Technical Paper 16

HISTORIC SCOTLAND
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# Green Deal financial modelling

## of a traditional cottage and tenement flat

Nicholas Heath, Tessa Clark & Gary Pearson

CHANGEWORKS

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Historic Scotland Technical Paper 16

# Green Deal financial modelling

## of a traditional cottage and tenement flat

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## Contents



## Introduction

*by Historic Scotland*

The UK Government is planning to introduce the 'Green Deal' in October 2012. The Department for Energy and Climate Change (DECC) describes the Green Deal as "a new, innovative … financial mechanism" that "eliminates the need to pay upfront for energy efficiency measures and instead provides reassurance that the cost of the measures should be recovered by savings on the electricity bill".[1]

With the launch of the Green Deal approaching, there is a need not only to outline to building professionals and homeowners the available measures suitable for the building fabric of older properties, but also to clarify which of these measures could be considered as eligible for a Green Deal finance package and what their benefits might be. Availability of Green Deal finance will be dependent on the planned measures meeting the 'Golden Rule', which is that "the expected financial savings must be equal to or greater than the costs attached to

[1] Department of Energy and Climate Change (DECC), 2012. *Green Deal*. [Website]. Available at: DECC http://www.decc.gov.uk/en/content/cms/tackling/green_deal/green_deal.aspx [Accessed: Feb. 2012].

the energy bill"[2], or – in other words – the payments on the loan must not exceed the anticipated energy savings of the household over the lifetime of the measure. With older properties, especially those with mass wall construction (e.g. single-leaf walls made from mortar-bedded stone), it is important that the right measures are adopted and the skills of the installers are up to the job. While much of the technical detail for appropriate interventions will be covered in Historic Scotland's forthcoming *Short Guide: Energy Efficiency in Traditional Buildings*, cost considerations and how they affect Green Deal eligibility under the Golden Rule will not be covered. Property owners and managers will be interested in outline costs; the reports in this Technical Paper will start this process.

The two research reports presented here are the result of a modelling project by Changeworks, a Scottish sustainable development organisation. The reports aim to address this information gap by articulating some of the fabric upgrade options that might be eligible for Green Deal finance, and discuss some of the issues around assessment, eligibility and expected savings. The measures outlined in the reports are all considered suitable for older buildings, especially pre-1919 dwellings, and in many cases may also be suitable for listed buildings. The measures have been tested in the Historic Scotland site trials programme, although due to the experimental nature of the work, accurate costs (which will affect the eligibility for the Green Deal) were hard to scale up for standard work. It is also accepted that the modelling packages used for the reports – the Reduced Data Standard Assessment Procedure (RdSAP) and the National Home Energy Rating (NHER) – will give a certain bias against older buildings due to the way the software has been configured and certain default values for building components have been fixed in. Work to improve RdSAP is ongoing, and we should expect more accurate modelling (and improved energy saving predictions) as RdSAP is progressively updated and the Green Deal programme rolled out.

Exactly how the Green Deal package will be delivered to the consumer will evolve as the market matures, but it is likely that consumers will be able to 'top up' some measures with additional separate funding if the Golden Rule is not met. This may also allow the procurement of additional enabling or repair works to the fabric while a contractor is established on site for the Green Deal works. It is well known that in any energy upgrade basic fabric maintenance is key if installed measures are to yield the full modelled benefit. Procurement of contractors through a Green Deal Provider may allow better access to skills for repairs and may be a real benefit of Green Deal packages. Some consumers, by virtue of their circumstances or the special nature of their dwelling, will be eligible for Energy Company Obligation (ECO) funding. This will address 'hard-to-treat' building elements in such households, particularly windows and walls, ensuring that improvements for older dwellings types will be available to as wide a range of people as possible.

With the consultation on the Green Deal still ongoing, this Technical Paper can only provide a starting point to discuss which upgrade measures might be feasible for traditional buildings. Once more details of the Green Deal have been confirmed by the UK Government, the reports in this paper might require updating. Historic Scotland will review the Green Deal financial modelling presented here once the Green Deal has been launched – also with the aim to include a larger variety of dwelling types.

[2] DECC, 2010. *The Green Deal: a summary of the Government's proposal*. [PDF] Available at: DECC http://www.decc.gov.uk/assets/decc/legislation/energybill/1010-green-deal-summary-proposals.pdf

## Executive Summary

*by Changeworks*

This Historic Scotland Technical Paper presents the findings of two separate financial modelling exercises undertaken on different traditional property types: a detached rural cottage and an urban tenement flat. The aim of the modelling was to assess the financial viability of a range of improvement measures under the forthcoming Green Deal and Energy Company Obligation (ECO) finance schemes, and test this in the face of numerous variables. The two reports in this Technical Paper were written separately and may be read independently.

A range of improvement measures was modelled for both property types. While these focused on energy efficiency measures, a biomass boiler was also modelled for the detached cottage. A summary of the measures modelled is provided below:

| **Building element** | **Improvement measure** | **Property modelled in** |
|---|---|---|
| Roof | Loft insulation, standard quilt | Cottage |
| Walls | Blown bead insulation behind lath and plaster, internal | Both |
| | Aerogel blanket, internal | Both |
| | 100mm wood fibre board, internal | Tenement flat |
| Windows | Draughtproofing | Both |
| | Energy-efficient glazing (secondary glazing in form of added acrylic or polycarbonate panes fitted to existing single-glazed windows) | Both |
| | Energy-efficient glazing (secondary glazing in form of added slim-profile window systems fitted to existing single-glazed windows) | Tenement flat |
| | Energy-efficient glazing (new sashes with conventional double-glazing units) | Tenement flat |
| | Energy-efficient glazing (new slim-profile double-glazing units fitted into existing sashes) | Both |
| | Timber shutter reinstatement | Tenement flat |
| Floors | Hemp board insulation below floorboards | Cottage |
| | Aerogel board insulation on solid floor | Cottage |
| Doors | New insulated external door | Both |
| | Insulation boards added to existing door | Both |
| Heating and hot water | Hot water cylinder and pipework insulation | Both |
| | Hot water cylinder thermostat | Tenement flat |
| | 'A' rated condensing gas boiler and controls | Tenement flat |
| | Biomass pellet boiler | Cottage |

Several variables were tested against the baseline findings to see what effect they would have on the eligibility of each measure for Green Deal finance. These included different energy modelling software tools, Green Deal interest rates, inflation and fuel prices, the rebound effect, heating patterns and user behaviour, household occupancy, and installation costs.

The **key finding**s from both reports are summarised below:

- Under the current version of RdSAP (the current tool of choice for Green Deal Assessments), a relatively small number of measures would meet the Golden Rule. The majority of measures would therefore require additional funding under the ECO Carbon Saving target. (Under NHER modelling, more measures would be eligible and the annual profits would be higher.)

- Of those measures that do meet the Golden Rule under RdSAP, there is only one improvement option for windows, one for walls and one for floors. This is doubly significant as none of these is guaranteed to be eligible for Green Deal finance (see below). If these are not eligible, none of the other modelled wall, window or floor options would be open to occupants of pre-1919 traditionally built properties without significant other funding.

- Several improvement measures that could perform well and make significant savings for householders are not recognised by the current version of RdSAP, and so would not be eligible for Green Deal finance. These include draughtproofing, internal window shutters and insulated external doors.

- Some improvement measures may fall outside the qualifying list for Green Deal finance despite showing considerable savings. These include solid floor insulation (not currently on the list of qualifying improvements), blown bead internal wall insulation (which requires further exploration and testing) and secondary glazing (if it is deemed 'portable' it may not qualify).

- In tenement flats windows often form a large part of the external wall area and may be a higher priority than external walls for insulation and associated funding. Most window improvement options would not currently meet the Golden Rule and so would need ECO funding. However, under current proposals they would not be eligible without also installing wall insulation, which may not be the most appropriate intervention in such properties.

- There is a considerable discrepancy between the savings predicted by different software programmes. (In most cases, NHER predicts considerable higher savings than RdSAP.) The current inability of RdSAP to account for a number of significant factors (e.g. U-values, heating patterns, location etc.) affects both its accuracy and the eligibility of many measures.

- All the variables tested could affect the viability of measures in practice. In particular, finance interest rates, installation costs and user behaviour (the rebound effect) were shown to be of considerable importance.

The high number of variables in Green Deal Assessments makes it impossible to guarantee that predicted savings will be delivered in practice. While the revised version of RdSAP could have a significant impact in this area, this could also place more pressure on householders to manage their behaviour and energy use prudently to ensure they realise the predicted savings. However, they will only do so if they are aware of the issues raised in this Technical Paper. This points to a future need for advice on and support for behaviour change and change to heating regimes.

As a householder in a traditional building, the Green Deal must be considered from two very different perspectives:

1. **Financial eligibility** – Will the measures I want to install be eligible for Green Deal finance (i.e. will they be predicted to save more than the repayments)?

2. **Financial viability** – If so, will I actually make the savings that were predicted? (If not, the householder will be paying more than they are saving.)

The latter point will be dictated by the level of ECO funding made available to particular products and installers. As this is a market-based mechanism, it is difficult to predict. It is possible that those products most easily accessible through ECO funding will be not only those that deliver the highest savings of carbon dioxide emissions, but also those that are most widely accessible (i.e. 'standard' insulation products). However, for many stone-built properties, especially those protected by planning legislation, it is the specialist – and often higher-cost – products that will be needed.

## About the authors

**Nicholas Heath** is a Senior Consultant at Changeworks, where he has worked since 2006. He has developed and led award-winning research and demonstration projects on energy efficiency and renewable energy in traditional and historic buildings across Scotland, and presented his work with Changeworks internationally. Project partners have included Historic Scotland, the Energy Saving Trust, Consumer Focus Scotland, the Joseph Rowntree Foundation, and various local authorities, housing associations and community organisations. With a background in social housing and sustainable energy, the main focus of his current work is energy performance, retrofit and behavioural issues surrounding older, traditionally built, hard-to-treat housing.

**Tessa Clark** joined Changeworks in 2011 as a researcher. She has worked on a variety of projects at Changeworks, including researching the experiences of social landlords with renewable heat, a Feed-in Tariffs research project and developing a European-wide fuel poverty initiative. Her main role is to carry out research, such as literature reviews, surveys and qualitative interviews, and disseminate findings through writing reports. In previous roles, Tessa has delivered energy efficiency advice to households and provided monitoring and evaluation support for environmental community projects. She holds a BSc (Hons) in Geography and MSc in Ecological Economics.

**Gary Pearson** joined Changeworks in 1998. His current role at Changeworks is Surveyor and Data Analyst, with a focus on hard-to-treat housing. He has conducted energy analysis using a variety of energy rating tools (including NHER, SAP and RdSAP), delivers EPCs and has written detailed reports on energy modelling. This has been carried out on a wide range of domestic properties, from single units to entire housing stocks. Gary has also written reports for a wide range of clients ranging from community groups to the Scottish Government. He is currently leading on the development of Changeworks' Carbon HEART stock analysis tool.

Research Report 1

# Green Deal financial modelling report 1:
## Traditional detached cottage

Nicholas Heath, Tessa Clark & Gary Pearson

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## Abbreviations

| | | |
|---|---|---|
| CERT | Carbon Emissions Reduction Target | Page 7 |
| DECC | Department of Energy and Climate Change | Page 5 |
| ECO | Energy Company Obligation | Page 7 |
| EPC | Energy Performance Certificate | Page 8 |
| NHER | National Home Energy Rating | Page 5 |
| RdSAP | Reduced data SAP | Page 5 |
| SAP | Standard Assessment Procedure | Page 5 |
| U-value | Overall heat transfer coefficient | Page 5 |
| VAT | Value Added Tax | Page 11 |

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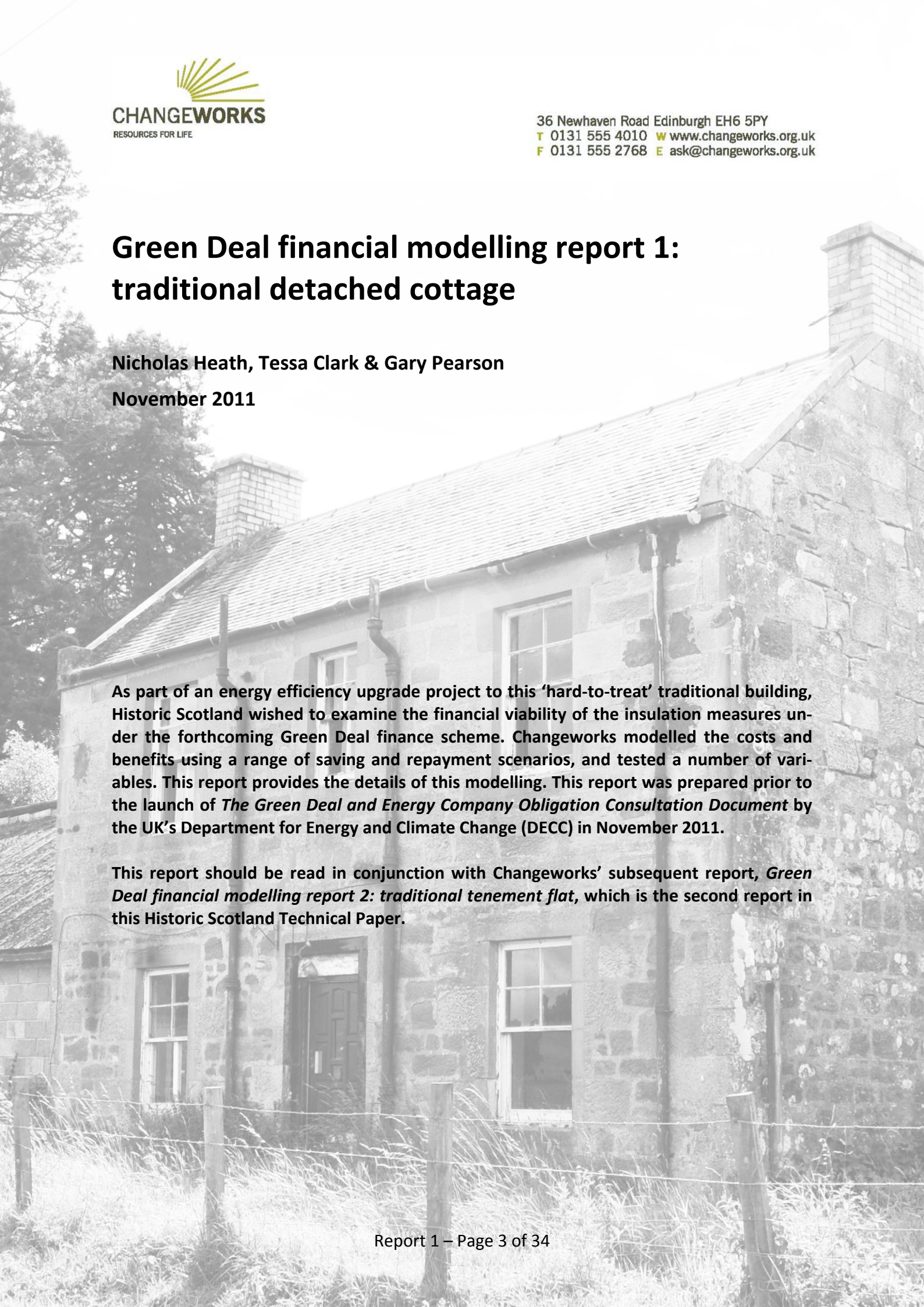
# Green Deal financial modelling report 1: traditional detached cottage

**Nicholas Heath, Tessa Clark & Gary Pearson**

**November 2011**



**As part of an energy efficiency upgrade project to this 'hard-to-treat' traditional building, Historic Scotland wished to examine the financial viability of the insulation measures under the forthcoming Green Deal finance scheme. Changeworks modelled the costs and benefits using a range of saving and repayment scenarios, and tested a number of variables. This report provides the details of this modelling. This report was prepared prior to the launch of *The Green Deal and Energy Company Obligation Consultation Document* by the UK's Department for Energy and Climate Change (DECC) in November 2011.**

**This report should be read in conjunction with Changeworks' subsequent report, *Green Deal financial modelling report 2: traditional tenement flat*, which is the second report in this Historic Scotland Technical Paper.**

## Contents

# 1. Introduction

Historic Scotland is upgrading a traditionally constructed stone cottage near Cumnock in rural East Ayrshire (southwest Scotland) to improve its thermal efficiency, incorporating a range of energy efficiency and renewable energy measures.

Historic Scotland was keen to examine the financial viability of these measures under the forthcoming Green Deal finance scheme and commissioned Changeworks to model the costs and benefits using a range of saving and repayment scenarios. Historic Scotland provided Changeworks with pre- and post-improvement thermal performance figures and capital costs.

Changeworks modelled the costs and savings for individual and grouped measures, and tested a number of variables and software packages to assess their impact. This report provides the details of this modelling. This report was prepared prior to the launch of *The Green Deal and Energy Company Obligation Consultation Document* by the UK's Department of Energy and Climate Change (DECC) in November 2011 (DECC, 2011b).

This report should be read in conjunction with Changeworks' subsequent report, *Green Deal financial modelling report 2: traditional tenement flat*, which is the second report of this Historic Scotland Technical Paper.

## 1.1 Baseline performance

The financial modelling for this report was carried out using two assessment procedures / software packages:

- Reduced data Standards Assessment Procedure (RdSAP)
- National Home Energy Rating (NHER)

RdSAP is a simplified version of the Standard Assessment procedure (SAP), the UK Government's recommended method system for measuring the energy rating of residential dwellings. NHER is a rating scale for the energy efficiency of housing (as well as a UK accreditation scheme for energy assessors). RdSAP and SAP are software package developed by BRE (formerly Building Research Establishment); NHER has been developed by National Energy Services, formerly a trading subsidiary of the National Energy Foundation.

In the NHER modelling, thermal performance data (U-values or heat transfer coefficients), provided by Historic Scotland, were input into the software. For RdSAP, the default values assumed by the program were used. The baseline performance used for the modelling is set out in Table 1 below.

**Table 1. U-values [W/m²K] used for the Green Deal financial modelling**

| Element | Description | U-value (RdSAP *) | U-value (NHER **) |
|---|---|---|---|
| Walls | Solid sandstone (600mm) | 1.5 | 1.25 |
| Floors | 63% solid, 37% timber | 1.2 | 3.5 |
| Windows | All sash single-glazed | 4.8 | 5.5 |
| Loft | No insulation present | 2.3 | 2.3 |
| Space and water heating | Coal fires (with back boiler and no radiators) and electric secondary heating. Hot water provided by back boiler. | (50% efficient) | (50% efficient) |
| Lighting | Low energy | (100%) | (100%) |
| * These are the default values assumed by RdSAP; these cannot be overwritten.<br>** These are the U-values measured by Historic Scotland *in situ* and input to NHER. | | | |

The baseline performance of the stone cottage has been modelled previously in considerable detail by Changeworks and Home Energy And Data Services. This data can be accessed in *Historic Scotland Technical Paper 8: Energy modelling of the Garden Bothy, Dumfries House* (Changeworks & Home Energy And Data Services, 2010).

# 2. Context

## 2.1 Green Deal and the Energy Company Obligation

The Green Deal is the UK Government's plan to drive increased energy efficiency in UK homes. From October 2012, finance will be available to householders to pay for improvement measures to their homes. This finance will be repayable through householders' fuel bills over a 25-year period or within the lifetime of a measure (whichever is shorter). Although earlier press releases stated a finance limit of £10,000 (DECC, 2011a), DECC's recently issued consultation document (DECC, 2011b) does not specify an upper limit.

The key element of the Green Deal is the 'Golden Rule', which states that the improvements must save more money than the householder repays. As some products are never likely to meet the Golden Rule due to high installation costs, an Energy Company Obligation (ECO) will also be brought into play with the aim of bringing down the costs of these measures so they can be offered by Green Deal providers. This will work in a similar way to existing Carbon Emissions Reduction Target (CERT) subsidies for cavity wall and loft insulation, and will fund measures for priority-group (e.g. low-income) householders and hard-to-treat homes (e.g. solid wall insulation). DECC's Green Deal consultation document (DECC, 2011b) currently proposes that the ECO will primarily fund solid wall insulation. The following quote from the DECC publication *Green Deal Finance: What is the Green Deal?* outlines how it will function:

> *"The ECO carbon target will focus on driving delivery of insulation systems for solid walled properties that cannot receive straightforward cavity wall insulation. It is likely that in many cases consumers will be incentivised to take-up these measures with combinations of ECO subsidy and Green Deal Finance. Suppliers and Green Deal Providers will need to work together to provide an offer to the consumer that comprises the optimum mix of support between Green Deal finance and ECO subsidy.*
>
> *"It will not fall to the consumer to bring Green Deal finance and ECO together."*
>
> (DECC, 2011c, p.2)

As many of the improvement measures needed for hard-to-treat homes are not likely to meet the Green Deal's Golden Rule criteria, they will have to be largely subsidised by the ECO. This research is, therefore, of particular interest, as the property in question would be termed 'hard-to-treat' under conventional definitions.

It is important to note that many details of the Green Deal (e.g. software packages, repayment interest rates, how inflation will be accounted for) are not yet confirmed. All figures in this report are, therefore, indicative; assumptions are detailed where required, and these should be taken into account when examining the figures.

## 2.2 Green Deal cost-effectiveness and variables

There are a number of variables which will affect the financial viability of Green Deal finance and the accuracy of this financial modelling. The key issues are outlined below.

### *2.2.1 Energy rating software*

Previous research (Changeworks & HEADS, 2010) has shown the variability of different energy modelling software packages to calculate the savings that will be made by energy-efficiency measures: different results will be produced depending on which package is used. This is particularly important for the Green Deal, as it is a software package that will test whether a measure meets the Golden Rule.

The UK Government is currently planning to use RdSAP software for Green Deal assessments. This is one of the more basic (i.e. least detailed) of the main software packages and is also the package used to generate Energy Performance Certificates (EPCs) for domestic buildings. It should, however, be noted that revised versions of both RdSAP and EPCs are anticipated in advance of the Green Deal's introduction with the intention of making them more robust.

For the purposes of this report, savings have been calculated using RdSAP software to mirror the current Green Deal set-up. To enable a meaningful comparison, savings have also been calculated using the more detailed NHER software. (Details of both software packages are included in the Appendix.)

In both cases, however, the running cost predictions are based on fuel costs that are only updated periodically. To provide savings figures that are as up to date as possible, Changeworks, therefore, took the energy use (kWh) figures calculated by each software and multiplied these by current (October 2011) fuel cost figures taken from the Sutherland Tables to provide the savings used in this report. (The Sutherland Tables [2011] provide regularly updated fuel costs for all main UK fuels. The fuel costs used from these tables are provided in the Appendix.)

### *2.2.2 Green Deal interest rates*

The interest rate attached to the finance will inevitably affect its attractiveness. It is anticipated that the Green Deal scheme is likely to be partly delivered through large companies, such as Marks & Spencer Plc. (M&S), Tesco Plc. and B&Q Plc., using interest rates still to be determined. Recent lending rates of these companies (interest rates at September 2011) are set out below, for comparison:

- M&S 6.4%
- Tesco 7.4%
- B&Q 10.8 to 19.8% (depending on the size of the loan)

(These interest rates are for loans with shorter timescales than the Green Deal's 25-year timescale; a longer timescale should allow a lower interest rate.)

DECC has confirmed verbally in September 2011 that the interest attached to Green Deal finance will be compound (i.e. they will work as with any commercial loan). This means that the interest rate applied to the finance will have a considerable impact on its viability.

For the purposes of this report, an interest rate of 5% has been assumed. Some variations have been modelled up to a maximum of 10%, which in some cases had a considerable impact on the viability of the measures. It is not anticipated that Green Deal finance would come with a higher interest rate than this. However, this cannot be guaranteed, as interest rates will be dictated by the market.

### *2.2.3 Inflation*

It is not possible to predict inflation rates accurately over 25 years. Different savings predictors for energy-efficiency measures apply inflation in different ways or do not apply it at all.

The Energy Saving Trust applies inflation to lifetime savings as 3.5% annual depreciation (i.e. the value of the savings that a measure makes will be worth less over time) on the premise that £100, for example, will be worth less in future years than it is today. To further complicate matters, rates of inflation are higher than bank interest rates at present which means the relative buying power of savings is being diminished over time (as per Scenario 1 in Table 2 below). However, inflation pressures can also aid the case for investing in Green Deal measures, because as fuel bills rise over time the associated savings will increase. These two scenarios are illustrated at a basic level in Table 2 below.

**Table 2. Description of modelling scenarios used**

| Scenario 1: Depreciation | Scenario 2: Increase |
|---|---|
| Insulation installed<br>\|<br>Year 1: £100 saved on annual bill<br>\|<br>Depreciation by 3.5%<br>\|<br>Year 2: £96.50 saved on annual bill | Insulation installed<br>\|<br>Year 1: £100 saved on annual bill<br>\|<br>Fuel prices rise by 15%<br>\|<br>Year 2: £115 saved on annual bill |

In August 2011 gas and electricity prices rose significantly for the second time in less than a year. While the cost of biomass pellets (the heating fuel for the cottage) remains competitive against gas prices, it is likely that all fuels will increase in cost over time. Further significant fuel price rises, above the Government's measured rate of inflation, would increase the savings made by insulation measures, making them more likely to meet the Golden Rule. This would apply in particular to measures that are currently borderline (i.e. those which only just fall short of meeting the Golden Rule).

For the Green Deal, it has not yet been decided how inflation will be accounted for in the overall savings and repayments calculations (DECC, 2011d).

For the purposes of this report, inflation has not been accounted for (i.e. it has been set at 0%). It was decided to take this approach in order to avoid confusion. However, inflation scenarios have been suggested in some instances to illustrate the issue.

### *2.2.4 Rebound effect*

There is increasing research (Cambridge Centre for Climate Change Mitigation Research et al., 2006; Energy Monitoring Company, 2008; Energy Saving Trust, 2004; Herring & Roy, 2007; Herring & Sorrell, 2008; Martin & Watson, 2006; Sanders & Phillipson, 2006; UK Energy Research Centre & Sorrell, 2007) suggesting that the actual savings made by insulation measures can often be considerably less than the predicted savings; this is known as the Rebound Effect (sometimes also called the Reduction Factor). In some instances, only c.50% of the predicted savings are realised by householders. In households where this occurs the end result could have a significant impact on the true viability of Green Deal finance, as the savings could then be less than the repayments. This would result in a net financial loss to the householder – and to future householders, as the repayments are attached to the property and not the individual (i.e. when a property is sold, the new occupants must continue the repayments).

It is important to note that the rebound effect will not be factored into any Green Deal calculations.

### *2.2.5 Heating patterns and user behaviour*

Most energy rating software models assume set heating patterns when predicting annual costs and emissions. RdSAP and NHER both assume that for the duration of the heating season the occupants will have the heating on for 9 hours per day during the week and 16 hours per day at weekends at temperatures of 21$^{o}$C in the living room and 18$^{o}$C in the rest of the home. (The longer heating season in northern Britain is not accounted for.)

Some people heat their homes for less time than this and / or to lower temperatures. In households where this occurs, the predicted savings would, therefore, be exaggerated. It is not yet known what the heating patterns will be in the cottage, as it is not yet occupied.

### *2.2.6 Number of occupants*

Most energy software models make an assumption on the number of occupants depending on the floor area of a property; in turn, the assumed number of occupants determines the predicted hot water consumption. In homes with more / fewer occupants than predicted, the energy use will vary, which then affects the accuracy of the predicted savings. For the cottage, the energy modelling assumes an occupancy of 2.1 people.

### *2.2.7 Installation costs*

This report uses costs provided by Historic Scotland. These costs include VAT and in most instances associated costs (e.g. for redecoration). However, the costs are based on pilot project costs, which are likely to differ from private household projects. If a householder is unable to secure an equally competitive price for their own improvement measures, this will reduce the cost-benefit margin.

## 3. Insulation measures

Table 3 below lists the energy-efficiency measures and costs provided by Historic Scotland unless otherwise stated.

**Table 3.** List of improvement measures

| No. | Measure | Details | U-value ($W/m^2K$) | Cost per unit excl. VAT | Total cost incl. VAT |
|---|---|---|---|---|---|
| 1 | Floor insulation (partial) | (Timber floor) Hemp boards fitted below floorboards | 0.4 | £1,000 | £1,200 |
| 2 | Floor insulation (partial) | (Solid floor) aerogel boards on top of concrete floor | 0.25 | £50 / $m^2$ | £1,193 |
| 3 | Wall insulation (whole house) | Bead insulation blown behind lath and plaster (plus joinery and redecoration) | 0.7 | £14 / $m^2$; 10% for making good | £2,981 |
| 4 | Wall insulation (whole house) | Aerogel blanket affixed behind steel mesh; plaster skim coat to finish (plus joinery and redecoration) | 0.7 | £40 / $m^2$ for insulation; £20 / $m^2$ for plasterwork; 10% for making good | £10,556 |
| 5 | Double glazing (whole house) | New slim-profile double-glazed units fitted into existing sashes | 1.8 | £400 / window | £3,840 |
| 6 | Secondary glazing (whole house) | Added acrylic or polycarbonate panes fitted to existing single-glazed windows | 2.5 | £60 / $m^2$ | £727 |
| 7 | Draughtproofing windows (whole house) | Windows dismantled and draughtproofing fitted | n/a | £300 / window | £2,880 |
| 8 | Front door upgrade | Insulated added to existing panelled front door | 0.4 | £50 / $m^2$ | £113 |
| 9 | Front door replacement | New insulated front door (existing frame retained) | 0.2 | £900 | £1,080 |
| 10 | Hot water cylinder and pipework insulation | Insulation added to hot water cylinder and pipework | n/a | £80 | £96 |
| 11 | Biomass boiler | Installation of a biomass pellet boiler to provide space and water heating | n/a | £15,000 | £18,000 |
| 12 | Loft insulation | 250mm of loft insulation added in loft space | 0.16 | £200 | £240 |

Many households may choose to undertake several improvement measures. (This 'package' approach is the intention of the Green Deal.) On this assumption, Changeworks also grouped the individual measures above listed in Table 3 into four different insulation 'packages', in order to calculate savings that could be made from carrying out multiple measures. The packages were grouped as detailed in Table 4 below.

**Table 4. Grouping of improvement measures by cost categories**

| **Package** | **Measures included** | **Cost** incl. VAT |
|---|---|---|
| Low cost | • 1+2: Whole-floor insulation (solid and timber)<br>• 3: Wall insulation (blown beads)<br>• 6: Secondary glazing<br>• 8: Front door upgrade<br>• 10: Hot water cylinder and pipework insulation<br>• 12: Loft insulation | £6,551 |
| Medium cost | • 1+2: Whole-floor insulation (solid and timber)<br>• 3: Wall insulation (blown beads)<br>• 5: Double glazing<br>• 8: Front door upgrade<br>• 10: Hot water cylinder and pipework insulation<br>• 12: Loft insulation | £9,663 |
| High cost | • 1+2: Whole-floor insulation (solid and timber)<br>• 4: Wall insulation (aerogel blanket)<br>• 5: Double glazing<br>• 9: Front door replacement<br>• 10: Hot water cylinder and pipework insulation<br>• 12: Loft insulation | £18,205 |
| Very high cost | • 1+2: Whole-floor insulation (solid and timber)<br>• 4: Wall insulation (aerogel blanket)<br>• 5: Double glazing<br>• 9: Front door replacement<br>• 10: Hot water cylinder and pipework insulation<br>• 11: Biomass boiler<br>• 12: Loft insulation | £36,205 |

It is important to be aware that cumulative savings for multiple measures are not simply a sum of the savings for each individual measure; they will be lower, since the baseline performance of the property improves with each measure added.

It should also be noted that the high and very high cost packages detailed Table 4 above may be beyond the limit of Green Deal finance, although this is likely to depend on individual providers and property-specific calculations.

### 3.1 Eligibility of measures

A definitive list of measures eligible for Green Deal finance is not yet available. However, there are some general points to bear in mind, particularly in relation to some of the improvement measures detailed above.

1. Because the Green Deal finance will be linked to the property rather than the occupants, measures that are deemed to be 'portable' may not be eligible for finance. This could lead to debate over the definition of 'portable' and whether it includes, for example, certain forms of secondary glazing.

2. The internal wall insulation options detailed in this report are relatively new to the market, and while they have been trialled by Historic Scotland they may not yet be widely available. Certain technical details (e.g. how to ensure complete coverage of the blown bead insulation, how to avoid thermal bridging, etc.) may require clarification, before the insulation industry is prepared to guarantee such insulation measures. This is significant, as without guarantee a measure is unlikely to be eligible for Green Deal finance.

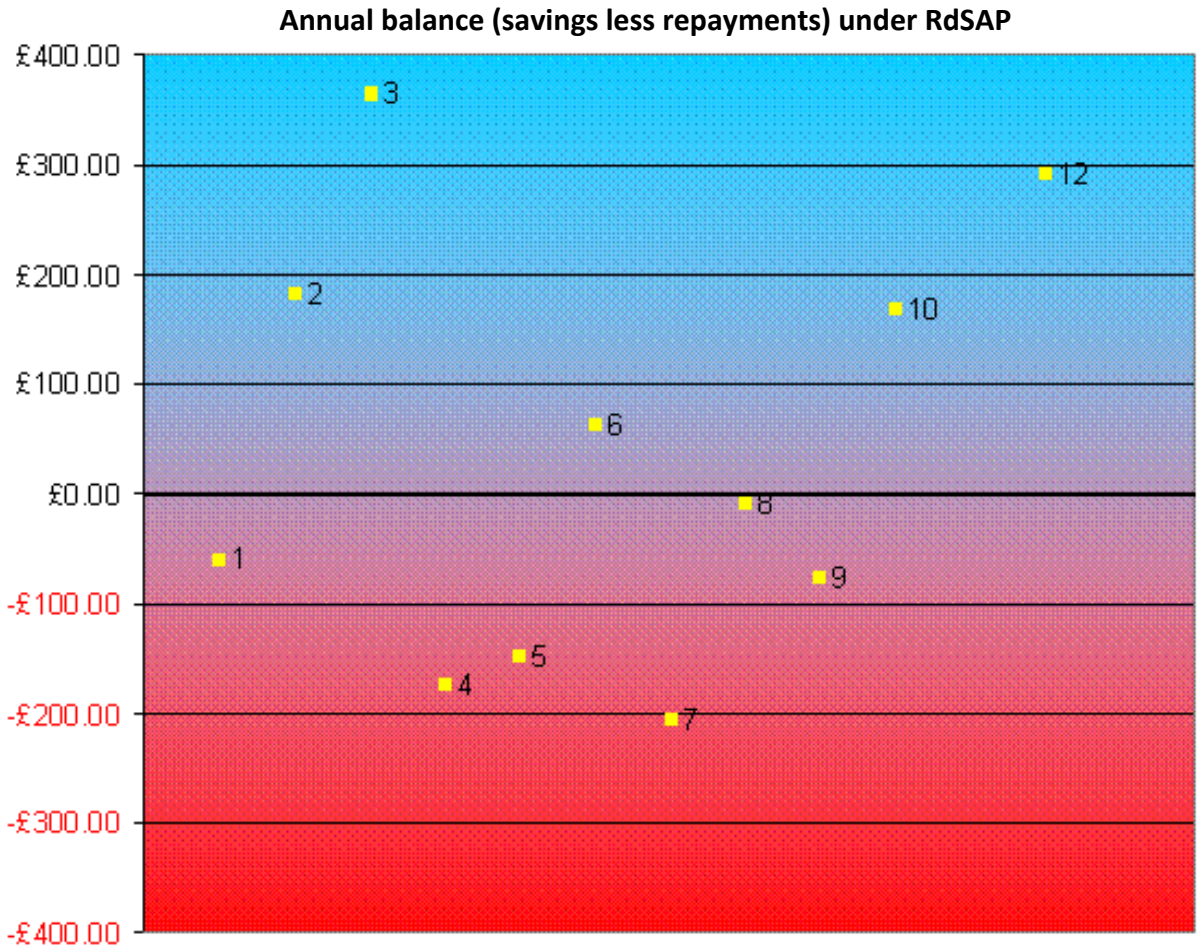
3. *Added following the release of DECC's 'Green Deal and Energy Company Obligation: Consultation Document' (DECC, 2011b):* The solid floor insulation detailed in this report is shown to make considerable savings in traditional buildings and to meet the Golden Rule making a significant net profit. However, it is not currently on the list of measures eligible for Green Deal finance (see Annex A in DECC [2011b, p.227]). This could considerably limit the insulation options for many householders in traditionally built pre-1919 properties.

4. Microgeneration options may be eligible for Green Deal finance. However, these would need to meet the Golden Rule without factoring in additional subsidies (e.g. Feed-in Tariffs, Renewable Heat Incentive) they may receive (DECC, 2011a). This affects the viability of the biomass boiler for Green Deal finance without considerable subsidy.

# 4. Results using RdSAP

## 4.1 Payback on individual measures

Under RdSAP savings assumptions and a 25-year repayment period with an interest rate of 5%, five of the twelve individual measures would meet the Green Deal's Golden Rule. The graph in Figure 1 provides an illustration of this.




| KEY | | | |
|---|---|---|---|
| 1 | Partial floor insulation (hemp board under timber floor) | 7 | Window draughtproofing – whole house |
| 2 | Partial floor insulation (aerogel board on solid floor) | 8 | Front door upgrade |
| 3 | Wall insulation (blown beads) – whole house | 9 | Front door replacement |
| 4 | Wall insulation (aerogel blanket) – whole house | 10 | Hot water cylinder and pipework insulation |
| 5 | Double glazing – whole house | 11 | Biomass boiler * |
| 6 | Secondary glazing – whole house | 12 | Loft insulation |

** The balance of the biomass boiler is not shown on this graph, as the balance is off the bottom of the graph.*

**Figure 1. Annual balance under RdSAP**

As shown in Figure 1 above, the five qualifying measures are:

- No. 2 - Partial solid floor insulation (aerogel board on concrete)
- No. 3 - Internal wall insulation throughout (blown beads)
- No. 6 - Secondary glazing throughout
- No. 10 - Hot water cylinder and pipework insulation
- No. 12 - Loft insulation

Detailed results are shown in Table 5 below, ranked according to net profit / loss.

**Table 5. Payback on individual measures (RdSAP predictions)**

| No. | Improvement | Cost incl. VAT | Annual saving | Annual repay-ment @ 5% | Annual balance (profit / loss) |
|---|---|---|---|---|---|
| 3 | Wall insulation through-out (bead insulation) | £2,981 | £577 | -£211 | **£365** |
| 12 | Loft insulation | £240 | £310 | -£17 | **£293** |
| 2 | Partial solid floor insulation (aerogel board on concrete) | £1,193 | £268 | -£85 | **£183** |
| 10 | Hot water cylinder and pipework insulation | £96 | £175 | -£7 | **£168** |
| 6 | Secondary glazing throughout | £727 | £114 | -£52 | **£62** |
| 8 | Front door upgrade | £113 | **£0** | -£8 | **-£8** |
| 1 | Partial timber floor insulation (hemp board under floorboards) | £1,200 | £26 | -£85 | **-£59** |
| 9 | Front door replacement | £1,080 | **£0** | -£77 | **-£77** |
| 5 | Double glazing throughout | £3,840 | £125 | -£272 | **-£148** |
| 4 | Wall insulation throughout (aerogel blanket) | £10,556 | £577 | -£749 | **-£172** |
| 7 | Window draughtproofing throughout | £2,880 | **£0** | -£204 | **-£204** |
| 11 | Biomass boiler | £18,000 | **-£261** | -£1,277 | **-£1,539** |

The blown bead internal wall insulation, loft insulation, partial solid floor insulation, and hot water cylinder and pipework insulation are all predicted to make considerably greater savings than the repayments (in particular the wall and loft insulation). The secondary glazing also shows a net profit, although this is less than the above measures.

RdSAP is unable to model either draughtproofing or door upgrades; nor is it able to model pipework insulation alone. So, while it is generally acknowledged that these will improve energy efficiency and, therefore, reduce heating costs, the savings cannot be represented using RdSAP. None of these measures would, therefore, meet the Golden Rule. (This also means that the savings attributed to 'hot water cylinder and pipework insulation' are actually for the 'hot water cylinder insulation' only.)

The partial timber floor insulation, double glazing and aerogel blanket internal wall insulation showed savings, but these were less than the repayments, and so these measures would also not meet the Golden Rule. It should be noted that the reason the aerogel blanket internal wall insulation fails to meet the Golden Rule is its high capital costs: although the savings are shown to be significant (£577/year), these are still outweighed by the installation costs.

The biomass boiler not only makes a considerable net loss, but actually results in increased fuel costs. This is because biomass fuel costs more than the fuel it would replace (coal). (It should also be noted that the Sutherland Tables include transportation costs in their biomass fuel cost.)

### 4.2 Payback on multiple measures

The Payback results for the improvement packages (as defined in Table 4) are shown in Table 6 below.

**Table 6. Payment on measurement packages (RdSAP predictions)**

| Improvement package | Cost | Annual saving | Annual repayment | Annual balance (profit / loss) |
|---|---|---|---|---|
| Low cost package | £6,551 | £664 | -£465 | **£200** |
| Medium cost package | £9,663 | £677 | -£686 | **-£9** |
| High cost package | £18,205 | £677 | -£1,292 | **-£615** |
| Very high cost package | £36,205 | £471 | -£2,569 | **-£2,097** |

These figures show that the 'low cost' package would generate considerable savings. However, the more expensive packages would not pay for themselves (with the higher-end packages making significant losses due to the high capital costs involved) indicating that these higher-cost measures bring proportionally smaller savings.

It should be noted that the 'very high cost' package saves less than the 'high cost' package. This is due to the additional fuel costs RdSAP predicts for biomass in comparison with the fuel it replaces (coal).

It is also interesting to note that there is no difference in the annual savings predicted by RdSAP for the 'medium cost' and 'high cost' packages, as RdSAP does not take account of different insulation materials. Put simply, wall insulation, for example, is wall insulation regardless of material. This is particularly significant given that the capital costs of the 'high cost' package are nearly double those of the 'medium cost' package.

## 4.3 Variables

As mentioned previously, there are many variables in any savings prediction method. Below some of the main variables are outlined.

### *4.3.1 Repayment interest rate*

The secondary glazing is an example of a measure that is close to borderline in terms of meeting the Golden Rule. Increasing the loan interest rate to 10%, savings are considerably reduced (by approx. 50%). However, this would still result in a net profit of £34/year.

Increasing the repayment interest rate to 10% also has a considerable effect on the net balance of some other measures:

- Blown bead internal wall insulation: drops from £365/year to £248/year Table 4 a 32% reduction in savings;
- 'Low cost' package: balance changes from a £200/year saving to a £57/year loss. This package only remains financially viable up to an interest rate of 8.9% – beyond this the package would result in a net loss.

### *4.3.2 Inflation*

Considering the effect of inflation and fuel cost rises is of most interest to borderline measures, such as the partial timber floor insulation. However, in this instance applying a fuel cost increase of 15% still does not make the partial timber floor insulation meet the Golden Rule.

It is worth noting that fuel price rises would increase the savings made by some measures considerably. For the blown bead internal wall insulation, for example, applying a fuel price rise of 15% increases the net balance from £353/year to £452/year.

### *4.3.3 Rebound effect*

Applying a rebound effect of 50% has the following effect on the annual balance (savings less repayments) of the five qualifying measures:

- Blown bead wall insulation: balance drops from £365/year to £77/year;
- Loft insulation: balance drops from £293/year to £138/year;
- Partial solid floor insulation: balance drops from £183/year to £49/year;
- Hot water cylinder and pipework insulation: balance drops from £168/year to £81/year;
- Secondary glazing: balance drops from £62/year to just £5/year.

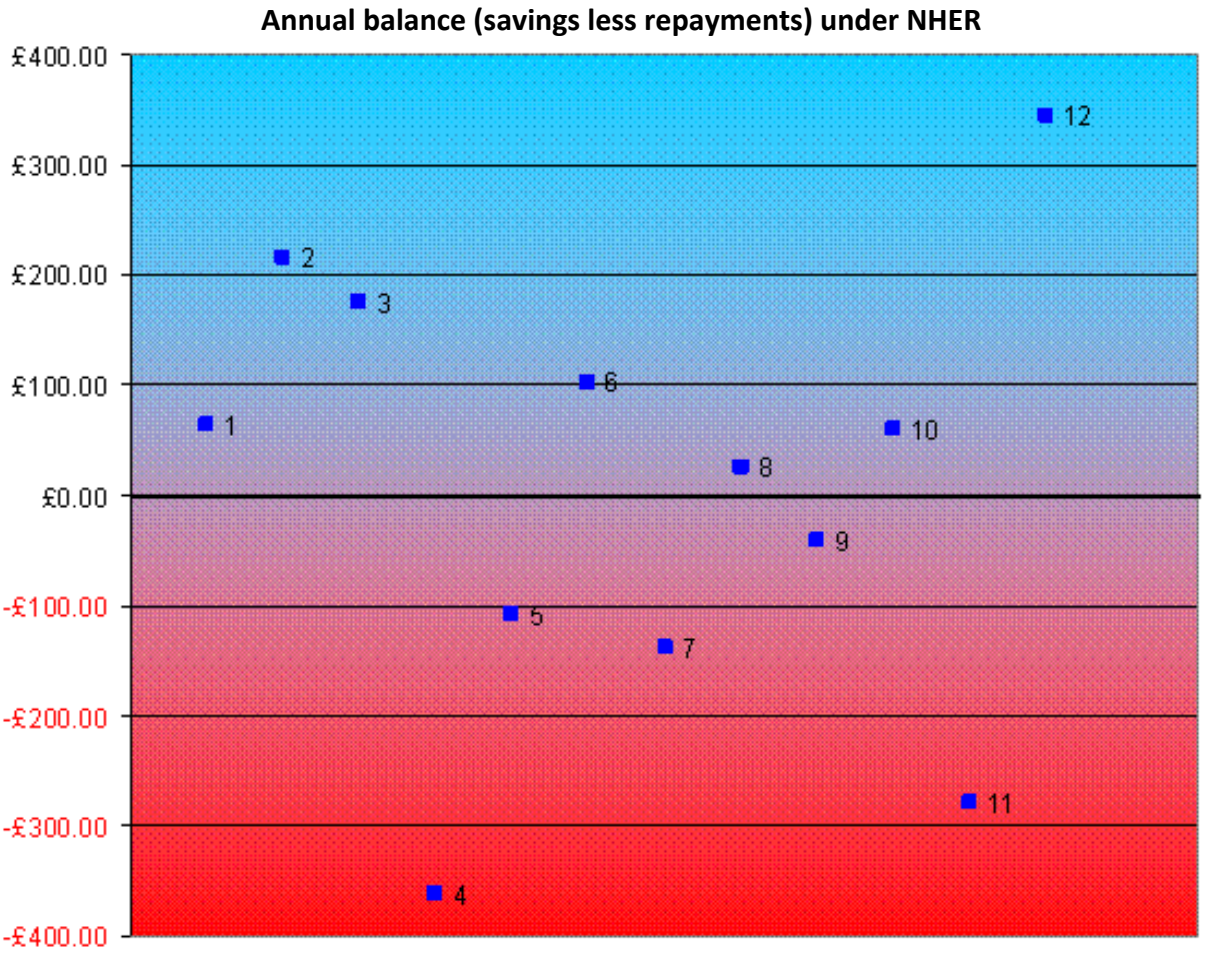
These figures show that applying the rebound effect has a significant effect on the savings that would be realised for all measures. In particular, the secondary glazing would only just break even in terms of realising a net profit / loss.

Applying a 50% rebound effect to the 'low cost' package would make it fail to meet the Golden Rule: the net balance would change from a £200/year profit to a £133/year loss.

# 5. Results using NHER

## 5.1 Payback on individual measures

Under NHER savings assumptions and a 25-year repayment period with an interest rate of 5%, seven of the twelve individual measures would meet the Green Deal's Golden Rule. Figure 2 below provides an illustration of this.




| KEY | | | |
|---|---|---|---|
| 1 | Partial floor insulation (hemp board under timber floor) | 7 | Window draughtproofing – whole house |
| 2 | Partial floor insulation (aerogel board on solid floor) | 8 | Front door upgrade |
| 3 | Wall insulation (blown beads) – whole house | 9 | Front door replacement |
| 4 | Wall insulation (aerogel blanket) – whole house | 10 | Hot water cylinder and pipework insulation |
| 5 | Double glazing – whole house | 11 | Biomass boiler |
| 6 | Secondary glazing – whole house | 12 | Loft insulation |

**Figure 2.** Annual balance under NHER

As shown in Figure 2, the seven qualifying measures are:

- No. 1 - Partial timber floor insulation (hemp board)
- No. 2 - Partial solid floor insulation (Spacetherm board)
- No. 3 - Internal wall insulation throughout (blown beads)
- No. 6 - Secondary glazing throughout
- No. 8 - Front door upgrade
- No. 10 - Hot water cylinder and pipework insulation
- No. 12 - Loft insulation

Detailed results are shown in Table 7 below, ranked according to net profit / loss.

**Table 7. Payback on individual measures (NHER predictions)**

| No. | Improvement | Cost | Annual saving | Annual repay-ment @ 5% | Annual balance (profit / loss) |
|---|---|---|---|---|---|
| 12 | Loft insulation | £240 | £362 | -£17 | **£345** |
| 2 | Partial solid floor insulation (aerogel board on concrete) | £,1193 | £301 | -£85 | **£216** |
| 3 | Wall insulation throughout (bead insulation) | £2,981 | £388 | -£211 | **£177** |
| 6 | Secondary glazing throughout | £727 | £155 | -£52 | **£104** |
| 1 | Partial timber floor insulation (hemp board under floorboards) | £1,200 | £150 | -£85 | **£65** |
| 10 | Hot water cylinder and pipework insulation | £96 | £68 | -£7 | **£61** |
| 8 | Front door upgrade | £113 | £34 | -£8 | **£26** |
| 9 | Front door replacement | £1,080 | £36 | -£77 | **-£41** |
| 5 | Double glazing throughout | £3,840 | £165 | -£272 | **-£107** |
| 7 | Window draughtproofing throughout | £2,880 | £66 | -£204 | **-£138** |
| 11 | Biomass boiler | £18,000 | £999 | -£1,277 | **-£278** |
| 4 | Wall insulation through-out (aerogel blanket) | £10,556 | £388 | -£749 | **-£361** |

Compared with RdSAP (see section 4.1), the NHER modelling enables a greater number of measures to meet the Green Deal's Golden Rule. The qualifying measures, however, vary, and not all those measures which qualify using NHER would qualify using RdSAP. (Specifically the partial timber floor insulation and front door upgrade options qualify using NHER but not RdSAP.)

The loft insulation is shown to have the greatest savings margin, due to its low capital cost and high predicted savings. The five measures which would not meet the Green Deal's Golden Rule using NHER modelling are the front door replacement, double glazing, window draughtproofing, the biomass boiler and the aerogel blanket internal wall insulation.

It is worth noting that, unlike RdSAP, NHER is able to account for both draughtproofing and door upgrades; savings for both measures were, however, shown to be modest.

The biomass boiler is shown to make very considerable savings (unlike with RdSAP – see section 4.1 and section 6.1). However, due to its high capital costs the savings are still outweighed by the finance repayments.

Further comparisons are detailed in section 6 of this report.

### 5.2 Payback on multiple measures

The packaged measures (see section 4.2) modelled using RdSAP were also modelled using NHER. Results are shown in Table 8 below.

**Table 8.** Payback on measure packages (NHER predictions)

| Improvement package | Cost | Annual saving | Annual repayment | Annual balance (profit / loss) |
|---|---|---|---|---|
| Low cost package | £6,551 | £1,562 | £465 | **£1,097** |
| Medium cost package | £9,663 | £1,578 | £686 | **£893** |
| High cost package | £18,205 | £1,784 | £2,006 | **-£222** |
| Very high cost package | £36,205 | £1,859 | £2,569 | **-£709** |

These figures show that the 'low cost' and 'medium cost' packages would both realise significant financial benefits using NHER predictions. (Using RdSAP, only the 'low cost' package resulted in a positive net balance.) It is interesting to note that the savings are very similar in both cases, indicating that the 'lost cost' package would achieve greater value for money.

The 'high cost' and 'very high cost' packages still fail to make a positive net balance, due to the considerable capital costs of some measures in those packages.

In all cases, NHER allocates significantly greater savings to these packaged measures than RdSAP.

## 5.3 Variables

### *5.3.1 Repayment interest rate*

As with the RdSAP scenarios, increasing the repayment interest rate can affect the viability of some of these measures, reducing the net savings or resulting in a net loss. Increasing the repayment interest rate to 10% has a considerable effect on the net balance of the following measures:

- Partial timber floor insulation: drops from £65/year to £18/year – a 72% reduction in savings;
- Pumped bead internal wall insulation: drops from £177/year to £60/year – a 66% reduction in savings;
- Medium-cost package: drops from £893/year to £514/year – a 42% reduction in savings.

### *5.3.2 Inflation*

In this case, the measure which fails to meet the Golden Rule by the narrowest margin is the front door replacement. However, even with a 15% increase in fuel costs this measure would still fail to meet the Golden Rule.

The scenario is more positive for the 'high cost' package on the other hand: applying a 15% increase in fuel costs would change the net balance from a £200/year loss to a £45/year profit, thus meeting the Golden Rule.

Fuel price rises could also increase the savings made by some already-qualifying measures considerably. For the low-cost package, for example, applying a fuel price rise of 15% increases the net balance from £1,097/year to £1,331/year.

### *5.3.3 Rebound effect*

Applying a rebound effect of 50% has the following effect on the annual balance (savings less repayments) of the seven qualifying measures:

- partial solid floor insulation: drops from £216/year to £66/year;
- partial timber floor insulation: changes from a £65/year profit to a £10/yr loss;
- blown bead internal wall insulation: changes from a £177/year profit to a £17/year loss;
- secondary glazing: drops from £104/year to £26/year;
- front door upgrade: drops from a £26/year to £9/year;
- hot water cylinder and pipework insulation: drops from a £61/year to £27/year;
- loft insulation: balance changes from a £345/year to £164/year.

These figures show that two of the qualifying measures, timber floor insulation and blown bead internal wall insulation, would no longer meet the Golden Rule if a 50% rebound effect occurred.

The packaged measures could also be considerably affected if a 50% rebound effect occurred: the net balance of the 'low cost' package would drop from £1,097/year to £316/year, and the net balance of the 'medium cost' package would drop from £893/year to £103/year.

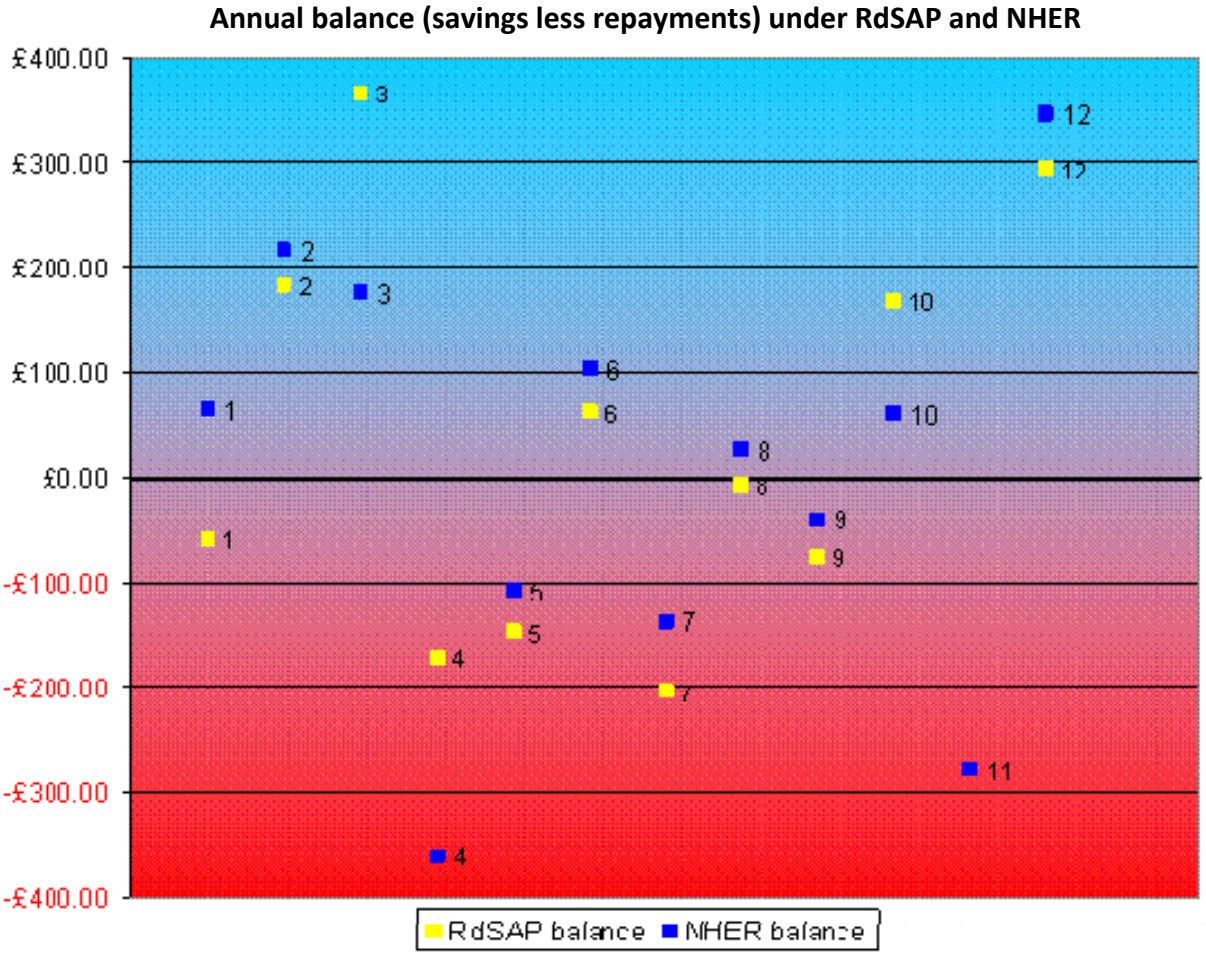
#### *5.3.4 Other variables*

The other variables detailed in section 4.3 (heating patterns and user behaviour, and number of occupants) would have the same impact on NHER predictions as on RdSAP predictions.

# 6. Comparison and conclusions

## 6.1 Software

Section 4 and section 5 show clear differences between RdSAP and NHER in terms of how much money is saved by measures and whether they would qualify for Green Deal's Golden Rule. Figure 3 below provides an illustration of this.




| KEY | | | |
|---|---|---|---|
| 1 | Partial floor insulation (hemp board under timber floor) | 7 | Window draughtproofing – whole house |
| 2 | Partial floor insulation (aerogel board on solid floor) | 8 | Front door upgrade |
| 3 | Wall insulation (blown beads) – whole house | 9 | Front door replacement |
| 4 | Wall insulation (aerogel blanket) – whole house | 10 | Hot water cylinder and pipework insulation |
| 5 | Double glazing – whole house | 11 | Biomass boiler * |
| 6 | Secondary glazing – whole house | 12 | Loft insulation |

** The biomass boiler under RdSAP is not shown on this graph, as the balance is off the bottom of the graph.*

**Figure 3. Annual balance under RdSAP and NHER**

Table 9 and Table 10 below show the savings predicted by RdSAP and NHER for both individual and packaged measures, with details of the assumptions made by each software. For each measure, the higher prediction is shown in bold. (N.B. These are savings only, not the net balance which is depicted in Figure 3 above.)

**Table 9. Annual savings by measures as predicted by RdSAP and NHER**

| Measure | Cost | RdSAP savings | NHER savings | RdSAP U-value assumptions | NHER U-value assumptions |
|---|---|---|---|---|---|
| 1. Partial timber floor insulation (hemp boards below floorboards) | £1,200 | £26 | **£150** | Drops from 1.2 (age band floor default) to 0.5 (retrofit default) across 37% of exposed floor area | Drops from 3.6 (Historic Scotland / Changeworks) to 0.4 across 37% of exposed floor area |
| 2. Partial solid floor insulation (aerogel board on concrete) | £1,193 | £268 | **£301** | Drops from 1.2 (age band floor default) to 0.5 (retrofit default) across 63% of exposed floor area | Drops from 3.6 (Historic Scotland / Changeworks) to 0.25 across 63% of exposed floor area |
| 3. Wall insulation throughout (blown beads) | £2,981 | **£577** | £388 | Drops from 1.5 (sandstone default) to 0.7 (internal insulation default) | Drops from 1.25 (sandstone default) to 0.7 |
| 4. Wall insulation throughout (aerogel blanket) | £10,556 | **£577** | £388 | | |
| 5. Double glazing throughout | £3,840 | £125 | **£165** | Drops from 4.8 (single glazing default) to 2 (post-2003 double glazing default) | Drops from 5.5 (Historic Scotland / Changeworks) to 1.8 |
| 6. Secondary glazing throughout | £727 | £114 | **£155** | Drops from 4.8 (single glazing default) to 2.4 (secondary glazing default) | Drops from 5.5 (Historic Scotland / Changeworks) to 2.5 |

| | | | | | |
|---|---|---|---|---|---|
| 7. Window draughtproofing throughout | £2,880 | £0 | **£66** | *Draughtproofing cannot be modelled in RdSAP* | All windows treated |
| 8. Front door upgrade | £113 | £0 | **£34** | *Door upgrades cannot be modelled in RdSAP* | Drops from 2.75 (Historic Scotland testing) to 0.4 |
| 9. Front door replacement | £1,080 | £0 | **£36** | *Door upgrades cannot be modelled in RdSAP* | Drops from 2.75 (Historic Scotland testing) to 0.2 |
| 10. Hot water cylinders and pipe insulation | £96 | **£175** | £68 | 25mm jacket upgraded to 160mm jacket. Pipe insulation cannot be modelled | 25mm jacket upgraded to a 160mm jacket. Pipe insulation can be modelled |
| 11. Biomass boiler | £18,000 | -£261 | **£999** | 65% efficient (default) | 85% efficient |
| 12. Loft insulation | £240 | £310 | **£362** | Drops from 2.3 to 0.16 | Drops from 2.3 to 0.16 |

**Table 10. Annual savings by cost packages as predicted by RdSAP and NHER**

| Measure | Cost | RdSAP savings | NHER savings | RdSAP U-value assumptions | NHER U-value assumptions |
|---|---|---|---|---|---|
| Low cost package | £6,551 | £664 | **£1,562** | As above | As above |
| Medium cost package | £9,663 | £677 | **£1,578** | | |
| High cost package | £18,205 | £677 | **£1,784** | | |
| Very high cost package | £36,205 | £471 | **£1,859** | | |

Some of the key findings are as follows:

- **Overall** – NHER predicts greater savings than RdSAP for 75% of the twelve individual measures modelled; the exceptions to this are the wall insulation options and the hot water cylinder and pipework insulation. One reason for this is that NHER assumes higher baseline running costs than RdSAP, so any predicted savings are likely to be higher.

- **Floors** – NHER predicts massively greater savings for floor insulation than RdSAP. For the solid floor insulation, in particular, NHER predicts savings nearly six times greater than those predicted by RdSAP. This is likely to be a result of the great difference in expectant U-values before and after adding insulation. (NHER drop of 3.6 to 0.25 for solid floor / 3.6 to 0.4 for timber floor, as opposed to 1.2 to 0.5 for RdSAP.)

- **Walls** – RdSAP predicts significantly higher (approx. 65%) savings for internal wall insulation than NHER. The selection of different insulation materials has no effect on the predicted savings, as both programs assume the same post-improvement U-values for both materials and both materials would achieve the same predicted thermal efficiency.

- **Windows** – RdSAP predicts higher (approx. 25%) savings for additional glazing (double and secondary) than NHER. RdSAP does not, however, recognise draughtproofing at all.

- **Doors** – NHER assumes relatively modest savings for both upgrade and replacement, while RdSAP does not recognise the improvements at all.

- **Biomass boiler** – RdSAP predicts higher running costs with a biomass boiler than without (i.e. with coal). However, NHER predicts running cost savings of nearly £1,000 – a considerable difference. One of the main reasons for this is that RdSAP assumes a relatively low seasonal boiler efficiency (65%), whereas NHER can be overwritten to individual boiler specifications (in this instance 85% average seasonal efficiency). This is shown to have a considerable effect on the predicted savings (as both programmes use the same fuel costs and recognise that biomass costs more than coal). In addition, NHER starts from a higher running cost baseline so predicted savings are likely to be greater (see first bullet point above).

- **Packaged measures** – For the reasons already mentioned above, NHER predicts significantly higher savings for the packaged measures. Both programmes show very little difference in savings between the 'low cost' and 'medium cost' packages, and the proportional savings continue to decrease with the higher-cost packages – this indicates a greater value for money in the 'low cost' package.

The greatest differences in predicted net balance (see Figure 3 above) arise with the following five individual measures: timber floor insulation, blown bead internal wall insulation, aerogel blanket internal wall insulation, hot water cylinder and pipework insulation, and the biomass boiler. The packaged measures also receive widely differing savings predictions.

These comparisons go some way to explaining the marked difference in the two lists of measures that would meet the Green Deal's Golden Rule.

As NHER is a more detailed software than RdSAP and is more sensitive (in that some of its assumptions can be adapted by the software user to tailor it more to the property in question); in many cases it can be said to be the more accurate of the two programmes. NHER also takes account of geographic location in the UK, unlike RdSAP, which should enable it to give a more accurate representation of Scotland's longer heating season and different weather conditions (compared with England). In addition, for the baseline (pre-improvement) energy consumption calculations NHER is able to distinguish between primary (coal) and secondary (electric) heating source, and allocate kWh and running costs to each; RdSAP cannot so this and do all heating kWh are attributed to coal. This affects the accuracy of the baseline figures, against which all improvement measures are modelled.

However, as stated earlier any software is inherently generic, and the relatively high heating pattern assumed by both programs is likely to generate savings figures that could be lower in reality. It should also be noted that an improved version of RdSAP is likely to be used for actual Green Deal assessment purposes (see section 2.2.1).

## 6.2 Other variables

It is clear that the number of variables makes it impossible to predict savings with any degree of certainty. Repayment interest rates are shown to be of considerable importance, (fuel cost rises perhaps less so). The capital costs for the different measures were provided by Historic Scotland, are based on pilot projects and in some cases partial measures, and include VAT. For a householder these costs may vary, and clearly if the installation costs rise significantly so, too, do the loan repayments, while the savings remain the same.

User behaviour is probably the greatest variable and cannot be factored into any savings prediction with accuracy: How many people live in a property, and how do they choose to heat it? Applying the rebound effect was shown to have a considerable impact on the real viability of Green Deal finance for a number of measures.

One area not covered in this report is the cumulative impact of the modelled costs and savings. However, the key finding (unsurprisingly) was that over such a long repayment period (25 years) the extrapolated savings or losses could be considerable.

## 6.3 Concluding comments

This report explores a number of key areas in relation to the Green Deal, assessment tools and the eligibility of improvement measures needed for older solid-walled properties.

- Some of the improvement measures modelled in this report could be considered experimental at this stage, and their eligibility for Green Deal finance is not yet certain. This could be significant, as the pumped bead internal wall insulation in particular shows considerable savings for householders, thus seems to be one of the most affordable wall insulation options and may not require ECO subsidy. The real cost and applicability of this measure should, therefore, be the subject of further scrutiny (including geographic presence of installers, typical costs, thermal imaging to detect and address missed areas and avoid thermal bridging, etc.).

- One of the measures that shows the greatest net profit is the solid floor insulation. However, as mentioned previously (see section 3.1), this is not currently on the list of measures eligible for Green Deal finance according to the Government's consultation document (see Annex A of DECC [2011b, p.227]). This may change once the consultation responses have been digested and acted upon. However, at present this would limit the improvement options available for householders in traditionally built pre-1919 properties.

- Other, more standard measures, such as loft insulation, show considerable savings. However, this particular installation is for relatively standard and straightforward loft. Insulating the lofts of many traditional buildings could be considerably more complex and costly (e.g. where there are coombed ceilings, dormer windows, loft conversions, full or partial flooring, flat roofs, etc.), which could affect their eligibility for Green Deal finance without subsidy.

- It should also be noted that these figures are based on one property type. Traditionally constructed dwellings cover many different styles (e.g. detached houses, 1.5-storey cottages, semi-detached and terraced houses, upper and lower villas, divided houses, tenement flats, etc.), and the improvement measures and impacts of these will vary considerably from property type to property type.

- The high number of variables in the financial modelling makes it impossible to guarantee that the savings calculated by either RdSAP or NHER (or any other modelling tool) will be delivered in practice. This could place more pressure on householders to ~~take~~ manage their behaviour and energy use prudently to try and maximise their chances of realising the predicted savings. This, however, will only happen if they are aware of the issues raised in this report. This points to a future need for advice on and support for behaviour change and change to heating regimes in traditional properties in particular.

As a householder, the findings of this report should, therefore, be considered from two very different perspectives:

1. **Finance eligibility** – Will the measures I want to install be eligible for finance under the Green Deal (i.e. will they be predicted to save more than the repayments)?

2. **Finance viability** – If the measures are eligible and I receive a loan, will I actually make the savings that were predicted? (If not, the householder will be paying more than they are saving.)

The latter point will be dictated by the level of ECO funding made available to particular products and installers. As this is a market-based mechanism, it is difficult to predict. It is likely that the products attracting the most ECO funding will be those that deliver the highest savings of carbon dioxide emissions and have the greatest market, rather than more the specialist products.

As the launch of the Green Deal draws nearer and consultation responses are received by DECC, there will be a closer interest in this area. There is significant potential to revisit the modelling and findings of this report in the future – with the savings calculations, variables and property types modelled and analysed in more depth.

## Appendix

**Software used:**

NHER Stock Assessor v2.0.11 – RdSAP (SAP 2005)

NHER Plan Assessor v4.5 – NHER (SAP 2005)

**Fuel costs (incl. VAT):**

All fuel cost tariffs are taken from the Sutherland Tables (October 2011).

Wood pellets (heating / hot water) – 5.61p/kWh

House coal – 3.68p/kWh

Electric (two-tier) –13.73p/kWh (21.7p/kWh first 900kWh)

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Research Report 2

# Green Deal financial modelling report 2:
## Traditional Tenement Flat

Nicholas Heath, Tessa Clark & Gary Pearson

CHANGEWORKS

## Abbreviations

| | | |
|---|---|---|
| CERT | Carbon Emissions Reduction Target | Page 7 |
| DECC | Department of Energy and Climate Change | Page 5 |
| ECO | Energy Company Obligation | Page 7 |
| EPC | Energy Performance Certificate | Page 8 |
| NHER | National Home Energy Rating | Page 5 |
| RdSAP | Reduced data SAP | Page 5 |
| SAP | Standard Assessment Procedure | Page 5 |
| U-value | Overall heat transfer coefficient | Page 5 |
| VAT | Value Added Tax | Page 11 |

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# Green Deal financial modelling report 2: traditional tenement flat

**Nicholas Heath, Tessa Clark & Gary Pearson**

**January 2012**

**In November 2011, Changeworks modelled the financial viability of a number of energy efficiency and renewable energy measures on a rural stone-built cottage for Historic Scotland. This report provides the results of similar modelling, conducted in January 2012, for a traditional tenement flat. Changeworks modelled the costs and benefits of suitable energy efficiency measures, using a range of saving and repayment scenarios and different software packages, to assess their viability for Green Deal finance.**

**This report should be read in conjunction with Changeworks' previous report, *Green Deal financial modelling report 1: traditional detached cottage*, which is the first report in this Historic Scotland Technical Paper.**

## Contents

# 1. Introduction

In a report carried out in November 2011 (see the first report of this Technical Paper), Changeworks carried out financial modelling on a number of energy-efficiency measures on a traditionally constructed stone cottage in the grounds of Dumfries House in rural Ayrshire (southwest Scotland). However, as there are many different types of pre-1919 dwellings in Scotland (e.g. detached, semi-detached and terraced houses; upper and lower villas; houses divided into flats; tenement flats; etc.), Historic Scotland was keen to model the financial viability and applicability of similar measures in different housing types.

This report, therefore, provides the results of a similar financial modelling exercise, testing the viability of a range of energy efficiency measures on a traditionally constructed stone tenement flat (in Edinburgh). Historic Scotland provided Changeworks with a list of measures to model, with pre- and post-improvement thermal performance figures and capital costs being agreed in advance. Changeworks modelled the costs and savings for individual and grouped measures, and tested a number of variables (including different software packages) to assess their impact. This report provides the details of this modelling.

This report should be read in conjunction with Changeworks' previous report, *Green Deal financial modelling report 1: traditional detached cottage*, which forms the first report of this Historic Scotland Technical Paper.

Unlike the previous report, this report was prepared after the launch of *The Green Deal and Energy Company Obligation: Consultation Document* by the UK Government's Department for Energy and Climate Change (DECC) in November 2011 (DECC, 2011b).

## 1.1 Baseline performance

The financial modelling for this report was carried out using two assessment procedures / software packages:

- Reduced data Standard Assessment Procedure (RdSAP)
- National Home Energy Rating (NHER)

RdSAP is a simplified version of the Standard Assessment Procedure (SAP), the UK Government's recommended method system for measuring the energy rating of residential dwellings. NHER is a rating scale for the energy efficiency of housing (as well as a UK accreditation scheme for energy assessors). RdSAP and SAP are software package developed by BRE (formerly Building Research Establishment); NHER has been developed by National Energy Services, formerly a trading subsidiary of the National Energy Foundation.

In the NHER modelling, thermal performance data (U-values or heat transfer coefficients), provided by Historic Scotland, were input into the software. For RdSAP, the default values assumed by the program were used. The baseline performance used for the modelling is set out in Table 1 below.

**Table 1. U-values [W/m²K] used for the Green Deal financial modelling**

| Element | Description | U-value (RdSAP *) | U-value (NHER **) |
|---|---|---|---|
| Walls | Solid sandstone (600mm) | 1.5 | 1.25 |
| Windows | Timber sash-and-case, single-glazed | 4.8 | 5.5 |
| Space heating | Wall mounted gas boiler pre-1998 (G-rated) with no time or thermostatic controls | (65% efficient) | (65% efficient) |
| Water heating | From boiler, minimal insulation (25mm jacket) and no thermostat | n/a | n/a |
| Lighting | Half low energy | n/a | n/a |

* These are the default values assumed by RdSAP; these cannot be overwritten.

** These are the U-values measured by Historic Scotland *in situ* and input to NHER.

# 2. Context

## 2.1 Green Deal and the Energy Company Obligation

The Green Deal is the UK Government's plan to drive increased energy efficiency in UK homes. From October 2012, finance will be available to householders to pay for improvement measures to their homes. This finance will be repayable through householders' fuel bills over a 25-year period or within the lifetime of a measure (whichever is shorter). Although earlier press releases stated a finance limit of £10,000 (DECC, 2011a), DECC's recently-issued consultation document (DECC, 2011b) does not specify an upper limit.

The key element of the Green Deal is the 'Golden Rule', which states that the improvements must save more money than the householder repays, (although it is important to note that this calculation is theoretical only). As some products are never likely to meet the Golden Rule due to high installation costs, an Energy Company Obligation (ECO) will also be brought into play with the aim of bringing down the costs of these measures so they can be offered by Green Deal providers. This will work in a similar way to existing Carbon Emissions Reduction Target (CERT) subsidies for cavity wall and loft insulation, and will fund measures for priority-group (e.g. low-income) householders and hard-to-treat homes (e.g. solid wall insulation). DECC's Green Deal consultation document (DECC, 2011b) currently proposes that the ECO will primarily fund solid wall insulation. The following quote from the DECC publication *Green Deal Finance: What is the Green Deal?* outlines how it will function:

> *"The ECO carbon target will focus on driving delivery of insulation systems for solid walled properties that cannot receive straightforward cavity wall insulation. It is likely that in many cases consumers will be incentivised to take-up these measures with combinations of ECO subsidy and Green Deal Finance. Suppliers and Green Deal Providers will need to work together to provide an offer to the consumer that comprises the optimum mix of support between Green Deal finance and ECO subsidy.*
>
> *"It will not fall to the consumer to bring Green Deal finance and ECO together."*
>
> (DECC, 2011c, p.2)

As many of the improvement measures needed for hard-to-treat homes are not likely to meet the Green Deal's Golden Rule criteria, they will have to be largely subsidised by the ECO. This research is, therefore, of particular interest, as the property in question would be termed 'hard-to-treat' under conventional definitions. This report on tenement dwellings is also of particular relevance to ECO funding, as the ECO's focus on wall insulation may be of less relevance in tenement flats where a considerable proportion of the external wall area is often glazing (i.e. large sash-and-case windows, often single-glazed) rather than stone.

It is important to note that many details of the Green Deal (e.g. software packages, repayment interest rates, how inflation will be accounted for) are not yet confirmed. All figures in this report are, therefore, indicative; assumptions are detailed where required, and these should be taken into account when examining the figures.

## 2.2 Green Deal cost-effectiveness and variables

There are a number of variables which will affect the financial viability of Green Deal finance and the accuracy of this financial modelling. The key issues are outlined below.

### *2.2.1 Energy rating software*

Previous research (Changeworks & Home Energy And Data Services, 2010) has shown the variability of different energy modelling software packages to calculate the savings that will be made by energy-efficiency measures: different results will be produced depending on which package is used. This is particularly important for the Green Deal, as it is a software package that will test whether a measure meets the Golden Rule.

The UK Government is currently planning to use RdSAP software for Green Deal assessments. This is one of the more basic (i.e. least detailed) of the main software packages and is also the package used to generate Energy Performance Certificates (EPCs) for domestic buildings. It should, however, be noted that revised versions of both RdSAP and EPCs are anticipated in advance of the Green Deal's introduction with the intention of making them more robust.

For the purposes of this report, savings have been calculated using RdSAP software to mirror the current Green Deal set-up. To enable a meaningful comparison, savings have also been calculated using the more detailed NHER software. (Details of both software packages are included in the Appendix.)

In both cases, however, the running cost predictions are based on fuel costs that are only updated periodically. To provide savings figures that are as up to date as possible Changeworks, therefore, took the energy use (kWh) figures calculated by each software package and multiplied these by current (October 2011) fuel cost figures taken from the Sutherland Tables to provide the savings used in this report. (The Sutherland Tables [2011] provide regularly updated fuel costs for all main UK fuels. Fuel costs used from these tables are provided in the Appendix.)

### *2.2.2 Green Deal interest rates*

The interest rate attached to the finance will inevitably affect its attractiveness. It is anticipated that the Green Deal scheme is likely to be partly delivered through large companies, such as Marks & Spencer Plc. (M&S), Tesco Plc. and B&Q Plc., using interest rates still to be determined. Recent lending rates (interest rates at January 2011) of these companies are set out below, for comparison:

- M&S 6.0%
- Tesco 6.1%
- B&Q 0 to 19.8% (depending on the size of the loan and any special offers)

(These interest rates are for loans with shorter timescales than the Green Deal's 25-year timescale; a longer timescale should allow a lower interest rate. Note that these interest rates have dropped since the previous report in November 2011.)

DECC has confirmed verbally (DECC, 2011d) that the interest attached to Green Deal finance will be compound (i.e. they will work as with any commercial loan). This means that the interest rate applied to the finance will have a considerable impact on its viability.

For the purposes of this report, an interest rate of 5% has been assumed. Some variations have been modelled up to a maximum of 10%, which in some cases had a considerable impact on the viability of the measures. It is not anticipated that Green Deal finance would come with a higher interest rate than this. However, this cannot be guaranteed as interest rates will be dictated by the market.

### *2.2.3 Inflation*

It is not possible to predict inflation rates accurately over 25 years. Different savings predictors for energy-efficiency measures apply inflation in different ways or do not apply it at all.

The Energy Saving Trust applies inflation to lifetime savings as 3.5% annual depreciation (i.e. the value of the savings that a measure makes will be worth less over time) on the premise that £100, for example, will be worth less in future years than it is today. To further complicate matters, rates of inflation are higher than bank interest rates at present, which means the relative buying power of savings is being diminished over time (as per scenario 1 in Table 2 below). However, inflation pressures can also aid the case for investing in Green Deal measures, because as fuel bills rise over time the associated savings will increase. These two scenarios are illustrated at a basic level in Table 2 below.

**Table 2. Description of modelling scenarios used**

| Scenario 1: Depreciation | Scenario 2: Increase |
|---|---|
| Insulation installed<br>\|<br>Year 1: £100 saved on annual bill<br>\|<br>Depreciation by 3.5%<br>\|<br>Year 2: £96.50 saved on annual bill | Insulation installed<br>\|<br>Year 1: £100 saved on annual bill<br>\|<br>Fuel prices rise by 15%<br>\|<br>Year 2: £115 saved on annual bill |

In August 2011 gas and electricity prices rose significantly for the second time in less than a year. Further significant fuel price rises, above the Government's measured rate of inflation, would increase the savings made by insulation measures, making them more likely to meet the Golden Rule. This would apply in particular to measures that are currently borderline (i.e. those which only just fall short of meeting the Golden Rule).

For the Green Deal, it has not yet been decided how inflation will be accounted for in the overall savings and repayments calculations (DECC, 2011d).

For the purposes of this report, inflation has not been accounted for (i.e. it has been set at 0%). It was decided to take this approach in order to avoid confusion. However, inflation scenarios have been suggested in some instances to illustrate the issue.

### *2.2.4 Rebound effect*

There is increasing research (Cambridge Centre for Climate Change Mitigation Research et al., 2006; Energy Monitoring Company, 2008; Energy Saving Trust, 2004; Herring & Roy, 2007; Herring & Sorrell, 2008; Martin & Watson, 2006; Sanders & Phillipson, 2006; UK Energy Research Centre & Sorrell, 2007) suggesting that the actual savings made by insulation measures can often be considerably less than the predicted savings. This is known as the *rebound effect* (sometimes also called the *reduction factor*). In some instances, only approximately 50% of the predicted savings are realised by householders. In households where this occurs, the end result could have a significant impact on the true viability of Green Deal finance, as the savings could then be less than the repayments. This would result in a net financial loss to the householder – and to future householders, as the repayments are attached to the property and not the individual, (i.e. when a property is sold, the new occupants must continue the repayments).

It is important to note that the rebound effect will not be factored into any Green Deal calculations.

### *2.2.5 Heating patterns and user behaviour*

Most energy rating software models assume set heating patterns when predicting annual costs and emissions. RdSAP and NHER both assume that, for the duration of the heating season, the occupants will have the heating on for 9 hours per day during the week and 16 hours per day at weekends at temperatures of 21°C in the living room and 18°C in the rest of the home. (The longer heating season in northern Britain is not accounted for.)

Some people heat their homes for less time than this and / or to lower temperatures. In households where this occurs, the predicted savings would, therefore, be exaggerated.

### *2.2.6 Number of occupants*

Most energy software models make an assumption on the number of occupants depending on the floor area of a property; in turn, the assumed number of occupants determines the predicted hot water consumption. In homes with more / fewer occupants than predicted, the energy use will vary, which then affects the accuracy of the predicted savings.

For the tenement flat, the energy modelling assumes an occupancy of 3.9 people.

### *2.2.7 Installation costs*

This report uses costs provided by Historic Scotland and Changeworks' *Energy Heritage* project (Changeworks, 2008). These costs include VAT and in most instances associated costs (e.g. redecoration). However, the costs are based on pilot project costs, which are likely to differ from private household projects. If a householder is unable to secure an equally competitive price for their own improvement measures, this will reduce the cost-benefit margin.

## 3. Insulation measures

Table 3 below lists the energy-efficiency measures and costs provided by Historic Scotland unless otherwise stated.

**Table 3.** List of improvement measures

| No. | Measure | Details | U-value ($W/m^2k$) | Cost per unit excl. VAT | Total cost incl. VAT |
|---|---|---|---|---|---|
| 1 | Internal wall insulation | Bead insulation blown behind lath and plaster (plus joinery and redecoration) | 0.7 | £14 / $m^2$ | £1,077 |
| 2 | Internal wall insulation | Aerogel blanket fastened to existing wall lining with steel mesh; plaster skim coat to finish (plus redecoration) | 0.7 | £60 / $m^2$ | £4,616 |
| 3 | Internal wall insulation | 100mm wood fibre insulation board; plasterboard finish (plus redecoration) * | 0.279 | £60 / $m^2$ | £4,616 |
| 4 | Draughtproofing | Windows dismantled and draughtproofing fitted | n/a | £300 / window | £1,800 |
| 5 | Energy-efficient glazing | Secondary glazing in form of added acrylic or polycarbonate panes fitted to existing single-glazed timber windows | 2.5 | £60 / $m^2$ | £1,093 |
| 6 | Energy-efficient glazing | New timber sashes with conventional double-glazing units | 1.8 | £800 / window | £5,280 |
| 7 | Energy-efficient glazing | New double-glazing units fitted into existing timber sashes | 1.8 | £400 / window | £2,640 |
| 8 | Energy-efficient glazing | Secondary glazing in form of added slim-profile window systems fitted to existing single-glazed timber windows | 1.6 | £800 / window | £4,800 |
| 9 | Window shutters | Reinstating internal timber shutters to windows | 2.2 ** | £300 / window | £1,980 |
| 10 | Front door replacement | New insulated front door (existing frame retained) | 0.2 | £1,200 | £1,440 |
| 11 | Front door upgrade | Insulation added to existing panelled front door | 0.4 | £50 / $m^2$ | £208 |

| | | | | | |
|---|---|---|---|---|---|
| 12 | Heating upgrade | High-efficiency condensing boiler and controls; increase hot water tank insulation | n/a | £4,000 | £5,280 |
| 13 | Hot water cylinder insulation | 160mm insulation jacket to replace existing 25mm jacket; pipework insulation | n/a | £80 | £96 |
| 14 | Hot water cylinder thermostat | Thermostat fitted to hot water cylinder | n/a | £80 *** | £96 |
| 15 | Change heating system to electric storage heating | Fan-assisted, automatic charge, electric storage heaters fitted in main living areas; electric panel heaters fitted in bedrooms; hot water tank insulation increased | n/a | £300 per heater *** | £2,376 |

* The improved U-Value for installing 100mm of wood fibre insulation board on a sandstone wall was calculated by Changeworks using NHER's U-value Calculator.

** This U-value assumes that the shutters are shut.

*** This is an estimated cost supplied by Changeworks.

### 3.1 Renewable energy

No microgeneration measures were modelled for the following reasons:

- Wind and hydro are unlikely to be viable in many built-up urban areas.
- Individual heat pumps are unlikely to be viable for mid-floor tenement flats.
- Photovoltaic and solar thermal panels were felt unlikely to be installed by most mid-floor tenement occupants; the former requires considerable roof space and would, therefore, be best-suited to top-floor flats, and the latter are possible (see Changeworks' *Renewable Heritage* project, [Changeworks, 2009]) but unlikely in most tenements with multiple private owners.
- Individual biomass boilers are unlikely to be viable in mid-floor tenement flats. Biomass stoves may be possible, but flue installations could be complex (running through flats above), environmental health may not approve such installations (due to concerns over particulate emissions), and it was felt unlikely to be widely installed by most mid-floor tenement occupants.

More information on the issues surrounding microgeneration in tenement buildings can be found in previous Changeworks reports (e.g. Changeworks, 2010).

### 3.2 Packaged measures

Many households may choose to undertake several improvement measures. (This 'package' approach is the intention of the Green Deal.) On this assumption, Changeworks also grouped the individual measures above into three different insulation 'packages', in order to calculate savings that could be made from carrying out multiple measures. The packages were grouped as detailed in Table 4 below.

**Table 4. Grouping of improvement measures by cost categories**

| **Package** | **Measures included** | **Cost** incl. VAT |
|---|---|---|
| Low cost | • 1: Internal wall insulation (blown beads)<br>• 5: Energy-efficient glazing (added acrylic or polycarbonate panes fitted to existing windows)<br>• 11: Front door upgrade<br>• 13: Hot water cylinder insulation<br>• 14: Hot water cylinder thermostat | £2,570 |
| Medium cost | • 2: Internal wall insulation (aerogel)<br>• 7: Energy-efficient glazing (new slim-profile double-glazing units fitted into existing sashes)<br>• 10: Front door replacement<br>• 13: Hot water cylinder insulation<br>• 14: Hot water cylinder thermostat | £8,888 |
| High cost | • 3: Internal wall insulation (wood fibre)<br>• 6: Energy-efficient glazing (new timber sashes with conventional double-glazing units)<br>• 10: Front door replacement<br>• 12: Heating upgrade (gas condensing boiler and controls) | £16,616 |

It is important to be aware that cumulative savings for multiple measures are not simply a sum of the savings for each individual measure; they will be lower, since the baseline performance of the property improves with each measure added.

It should also be noted that the 'high cost' package detailed above may be beyond the limit of Green Deal finance, although this is likely to depend on individual providers and property-specific calculations.

### 3.3 Eligibility of measures

DECC's Green Deal consultation contains a list of applicable measures (DECC, 2011b, Annex A, p.227). All the measures on the list applicable to the tenement have been modelled. There are some general points to bear in mind, particularly in relation to some of the improvement measures detailed above.

1. Because the Green Deal finance will be linked to the property rather than the occupants, measures that are deemed to be 'portable' may not be eligible for finance. This could lead to debate over the definition of 'portable' and whether it includes, for example, certain forms of secondary glazing.

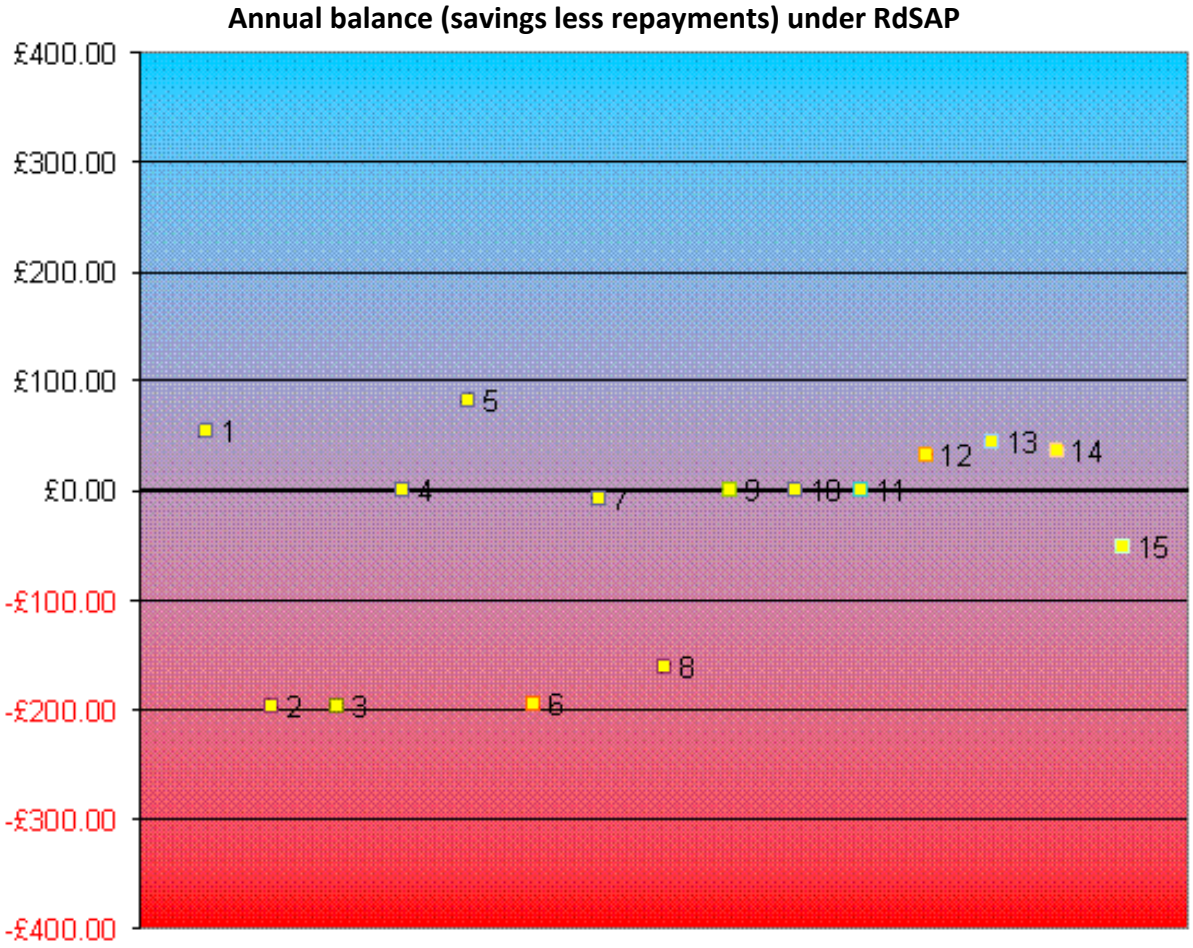
2. Another of the window improvement options, the timber shutter reinstatements, may not be eligible for Green Deal finance, as this measure is not currently recognised by RdSAP. Timber shutters are only effective when closed, and as they are not a permanent energy-saving measure they may not be deemed eligible for finance – although they have the potential to make considerable savings if used effectively.

3. The internal wall insulation options detailed in this report are relatively new to the market, and while they have been trialled by Historic Scotland they may not yet all be widely available. Certain technical details (e.g. how to ensure complete coverage of the blown bead insulation, how to avoid thermal bridging, etc.) may require clarification, before the insulation industry is prepared to guarantee such insulation measures. This is significant, as without guarantee a measure is unlikely to be eligible for Green Deal finance.

# 4. Results using RdSAP

## 4.1 Payback on individual measures

Under RdSAP savings assumptions and a 25-year repayment period with an interest rate of 5%, five of the fifteen individual measures would meet the Green Deal's Golden Rule. Figure 1 below provides an illustration of this.




| KEY | | | |
|---|---|---|---|
| 1 | Internal wall insulation (blown beads) | 9 | Reinstating timber shutters to windows * |
| 2 | Internal wall insulation (aerogel) | 10 | New high-performance external door * |
| 3 | Internal wall insulation (wood fibre) | 11 | Upgrading existing external door * |
| 4 | Draughtproofing * | 12 | High-efficiency condensing boiler and controls |
| 5 | Energy-efficient glazing (added acrylic or polycarbonate panes) | 13 | Hot water cylinder insulation |
| 6 | Energy-efficient glazing (new timber sashes with conventional double-glazing) | 14 | Hot water cylinder thermostat |
| 7 | Energy-efficient glazing (new slim-profile double-glazing units in existing sashes) | 15 | Electric fan-assisted storage heaters and panel heaters |
| 8 | Energy-efficient glazing (added slim-profile window systems) | | |

** These measures cannot be modelled using RdSAP.*

**Figure 1. Annual balance under RdSAP**

As shown above, the five qualifying measures are:

- No. 1 - Internal wall insulation (blown beads)
- No. 5 - Energy-efficient glazing (added acrylic or polycarbonate panes)
- No. 12 - High-efficiency condensing boiler and controls
- No. 13 - Hot water cylinder insulation
- No. 14 - Hot water cylinder thermostat

Detailed results are shown in Table 5 below, ranked according to net profit / loss.

**Table 5. Payback on individual measures (RdSAP predictions)**

| **No.** | **Improvement** | **Cost** incl. VAT | **Annual saving** | **Annual repayment** @ 5% | **Annual balance** (profit / loss) |
|---|---|---|---|---|---|
| 5 | Energy-efficient glazing (added acrylic or polycarbonate panes) | £1,093 | £160 | -£78 | **£82** |
| 1 | Internal wall insulation (blown beads) | £1,077 | £130 | -£76 | **£54** |
| 13 | Hot water cylinder insulation | £96 | £51 | -£7 | **£44** |
| 14 | Hot water cylinder thermostat | £96 | £43 | -£7 | **£36** |
| 12 | High-efficiency condensing boiler and controls | £5,280 | £407 | -£375 | **£32** |
| 7 | Energy-efficient glazing (new slim-profile double-glazing units in existing sashes) | £2,640 | £179 | -£187 | **-£8** |
| 11 | Upgrading existing external door | £208 | £0 | -£15 | **-£15** |
| 15 | Electric fan-assisted storage heaters and panel heaters | £2,376 | £118 | -£169 | **-£51** |
| 10 | High thermal performance external door | £1,440 | £0 | -£102 | **-£102** |
| 4 | Draughtproofing | £1,800 | £0 | -£128 | **-£128** |
| 9 | Reinstating timber shutters to windows | £1,980 | £0 | -£140 | **-£140** |
| 8 | Energy-efficient glazing (added slim-profile window systems) | £4,800 | £179 | -£341 | **-£161** |
| 6 | Energy-efficient glazing (new timber sashes with conven-tional double-glazing units) | £5,280 | £179 | -£375 | **-£195** |
| 2 | Internal wall insulation (aero-gel) | £4,616 | £130 | -£328 | **-£197** |
| 3 | Internal wall insulation (wood fibre) | £4,616 | £130 | -£328 | **-£197** |

The acrylic or polycarbonate panes added to existing windows provides the largest annual profit of all the measures (£82). All of the other qualifying measures (blown bead wall insulation, high-efficiency condensing boiler and controls, hot water cylinder insulation, and hot water cylinder thermostat) would realise an annual profit of £30 to £55.

RdSAP is currently unable to model draughtproofing, door upgrades or reinstating timber shutters. So, while it is generally acknowledged that these will improve energy efficiency and, therefore, reduce heating costs, the savings cannot be represented using RdSAP. None of these measures would, therefore, meet the Golden Rule. However, it seems likely that the revised version of RdSAP will be able to model draughtproofing.

The installation of electric fan-assisted storage heaters and panel heaters, installation of new slim-profile double-glazing units fitted into existing sashes, addition of slim-profile window systems fitted to existing windows, installation of new timber sashes with conventional double-glazing units, and both other forms of internal wall insulation all showed savings, but these were less than the repayments and so these measures would not meet the Green Deal's Golden Rule. However, two measures were very close to eligibility: the new slim-profile double-glazing units fitted into existing sashes (£8 loss a year) and upgrading the existing external door (£15 loss a year).

### 4.2 Payback on multiple measures

The payback results for the improvement packages (as defined in Table 4) are shown in Table 6 below.

**Table 6. Payback on measure packages (RdSAP predictions)**

| **Improvement package** | **Cost** incl. VAT | **Annual saving** | **Annual repayment** @ 5% | **Annual balance** (profit / loss) |
|---|---|---|---|---|
| Low cost | -£2,570 | £356 | -£182 | **£174** |
| Medium cost | -£8,888 | £374 | -£631 | **-£257** |
| High cost | -£16,616 | £501 | -£1,179 | **-£678** |

The 'low cost' package is the only package that would meet the Green Deal's Golden Rule. The 'medium cost' package only saves slightly more money per year than the 'low cost' package, despite costing more than three times as much, and as a result this package would result in a considerable net loss. The 'high cost' package saves more money, but is much more expensive to install; so that, too, would fail to meet the Golden Rule.

### 4.3 Variables

As mentioned previously, there are many variables in any savings prediction method. Below some of the main variables are outlined.

### *4.3.1 Repayment interest rate*

Increasing the loan interest rate to 10% has a considerable impact on the net balance of some of the qualifying measures:

- Energy efficient glazing (added acrylic or polycarbonate panes fitted to existing single-glazed windows): £82/year to £39/year (52% reduction)
- Internal wall insulation (blown beads): £54/year to £12/year (78% reduction).

In addition, the high-efficiency condensing boiler and controls would become ineligible for the Green Deal under a 10% interest rate, since the annual balance would reduce from £32/year profit to £175/year loss.

The hot water cylinder thermostat and insulation would only be marginally affected by a 10% interest rate (reduction of £36/year to £33/year and £44/year to £41/year respectively).

Increasing the interest rate also considerably decreases the annual profit from the 'low cost' package of measures from £177/year to £79/year (55% reduction).

### *4.3.2 Inflation*

Considering the effect of inflation and fuel cost rises is of most interest to borderline measures, such as the new slim-profile double-glazing units fitted into existing sashes. Applying a fuel cost increase of 15% would change the net balance from an £8/year loss to a £19/year profit, thus meeting the Golden Rule.

It is worth noting that fuel prices would increase the savings made by some measures considerably. For the high-efficiency boiler, for example, applying a fuel price rise of 15% increases the net balance from £32/year to £93/year. Likewise, applying the same fuel price rise to the electric heating installation would change the net balance from a £51/year loss to a £106/year profit, thus meeting the Golden Rule.

### *4.3.3 Rebound effect*

Applying a rebound effect of 50% to the qualifying measures means that the following measures would change from a profit to a loss:

- Internal wall insulation (blown beads): £54/year profit to £11/year loss
- High-efficiency condensing boiler and controls: £32/year profit to £171/year loss

Applying the same rebound effect to the remaining qualifying measures has the following effects:

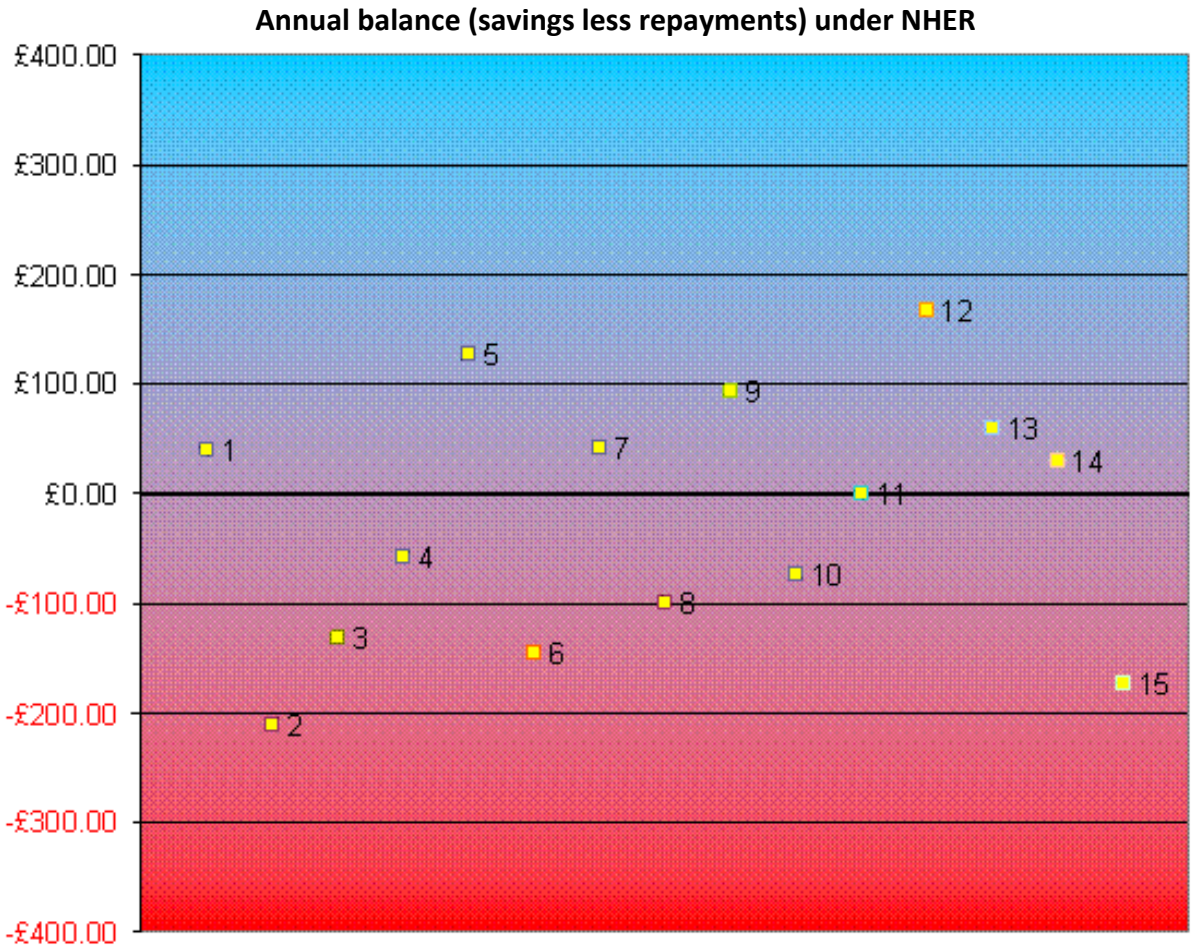
- Energy-efficient glazing (added acrylic or polycarbonate panes fitted to existing single-glazed windows): £82/year to £2/year (98% reduction)
- Hot water cylinder insulation: £44/year to £19/year (57% reduction)
- Hot water cylinder thermostat: £36/year to £22/year (39% reduction)

Applying the same rebound effect to the 'low cost' package of measures would reduce the net balance from a £174/year profit to a £4/year loss, meaning it would fail to meet the Golden Rule, albeit marginally.

# 5. Results using NHER

## 5.1 Payback on individual measures

Under NHER savings assumptions and a 25-year repayment period with an interest rate of 5%, eight of the fifteen individual measures would meet the Green Deal's Golden Rule. Figure 2 below provides an illustration of this.




| KEY | | | |
|---|---|---|---|
| 1 | Internal wall insulation (blown beads) | 9 | Reinstating timber shutters to windows |
| 2 | Internal wall insulation (aerogel) | 10 | New high-performance external door |
| 3 | Internal wall insulation (wood fibre) | 11 | Upgrading existing external door |
| 4 | Draughtproofing | 12 | High-efficiency condensing boiler and controls |
| 5 | Energy-efficient glazing (added acrylic or polycarbonate panes) | 13 | Hot water cylinder insulation |
| 6 | Energy-efficient glazing (new timber sashes with conventional double-glazing) | 14 | Hot water cylinder thermostat |
| 7 | Energy-efficient glazing (new slim-profile double-glazing units in existing sashes) | 15 | Electric fan-assisted storage heaters and panel heaters |
| 8 | Energy-efficient glazing (added slim-profile window systems) | | |

**Figure 2. Annual balance under NHER**

As shown above, the eight qualifying measures are:

- No. 1 - Internal wall insulation (blown beads)
- No. 5 - Energy-efficient glazing (added acrylic or polycarbonate panes)
- No. 7 - Energy-efficient glazing (new slim-profile double-glazing units in existing sashes)
- No. 9 - Reinstating timber shutters to windows
- No. 11 - Upgrading existing external door
- No. 12 - High-efficiency condensing boiler and controls
- No. 13 - Hot water cylinder insulation
- No. 14 - Hot water cylinder thermostat

Detailed results are shown in Table 7 below, ranked according to net profit / loss.

**Table 7. Payback on individual measures (NHER predictions)**

| **No.** | **Improvement** | **Cost** incl. VAT | **Annual saving** | **Annual repayment** @ 5% | **Annual balance** (profit / loss) |
|---|---|---|---|---|---|
| 12 | High-efficiency condensing boiler and controls | £5,280 | £542 | -£375 | **£168** |
| 5 | Energy-efficient glazing (added acrylic or polycarbonate panes) | £1,093 | £205 | -£78 | **£127** |
| 9 | Reinstating timber shutters to windows | £1,980 | £233 | -£140 | **£93** |
| 13 | Hot water cylinder insulation | £96 | £67 | -£7 | **£60** |
| 7 | Energy-efficient glazing (new slim-profile double-glazing units in existing sashes) | £2,640 | £229 | -£187 | **£42** |
| 1 | Internal wall insulation (blown beads) | £1,077 | £116 | -£76 | **£40** |
| 14 | Hot water cylinder thermostat | £96 | £37 | -£7 | **£30** |
| 11 | Upgrading existing external door | £208 | £15 | -£15 | **£1** |
| 4 | Draughtproofing | £1,800 | £69 | -£128 | **-£59** |
| 10 | High thermal performance external door | £1,440 | £29 | -£102 | **-£73** |
| 8 | Energy-efficient glazing (added slim-profile window systems) | £4,800 | £241 | -£341 | **-£100** |

| | | | | | |
|---|---|---|---|---|---|
| 3 | Internal wall insulation (wood fibre) | -£4,616 | £195 | -£328 | **-£133** |
| 6 | Energy-efficient glazing (new timber sashes with conventional double-glaz-ing) | £5,280 | £229 | -£375 | **-£145** |
| 15 | Electric fan-assisted storage heaters and panel heaters | £2,376 | -£5 | -£169 | **-£174** |
| 2 | Internal wall insulation (aerogel) | £4,616 | £116 | -£328 | **-£211** |

Compared with RdSAP (see section 4.1), using NHER allows a greater number of measures to meet the Green Deal's Golden Rule. The additional qualifying measures are: reinstating timber shutters, new slim-profile double-glazing units fitted into existing sashes and upgrading the existing external door. In the first and last instances this can partly be explained by the fact that RdSAP does not allocate savings to reinstating shutters or replacing doors, whereas NHER does.

Boiler, glazing and window shutter measures are shown to make the greatest net profit.

Generally, eligible measures achieve a greater annual profit using NHER modelling compared to RdSAP modelling. The measure which provides the highest annual profit is the high-efficiency condensing boiler and controls (£168). The second-largest annual profit is realised from adding acrylic or polycarbonate panes to the existing windows (£127). Interestingly, under NHER (unlike RdSAP) the wood fibre internal wall insulation achieves considerably greater savings than the aerogel material, due to the better U-value (achieved by a greater depth of material).

Further comparisons are given in section 6 of this report.

### 5.2 Payback on multiple measures

The packaged measures (see section 4.2) modelled using RdSAP were also modelled using NHER. Results are shown in Table 8 below.

**Table 8. Payback on measure packages (NHER predictions)**

| **Improvement package** | **Cost** incl. VAT | **Annual saving** | **Annual repayment** @ 5% | **Annual balance** (profit / loss) |
|---|---|---|---|---|
| Low cost | -£2,570 | £417 | -£182 | **£235** |
| Medium cost | -£8,888 | £445 | -£631 | **-£186** |
| High cost | -£16,616 | £766 | -£1,179 | **-£413** |

The 'low cost' and 'medium cost' packages provide very similar annual savings, despite the 'medium cost' package costing over three times as much. However, only the 'low cost' package is eligible under the Green Deal's Golden Rule, due to the considerably higher re-payments required of the 'medium cost' package. The 'high cost' package is much more expensive to install, and while it creates higher financial savings it would not meet the Golden Rule.

In all cases, NHER allocates significantly greater savings to these packaged measures than RdSAP. This means that whereas the 'medium cost' package would not have been eligible for the Green Deal under RdSAP, it would be using NHER.

## 5.3 Variables

### *5.3.1 Repayment interest rate*

As with the RdSAP scenarios, increasing the repayment interest rate can affect the viability of some of these measures, reducing the net savings or resulting in a net loss. Increasing the interest rate to 10% would result in a net loss for the following measures:

- High-efficiency condensing boiler and controls: from £167/year profit to £39/year loss
- Energy-efficient glazing (new slim-profile double-glazing units fitted into existing single-glazed sashes): from £42/year profit to £61/year loss
- Internal wall insulation (blown beads): from £40/year profit to £3/year loss
- Upgrading existing external door: from £1/year profit to £8/year loss

Changing the interest rate to 10% also has a considerable effect on the annual profit of the following measures (although they remain positive):

- Reinstating timber shutters to windows: from £93/year to £15/year (84% reduction)
- Energy-efficient glazing (added acrylic or polycarbonate panes fitted to existing single-glazed windows): from £127/year to £84/year (34% reduction)

Changing the interest rate to 10% for the hot water cylinder and thermostat has minimal impact.

For the packaged measures, changing the interest rate to 10% has a considerable impact:

- 'Low cost' package: from £235/year profit to £134/year profit (43% reduction)

### *5.3.2 Inflation*

Applying a 15% increase in fuel costs has the greatest impact on the heating measures. For the electric heating system, the net balance would change from a £174/year loss to an £18/year loss. This measure would still fail to meet the Golden Rule, albeit marginally, and if

fuel costs were to rise by more than this it would become viable. For the high-efficiency condensing boiler, applying a fuel price rise of 15% increases the net balance from £168/year to £249/year.

### *5.3.3 Rebound effect*

Applying a rebound effect of 50% to the qualifying measures again has a significant impact. All of the following measures would now result in a net loss rather than a net profit:

- High-efficiency condensing boiler and controls: drops from £168 profit/year to £103 loss/year
- Reinstating timber shutters to windows: drops from £93 profit/year to £101 loss/year
- Energy-efficient glazing (new slim-profile double-glazing units fitted into existing sashes): drops from £42 profit/year to £73 loss/year
- Internal wall insulation (blown beads) : drops from £40 profit/year to £18 loss/year
- Upgrading existing external door: drops from £1 profit/year to £7 loss/year

Applying the 50% rebound effect to the remaining qualifying measures reduces the annual profits considerably:

- Energy-efficient glazing (added acrylic or polycarbonate panes fitted to existing single-glazed windows) : drops from £127 profit/year to £25 profits/year (80% reduction)
- Hot water cylinder thermostat: drops from £30 profit/year to £12 profit/year (60% reduction)
- Hot water cylinder insulation: drops from £60 profit/year to £27 profit/year (55% reduction)

Applying the rebound effect to the two qualifying packages of measures would result in the low-cost package dropping from £235/year to £26/year (89% reduction): a marginal profit given the high capital costs and likely disruption of the works.

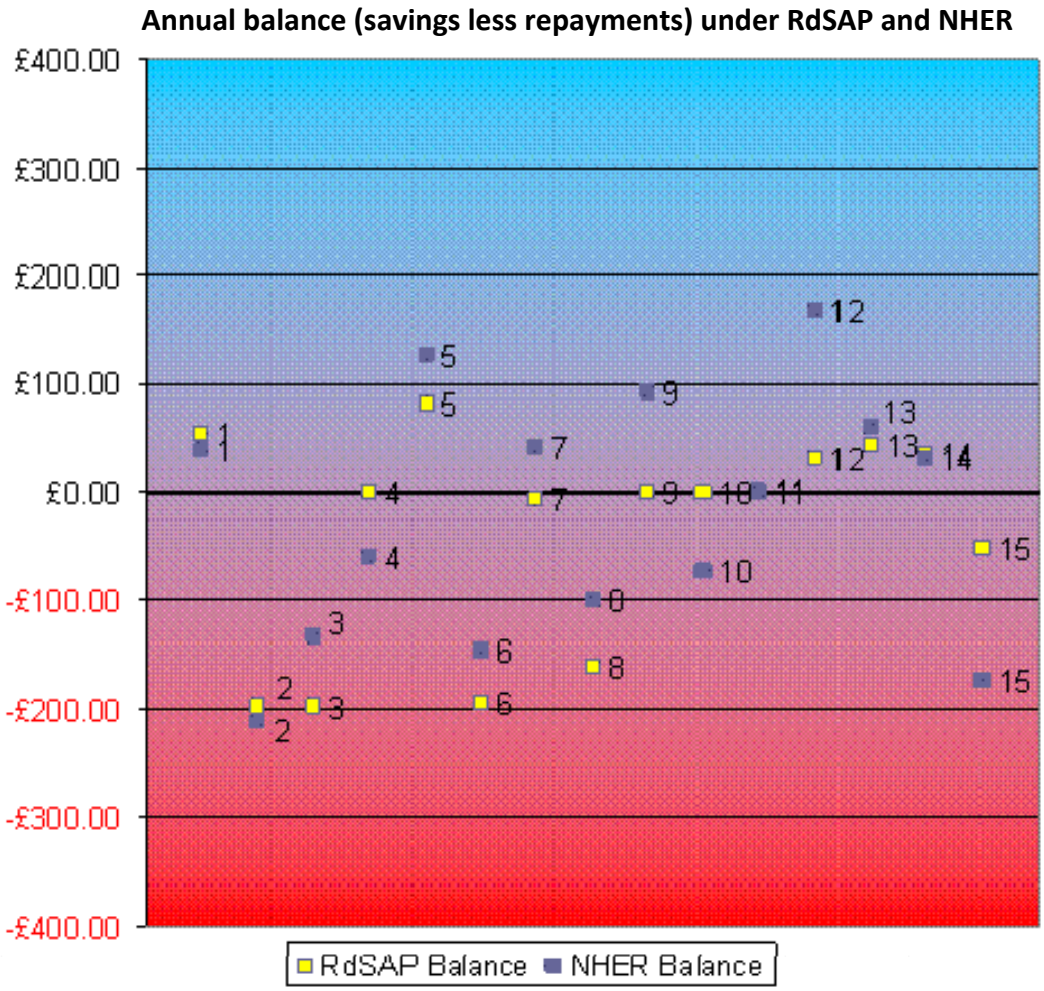
### *5.3.4 Other variables*

The other variables detailed in section 3.3 (heating patterns and user behaviour, and number of occupants) would have the same impact on NHER predictions as on RdSAP predictions.

# 6. Comparison and conclusions

## 6.1 Software

There is a clear difference between RdSAP and NHER in terms of which measures would qualify for the Green Deal's Golden Rule. Figure 3 below provides an illustration of this.




| KEY | | | |
|---|---|---|---|
| 1 | Internal wall insulation (blown beads) | 9 | Reinstating timber shutters to windows |
| 2 | Internal wall insulation (aerogel) | 10 | New high-performance external door |
| 3 | Internal wall insulation (wood fibre) | 11 | Upgrading existing external door |
| 4 | Draughtproofing | 12 | High-efficiency condensing boiler and controls |
| 5 | Energy-efficient glazing (added acrylic or polycarbonate panes) | 13 | Hot water cylinder insulation |
| 6 | Energy-efficient glazing (new timber sashes with conventional double-glazing) | 14 | Hot water cylinder thermostat |
| 7 | Energy-efficient glazing (new slim-profile double-glazing units in existing sashes) | 15 | Electric fan-assisted storage heaters and panel heaters |
| 8 | Energy-efficient glazing (added slim-profile window systems) | | |

**Figure 3. Annual balance under NHER**

Table 9 and Table 10 below show the savings predicted by RdSAP and NHER for both individual and packaged measures, with details of the assumptions made by each software. For each measure, the higher prediction is shown in bold. (N.B. These are savings only, not the net balance; this is shown in Figure 3 above.)

**Table 9. Annual savings by measures as predicted by RdSAP and NHER**

| Measure | Cost | RdSAP savings | NHER savings | RdSAP U-value assumptions | NHER U-value assumptions |
|---|---|---|---|---|---|
| 1. Internal wall insulation (blown beads) | £1,077 | **£130** | £116 | Drops from 1.5 (sandstone default) to 0.7 (internal insulation default) | Drops from 1.25 (Historic Scotland / Changeworks) to 0.7 |
| 2. Internal wall insulation (aerogel) | £4,616 | **£130** | £116 | Drops from 1.5 (sandstone default) to 0.7 (internal insulation default) | Drops from 1.25 (Historic Scotland / Changeworks) to 0.7 |
| 3. Internal wall insulation (wood fibre) | £4,616 | £130 | **£195** | Drops from 1.5 (sandstone default) to 0.7 (internal insulation default) | Drops from 1.25 (Historic Scotland / Changeworks) to 0.279 |
| 4. Window draughtproofing throughout | £1,800 | £0 | **£69** | *Draughtproofing cannot be modelled in RdSAP* | All windows treated |
| 5. Energy-efficient glazing (added acrylic or polycarbonate panes) | £1,093 | £160 | **£205** | Drops from 4.8 (single glazing default) to 2.4 (secondary glazing default) | Drops from 5.5 (Historic Scotland / Changeworks) to 2.5 |
| 6. Energy-efficient glazing (new timber sashes with conventional double-glazing) | £5,280 | £179 | **£229** | Drops from 4.8 (single glazing default) to 2 (post-2003 double glazing default) | Drops from 5.5 (Historic Scotland / Changeworks) to 1.8 |
| 7. Energy-efficient glazing (new slim-profile double-glazing units in existing sashes) | £2,640 | £179 | **£229** | Drops from 4.8 (single glazing default) to 2 (post-2003 double glazing default) | Drops from 5.5 (Historic Scotland / Changeworks) to 1.8 |

| | | | | | |
|---|---|---|---|---|---|
| 8. Energy-efficient glazing (added slim-profile window systems) | £4,800 | £179 | **£241** | Drops from 4.8 (single glazing default) to 2 (post-2003 double glazing default) | Drops from 5.5 (Historic Scotland / Changeworks) to 1.6 |
| 9. Reinstating timber shutters to windows | £1,980 | £0 | **£233** | *Shutters cannot be modelled in RdSAP* | Drops from 5.5 (Historic Scotland / Changeworks) to 2.2 (Historic Scotland / Changeworks). Assumes shutters are shut all the time. |
| 10. High thermal performance external door | £1,440 | £0 | **£29** | *Door upgrades cannot be modelled in RdSAP* | Drops from 2.75 (Historic Scotland testing) to 0.2 |
| 11. Upgrading existing external door | £208 | £0 | **£15** | *Door upgrades cannot be modelled in RdSAP* | Drops from 2.75 (Historic Scotland testing) to 0.4 |
| 12. High-efficiency condensing boiler and controls | £5,280 | £407 | **£542** | Boiler efficiency increases from 65% to 90.2%. Room thermostat, thermostatic radiator valves and timer added. Hot water tank insulation is increased from a 25mm jacket to 160mm jacket and a hot water tank thermostat is added. | |
| 13. Hot water cylinder insulation | £96 | £51 | **£67** | Hot water tank insulation is increased from a 25mm jacket to 160mm jacket. | |
| 14. Hot water cylinder thermostat | £96 | **£43** | £37 | Hot water tank thermostat is added. | |
| 15. Electric fan-assisted storage heaters and panel heaters | £2,376 | **£118** | -£5 | Existing gas boiler system is replaced with fan-assisted electric storage heaters and electric panel heaters provide secondary heating. The storage heaters are automatically controlled. Hot water tank insulation is increased from a 25mm jacket to 160mm jacket. Hot water is now dual immersion. | |

**Table 10. Annual savings by cost package as predicted by RdSAP and NHER**

| Measure | Cost | RdSAP savings | NHER savings | RdSAP U-value assumptions | NHER U-value assumptions |
|---|---|---|---|---|---|
| Low cost package | £2,570 | £356 | **£417** | as above | as above |
| Medium cost package | £8,888 | £374 | **£445** | | |
| High cost package | £16,616 | £501 | **£766** | | |

The main differences between RdSAP and NHER modelling are shown below:

- **Overall** – NHER assumes higher savings for 11 out of the 15 measures and for all three of the packaged measures, compared to RdSAP. One reason for this is that NHER assumes higher baseline running costs than RdSAP, so any predicted savings are likely to be higher.

- **Walls** – Under RdSAP, the predicted savings for internal wall insulation are the same regardless of the type of insulation used, whereas NHER allocates a significantly higher saving to the wood fibre insulation product (compared with blown beads or aerogel insulation). This may be due to the considerable extra depth of insulating material. The predicted saving for the wood fibre insulation product is significantly higher using NHER than RdSAP, but slightly lower than RdSAP for the two other products.

- **Windows –** NHER assumes a larger saving for all types of energy-efficient glazing in comparison to RdSAP (approx. 28 to 30% increase). RdSAP does not allocate any savings to draughtproofing or reinstating timber shutters; so NHER shows them in a much more favourable light. However, it is important to note that the considerable saving (£233/year) attributed to shutters using NHER is based on them being permanently closed. It is not possible to model measures on a part-time basis. So, it is inevitable that the real savings would be lower, as shutters will generally only be closed at night.

- **Door** – NHER assumes relatively modest savings for both upgrade and replacement, while RdSAP does not recognise the improvements at all.

- **Heating systems** – NHER assumes a higher saving than RdSAP for a high-efficiency boiler. This is probably due to the fact NHER assumes higher baseline energy consumption and running costs. Both RdSAP and NHER make the same assumptions as to the efficiency of the old boiler, and both are able to factor in the exact percentage of efficiency of the new boiler.

The greatest differences in predicted net balance (see Figure 3 above) arise with

- electric fan-assisted storage heaters and panel heaters, and
- high-efficiency condensing boiler and controls.

There are also considerable differences in predictions for:

- draughtproofing
- new slim-profile double-glazing units fitted into existing sashes
- added slim-profile window systems fitted to existing single-glazed windows
- added acrylic or polycarbonate panes fitted to existing single-glazed windows
- reinstating timber shutters to windows
- high thermal performance external door

These comparisons go some way to explaining the marked difference in the two lists of measures that would meet the Green Deal's Golden Rule.

As NHER is a more detailed software package than RdSAP and is more sensitive (in that some of its assumptions can be adapted by the user to tailor it more to the property in question); in many cases it can be said to be the more accurate of the two programmes. NHER also takes account of geographic location in the UK, unlike RdSAP, which should enable it to give a more accurate representation of Scotland's longer heating season and different weather conditions (compared with England). In addition, for the baseline (pre-improvement) energy consumption calculations, NHER is able to distinguish between primary (coal) and secondary (electric) heating source, and allocate kWh and running costs to each; RdSAP cannot do this, and so all heating kWh are attributed to coal. This affects the accuracy of the baseline figures, against which all improvement measures are modelled.

However, as stated earlier, any software is inherently generic, and the relatively high heating pattern assumed by both programs is likely to generate savings figures that could be lower in reality. It should also be noted that an improved version of RdSAP is likely to be used for actual Green Deal assessment purposes (see section 2.2.1), which among other things should be able to take account of geographic location.

### 6.2 Other variables

It is clear that the number of variables makes it impossible to predict savings with any degree of certainty. Repayment interest rates are shown to be of considerable importance, and fuel cost rises can make a significant difference to the viability of new heating systems. The capital costs for the different measures were provided by Historic Scotland, are based on pilot projects and in some cases partial measures, and include VAT. For a householder these costs may vary, and clearly if the installation costs rise significantly so, too, do the loan repayments, while the savings remain the same.

User behaviour is probably the greatest variable and cannot be factored into any savings prediction with accuracy: How many people live in a property, and how do they choose to

heat it? Applying the rebound effect was shown to have a considerable impact on the real viability of Green Deal finance for a number of measures.

One area not covered in this report is the cumulative impact of the modelled costs and savings. However, the key finding (unsurprisingly) was that over such a long repayment period (25 years), the extrapolated savings or losses could be considerable.

### 6.3 Concluding comments

This report explores a number of key areas in relation to the Green Deal, assessment tools and the eligibility of improvement measures needed for traditional stone-built tenement flats.

- A number of energy-efficiency measures have been found to be eligible under the Golden Rule using both RdSAP and NHER modelling, although under NHER modelling more measures would be eligible and the annual profits would be higher. It is significant that under the current version of RdSAP – the current tool of choice for Green Deal assessments – a relatively small number of measures would meet the Golden Rule; the majority would, therefore, require additional funding under the ECO.

- Of those measures that do meet the Golden Rule under RdSAP, there is only one window improvement option and one wall improvement option. This is doubly significant as neither of these is guaranteed to be eligible for Green Deal finance (see below and section 3.3), and if they were deemed ineligible this would leave no wall or window options open to occupants of traditionally built pre-1919 properties. The only other major improvement measure to meet the Golden Rule is a new boiler: the net balance is, however, relatively small under RdSAP and if the installation costs rose significantly (not inconceivable, given the complexities of many older properties) it could then fail to meet the Golden Rule.

- Some of the improvement measures modelled in this report may not be eligible for Green Deal finance despite meeting the Golden Rule. This could be significant in some cases. For example, the blown bead internal wall insulation would seem to provide a relatively affordable and beneficial wall solution for householders (minimal disruption, no loss of space) and, thus, may not require ECO subsidy. Indeed, it is the only wall improvement measure that meets the Golden Rule; both other options fall some way short. However, the real cost and applicability of this measure should be the subject of further scrutiny (including geographic presence of installers, typical costs, thermal imaging to detect and address missed areas and avoid thermal bridging, etc.), to ensure it satisfies the necessary criteria to be an eligible measure (see section 3.3). Draught-proofing, timber window shutters and external door upgrades also show savings under NHER but not under RdSAP. Whether they show savings under the revised version of RdSAP could be significant for many householders wishing to implement these measures.

- The issue of window versus wall insulation is of critical importance in the case of tenement properties. As mentioned previously, in many tenement flats (particularly those with bay windows) a relatively large proportion of the external wall area is actually windows, which are commonly single-glazed. These have a far worse thermal performance than 600mm of sandstone with a lath and plaster internal finish. This report shows that most window improvement options would not currently meet the Golden Rule due to their high installation costs. However, under current ECO proposals they would not be eligible for ECO funding without also installing wall insulation. In cases where there is little external wall area, this may not be the most effective solution (either in financial or energy-saving terms), and it may be sensible to focus solely on the windows. The current ECO proposal would not allow this.

**Figure 4.** Glazing forms a large proportion of many tenement walls

- The high number of variables in the financial modelling makes it impossible to guarantee that the savings calculated by either RdSAP or NHER (or any other modelling tool) will be delivered in practice. This could place more pressure on householders to manage their behaviour and energy use prudently, to try to maximise their chances of realising the predicted savings. However, this will only happen if they are aware of the issues raised in this report. This issue points to a future need for advice on and support for behaviour change and change to heating regimes in traditional properties in particular.

As a householder, the findings of this report should, therefore, be considered from two very different perspectives:

1. **Finance eligibility** – Will the measures I want to install be eligible for finance under the Green Deal (i.e. will they be predicted to save more than the repayments)?

2. **Finance viability** – If the measures are eligible and I receive finance, will I actually make the savings that were predicted? (If not, the householder will be paying more than they are saving.)

The latter point will be dictated by the level of ECO funding made available to particular products and installers. As this is a market-based mechanism, it is difficult to predict. It is likely that the products attracting the most ECO funding will be those that deliver the highest savings of carbon dioxide emissions and have the greatest market, rather than more specialist products. However, in the case of some stone-built properties – especially those protected by planning legislation – it is the specialist products (with a higher price tag) that will be required.

As the launch of the Green Deal draws nearer and consultation responses are considered by DECC, there will be a closer interest in this area. There is significant potential to revisit the modelling and findings of this report in the future – with the savings calculations, variables and property types modelled and analysed in more depth.

# Appendix

**Software used:**

NHER Stock Assessor v2.0.11 – RdSAP (SAP 2005)

NHER Plan Assessor v4.5 – NHER (SAP 2005)

**Fuel costs (incl. VAT):**

All fuel cost tariffs are taken from the Sutherland tables (October 2011).

Mains gas (heating, hot water and cooking) – 3.92p/kWh (8.64p/kWh first 2680kWh)

Electric (lights and appliances) –13.73p/kWh (25.23p/kWh first 900kWh)

Electric (white meter for storage heaters modelling) – day rate: 14.3p/kWh (26.65p/kWh first 900kWh) / night rate: 7.08p/kWh

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