Improving the energy efficiency of older off-gas grid houses; Retrofit options for a 1950s ex-SSHA estate in Dailly

for

Ayrshire Housing

Author: **Prof John I Currie**
Scottish Energy Centre

EXECUTIVE SUMMARY

The Scottish Funding Council Follow-On Innovation Voucher Scheme was utilized to fund a study to establish the potential for identifying energy reduction measures utilising low and zero carbon technologies (LZCT) for their hard-to-treat housing stock.

This study has shown that savings can be made in a number of areas, including changes to the building fabric, demand reduction and incorporation of low and zero carbon technology measures. Such actions could save up to **322MWh** of energy per year across the current stock of 32 dwellings at Dailly which, at current charges, could save over **£36,000** in utility costs to tenants and significantly reduce the stock carbon footprint by some **68.5tonnes** of CO_2 if fully implemented.

The study will hopefully benefit the housing association and form the basis of a strategic improvement plan for the energy efficient upgrade of hard to treat properties. A large proportion of their portfolio of their current stock fall into this category and the housing association are seeking to acquire knowledge into how to assess and upgrade these properties effectively.

PREAMBLE

1.0 Objectives

Following the successful award of a SFC Follow-On Innovation Voucher, Ayrshire Housing in collaboration with the Scottish Energy Centre (SEC) at Edinburgh Napier University have worked to define the practicality of integrating energy efficient retrofit measures into a portfolio of hard-to-treat housing stock in the village of Dailly.

The project was initiated following a meeting by staff from Edinburgh Napier University in April 2012 which identified a potential project furthering the collaborative relationship between the academic partner and SME. The project sought to define the options for energy efficiency and mitigation measures into existing housing stock in order to work towards improved housing stock quality standards and reduce fuel poverty for vulnerable tenants.

This study builds on previous collaboration between the University and Ayrshire Housing; evaluating the enhanced heating and ventilation systems fitted in two of Ayrshire Housing's new build projects. Both developments were outwith the gas supply area and, in terms of a standard specification, were fitted with electric storage heaters and immersion water heaters. The studies evaluated the usefulness of alternative or additional measures both to reduce energy consumption and improve user flexibility. The intention is of the proposed study is to identify options to introduce previously trialled technologies into these properties.

Key areas for action were identified for inclusion in this Study and are summarised in Table 1 and addressed under various sections in the main report.

Description of Activity	Deliverable/Milestones
Building Fabric, Servicing and Occupant Survey	Base line data obtained.
Buildings Survey	Survey data provided for input to model
Base-line Simulation	Validated model/s generated.
Identification of upgrades	House types and upgrades identified including assessment of fabric upgrades
Intervention Simulations	Completed simulations of potential interventions
Feasibility assessment for upgrades	Feasibility study completed
Report Writing	Strategic improvement plan for dwelling type

Table 1 Feasibility Study Activity Table

This feasibility study will lead to a long-term relationship because the outcomes will be used to attract further funding to develop the technologies within the business. By combining the partner's expertise and experience's, an intrinsic and genuine partnership will be developed, leading to further projects.

2.0 Background

The association has a stock of 32 ex-SSHA houses in the village of Dailly. All were built in 1955 and are of traditional construction. Originally heated by coal fires they now have electric storage heaters (dating from 2001). EPC energy efficiency ratings (SAP 2005) are in the range 36 to 44. These low ratings are despite the addition of cavity fill, enhance loft insulation and double glazing over the years.

The sample stock is typical of much of social housing provision in rural areas. It is envisaged therefore that if the effectiveness of proposed strategies can be demonstrated, it would provide assistance to social landlords in planning their modernisation strategies. In terms of business development, it would assist designers, contractors and suppliers to establish niches in the application of established but still fairly novel (for social landlords) technologies.

It will evaluate fabric-first improvement options and identify the costs & benefits of approaches which focus on either simply augmenting the existing heating systems as against more extensive renewal of the heating and ventilation systems. It will identify what additional measures can usefully be introduced to further enhance thermal performance and air quality still further for the benefit of the occupants.

3.0 Existing Stock

It was proposed that access would be obtained to a representative sample of the Dailly housing stock including end- and mid-terraced 1.5 and 2-storey dwellings (Plates 1 & 2). Four different house types were surveyed by ARPL Architects for the purpose of this study and as-built architectural drawings provided; a sample of which are presented in Appendix 1. Energy Performance Certificates for the existing dwellings were also provided by Ayrshire Housing; an example of which is shown in Appendix 2.

Plate 1 1.5 storey dwellings

Plate 2 Two storey dwellings

A site visit was arranged for 4th October 2012 where it was proposed that access would be arranged to the following dwellings:

- 5 Hadyard Terrace – 1.5 storey, end-terrace
- 34 Hadyard Terrace – 2 storey, mid-terrace
- 36 Hadyard Terrace – 2 storey, end-terrace
- 59 Hadyard Terrace – 1.5 storey, mid-terrace

A field survey of these households was undertaken together with key members of Ayrshire Housing staff. This was used to help identify the existing conditions and construction of each property to inform potential upgrade measures. Heating bills (where available) occupancy demographic, and heating type were recorded, with additional information on secondary heating, usage and comfort. Measurements of dwelling air permeability were undertaken on two of the properties and the results presented in Appendix 3.

The airtightness test results for these are presented below:

Dwelling	Permeability ($m^3/h.m^2$)
5 Hadyard Terrace	11.98
30 Hadyard Terrace	12.42

Current building design practice and energy performance directives generally seek to achieve building envelope air permeability of less than $10m^3/h.m^2$ and it is pleasing to see that the Dailly dwellings perform relatively well against this metric; considering their age and during a period of construction when airtightness detailing was not a consideration.

4.0 Building Model

Utilising the drawing information provided by ARPL Architects a model of the building was developed using Cymap building energy modelling software. Input data from the building envelope, orientation, fenestration, heating system and occupancy patterns was compiled to provide a baseline simulation for the building as originally constructed. Thermal upgrades to the building as they exist at present were then input to the model and sense checked with the energy cost and usage information provided by the tenants and the present EPC certification; which utilises RdSAP methodologies obtained from stock condition survey reports.

Access could only be arranged to 3 of the properties originally identified, one of which was presently unoccupied. Given the data availability and limited differences between the properties as-surveyed it was decided to model a generic building form. Models were developed for building fabric/ventilation gains and losses only, neglecting occupancy, appliance and latent gains in order to provide a comparison platform.

4.1.1 Baseline Model

Utilising pre-intervention building fabric and electrical storage heating, a baseline simulation of the dwellings was undertaken. This estimated the heating energy requirement to achieve a comfort control temperature of 19°C within the dwelling over a 9 month notional heating season. A typical energy consumption graph showing how the annual heating energy consumption profile is developed to meet local climatic weather conditions is shown in Fig. 1 below.

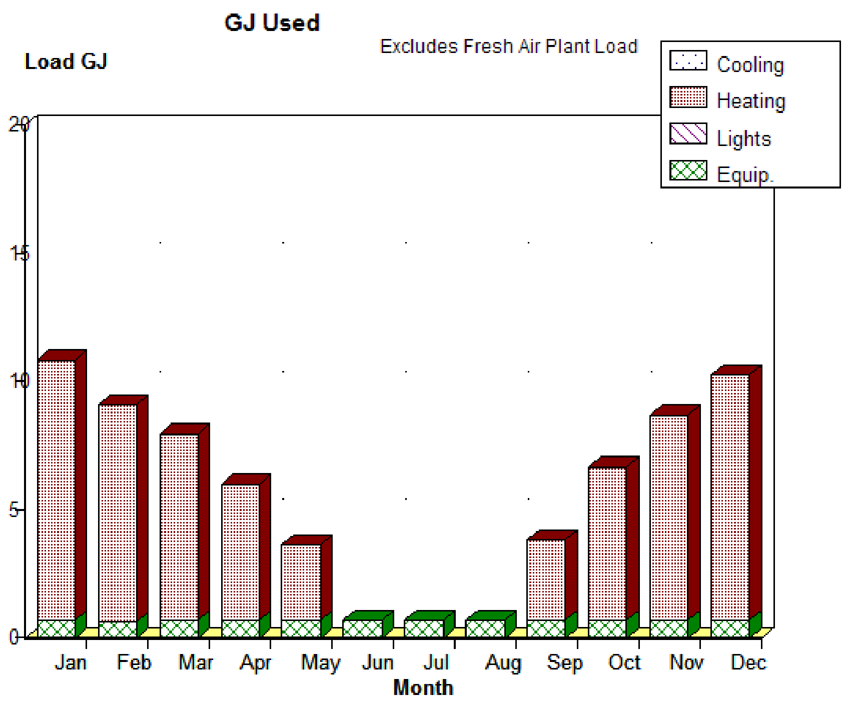


Fig. 1 Typical Annual Heating Energy Demand Profile

This was developed for the generic construction and the baseline energy consumption for electric storage heating an as-built dwelling, with no insulation or glazing improvement measures, was estimated to be 16,860kWh per annum.

Domestic hot water provision for the dwellings was calculated per the Standard Assessment Procedure (SAP) methodology which utilises the total floor area to calculate hot water energy requirements. The dwellings assessed range from 93-95m^2 floor area which equates to an average annual consumption of 2325kWh. The total heating and hot water energy consumption was thus calculated as shown in Table 1 below:

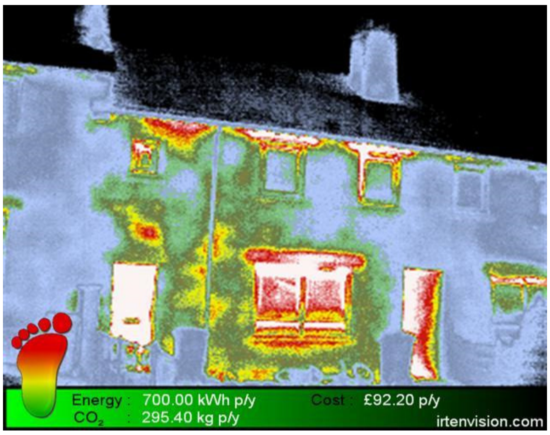
Intervention Status	Heating Energy (kWh/annum)	CO_2 emissions (kg)
As-built	19,185	5755

Table 1 Baseline Energy Profile

In the original dwellings heating was ostensibly provided by open coal fires and back boiler installations, the fuel for which was often provided to many of the occupants' free-of-charge as a result of working in the coal mining industry.

4.1.2 Current Fabric Scenario

Since their initial construction in the 1950's the buildings have undergone thermal performance upgrade including the fitting of double glazing and the reported installation of cavity wall and loft insulation. No destructive testing was undertaken to validate the existence and/or quality of cavity fill although thermographic survey data was provided which would tend to suggest that this might not be the case (Plates 3&4). In fact, close inspection of the outer render coat on the buildings could not identify the existence of cavity fill hole patterns.



Plates 3&4 Infra Red thermographic images of No.5&34 Hadyard Terrace

Where access could be gained, insulation was identified as having been installed under-roof; below the sarking of pitched roof areas (Plate 5).

Inputting such fabric upgrade measures into the baseline model identified the relevant benefit of each on the fabric heating energy consumption for the dwellings as presented in Table 2 below:

Intervention	Heating Energy Reduction (kWh/annum)	Improvement over As-built (%)	CO_2 reduction (kg)
Double Glazing	1,283	6.7	550
Loft Insulation	2,847	14.8	1,224
Total	**4,130**	**21.5**	**1,774**
Adjusted Baseline - 15,055kWh per annum			

Table 2 Initial Intervention Benefits

Utilising the data from Table 2 it was thus estimated that the current energy consumption of the generic dwelling type was 15,055kWh per annum which, with the presently installed electric heating would result in carbon emissions of some 6,470kg per dwelling per annum. This was used as the baseline consumption for the dwellings against which the various intervention options were assessed in Section 5 below.

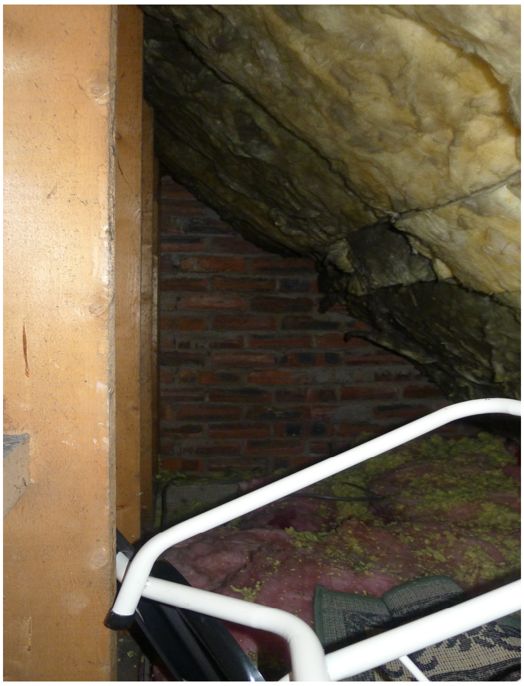


Plate 5 Roof Insulation

5.0 Fabric Upgrade Options

5.1 Loft Insulation

Scope exists to further improve the building fabric energy performance by adding additional loft insulation to achieve the currently recommended minimum of 270mm glass wool (or equivalent). Care should be taken when doing so to protect service water tanks and pipework as well as electrical cabling and heat producing appliances.

By installing additional insulation, thereby reducing the roof structure U-value to $0.2W/m^2.K$, an additional energy reduction, as tabulated in Table 3, of 1220kWh is identified.

5.2 Cavity Wall Insulation

Little evidence could be gained from a visual survey regarding the presence or otherwise of cavity wall insulation, this is presently being evaluated by physical intervention assessment. By installing blown mineral fibre insulation into the wall cavities it is estimated that an energy reduction of 2,394kWh (see Table 3) could be achieved for the generic house type.

5.3 Glazing Improvements

UPVC double glazing was installed in all properties. As with all double glazing, one key issue is the longevity of the seal which is important when there are inert noble gases (or vacuum) in the cavity; as these generally characterise the thermal efficiency of the unit. If this fails, the thermal performance of the glazing is reduced; creating additional problems such as internal condensation. These performance reductions often go un-noticed and cannot readily be resolved, making total replacement the most viable option. Replacing the glazing with high performance double or triple glazing units can be a means to realise further improvements in the stock, albeit an expensive option.

By installing modern high performance double glazing units achieving an overall U-value of 1.4W/m^{2}K or better, it is estimated that a reduction of some 670kWh (see Table 3) will be achieved through their enhanced area-weighted U-value characteristics. Attention is also drawn to long term care and warranty issues surrounding some modern glazing systems, particularly if manufactured overseas; where replacement on breakage may prove problematic.

5.4 Party Wall Insulation

Work undertaken by University College London and Leeds Metropolitan University (Lowe et al, 2007) looking at heatloss in party wall cavities for masonry construction identified that the heatflux into a party wall cavity is equivalent to an effective U-value of 0.6W/m^{2}K. Assuming that the Dailly houses might have cavity party wall construction, heatloss from the dwelling via the party wall cavity can be reduced for example by filling the cavity of the party wall with mineral fibre, or by inserting a flexible membrane or plastic sleeved cavity closer across the cavity in the plane of the roof insulation. Applying such retrofit measures reduces the cavity heatloss into the roofspace and could save an estimated 630kWh per annum.

Intervention	Heating Energy Reduction (kWh/annum)	Improvement over Baseline (%)	CO_2 reduction (kg)
Additional Loft Insulation	1,220	8.1	525
Cavity Wall Insulation	2,394	15.9	1029
High Performance Glazing	670	4.4	288
Party Wall Insulation	630	4.2	270
TOTAL	**4914**	**18.6**	**2112**

Table 3 Fabric Intervention Benefits

6.0 Low and Zero Carbon Technology Integration Options

This section explores the opportunities for incorporating renewable energy technologies within the dwelling in order to mitigate the current and future primary energy demand.

6.1 Solar Thermal

Based on a previous study into the implementation of such technology by Ayrshire Housing at a new-build development in Maidens, solar thermal heating technologies could be successfully implemented into the Dailly housing stock through fitting flat-plate or evacuated tube collectors on southerly oriented roof areas and connecting these to upgraded domestic hot water tanks with secondary heating coils installed (Plates 6&7). For a $4m^2$ flat plate collector installation it is estimated that an annual yield of 1650kWh could be contributed to domestic hot water needs for the dwellings.

Plate 6 Solar Hot Water Installation

Plate 7 DHW Tank

Solar thermal installations are eligible for the Renewable Heat Incentive (RHI) scheme. Present estimates suggest that this could generate 8.9p/kWh, which equates to some £145 per annum. Advice should be sought from a Microgeneration Certification Scheme (MCS) approved installer for cost, installation, and planning advice http://www.microgenerationcertification.org/.

6.2 Positive Input Ventilation

Previous work by the Building Research Establishment (BRE, 1999) and the author (Currie, 2006), established the benefits of the NuAire Drimaster PIV system installed in an Ayrshire Housing development in Ballantrae as contributing a minimum of 550 kWh over a heating season to the dwelling.

Plate 8 NuAire Positive Input Ventilation System

By incorporating a solar pre-heating element to this utilising the roof construction (see Plate 9 below) it is possible to significantly enhance the efficiency of this type of installation. The Ballantrae project incorporated a glazed façade on the south elevation of the dwellings which was utilised to provide pre-heated air to the PIV system and the net benefit of this was estimated as a 1507kWh per annum. This was typical of the net benefits from a solar pre-heated collector used in this configuration and reported by Macgregor et al, 1996.

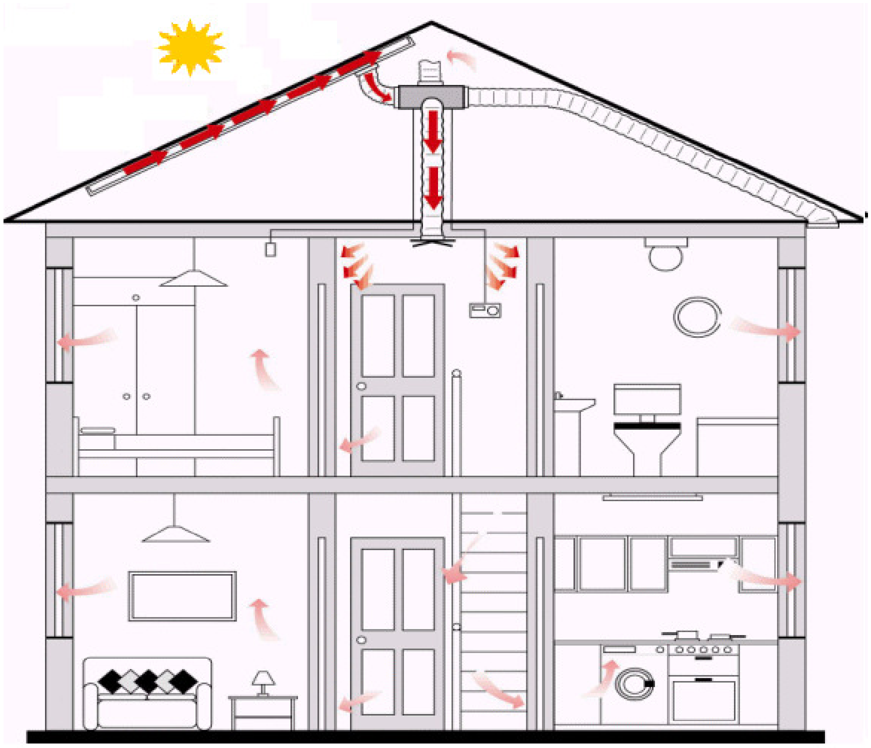


Plate 9 Solar Collector Enhanced PIV System

6.3 Solar PV

Areas of south facing roof space (SSW) could potentially provide a location for the installation of renewable energy technologies, such as solar PV, to displace mains electrical energy demand. For instance, installation of a 2.5kWp PV array could potentially generate some 2,000MWh per annum, depending on technology employed, and could save up to **£230** per annum in purchased electricity (excluding income from Feed in Tariff which is presently estimated at 2,000kWh @ 17.5p/kWh = £350). It is recommended that a comprehensive site survey be undertaken first by an approved installer to validate the available resource, building structural suitability, electrical supply/demand capacity and any planning issues. Advice should be sought from a Microgeneration Certification Scheme (MCS) approved installer in this respect http://www.microgenerationcertification.org/.

6.4 Air Source Heat Pump

The new build development undertaken by Ayrshire Housing at Maidens (discussed in Section 6.1) incorporated a number of NIBE Fighter 360 exhaust air source heat pump units which utilise heat rejected in bathroom and kitchen exhaust air as a source for low temperature hot water heating. Heat pumps utilise the thermodynamic efficiency of a closed cycle working fluid to gain thermal advantage as lower-entropy is required to compress the fluid than is released in the high grade heat generated. In such heat pumps the heat delivered can be 3-4 times the electrical energy consumed, and is often referred to as the Coefficient of Performance (COP).

The Maidens study indicated that such technologies could reduce the annual dwelling heating and hot water energy demand by up to 19.3% over conventional electric storage heating for such new build properties. If such technologies could be retrofitted into the Dailly properties (given the spatial requirements for the heat pump and ductwork, plus the need for extended surface radiators to operate at lower delivery temperature) then annual savings of up to 1957kWh might accrue. However the present tariff structures offered by utility providers do not allow such technologies to financially benefit the occupiers fully and, unless the ASHP operation can be re-profiled to operate for significant periods at lower unit rates, this will not be translated into lower cost to the occupants.

6.5 Electric Storage Heating

Electric storage heating was, and still is, deemed to be a cost-effective solution to providing heating to dwellings in off-grid gas areas. System efficiencies have recently been improved through the use of smart technologies which control the charge and discharge cycle rates of such systems whilst incorporating the capacity to ‘absorb’ localised or embedded energy generation capacity. One such system (GlenDimplex ‘Quantum’) is presently being trialled in Dublin with savings of 20% energy and 30% cost being reported in comparison to ‘older’ storage heating systems. The system is being launched by Scottish and Southern Energy at the European Parliament on 26th February 2013 and may be worthy of consideration once independently validated data on system efficiencies becomes more widely available.

6.6 Community Heating

Another option worthy of consideration for such a community might be the adoption of a community heating scheme; utilising a centralised energy centre to provide heating and hot water over a district heating network. Hydraulic interface units installed in each dwelling meter and supply heating and hot water on-demand with utility billing and collection being operated by an energy supply company (ESCo), who operate and maintain the heating network. Some government funding mechanisms have recently been announced for such initiatives but calculation of the net benefits are presently outside the scope of this study. There are also issues surrounding the mixed ownership of dwellings on the estate which might affect the physical and economic viability of such a venture.

Table 4 below presents a summary of the potential benefits of each renewable intervention measure identified. It should be noted that whilst a number of the technologies can be readily retrofitted as complimentary to each other, the ASHP system cannot, and should thus be viewed as an alternative energy mitigation measure.

Intervention	Heating Energy Reduction (kWh/annum)	Improvement over Baseline (%)	CO_2 reduction (kg)
Solar thermal	1,650	10.9	709
Solar preheated PIV	1,507	10.0	648
Solar PV	2,000	13.2	860
Air Source Heat Pump **	1,957	13.0	840
TOTAL	**7114**	**47.1**	**3057**

** Technology cannot be installed in conjunction with others identified

Table 4 Renewable Technology Intervention Benefits

7.0 Conclusions

A study of the Dailly site has identified that the dwellings provide a good opportunity for the application of a range of intervention measures both to fabric and servicing through which to reduce the primary energy costs and improve the carbon footprint of the community.

This study has shown that savings can be made in a number of areas, including improvements to the building fabric which require low capital investment and for which grant funding may be available, to higher value intervention measures which include renewable technologies.

From a post-construction energy consumption estimate of 19,185kWh per dwelling, where coal was used as the primary heating energy source, the dwellings in their current form are estimated to consume 15,055kWh on average for heating and hot water. Adoption of the fabric intervention measures identified in the report could reduce this to 10,141kWh per annum which, incorporating a mix of low and zero carbon technologies, could be further reduced to a value approaching 4,984kWh per annum; effectively cutting the annual fuel bill to the occupants by approximately two thirds.

The study will hopefully benefit the housing association in respect of developing a strategic improvement plan for the energy efficient upgrade of hard to treat properties. A large proportion of their portfolio of apartments fall into this category and the team are seeking to acquire knowledge into how to assess and upgrade these properties effectively.

8.0 References

BRE (1999) Building Research Establishment Technical Report CR 106/99 Monitoring and Evaluation of Domestic Supply Ventilation Systems.

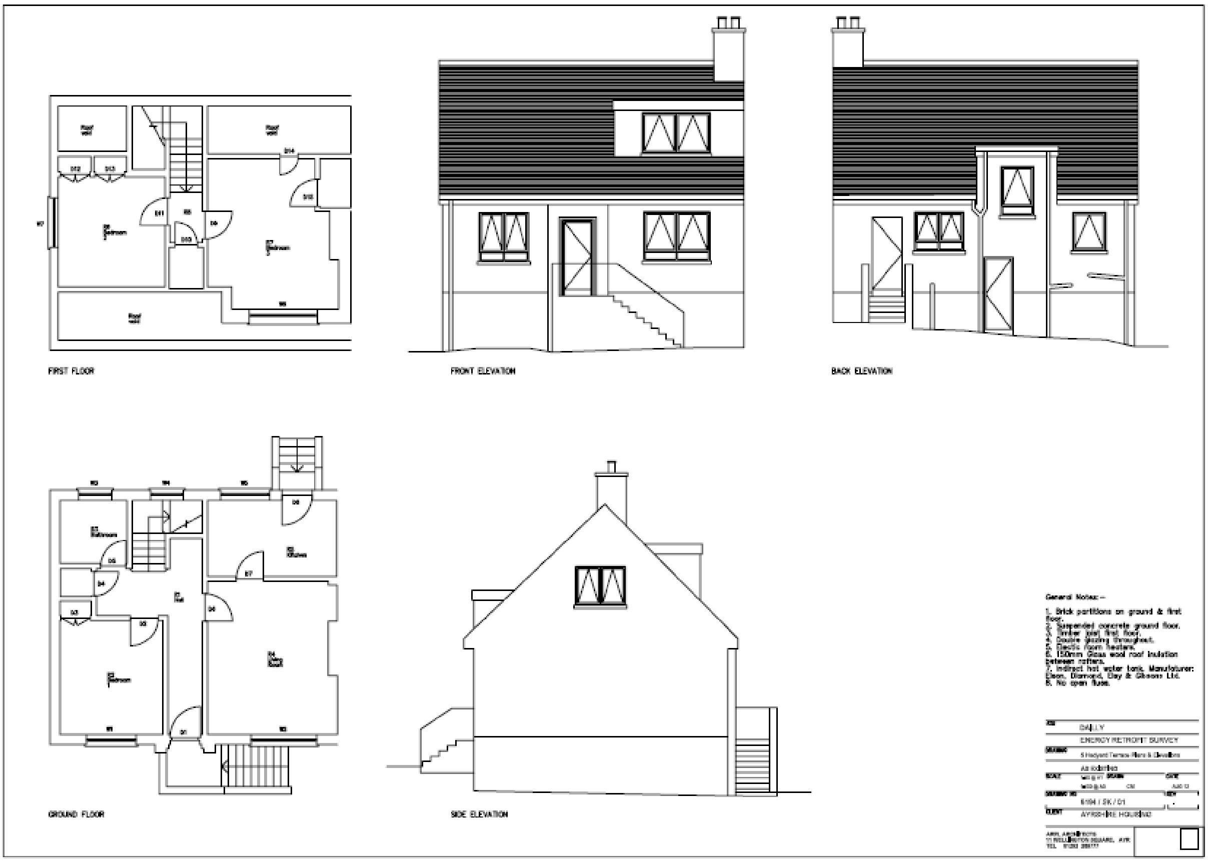
BRE (1999) Building Research Establishment Technical Report CR 379/99 Low Energy Positive Input Ventilation in Dwellings.

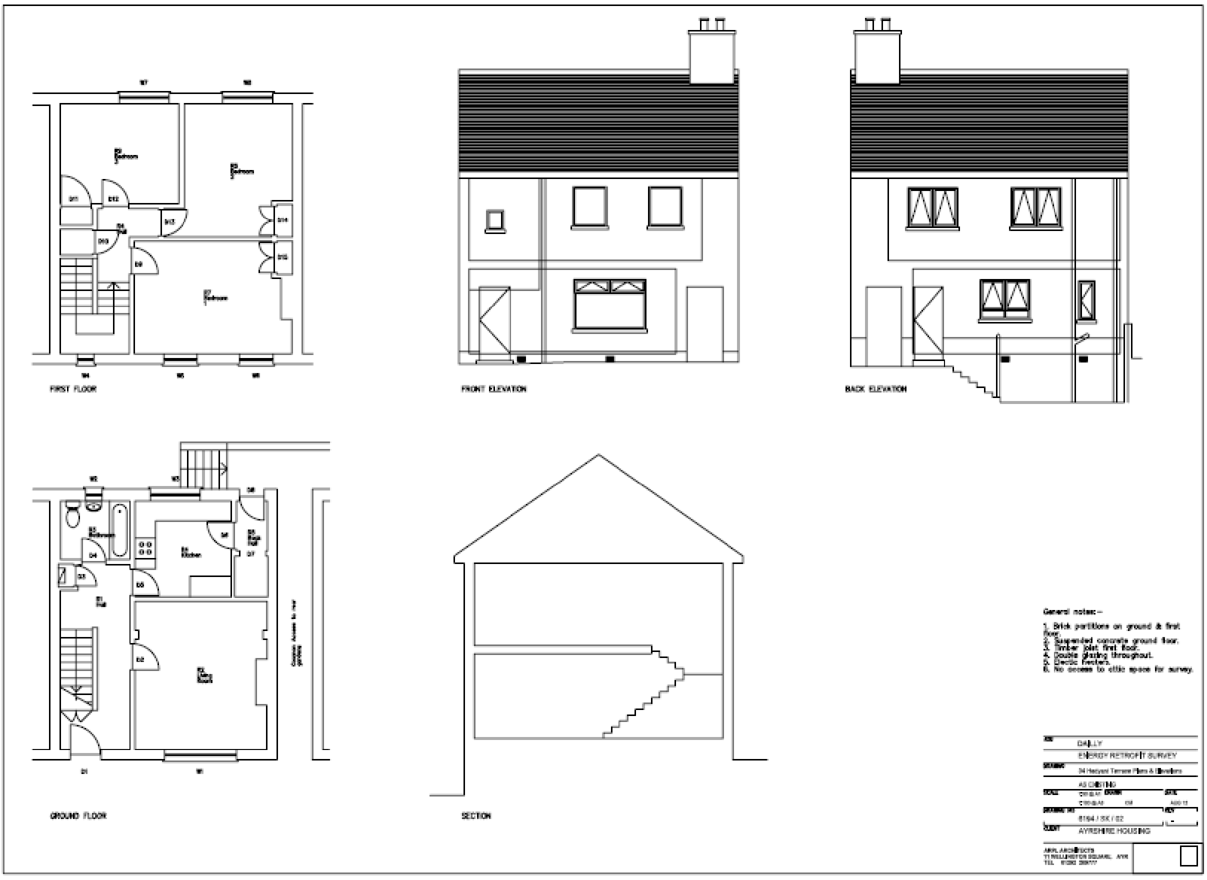
Currie, J.I. (2006) Sunspace Augmented Positive Input Ventilation of Buildings, EuroSun 2006, Glasgow, ISBN 0 904963 73 1

Currie, J., Capper, G., Holmes, J., (2006) Energy Efficiency Improvements through Sunspace Augmented Positive Input Ventilation of Buildings, Energy Performance & Indoor Climate, Vol. 3, 613-618, ISBN 2-86434-122-5

MacGregor A. W. K., Currie J. I., and Taylor A., (1996) *Breathing Sunshine into Scottish Housing*, proceedings of EuroSun'96, Freiburg.

Appendix 1
Architectural Drawings of House Styles


FIRST FLOOR
FRONT ELEVATION
BACK ELEVATION
GROUND FLOOR
SIDE ELEVATION
General Notes: -
1. Brick partitions on ground & first floor.
2. Suspended concrete ground floor.
3. Timber joist first floor.
4. Double glazing throughout.
5. Electric room heaters.
6. 150mm Glass wool roof insulation between rafters.
7. Indirect hot water tank. Manufacturer: Elson, Diamond, Day & Gibsons Ltd.
8. No open flues.
DAILLY
ENERGY RETROFIT SURVEY
AS EXISTING
6194 / SK / 01
AYRSHIRE HOUSING


FIRST FLOOR
FRONT ELEVATION
BACK ELEVATION
GROUND FLOOR
SECTION
General notes: -
1. Brick partitions on ground & first floor.
2. Suspended concrete ground floor.
3. Timber joist first floor.
4. Double glazing throughout.
5. Electic heaters.
6. No access to attic space for survey.
DAILLY
ENERGY RETROFIT SURVEY
AS EXISTING
6194 / SK / 02
AYRSHIRE HOUSING
AKRL ARCHITECTS

Appendix 2
Typical EPC Document

Energy Performance Certificate

Address of dwelling and other details

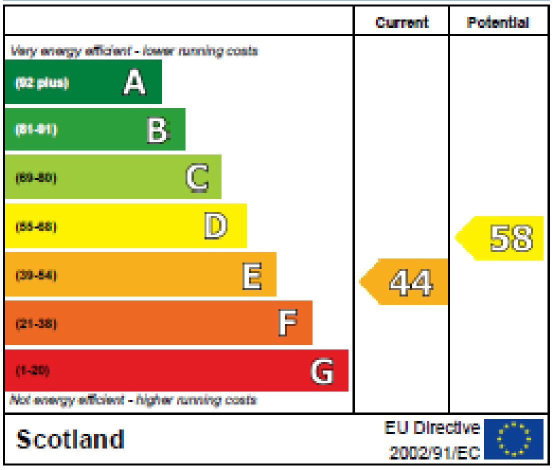
34 HADYARD TERRACE,
DAILLY,
KA26 9SS

Dwelling type:	Mid-terrace house
Name of approved organisation:	RICS Protocol for Scotland
Membership number:	RICS100110
Date of certificate:	17 September 2009
Reference number:	0130-2143-7110-0591-3271
Total floor area:	93 m²
Main type of heating and fuel:	Electric storage heaters

This dwelling's performance ratings

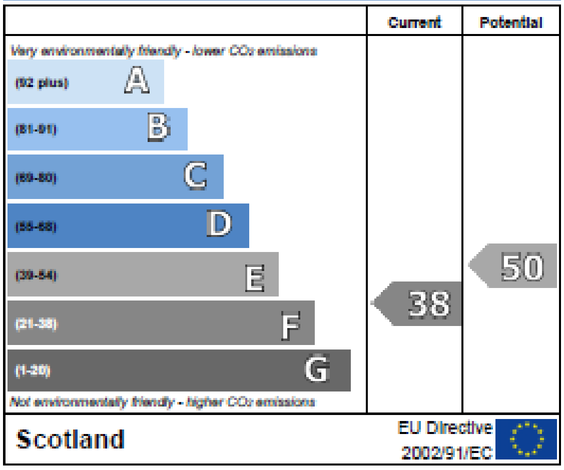
This dwelling has been assessed using the RdSAP 2005 methodology. Its performance is rated in terms of the energy use per square metre of floor area, energy efficiency based on fuel costs and environmental impact based on carbon dioxide (CO_2) emissions. CO_2 is a greenhouse gas that contributes to climate change.

Energy Efficiency Rating



The energy efficiency rating is a measure of the overall efficiency of a home. The higher the rating the more energy efficient the home is and the lower the fuel bills are likely to be.

Environmental Impact (CO_2) Rating



The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions. The higher the rating the less impact it has on the environment.

Approximate current energy use per square metre of floor area: 498 kWh/m² per year
Approximate current CO_2 emissions: 75 kg/m² per year

Cost effective improvements

Below is a list of lower cost measures that will raise the energy performance of the dwelling to the potential indicated in the tables above. Higher cost measures could also be considered and these are recommended in the attached energy report.

1 Cavity wall insulation	2 Low energy lighting for all fixed outlets

A full energy report is appended to this certificate

energy saving recommended
Certification mark

Information from this EPC may be given to Energy Saving Trust to provide advice to householders on financial help available to improve home energy efficiency.

For advice on how to take action and to find out about offers available to make your home more energy efficient, call 0800 512 012 or visit www.energysavingtrust.org.uk

N.B. THIS CERTIFICATE MUST BE AFFIXED TO THE DWELLING AND NOT BE REMOVED UNLESS IT IS REPLACED WITH AN UPDATED VERSION

Appendix 3
House Permeability Test Results

BUILDING LEAKAGE TEST

Appendix 3
Hadyard Terrace
Dailly

Date of Test: 4/10/12
Test File: 5 Hadyard Terrace Depressurisation

Technician: J.I. Currie

Customer: Ayrshire Housing

Phone:
Fax:

Building Address: 5
Hadyard Terrace
Dailly,

Test Results at 50 Pascals:

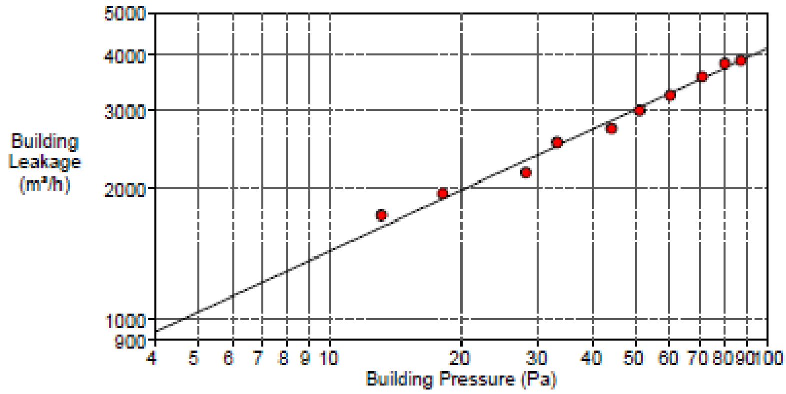
V50: Airflow (m^3/h)	3007 (+/- 1.0 %)
n50: Air Changes per Hour (1/h)	11.79
w50:	
q50: $m^3/(h*m^2)$ Surface Area	11.98

Leakage Areas: 1596.3 cm^2 (+/- 3.4 %) Canadian EqLA @ 10 Pa or 6.36 cm^2/m^2 Surface Area
1008.7 cm^2 (+/- 5.1 %) LBL ELA @ 4 Pa or 4.02 cm^2/m^2 Surface Area

Building Leakage Curve: Air Flow Coefficient (Cenv) = 489.7 (+/- 7.7 %)
Air Leakage Coefficient (CL) = 494.1 (+/- 7.7 %)
Exponent (n) = 0.462 (+/- 0.019)
Correlation Coefficient = 0.99315

Test Standard:	EN 13829	Test Mode:	Depressurization
Type of Test Method:	B	Regulation complied with:	B
Equipment:	Model 3 Minneapolis Blower Door, S/N 15292		

Inside Temperature:	17 °C	Volume:	255 m^3
Outside Temperature:	9 °C	Surface Area:	251 m^2
Barometric Pressure:	99140 Pa	Floor Area:	
Wind Class:	0 Calm	Uncertainty of Building Dimensions:	2 %
Building Wind Exposure:	Partly Exposed Building	Year of Construction:	1956
Type of Heating:	Electric Storage		
Type of Air Conditioning:	None fitted		
Type of Ventilation:	None		



BUILDING LEAKAGE TEST

Appendix 3
Hadyard Terrace
Dailly

Date of Test: 4/10/12		Technician: J.I. Currie	
Test File: 30 Hadyard Terrace Depressurisation			
Customer:	Ayrshire Housing	Building Address:	30 Hadyard Terrace Dailly,
	Phone: Fax:		

Test Results at 50 Pascals:

V50: Airflow (m^3/h)	3006 (+/- 0.6 %)
n50: Air Changes per Hour (1/h)	12.27
w50:	
q50: $m^3/(h*m^2)$ Surface Area	12.42
Leakage Areas:	1419.5 cm^2 (+/- 2.8 %) Canadian EqLA @ 10 Pa or 5.87 cm^2/m^2 Surface Area 839.2 cm^2 (+/- 4.5 %) LBL ELA @ 4 Pa or 3.47 cm^2/m^2 Surface Area
Building Leakage Curve:	Air Flow Coefficient (Cenv) = 371.0 (+/- 7.0 %) Air Leakage Coefficient (CL) = 371.6 (+/- 7.0 %) Exponent (n) = 0.534 (+/- 0.018) Correlation Coefficient = 0.99538

Test Standard:	EN 13829	Test Mode:	Depressurization
Type of Test Method:	B	Regulation complied with:	B
Equipment:	Model 3 Minneapolis Blower Door, S/N 15292		

Inside Temperature:	13 °C	Volume:	245 m^3
Outside Temperature:	13 °C	Surface Area:	242 m^2
Barometric Pressure:	99140 Pa	Floor Area:	
Wind Class:	0 Calm	Uncertainty of	
Building Wind Exposure:	Partly Exposed Building	Building Dimensions:	2 %
Type of Heating:	Electric Storage	Year of Construction:	1956
Type of Air Conditioning:	None fitted		
Type of Ventilation:	None