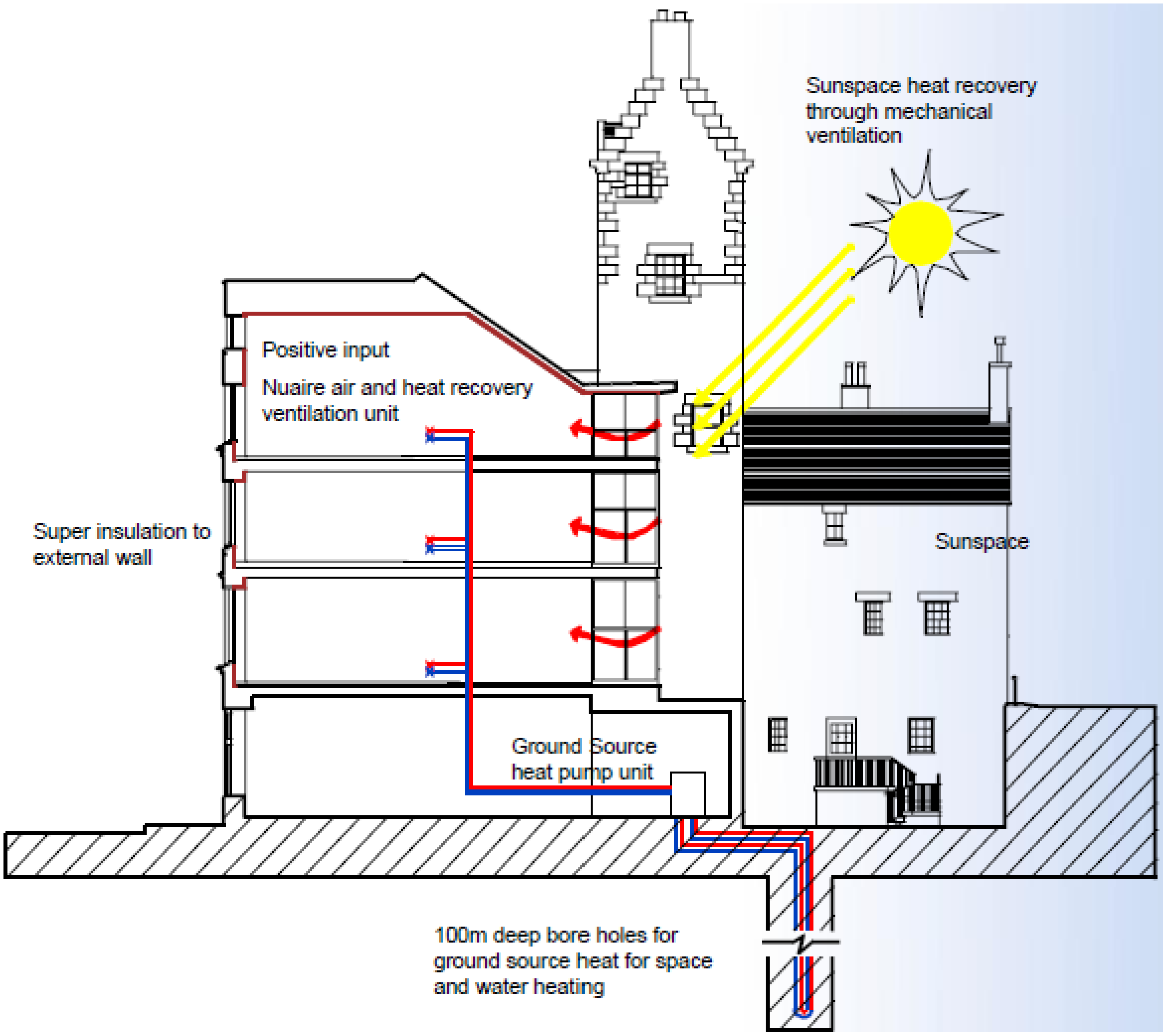
Alongside this was a programme of extensive stone conservation and façade protection funded and monitored by the Edinburgh World Heritage Trust. The project was completed during 2008.

The drilling rig onsite for the ground source heat pumps bore holes with the existing south elevation prior to the installation of the sunspaces

Project management

The project management arrangements employed to deliver the challenging brief set by Hillcrest Housing Association was one of collaboration with key suppliers and stakeholders**.** This vital collaboration took place from the onset at RIBA stages A and B, Inception and Feasibility. It was at these stages that key decisions were made to ensure the smooth integration of architecture and services. This collaboration included:

- Early meetings with Scottish Community and Householder Renewables Initiative (SCHRI) – where advice was given on options for renewable technologies, funding available, list of accredited suppliers and designers.
- Establishing agreed levels of thermal insulation of the building fabric to allow details of other strategies to be developed such as the ground source heat pumps, underfloor heating, and heat recovery strategies.
- Appointment of a Service Engineer with specialist knowledge of renewable technologies to advise on early design ideas and options.
- Environmental modelling carried out on proposed sunspaces to identify the optimum area of glazing to maximise solar energy saving but avoid excessive overheating.
- Meetings with mechanical ventilation and heat recovery (MVHR) suppliers and designers to discuss system installations ensuring distribution routes, service zones, outlets and terminals were integrated into plan layouts and architectural forms.
- Meetings with Clear Sky accredited installers to discuss the installation of GSHP, including the viability of the project for this technology; desk top studies carried out to check viability of using GSHP for a community heating system – the extent of bore holes required to meet designed heat losses, checking access for drilling rigs, and suitability of available land to install the heat pump.
- Co-ordination meetings between the appointed Clear Sky installer and design team service engineer to develop informed performance specifications to be used in the contract.
- Strategic overview meetings between the appointed Clear Sky installers and the client to clarify the visual impact of the GSHP, how it will be installed and work, key issues regarding backup strategies and health & safety issues such as how to deal with the risk of Legionnaires disease.



Integrated strategy for renewable energy

Procurement

The procurement process selected to deliver the low carbon designs on the project involved a series of contractor-designed packages included in a standard JCT Contract (with Quantities) and based upon performance specifications developed by the project Service Engineer Faber Maunsell. The process involved developing a pre-contract, detailed understanding of the key installations with the suppliers involved. Most critically in this project was the ground source heat pumps supplied by Eco Heat Pumps. By the time work began on site, the following documents had been prepared and procedures followed:

- The selection of a Clear Skies accredited supplier, Eco Heat Pumps.
- Assessment of the viability of the heat pump for this type of project.
- Sizing of the heat pump based on supplied heat losses for the 17 flats, using national geological data to calculate the number and depth of bore holes required (10Nr at 100 metres deep to give 51KW load). Then, checking available space to confirm this can be achieved.
- Induction meetings with clients to discuss system operation, metering, and distribution to the 17 dwellings.
- Meetings with drilling rig companies to confirm that there were suitable rigs available to negotiate the restricted access.
- Detailed site investigation undertaken to confirm the findings of the desktop study.
- Meetings with the Service Engineer and Eco Heat Pumps to develop detailed performance specifications for the ground source heat pump.

A similar process was followed to develop detailed performance specifications for:

- ❖ The positive input ventilation and heat recovery
- ❖ The hot & cold water installation/distribution
- ❖ All electrical Installations
- ❖ The underfloor space heating

The detailed performance specifications in turn became key contract documents, embedding system and client requirements into the contract. The tendering process itself was a conventional single stage selecting tender, followed by a tender report from the project QS recommending Clark Contracts as the main contractor. Clark Contracts in turn subcontracted all M&E works to James Frew, who in turn entered into subcontractor agreements for the individual specialist works for the:

- ❖ Ground source heat pump
- ❖ Underfloor heating
- ❖ Hot and cold water
- ❖ Positive input ventilation and heat recovery.

The performance specifications for each of these sections of work had clear outcomes required by the contractor in terms of:

- ❖ Production of detailed drawings
- ❖ Calculations in support of designs
- ❖ Commissioning of system
- ❖ Induction of client of system operation
- ❖ Provision of detailed health and safety file documenting as built drawings, products and manufactures, warranties and maintenance requirements.

The process of approval of each installation involved preliminary proposals, drawings, products and specifications being prepared by James Frew, which in turn were reviewed and commented on by the project service engineer, measured against the required outcomes of the performance specification: this process concluded when the project service engineer had no further comments and the detailed drawings and specifications were then adopted as contract documents.

Prior to work starting on site, a high level services meeting was held, involving specialist installers, M&E subcontractor, main contractor, and design team members, to discuss programming, co-ordination with other trades, and any outstanding issues.

During key times of the installation, in addition to the general works Clerk of Works, Faber Maunsell provided specialist M&E Clerk of Works to monitor work in progress. This included:

- ❖ Checks on first fix installations
- ❖ Checks on second fix & component installation
- ❖ Checks at commissioning and before practical completion
- ❖ Client technical staff induction of operational features of installations.

The culmination of these actions has contributed to producing the following good internal environments:

Comfort
A warm comfortable environment is key to occupants' sense of quality in their home environment: underfloor heating provides evenly distributed heat at low level where it is wanted. This type of heating is ideally suited to being served by a ground source heat pump as it supplies low pressure water at low temperatures (35-45°C) to the underfloor heating circuits unlike conventional radiators where the water circulates at up to twice this temperature.

Air Quality
Good air quality is fundamental to high quality occupant experience of their internal environment, which to a large extent relies on an efficient ventilation system. With high levels of insulation and air tightness (provided by new secondary glazing) a mechanical ventilation system is essential to ensure air quality and avoid problems of condensation. The specified positive input ventilation system with heat recovery provides both incoming conditioned fresh air and recovered heat through a flat plate heat exchanger, gathered from expelled stale air from kitchen and bathroom. In addition, warm air from the sunspaces is also collected and passed through the heat exchanger, providing valuable free solar heating to each flat.

Noise intrusion
Within busy urban locations such as Gilmour's Close in the Grassmarket, noise pollution is a major problem. Coupled with conservation requirements to retain the existing sash and case windows, the solution was to install high quality secondary glazing, providing both a significant reduction on traffic noise and reduction of heat loss through the glazing and ventilation losses.

External space and warmth
Within an urban environment where garden space is limited, the sunspaces provide not only passive solar gains but also much needed amenity space associated with each flat.

As well as these environmental factors, the building also meets the following standards:

- ❖ **Housing for Varying Needs (HFVN)**

The quality of the internal environment relies heavily on the design plans being able to carry out fully the normal activities of eating, sleeping and relaxing. By design to current design standards defined by HFVN, we have ensured a functional and pleasing internal layout for each flat.

- ❖ **Secure by Design**

The development has been awarded Secure by Design status confirming that the principles of community safety are embedded in the development, ensuring that each tenant feels safe in their home.

Minimising energy consumption and the carbon footprint

To minimise non-renewable energy consumption and reduce the building's carbon footprint, we specified a ground source heat pump to provide onsite renewable energy for hot water and space heating. The GSHP was a Thermia Robust 38 model supplied by Eco Heat Pumps who also supplied all the hardware required for this system. Fourteen 70m vertical bores were drilled into the bedrock at the rear of the building and this in itself proved a logistical challenge as the only way of accessing the rear of the building is through one of two close pends, 2m wide and 2.5m high. A specialist drilling rig was commissioned to crawl through the pend and over a period of several days drilled the deep holes for the pipe loop (because of the site location and its restricted footprint, the conventional coil loop system of GSHP laid out over a large area at shallow depth was not possible and a deeper, more intensive system was specified which took up less ground area).

The GSHP was connected to a communal heating and hot water system that supplies both closes with hot water, heating the flats via a low temperature under-floor heating system from Velta. Each flat has three thermostats, one of which is located in the sunspace, to control the room temperatures.

Heat meters have also been fitted to measure the efficiency of the heat pump installation. Initial calculations predict an efficiency rating of 4:1, but we intend to monitor this and also collect data from each flat to assess the true impact of this renewable system on the tenants' fuel bills.

A plantroom was constructed at the rear of the building to accommodate the GSHP hardware

Building form and fabric, façade, orientation

This project re-uses an existing historic tenement building which has a nominal footprint, with shop units on the ground floor and four storeys of refurbished flats above. The existing building fabric is a solid masonry construction with plasterboard lining which had an exceptionally high heat loss and U-value.

Our objective was to significantly improve the U-value and reduce the heat loss from the new homes above the basic requirements of the Scottish Building Standards. To achieve this, 100mm of mineral wool was fitted to the inside of the masonry and a 50mm air gap created within which was hung Alreflex 2L-2 dry lining wall insulation which consists of two layers of polythene bubble sheet faced on both sides with an aluminium foil lining. This make-up was then sheeted with plasterboard and the combined effect was an improvement from approx 3.0 W/m²K to 0.22 W/m²K.

300mm of mineral wool quilt was added within the roof space to achieve a U-value of 0.14 W/m²K**.** Between each flat a sacrificial ceiling contained 100mm of insulation, primarily for acoustic compliance, but the Velta underfloor heating system was laid within 50mm rigid polystyrene to minimise any heat loss beneath.

The windows also posed a significant problem, being original sash and case single glazed units. Due to the building's location within the Edinburgh World Heritage site, it was not possible to replace the windows with double or triple glazing, so we opted for secondary glazing, which had to meet EWHT's conservation requirements, to help reduce the heat loss from the flats.

The orientation of the building is east-west along the southern edge of the Grassmarket and as such, the rear elevation was not susceptible to as strict conservation controls as the front street elevation to the north. To maximise passive solar gain, we designed south-facing sunspaces which are cantilevered off the main structural core of the building. These provide passive solar gain which, combined with a positive input heat recovery system, minimise the requirements for a non-renewable energy source, and provide attractive semi outdoor spaces within the high-density fabric of the Old Town.

Building services

A positive input whole home heat recovery system from Expelair was specified to work in tandem with the sunspaces and the GSHP to minimise the use of non-renewable energy.

The MVHR system provides whole home ventilation using a combination of the positive input ventilation principle, continuous low level extract ventilation and heat exchange heat recovery.

Simultaneously, air is extracted from 'wet' areas such as the kitchen, bathroom and sunspace. Supply and extract pass through a heat exchanger which transfers heat to the supply air and discharges the extract air outside.

Avoiding overheating

The positive input heat recovery system minimises the need for mechanical cooling due to summertime overheating by monitoring the internal temperature and drawing fresh air into the building. All sash and case windows are openable for natural ventilation and the sunspaces also have openable windows to give tenants control over the internal temperature.

Renewables

As mentioned above, a ground source heat pump from Eco Heat Pumps was specified to minimise non-renewable energy consumption and reduce the building's carbon footprint. This was partially funded by the SCHRI with the remainder of the cost being funded from Hillcrest Housing Association's own funds.

The street elevation to the north with the completed EWHT funded conservation work

Sustainable construction

It is well known that reusing and refurbishing old buildings can save more CO_2 emissions than building environmentally friendly new ones. In this instance we have taken a redundant city centre building and through grant aided conservation and the implementation of a sustainable design strategy we have extended the lifespan of the building and provided new accommodation without the emissions, waste and use of embodied energy associated with constructing a new building.

The conservation work included repairing the stone façade with natural stone and lime mortar, the re-use of the existing slates and the addition of second-hand Scottish slates where required, and the overhauling of the existing sash and case windows.

Because we were reusing an existing building, apart from the strip-out (where waste from the old building was sorted by skip), there was significantly less waste produced in the refurbishment than in the construction of equivalent new building.

A minimal amount of concrete was used throughout the building (primarily for the new GSHP plant room), and as noted, all stonework repairs and re-pointing was undertaken with lime mortar.

Steel was used to cantilever the sunspaces from the original structure of the building but this can be recycled at the end of its lifespan.

Structural and finishing timber was from a sustainable source whilst all insulation materials used have a low GWP and ODP of zero.

The aluminium cladding to the sunspaces is 100% recyclable.

The location of the site on the main busy thoroughfare of the Grassmarket combined with the fact that the rear of the building can only be accessed by vehicles through a 3m high pend meant that the removal of waste (as well as the delivery of materials) had to be carefully coordinated and limited.

A bus stop and pedestrian crossing in front of the site restricted the number of skips which could be loaded at any one time so waste was generally sorted on-site prior to being taken to the front of the building and removed.

And the omission of wet trades from the construction process meant that significantly less water was used in this refurbishment than compared to a new build, and this minimised the amount of potential discharge of contaminated liquids into the existing drainage system.

Costs

This low carbon design strategy has resulted in an overall higher capital cost for this project. These additional capital costs can be attributed to:

Additional thermal insulation to achieve lower U-values	£1,000
GSHP installation and pipework	£5,500
MVHR unit	£1,000
Underfloor heating coils and manifold	£500
Sunspace construction	£4,000
Secondary glazing	£1,000
Total cost per flat	£13,000
Total project cost	£221,000

The £100,000 cost of the GSHP was partially funded by the SCHRI with a grant of £40,000. Of the remaining £60,000, Hillcrest were able to allocate equivalent HAG funding for the cost of 17 conventional condensing gas boilers, the remainder of the cost (£22,000) being funded from Hillcrest Housing Association's own funds. Hillcrest were then able to re-coup this cost by charging the tenant's a higher rental rate to reflect part of the fuel bill saving.

The initial capital costs of a ground source heat pump system is more than a conventional oil or gas fired boiler, but the initial one-off expense is offset by the lower running costs, lower maintenance and low servicing requirement. Clients also have the security of knowledge that the majority of their heating and cooling energy comes out of your ground, is under their control and will not increase in price. Gas prices are continuing to rise and supplies will eventually run out. The GSHP relies only on electricity, which can be sourced from hydro, wind or wave, and will provide more certain cost security in the long term. And with an estimated bay-back period of 4-5 years based upon 2007 gas prices, tenants can expect to save in the region of between £300-400 per year in fuel costs.

The whole life cost implications of the GSHP over a lifespan of 30 years are significantly lower than a gas or oil fired boiler and can be addressed as follows:

Lifespan of heat pump	30 years
Lifespan of conventional boiler	15 years
Cost of boiler renewal	£1,500 per unit
Safety check	£100 per visit
Maintenance check	£100 per visit
Cost of replacing conventional gas boiler for all 17 units	£34,000 at £1,500
Cost of gas safety check	£51,000
Cost of maintenance check	£51,000
Total cost	£136,000
Cost of twice yearly safety and maintenance checks for the GSHP	£1,000 per year
Total cost	£30,000
Whole life saving cost	£106,000

Occupants' experience

Since the building's occupation in June 2008 general feedback on the quality of occupancy has been limited although a tenants' satisfaction survey will be carried out at the end of the defects period. From the beginning of the winter we have been closely monitoring the performance of the GSHP and underfloor heating to ensure it meets the tenants' requirements.

The heat pump has been monitored to ensure it is delivering the required heat input but we have become aware of some flat-specific heating issues: four of the seventeen flats have had occurrences of imbalanced heat output to separate rooms.

Through a combination of site visits to monitor ambient temperatures and advice from Eco Heat Pumps, it would appear that whilst the heat pump is delivering appropriate heat to the flats there may be a simple issue with the balancing of the system at the flat manifold. In some instances, design temperatures are being exceeded in one room and not met in another and to resolve this requires the manifold distribution for each flat to be re-balanced.

Once this has been undertaken we will continue to monitor the temperatures to ensure maximised tenant comfort during the winter months. Conversely, we are aware that during the summer months, we will need to closely monitor the Expelair MVHR system to ensure overheating does not occur, either due to hardware and technical issues of user control understanding. Currently, the sunspaces are providing valuable drying space and semi-outdoor space for this city centre building, without which tenants would be struggling to dry clothes without the aid of tumble driers or using clothes horses in internal rooms. This can lead to potential condensation problems within the flats and subsequent potential health issues such as asthma.

Generally, whilst is has been demonstrated that the various technologies are performing both as designed and to meet user requirements, particular challenges experienced have included the induction of the system to the tenants who require supported accommodation and ensuring their understanding of how the systems work.