July 2013

IN-DEPTH REPORT

FUTUREFIT

Monitored Data Analysis

Verco

Affinity Sutton

Document type:	Report
Client:	Affinity Sutton
Client contact:	Jeremy Kape, Alexandra Willey
Other details:	

Title:	FutureFit Phase 2 – Monitored data analysis
Date:	15/04/2013

Author:	Anita Baranyi
Signature	.... (hard copy only)
Date:	.... (hard copy only)

QA:	Pratima Washan
Signature	.... (hard copy only)
Date:	.... (hard copy only)

Author contact details

Email: anita.baranyi@vercoglobal.com

Telephone: 07787 975 248

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CONTEXT

FutureFit is Affinity Sutton's flagship project that aims to provide a unique insight into how the Green Deal could work in the social housing sector. A pilot was implemented in 2011, following which electricity and gas consumption was monitored for 101 retrofitted properties and another 49 properties that received lifestyle advice. This report presents the findings from the analysis of energy data for the FutureFit properties to reveal insights into the performance and financing of low carbon retrofit measures. The analysis was carried out for a sub-set of properties with reliable pre and post-retrofit data.

The key questions raised for the purpose of this analysis are:

- Did the households reduce their gas / electricity consumption post retrofitting works? If not, what could be the reasons?
- Did the households reduce their gas / electricity usage to the same extent as the SAP modelling? If not, what could be the reasons?
- Did the provision of lifestyle advice to tenants have an effect on gas / electricity consumption?
- In light of the total energy savings, what are the implications for financing retrofit measures via Green Deal for Affinity Sutton housing stock?

The conclusions drawn in this report reflect the situation for the FutureFit properties, and it is not possible to draw statistically significant conclusions for the wider population of retrofitted homes in the UK. Nevertheless, the analysis provides valuable insights on likely trends.

KEY FINDINGS

- When compared to pre-retrofit energy bill data, most households reduced their space heating energy consumption post-retrofit.
- In contrast, most households did not reduce their electricity consumption post-retrofit although the data showed huge variations. The likely reasons for the large positive and negative fluctuations are unexplained.
- Considering total energy bills, the general increase in electricity consumption and the higher unit price of electricity eroded the positive gas bill savings for a number of properties.
- Most households did not reduce their energy usage post-retrofit to the same extent as the SAP modelling predicted. There is likely to be a combination of reasons for this:
    - SAP modelling overpredicts baseline energy use in a household and therefore the proportion of energy saved will be greater in absolute terms
    - Implementing energy efficiency measures in reality does not result in as high energy savings as SAP predicts.
    - For the FutureFit properties, the proposed in-use factors that aim to reduce the SAP modelled energy savings for specific measures account for less than half of the unrealised SAP energy savings.

    - There was evidence of underheating for some properties. When the tenants are underheating their homes, the works carried out will bring smaller energy bill savings in absolute terms than SAP estimates.
    - Based on tenant surveys, one likely reason for the unrealised space heating savings could be the difficulty experienced in using some of the installed equipment (e.g. zoned heating).
- It appears that lifestyle advice may have had a positive effect on energy savings for the FutureFit properties; especially on gas consumption as the trend in the electricity saving figures were inconclusive.

Further findings

- There appear to be no higher gas savings associated with the medium package of works compared with the low package of works. At the same time, tenants in a property with medium a retrofit package did not report feeling warmer than those living in a home where low package of measures was installed.
- Examining the gas savings on a per archetype basis showed no obvious pattern. However, older, larger properties (archetypes 7 and 13) look to be the 'best performing'. Archetype 7 was the only archetype to show a positive NPV for a low carbon package of works in the Green Deal financial analysis conducted previously. Archetype 7 is a house built between 1930 and 1949 with cavity walls.
- There is evidence to suggest that the tenants' perception of their energy consumption pattern can be very different from reality.

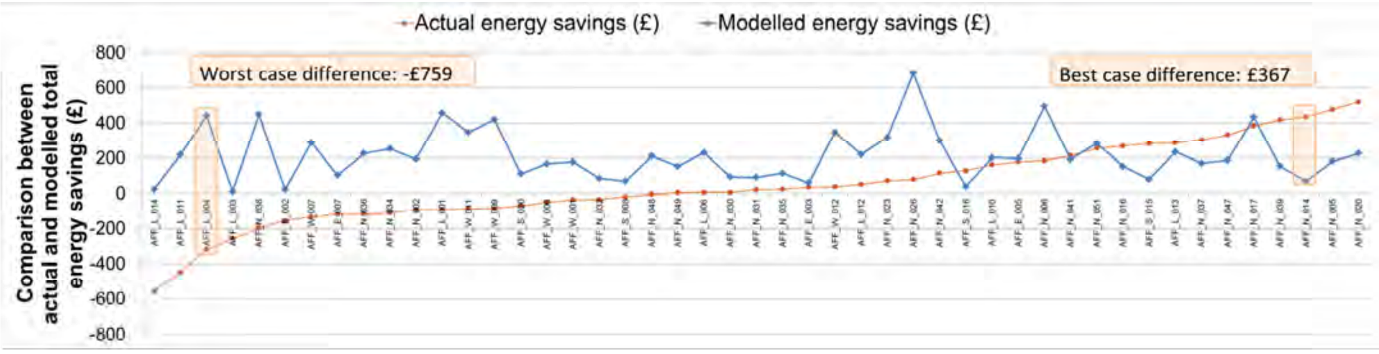
COMPARISON OF MODELLED AND ACTUAL ENERGY SAVINGS

Gas heated properties

The data shows huge variability in actual and modelled energy savings as shown in the figure below. There are 47 gas heated retrofitted properties with reliable gas and electricity data and they are arranged in increasing order of actual savings (red line). The red line crosses the zero line about half way. On the right are 27 properties that saved on their total energy bills and on the left the 20 properties that increased their bills post-retrofit. The properties that lie towards the extreme right hand side of the graph are the properties where the actual energy savings are higher than the modelled savings. Only 10 out of the 47 gas heated properties would have benefited from Green Deal financing based on their actual savings.

Across the 47 gas heated properties, the average modelled savings is £217. In comparison, the average actual energy savings are 77% less, or about £49. This equates to actual carbon dioxide emission reductions for the gas heated properties of 245kgCO_2/year on average.

Actual and modelled total energy savings for gas heated properties (£)



Electrically heated properties

The 7 electrically heated properties with reliable data saved on average £557, which equates to a carbon emission reduction of 1873kg CO_2/year. Households saved on average more than the SAP predicted savings of £364. All electrically heated properties decreased their bills. The magnitude of savings was between £50 and £1470.

Combined average

Considering the ratio of gas heated and electrically heated properties in Affinity Sutton's stock, the weighted average savings are indicated in the table below. Only 40% of the modelled savings are realised in actual. The same weighted average approach shows that three quarters of properties saved less on energy bills than SAP predicted. The application of in-use factors will make up for some but not all of this shortfall; assuming that they will be applied to the Green Deal financial calculations.

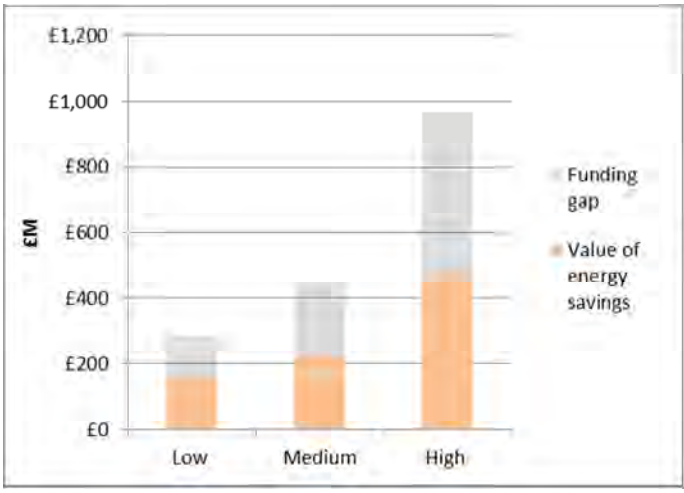
Summary of total energy savings

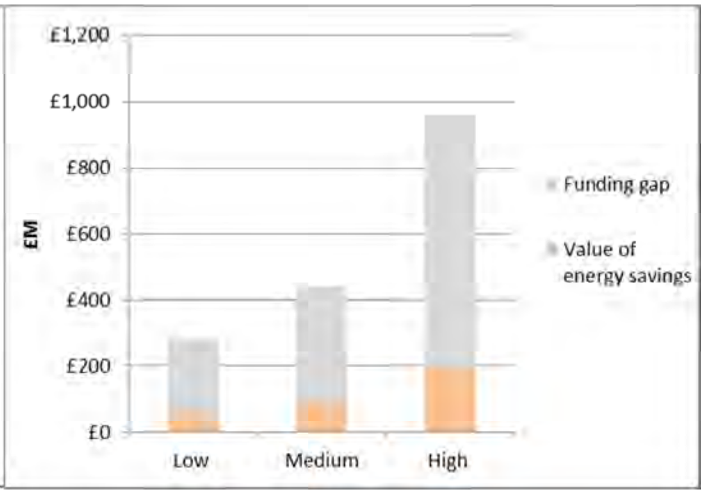
TOTAL ENERGY	Sample size with reliable data	No. of properties that saved on bills	No. of properties that didn't save on bills	Average saving - actual	Average saving - modelled	Realised SAP savings	Didn't realise SAP savings
Gas heated properties	47	27	20	£49	£217	10	37
Electrically heated properties	7	7	0	£557	£364	4	3
Weighted average (as per stock prevalence)	NA	61%	39%	£90	£229	24%	76%

GREEN DEAL IMPLICATIONS

Previously, a technical and financial analysis[1] was undertaken by Verco to understand the potential to finance a retrofit programme by capturing the revenue from energy savings. The NPV (Net Present Value[2]) of the modelled energy savings were significant in magnitude but only covered around half of the capital costs of energy efficiency measures. The findings from this study indicate that only 40% of the modelled savings was realised on average for the FutureFit properties. This will widen the funding gap further as illustrated in the figures below.

Implications of unrealised SAP savings on the retrofit investment funding gap





However, on an individual property basis the picture is not quite homogeneous. The inconsistency in modelled versus actual savings highlights a key issue: while averages indicate an overall trend, the range of the underlying data points is also important. Whilst overall the SAP modelled savings were higher, the consequences of signing up to the Green Deal based on modelled savings is very different for the properties that didn't achieve the level of savings SAP predicted compared to the ones that overachieved.

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[1] Report available at www.affinitysutton.com/PDF/FutureFit%20Finance%20Programme_Final%20report.pdf

[2] Net Present Value (NPV) is a standard method for using the time value of money to appraise long-term projects. A discounted cash flow analysis was carried out taking into account the capital and maintenance costs for the measures and the value of energy savings over a 20 year period. The discount rate used was 6% which broadly reflects the cost of capital for Affinity Sutton

1. Introduction

1.1 Context

FutureFit is Affinity Sutton's flagship project that aims to provide a unique insight into how the Green Deal could work in the social housing sector. Previously, a technical and financial analysis using modelled energy data was undertaken by Verco to understand the potential to finance a retrofit programme by capturing the revenue from energy savings[3]. The NPV (Net Present Value[4]) of the modelled energy savings were significant in magnitude but only covered around half of the capital costs of energy efficiency measures.

Under the FutureFit project, a retrofit pilot was implemented in 2011, following which 12 months of monitored electricity and gas consumption data was collated. The pilot included 101 properties that had low / medium / high levels of energy efficient work packages installed and another 49 properties whose residents received energy conscientious lifestyle advice. Around half of the retrofitted properties were also visited to give lifestyle advice. The monitored energy data was analysed and compared with pre-works energy consumption data from bills, and modelled energy consumption data calculated using SAP 2005 methodology. This report presents the key findings of this in-depth data analysis carried out by Verco and reveals further insights into the performance and financing of low carbon retrofitting, based on the comparison of actual and modelled energy bill savings.

Due to the sample size and the process for selecting properties it is not possible to draw statistically significant conclusions and to carry out hypothesis testing, i.e. the conclusions drawn in this report reflect the situation for the FutureFit properties, and may not necessarily apply to the wider population of retrofitted homes in the UK. Nevertheless, the analysis provides valuable insights on the potential energy savings for individual properties as well as overall trends for particular set of properties.

1.2 Aims and objectives

The aim of this report is to analyse the energy savings realised from retrofitting works based on monitored consumption and the implications of this for the financial analysis conducted previously using modelled energy data. The key questions to investigate are:

- Did the households reduce their gas / electricity consumption post retrofitting works?
- Did the households reduce their gas / electricity usage to the same extent as the SAP modelling?
- If not, what could be the reasons why?
    - How accurately does SAP estimate energy consumption?
    - Is there a difference between the actual and predicted proportion of energy saved due to the low carbon works?
    - Do in-use factors applied to the SAP savings account for the unrealised modelled savings?

[3] Report available at www.affinitysutton.com/PDF/FutureFit%20Finance%20Programme_Final%20report.pdf

[4] Net Present Value (NPV) is a standard method for using the time value of money to appraise long-term projects. A discounted cash flow analysis was carried out taking into account the capital and maintenance costs for the measures and the value of energy savings over a 20 year period. The discount rate used was 6% which broadly reflects the cost of capital for Affinity Sutton.

    - Are the properties under or overheated?
    - Is the installed equipment used correctly?
    - Does the qualitative data from the residential survey provide any explanation?
- What effect does giving lifestyle advice have on energy consumption?
- In light of the energy savings analysis results, what are the revised conclusions with regard to the relevance of Green Deal as a financing mechanism for upgrading for Affinity Sutton's housing stock?

Alongside these key questions that make up the primary analysis, the FutureFit dataset is suitable to examine the following aspects:

- Do households that had more extensive retrofitting works carried out save proportionately more energy?
- Do the energy savings vary on an archetype basis?
- How do tenants' perception of energy use post installation compare with monitored energy use?

2. Methodology

As part of the pilot, data loggers and internal temperature sensors were installed into each of the 150 FutureFit properties. Over 12 months of data was collected. Prior to the statistical analysis, the data was checked for outliers and abnormality and the unreliable data was separated out. Degree days were factored in to account for the differences in external temperature by region compared with the assumptions in SAP model. The next section explains the data preparation steps in more detail.

A summary of the sample size by different categories of data (heating fuel, data reliability and intervention type) is provided in Appendix 3.

2.1 Data preparation

The rigorous energy data preparation was conducted in five stages, which is explained below. Attention to detail was important in order to maintain data integrity and confidence in the conclusions.

1. **Data specification** – data inputs for the analysis were specified as below:
   - **Actual pre**: annual gas and electricity consumption derived from energy bills prior to the date of works carried out / behaviour advice received (i.e. intervention). The bills used were selected according to two rules:
     i. Bills' end date to be as close to the start of the intervention as possible
     ii. Bill data spanning as close to 365 days as possible

     Start and end dates of the bills were chosen as per the rules above. Useable days, i.e. the number of days between the start and end dates of the bill period to be used for pro-rating consumption to an annual figure, were then worked out.
   - **Actual post**: monitored gas and electricity consumption as measured by sensors installed in each of the properties post- intervention.

     The first 365 days of energy consumption data was recorded. Useable days, i.e. the number of days within this one year period where data was available, were recorded. (Some gaps in data availability occurred due to data logger batteries running out, main supply switched off, incorrect installation, and other issues)
   - **Modelled pre**: annual gas and electricity consumption pre intervention as estimated by SAP modelling based on the property characteristics
   - **Modelled post**: annual gas and electricity consumption post intervention as estimated by SAP modelling based on the property characteristics
   - **Dwelling internal temperature:** living room temperature as recorded by sensors every 5 minutes

2. **Data review and cleanse** – The datasets above were sense checked and reviewed for missing data. Initial graphs of the data collected revealed a number of outliers. Sense checking against magnitude and trend led to double checking some of the original bills provided by energy companies (to verify the presence of imperial meters and correct start dates), revisiting

the notes logged against sensors (some were recalibrated and not noted) and re-modelling of some of the archetypes in SAP.

3. **Data integrity indicator** – The actual (pre and post) datasets were pro-rated based on the 'useable days' in order to work out the energy consumption for exactly 365 days. Annual energy consumption figures that are extrapolated from less or more than 365 days data may be skewed. The lower the number of useable days, the less the confidence in the accuracy of the annual energy consumption figures. Similarly, in case of energy data from bills, if the usable days are more than 365 days, this will also impact results due to the variations in energy consumption patterns over the year depending on the season. Therefore red, amber or green (RAG) indicators were assigned for each of the pro-rated gas and electricity actual consumption figures based on the rules in the following table:

Table 2-1 Data reliability - RAG rules for useable days

Useable Days	Green	Amber	Red
Actual pre	365 days + or – up to 3 weeks (344< Green < 386)	365 days + or - up to 3 months (272 < Amber < 344 386 < Amber < 458)	365 days + or - 3 months or more 272 > Red 458 < Red
Actual post	365 days + or –6 weeks (323< Green < 407)	365 days + or - up to 3 months data (272 < Amber < 344 386 < Amber < 458)	365 days + or - 3 months or more 272 > Red 458 < Red

Where the useable days were 365 days + or – maximum 21 days (i.e. 3 weeks) the corresponding pre-intervention annual energy consumption figure was deemed as fairly accurate and given a 'green' status. For the post-intervention annual consumption figures, the 'green' threshold was relaxed to 42 days (i.e. 6 weeks), as the data gaps tended to be relatively shorter periods dispersed around the year. The 'red' threshold was set at greater than 3 months; 3 months or more of missing data could exclude the principal cold or warm seasons entirely making the pro-rated energy consumption figure very unreliable.

4. **Data normalisation** – Actual pre and post data does not come from exactly the same one year period. In order to achieve a fair comparison of energy use over the timeframe, degree-days were factored in. Degree-days give an indication of the relative external temperatures over specified time periods. It was revealed that the post intervention year's winter in most cases (i.e. for the majority of property locations) was milder than the pre-intervention winter. As external temperatures affect the space heating demand, the space heating proportion of the gas consumption figures were adjusted by a degree day scaling factor. This way a direct comparison of gas consumption in a colder vs. a warmer winter was possible in a statistically robust way. The following points minimised the margin of error in this normalisation exercise:
   - The scaling factor was different for each of the five geographical regions the properties are located in.
   - The space heating proportion for each property was specified using the corresponding archetype SAP model.

- The actual consumption figures were brought in line with the degree days used in SAP modelling to ensure fair comparison of the actual and modelled data points.

5. **Data selected for statistical review** – The pro-rated, degree-day normalised dataset was filtered to omit all data with poor integrity ('red' status) to ensure that the analysis is conducted on a robust dataset. For the gas consumption analysis, properties with 'red' gas data (or no gas data) for the pre actual or post actual figures were omitted. The same exercise was conducted separately for the electricity usage analysis.

2.2 Data limitations and modelling assumptions

There key data limitations are outlined below.

Firstly, pre-works energy bills for a suitable time period were not available for all the properties. For example, most of the high package properties were void pre-installation.

Secondly, missing energy data was estimated by pro-rating according to 'useable days'. As an example, annual energy consumption may have had to be extrapolated from 6 months of mainly summer consumption due to the frequency of energy billing or, in case of post-works data, the length of time the monitoring equipment was down. There is a clear bias in this extrapolation for the estimation of annual heating and lighting energy used. These two limitations have been mitigated by the RAG indicators explained in the preceding section denoting data quality and the exclusion of the 'red' status properties from the analysis.

Thirdly, only 41% of the energy bill data pre-intervention was based on actual readings, with the remaining 59% being either based on estimated bills by energy companies or the source of bill data being unknown. This will inevitably reduce the accuracy of the actual pre-works data.

Finally, whilst the SAP modelling carried out was mostly based on the actual property characteristics, archetype modelling was used as an estimate for modelling the 49 lifestyle advice properties and 26 of the retrofitted properties.

Further limitations of the dataset and the modelling assumptions made include:

- Degree day normalisation for each property was based on a regional average.
- Energy used for heating only was not monitored / cannot be deducted from bills and therefore hot water and heating consumption ratios from SAP models were used as a proxy.
- The difference in actual occupation compared to SAP assumptions is unknown. This would have a significant impact on hot water usage.
- The SAP formula to calculate appliance use includes some gas consumption for cooking which can affect the overall accuracy of the estimate.
- Gas consumption was monitored in volume (m^3) of gas. Its calorific value varies marginally each day by location of natural gas delivery. A factor of 11.2 for was used to convert to kWh, based on the average calorific value for England between 1st May 2011 and 30th April 2012.

- Individual boiler efficiencies are unknown so properties with a lower efficiency boiler than SAP assumes would have used more gas to heat the internal space than SAP predicts. This adds an unknown variable when assessing the energy savings realised from insulation measures.
- The data loggers installed to monitor electricity usage in the properties were assumed to have minimal impact on the average annual electricity consumption: This is estimated to be around 44kWh/year.

In subsequent sections, all energy cost savings are based on unit costs of 4.43p/kWh and 14.48p/kWh for gas and electricity respectively (DECC Dec 2012). The carbon emissions factors used are 0.487 kgCO_2/kWh for electricity and 0.194 kgCO_2/kWh for gas consumption.

2.3 Internal temperature

To better understand patterns of underheating / overheating and in turn the impact of these on energy savings in the FutureFit properties, two parameters were derived from internal temperature data measured at 5 minute intervals:

- The % of time the heating was on in a particular property;
- The average maximum daily temperatures.

The assumptions made to derive these parameters are as below:

- For the sake of simplicity, data for the three core winter months from Dec- Feb was used.
- The tenant did not leave the property vacant for a significant time period during these 3 months.
- The % of time the heating was on is estimated by assuming this time period equates to increasing temperatures. This estimation is relatively simplistic as it does not take into account other factors that can impact internal temperatures (e.g. sudden change in external temperature).
- Maximum daily temperature is used as a proxy for thermostat temperature setting.

3. Gas consumption analysis

The retrofitted properties had a number of energy efficiency measures installed, mostly impacting on the energy needed to heat the properties to a comfortable temperature. This section of the report investigates the questions raised in section 1.2 'Aims and objectives', with respect to gas consumption.

3.1 Sample size

An analysis was conducted on properties whose RAG rating was green or amber, disregarding properties where any of the actual gas pre or post data was flagged as red. The final sample size of properties is as follows:

Table 3-1 Number of properties in the cleansed dataset

Total included: 82	Advice	Works only	Works and advice
Green and amber properties	26	29	27

There are 82 properties in the green and amber dataset. The remaining 68 properties were not included due to the following reasons:

Table 3-2 Number of properties excluded from the dataset

Total excluded: 68	Electric property	Actual pre works data 'red'	Actual pre works data not available	Actual post-works monitored data 'red'
Number of properties	15	18	29	6

3.2 Actual gas savings

Figure 3-1 and Figure 3-2 show actual gas savings in £s and as a % of the baseline gas consumption pre-works for the 82 properties analysed. The graphs show that 60 out of the 82 properties saved on their gas bills, but some others increased their gas consumption significantly. In case of retrofitted properties (works only or works and advice) 45 out of the 56 decreased their gas bills. The 56 retrofitted properties saved £72 on average, ranging from -£260 to £350 for individual properties. The 26 advice properties saved £42 (see section 3.5.1).

There are 4 retrofitted properties where the gas bills increased by more than 50% (more than 100% in two retrofitted cases). This unexpected result has to be viewed in the context of the data and modelling limitation outlined in section 2.2. Such extreme data points will inevitably skew the calculated averages. Further analysis and engagement with the residents is needed to investigate the validity of these data points. If these four retrofitted properties were to be disregarded from the analysis, the average actual saving for the retrofitted properties would be marginally higher at £87.

Figure 3-1 Annual saving in gas consumption (£s)

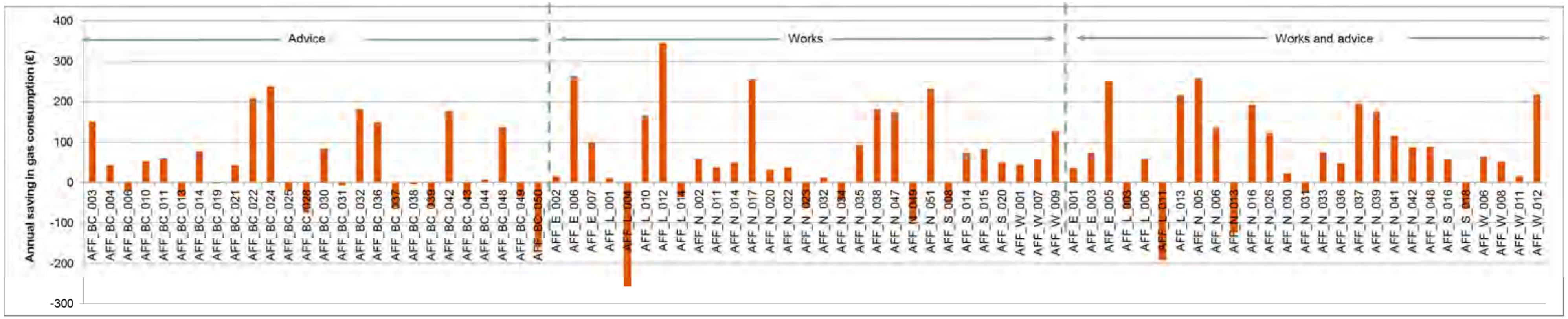
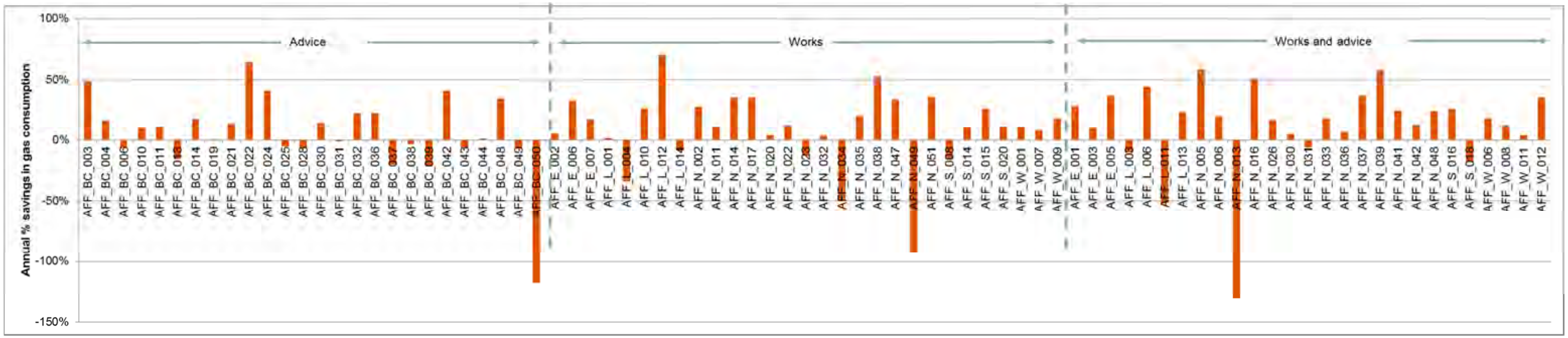


Figure 3-2 Annual saving in gas consumption (% of baseline)



Survey responses for the worst performing properties (i.e. those households that increased their actual gas bill by 10% or more were collated. These are shown in Figure 0-2 in Appendix 1. The answers (where existed) did not provide an explanation to increased gas bills. In fact, these tenants tended to agree with the statement that they saved money post intervention. This highlights a key point: a tenant's perception of their energy consumption pattern can be very different from reality. With direct debit payments, estimated bills, increased energy prices and differences in weather from year to year, it can be very hard for a tenant to have a good enough understanding of their energy consumption trends.

3.3 Actual savings vs. SAP modelled savings for retrofitted properties

Figure 3-3 compares actual and modelled gas savings for the 56 retrofitted properties. The red dots are the actual gas savings and the blue dots are the savings predicted by SAP models. While most properties did save on their gas bills, the savings were not as high as the SAP modelling estimated.

The average of the modelled savings is £153, but only £72 or about half of this saving was realised on average. This equates to a 53% reduction on predicted savings. Even if the four retrofitted properties with questionable data (see section 3.2) were to be disregarded, the revised modelled average saving would be £150 compared to a revised average actual saving of £87, which equates to a 42% reduction on predicted savings.

Figure 3-4 shows the mathematical difference between actual savings and SAP savings (i.e. actual savings minus SAP modelled savings). 36 of the 56 properties are below the zero line. These are the properties where SAP overestimated the gas savings. In fact, for 19 properties SAP overestimated savings by more than £100. At the same time, for 20 of the 56 properties the bars are above the zero line, indicating that the properties saved more than SAP estimated. This inconsistency highlights a key point: while averages indicate an overall picture, the range of the underlying data points is also important. Whilst overall the SAP models tend to overestimate savings, the consequences of signing up to the Green Deal based on modelled savings is very different for the 36 properties which didn't achieve the level of savings SAP predicted and the 20 which overachieved.

Table 3-3 Actual and modelled gas savings from retrofitting

	All works properties	
	Actual	Modelled
Average saving (kWh)	1,631	3,455
Average saving (%)	15%	22%
Average cost saving (£)	£72	£153

Figure 3-3 Comparison between actual and modelled gas savings (£) for retrofitted properties

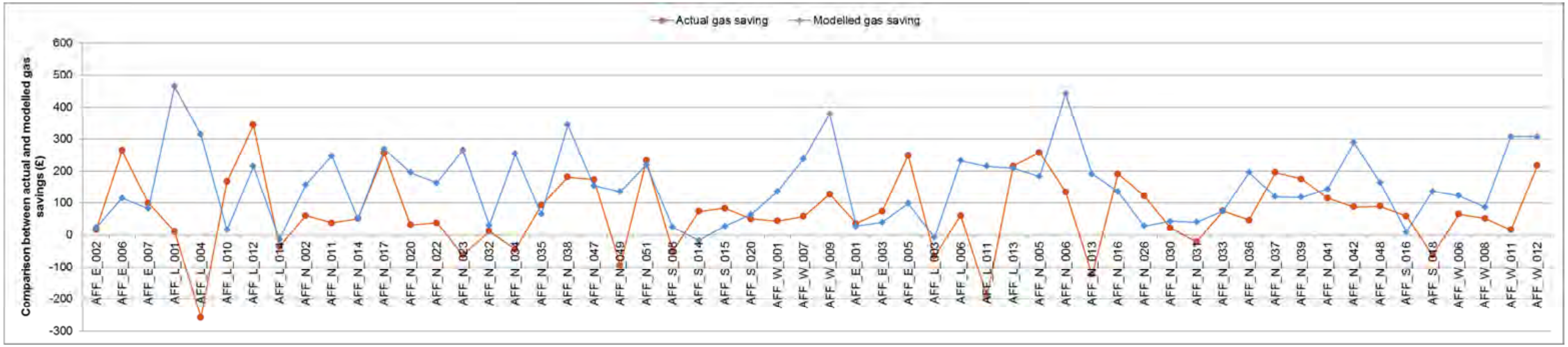


Figure 3-4 Difference between actual and modelled gas savings (£) for retrofitted properties (actual savings minus modelled savings)

3.4 Exploring potential reasons for unrealised SAP savings

This section explores the potential reasons for the differences between the gas bill savings predicted by SAP versus actual savings realised through installed low carbon measures. Possible explanations could include:

- SAP modelling overpredicts baseline energy use in a household and therefore the proportion of energy saved will be greater in absolute terms.
- Implementing energy efficiency measures does not result in as high energy savings as SAP predicts due to difference in performance standards (e.g. product efficiencies or U-values) or quality of installation. Could in-use factors rectify this?
- The tenants find the installed equipment difficult to use, which may compromise its performance
- The tenants are underheating their homes (i.e. either heating it to a lower temperature than what is considered adequate or running the heating for a limited number of hours), and therefore the works carried out will bring smaller energy bill savings in absolute terms than SAP predicts.
- The tenants are overheating their homes post-works compared to pre-works, i.e. comfort take. This potential reason is not investigated in the analysis due to the unavailability of pre-works internal temperatures.

3.4.1 SAP overpredicts baseline consumption for space heating

Comparing the actual pre-works and modelled pre-works gas bills for the 82 properties analysed reveals that the SAP predicted baseline gas bill is much higher than actual gas bills in most cases. On average, the modelled pre-works bills are higher by 50% or £235 as shown in Table 3-4 below. Please refer to Figure 0-1 in the appendices for the full dataset.

Existing body of research on the SAP methodology corroborates this finding. The DEMScot report (Modelling Greenhouse Gas Emissions from Scottish Housing: Final Report, 2009) notes that in old dwellings SAP can over-predict space heating energy because old dwellings are often heated to a lower standard than modern ones, a compromise between running costs and thermal comfort on the part of the occupants of older dwellings. The modelling for this report was conducted in SAP 2005 but the next version of the methodology, SAP 2009, is not expected to change in this regard.

Given this over-prediction in modelled baseline gas consumption, even if the proportion (or percentage) of energy savings realised in actual were similar to those predicted by SAP, the actual savings will be lower in absolute terms. It is therefore reasonable to conclude that this over-prediction does account in part for the unrealised savings.

Table 3-4 Actual and modelled gas pre-intervention baseline

	Pre actual	Pre modelled
Average gas consumption (kWh)	10,590	15,883
Average gas bill (£)	£469	£704

3.4.2 SAP overpredicts the energy savings from individual retrofit measures

Another likely reason for the unreleased savings could relate to the underperformance of the individual retrofit measures compared to SAP estimates. While the data collected as part of the FutureFit project does not allow the performance of individual measures to be appraised, the dataset does provide some general indicators. The average property saved 15% compared with 22% from the SAP modelling[5]. If the over-prediction of baseline consumption as discussed in Section 3.4.1 above accounted for all of the difference, we would expect to see a proportionate saving in actual gas bills of 22% on average. A 15% average saving indicates that there are other factors at play, potentially relating to the performance of the individual measures. In the Green Deal guidance issued by DECC, this issue of underperformance has been acknowledged. To rectify this problem, the Green Deal finance calculation now includes certain correction factors for each measure, referred to as 'in-use' factors. So could in-use factors account for the unrealised savings?

There are still uncertainties surrounding the exact application of in-use factors. The factors range from 25-35% for insulation measures such as wall and loft insulation, and between 10-15% for other energy efficiency measures such as draft proofing, replacement glazing, and cylinder thermostat.

Considering the retrofitted measures implemented at the Affinity Sutton properties, the application of in-use factors would result in a reduction of around 15-25% on SAP modelled savings. This is still significantly short of the 53% average reduction in actual savings (£72) compared to SAP modelled savings (£153). On an individual property basis this shortfall can be even more significant.

To conclude, in-use factors alone do not account for the unrealised savings in the FutureFit properties.

3.4.3 Ease of use for installed equipment

The tenants in properties that had works done were asked whether they found the equipment installed hard to use. In their responses, some of the tenants highlighted zoned heating and heat recovery fans as particularly problematic in this regard. The full results are shown in Figure 3-5.

The analysis shows no obvious correlation between a yes/no answer and positive savings, although it appears that the 'yes' properties saved less. However, 7 data points is a small sample for drawing any conclusions. 5 out of the 11 properties which did not reduce their gas consumption at all answered this question, out of which 3 found the equipment hard to use.

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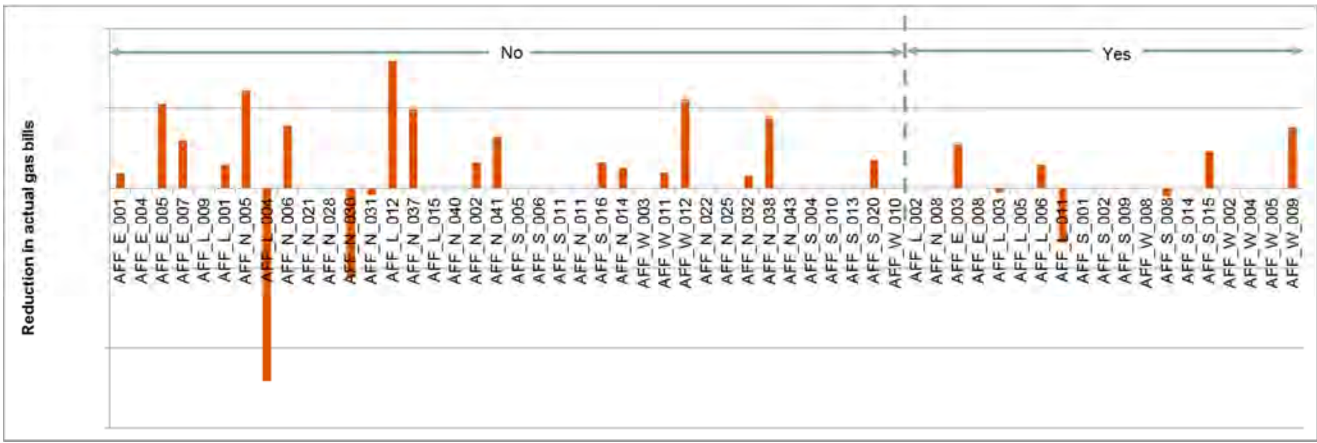
[5] Out of the 56 retrofitted properties, 45 saved on their gas bill in actual; the remaining households increased their gas usage. As outlined in section 3.1, there are four properties which increased their gas consumption between 50% and 130%. Due to the data and modelling limitations mentioned earlier and resident specific issues being currently explored, these data points may not be fit for purpose. 17% is the average actual saving reduction excluding the four properties. This is closer but still below the revised modelled 21%.

Figure 3-5 Residential survey – Did you find the installed equipment hard to use?



3.4.4 The tenants underheat their properties

This section investigates whether the internal temperature data available explains some of the unrealised savings in gas bills. Two parameters were derived from internal temperatures measured at 5 minute intervals (see assumptions made in section 2.3):

- The average maximum daily temperatures over a three month period from Dec- Feb.
- The % of time when the heating was on.

Figure 3-6 shows the distribution of average maximum internal temperature for the 150 FutureFit properties. They vary considerably between the households; from 14°C to 26°C with an average of 21.6°C

Figure 3-6 Average maximum internal temperatures

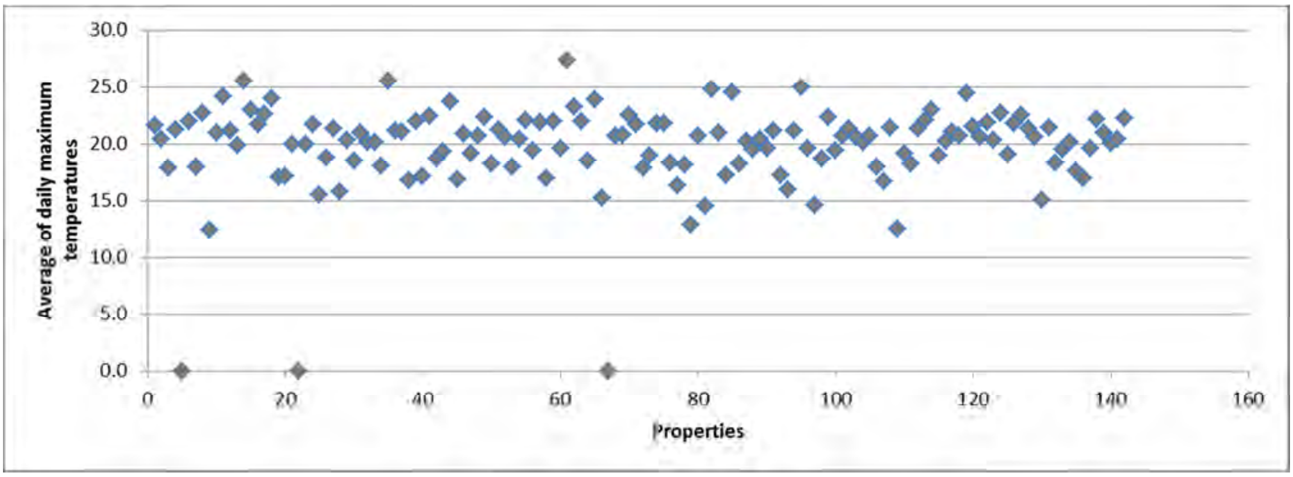
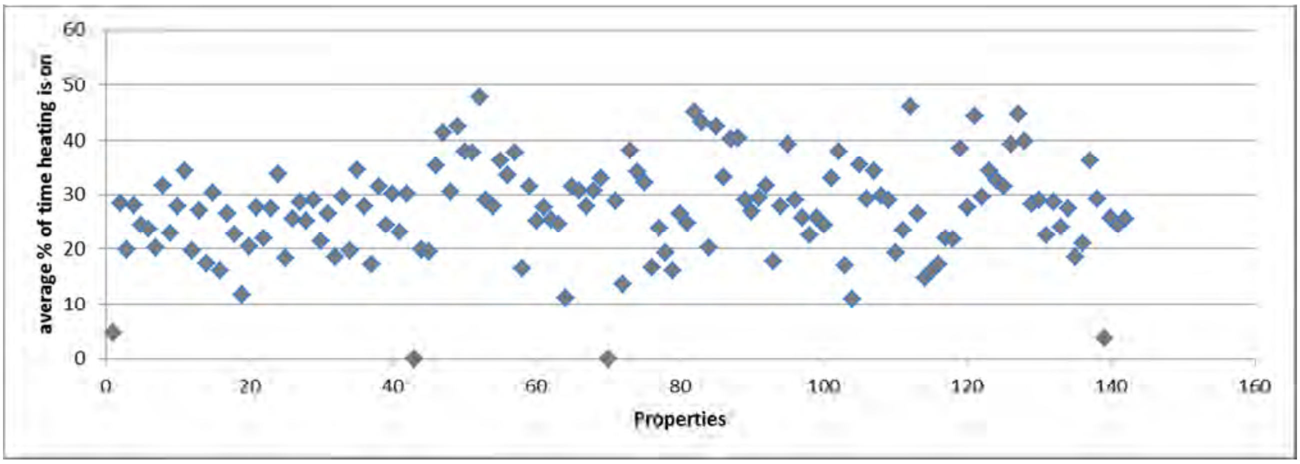


Figure 3-7 shows the percentage of time the properties were heated on average over the three month winter period. This variable also varies considerably from 10% to 45%, with an average of 26%.

Figure 3-7 Percentage of time properties heated



The analysis suggest that the heating patterns of tenants cover a wide range, and therefore tend to be in certain instances very different from SAP assumptions.

The analysis also indicates that underheating (i.e. either lower internal temperatures or reduced heating hours) may be a contributing factor to unrealised SAP energy savings in certain (but not all) properties, as discussed below.

The internal temperature figures for the 8 properties that had the highest unrealised gas savings compared to SAP were investigated as shown in Table 3-5. The rankings column refers to the position of the property relative to the other 82 FutureFit properties; lower internal temperatures and shorter heating periods are denoted by the smaller numbers.

The three highlighted households have rankings in the bottom third of the dataset (i.e. they have amongst the lowest internal temperatures and shortest heating period). Two of these properties, N_034 and N_013, have unusually small gas consumption bills, which supports the findings from the internal temperature analysis.

Table 3-5 Properties with lowest gas savings compared to SAP modelling

	Average max temp.	Temperature ranking	% time heating on	Heating on ranking	Actual pre-works (kWh)	Actual post-works (kWh)	Modelled pre-works (kWh)	Modelled post-works (kWh)	Actual savings kWh	Modelled savings (kWh)	Act - Mod savings (£)
AFF_N_034	18.0	11	18%	11	2,107	3,146	16,182	10,447	- 1,039	5,735	- 300
AFF_W_011	18.4	14	21%	23	9,390	9,041	19,910	12,969	349	6,941	- 292
AFF_N_013	19.9	24	19%	14	2,146	4,949	11,661	7,353	- 2,804	4,308	- 315
AFF_L_001	20.1	26	29%	49	16,765	16,523	23,176	12,693	242	10,483	- 454
AFF_N_006	20.8	32	38%	73	15,512	12,475	25,439	15,478	3,037	9,961	- 307
AFF_L_004	21.1	34	34%	64	16,969	22,790	18,743	11,652	- 5,822	7,091	- 572
AFF_W_009	21.3	37	27%	40	15,997	13,124	19,910	11,374	2,873	8,536	- 251
AFF_N_023	26.3	75	42%	78	11,310	12,716	17,455	11,457	- 1,405	5,998	- 328

For the remaining properties in the table, the energy data was overlaid with other supplementary information from tenant surveys to understand the likely reasons for the unrealised savings. There is likely to be a combination of reasons such as SAP overestimation of energy bill and /or the effects of the works, comfort take, difficulty in using the installed equipment and underheating among others. Based on the data availably it is not possible to state the exact combination of reasons for the unrealised gas savings for each property.

3.5 Further analysis

The analysis so far focused on the actual gas savings and the extent to which savings predicted by SAP were realised following the installation of the energy efficiency measures. Further analysis of the dataset answers these questions:

- What effect does giving lifestyle advice have on energy consumption?
- Do tenants in properties that have had more extensive retrofitting works carried out save more energy?
- Is there a difference between energy savings on an archetype basis?

3.5.1 The effect of lifestyle advice

There were 49 properties which received lifestyle advice; 26 had suitable data. All except 4 households decreased their gas bills or increased it only slightly. The 26 properties saved £42 (6%) on average. This is relatively high considering the average retrofitted property saved £72. The retrofitted properties which also received lifestyle advice saved slightly more than works only properties, £77 versus £67, as summarised in Table 3-6.

Therefore it appears that lifestyle advice has had had a positive effect on gas savings for both advice only and retrofitted properties.

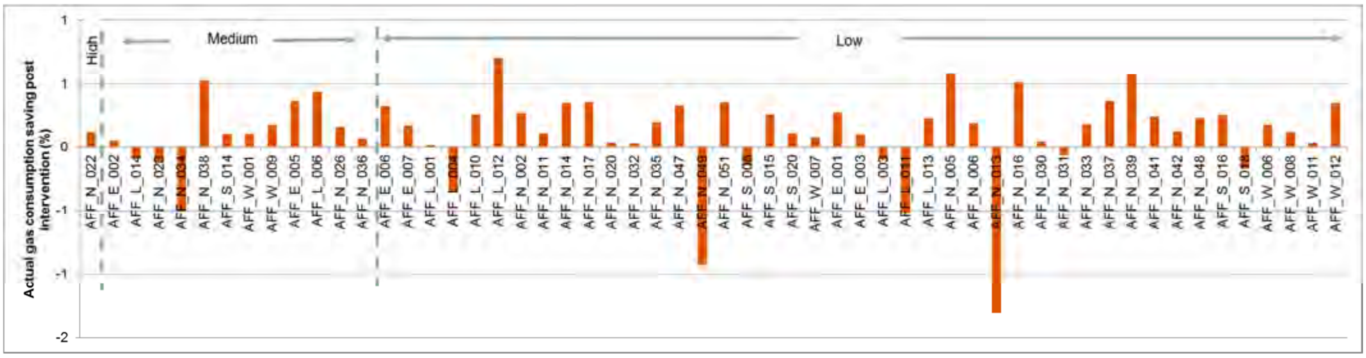
Table 3-6 Average gas savings for the three property groups

	Advice (Group 3)	Works only (Group 1)		Works and advice (Group 2)	
	Actual	Actual	Modelled	Actual	Modelled
Average saving (kWh)	942	1,523	3,594	1,747	3,305
Average saving (%)	6%	10%	22%	13%	21%
Average cost saving (£)	£42	£67	£159	£77	£146

3.5.2 The effect of different levels of retrofit packages

Works packages were grouped into low, medium and high packages. The average % savings in properties' that had a medium package installed were similar to those with low packages, a saving of 11% compared to 12% for the low package. Most properties that had a high package installed were void properties. Only one property with a high package had suitable data and its gas savings were not significantly higher than those with low or medium packages. Please refer to Figure 3-8 below.

Figure 3-8 Actual gas saving (%) by package level



3.5.3 Savings by archetype

The analysis does not indicate any pattern. Most archetypes have a proportion of properties that did not save on their gas bills. However archetypes 7, 13, 20 and 21 look to be the 'best performing'. Please refer to Figure 0-4 and Table 0-1 in Appendix 1 for details. Interestingly, in the Green Deal financial analysis conducted as part of the Phase1 FutureFit report, Archetype 7 was the only archetype to show a positive NPV (£550) of the investment based on modelled energy data. Archetype 7 is a house built between 1930 and 1949 with cavity walls. The retrofitting works were: cavity wall insulation, airtightness improvements, heat recovery fan, pipework and cylinder insulation.

4. Electricity consumption analysis

4.1 Sample size

An analysis of electricity consumption data was conducted for properties whose overall RAG rating was green or amber, i.e. disregarding properties where any of the actual electricity pre or post-works data was flagged as red or where data was not available. Also, the 15 electrically heated properties were removed as these properties are analysed separately in section 4.4. The retrofitting works have a larger impact on the electricity consumption of electrically heated properties and including them in the statistical analysis would bias the results. The filtered sample size consisted of 85 properties as indicated below:

Table 4-1 Number of properties in the cleansed dataset

Total included: 85	Advice	Works only	Works and advice
Green and amber properties	34	27	24

The remaining 57 properties were not included in the green/amber dataset due to the following reasons:

Table 4-2 Number of properties excluded from the dataset

Total excluded: 50	Actual pre-works data 'red'	Actual pre-works data not available	Actual post-works monitored data 'red'
Number of properties	27	19	4

4.2 Actual electricity savings

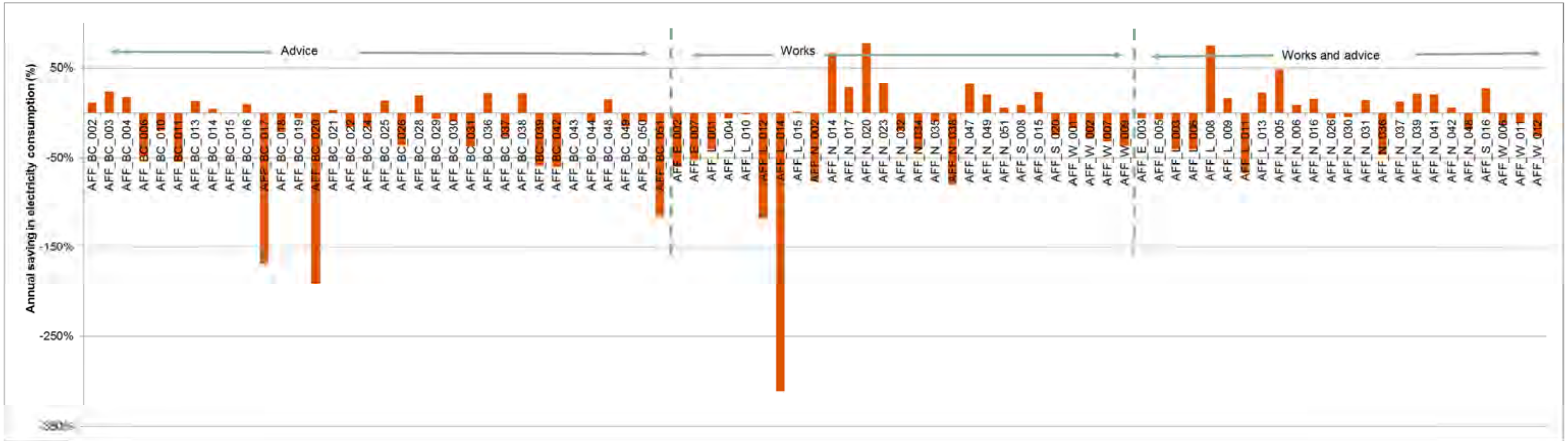
Figure 4-1 and Figure 4-2 show actual electricity savings in £s and as a % of the baseline for the 85 gas heated properties. Surprisingly, of the total, only 34 of the properties reduced their electricity bills and the remaining 51 increased. Just looking at the 51 retrofitted properties, only 22 saved on their electricity bill. The average electricity bill saving for retrofitted properties was -£19. However, the averages do not convey the full story. There are a number of extreme data points showing an increase or decrease of electricity bills of over £200. The average saving for the 34 advice properties was -£50 (see section 4.3.2 for details).

It is worth noting that the retrofitting works were primarily concerned with reducing heat losses from the building fabric and therefore the space heating demand, rather than impacting the electricity consumption significantly. Measures such as heat recovery ventilation would increase electricity consumption marginally although this is expected to be minimal for most properties, around 1.5%. On the other hand, lifestyle advice would potentially have encouraged tenants to correct wasteful behaviour. Also the installation of V-phase in some properties should have marginally reduced electricity consumption. On the whole, electricity consumption was expected to be similar to before intervention with some minor fluctuations, while much significant changes can be seen for the majority of properties as shown in Figure 4-2.

Potential explanations for these changes were investigated, such as change in tenancy or data inconsistencies, though these did not provide a full explanation. L_014 was found to have had new tenants from August 2011, the beginning of the monitoring year. L_014 was the worst performing property in terms of electricity savings with an increase in bills of 270%. To understand whether With data inconsistences could be a contributing factor, only data assigned a ‘green’ status was examined. Even this dataset was found to have significant variations and inconsistencies.

Figure 4-1 Annual electricity bills savings (£)

Figure 4-2 Annual electricity savings (kWh)



4.3 Actual savings vs. modelled SAP savings for retrofitted properties

The actual pre-works and post-works data discussed in the previous section showed that most of households did not save on their electricity bills, with average negative savings of -£19. In comparison, SAP predicted much higher savings ranging from £0 to £60, with an average of £55.

Table 4-3 Comparison of actual and modelled electricity savings

	All works properties	
	Actual	Modelled
Average saving (kWh)	-128	378
Average saving (%)	-4%	9%
Average cost saving (£)	-£19	£55

Figure 4-3 shows the modelled and actual electricity savings for the 51 retrofitted properties. The red dots are the actual electricity savings and the blue dots are the SAP savings.

Figure 4-4 shows the mathematical difference between actual savings and SAP savings (i.e. actual savings minus SAP savings). SAP predicted savings are higher for 36 of the 51 properties (i.e. those below the zero line). In fact, for most of these properties below the line, the modelled savings exceed actual savings by more than £100. At the same time, there are 15 properties that saved more than SAP predicted.

The gas analysis highlighted a similar trend. A key consideration for financing retrofit measures through bills savings is that while overall the modelling tends to predict higher savings, the consequences of signing up to the Green Deal based on modelled savings varies significantly from property to property.

Figure 4-3 Comparison between actual and modelled electricity savings for retrofitted properties (£)

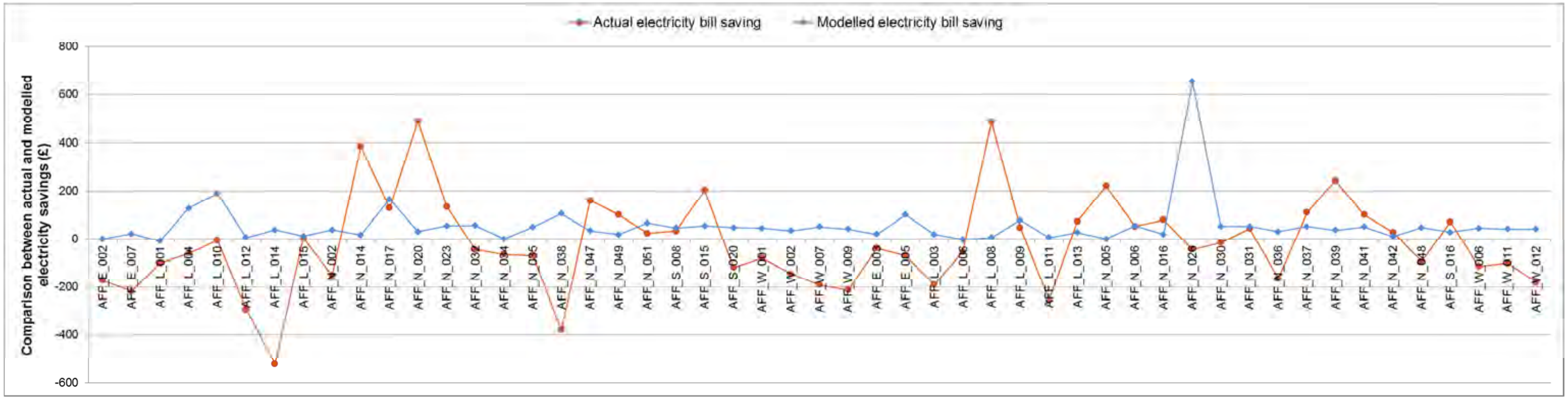
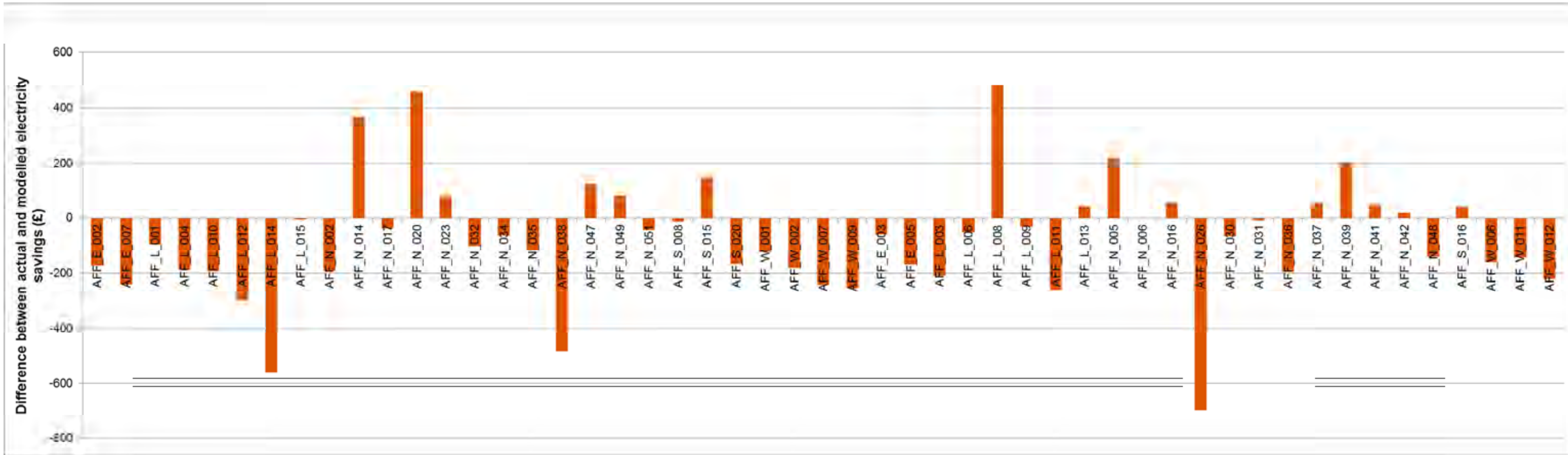


Figure 4-4 Difference between actual and modelled electricity savings (£) for retrofitted properties (actual savings minus modelled savings)



4.3.1 Potential reasons for unrealised SAP savings

The potential reasons for the unrealised savings as predicted by SAP were explored:

The average pre-intervention actual electricity bill for these FutureFit properties is £494 while the modelling average bill is £611 or 24% higher. The modelled electricity bill is significantly higher than actual bills for 60 out of 85, or 71% of the properties. Therefore even if the actual proportion and the SAP proportion of energy savings realised are the same, the modelled savings will be higher in absolute terms. Please refer to Figure 0-1 in Appendix 2 for detailed data.

The number of occupants also influences the electricity consumption in a household, and where occupancy levels are significantly different from SAP assumptions, this will impact on electricity usage.

SAP models estimated the proportion of energy savings at an average of 9% for the 51 retrofitted properties. This in itself could be unrealistically high as the retrofitting works that were carried out were mainly affecting the fabric of the buildings and there was little scope to save on electricity bills (except for energy efficient lighting). The actual savings were -4% on average. Therefore a key reason for SAP overestimating the electricity savings for the FutureFit properties is that the actual savings themselves are not realised.

4.3.2 Lifestyle advice

The summary table below shows conflicting conclusions about the effects of lifestyle advice. On the one hand households that had works done and received lifestyle advice saved 2% on their electricity bill while those that had works done increased their electricity bill by 10%. However households who were given lifestyle advice only also increased their bill by -10%.

The effect of energy saving behaviour advice is inconclusive based on the electricity consumption figures for the FutureFit properties.

Table 4-4 The effects of lifestyle advice

	Advice (Group 3)	Works only (Group 1)	Works and advice (Group 2)
	Actual	Actual	Actual
Average saving (kWh)	-342	-300	65
Average saving (%)	-10%	-10%	2%
Average electricity bill saving (£)	-£50	-£43	£9

4.4 Electrically heated properties

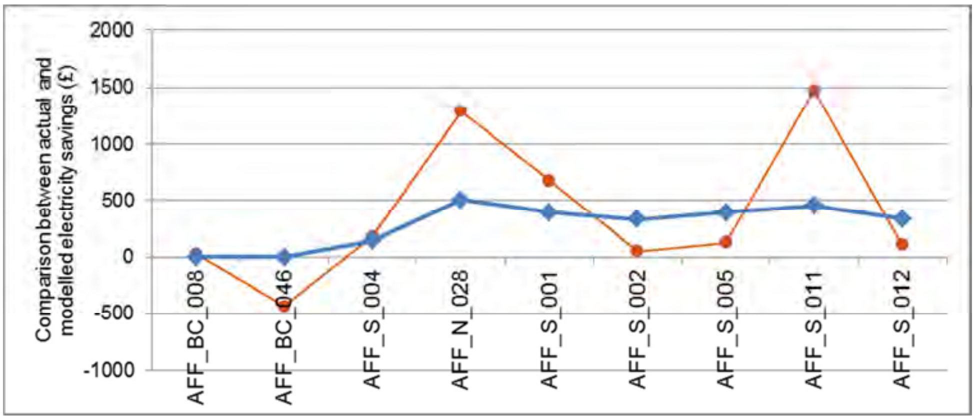
The table below summarises the main data for the 9 green or amber electrically heated FutureFit properties. Comparing the actual pre and the modelled pre columns shows that SAP overestimates the baseline electricity consumption significantly in most cases.

Table 4-5 Key data for electrically heated properties

Property	Package level	Actual pre (kWh)	Actual post (kWh)	Modelled pre (kWh)	Modelled post (kWh)	Actual savings (£)	Modelled savings (£)	Modelling based on
AFF_BC_008	N	6,775	6,572	12,501	12,501	£29	£0	Arch
AFF_BC_046	N	1,879	4,870	11,199	11,199	-£433	£0	Arch
AFF_S_004	L	5,319	4,094	13,929	12,938	£177	£143	Prop
AFF_N_028	L	13,043	4,136	18,956	15,474	£1,290	£504	Prop
AFF_S_001	L	5,645	980	11,199	8,496	£675	£391	Prop
AFF_S_002	M	5,804	5,436	10,875	8,593	£53	£330	Prop
AFF_S_005	L	3,129	2,260	11,199	8,496	£126	£391	Arch
AFF_S_011	H	14,034	3,876	13,414	10,286	£1,471	£453	Prop
AFF_S_012	M	11,249	10,504	11,521	9,203	£108	£336	Arch
Average		**7,431**	**4,748**	**12,755**	**10,798**	**388**	**283**	

The modelled savings are fairly consistent at around £300 - £500 while the range of actual savings is inconsistent. All of the seven retrofitted properties reduced their electricity consumption but some only slightly and less than SAP estimated and some considerably more than SAP estimated. These seven properties saved on average £557, higher than the SAP modelled average saving of £364.

Figure 4-5 Actual electricity bill savings and modelled savings



In conclusion, the data for electrically heated properties reflects a similar trend as was the case with gas heated properties. While modelled electricity bills tend to be higher than actual in general, the magnitude of savings realised vary considerably from property to property.

5. Total energy analysis and conclusions

5.1 Key findings

The key questions raised for the purpose of this study were:

- Did the households reduce their total energy bills post retrofitting works? If not, what could be the reasons?
- Did the households reduce their total energy bills to the same extent as the SAP modelling? If not, what could be the reasons?
- Did the provision of lifestyle advice to tenants have an effect on energy bills?
- In light of the total energy savings, what are the implications for financing retrofit measures via Green Deal for Affinity Sutton housing stock?

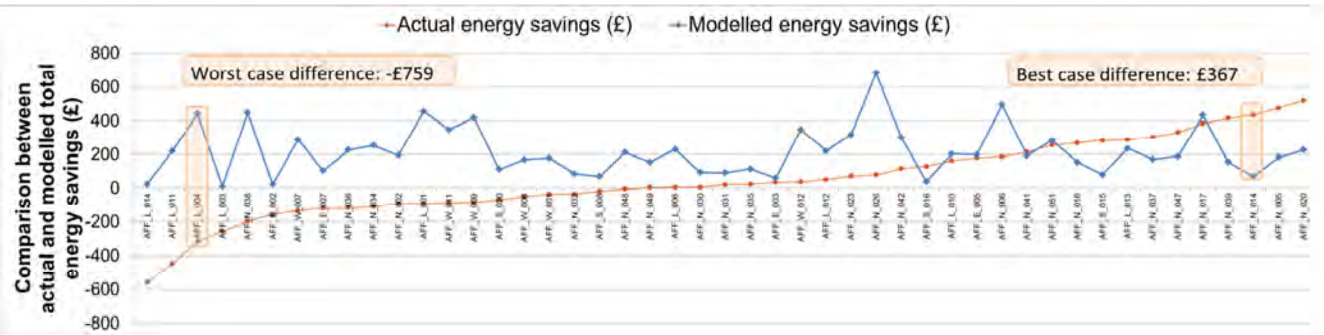
This section summarises the answers determined in previous chapters and also provides insights on the combined gas and electricity savings in FutureFit properties.

5.1.1 Total bill savings in gas-heated properties

The data shows huge variability in actual and modelled energy savings as shown in the figure below. There are 47 gas-heated retrofitted properties with reliable gas and electricity data and they are arranged in increasing order of actual savings (red line). The red line crosses the zero line about half way. On the right are 27 properties that saved on their total energy bills and on the left the 20 properties that increased their bills post-retrofit. The properties that lie towards the extreme right hand side of the graph are the properties where the actual energy savings are higher than the modelled savings. Only 10 out of the 47 gas heated properties would have benefited from Green Deal financing based on their actual savings.

Across the 47 gas heated properties, the average modelled savings is £217. In comparison, the average actual energy savings are 77% less, or about £49.

Table 5-1 Actual and modelled total energy savings for gas heated properties



Whilst most properties saved on their gas bills (£72), in general the savings were not as high as SAP modelling estimated (£153). The average actual savings equate to a 53% reduction on estimated savings. However looking at the whole range (Table 5-2 below), while 36 properties didn't achieve the estimated SAP savings, for 20 properties the modelling underestimated the actual savings.

Similarly for 36 of the 51 properties in the electricity consumption dataset SAP overestimated the electricity savings but for the remainder the actual savings were higher than the modelled. Therefore it cannot be said that SAP consistently overestimates energy savings.

The retrofitting works did not affect electricity consumption considerably yet a large number of high negative and high positive percentage changes were observed in the post retrofitting year compared to the baseline. For the worst performing property a change of tenants is the likely reason for the significant increase in electricity bills. Considering the data and modelling limitations and potential increase in appliance use in households some fluctuations were expected but they do not account for the high percentage changes. These remain partly unexplained.

Both gas and electricity data sets exhibited extreme data points whose validity may not hold, but even with their omissions the trend in the findings remained very similar.

Table 5-2 Summary of electricity and gas savings for gas heated properties

Gas heated properties	Sample size	No. of properties that saved	No. of properties that didn't save	Average saving - actual	Average saving - modelled	Realised SAP savings	Didn't realise SAP savings
Gas consumption	56	45	11	£72	£153	20	36
Electricity consumption	51	15	36	-£19	£55	15	36

5.1.2 Total bill savings in electrically heated properties

The 7 electrically heated retrofitted properties with reliable data saved on average £557. Households saved on average more than the SAP predicted savings of £364. All electrically heated properties decreased their bills. The magnitude of savings was between £50 and £1470.

5.1.3 Combined average bill savings

Considering the ratio of gas heated and electrically heated properties in the Affinity Sutton's entire stock, the weighted average savings are indicated in the table below. The weighted average modelled savings is £229. Only 40% of the modelled savings are realised in actual, or about £90.

Based on an investment level of £6.6k for a low package of measures, £10k for a medium and £25k for a high package, the weighted average level of investment to realise the £90 average energy bill saving is £7,685.

The same weighted average approach for the whole of Affinity Sutton's stock shows that three quarters of properties saved less on energy bills than SAP predicted. As discussed in section 3.4.2, the application of in-use factors makes up for some but not this entire shortfall.

Table 5-3 Summary of energy bill savings

TOTAL ENERGY	Sample size	No. of properties that saved	No. of properties that didn't save	Average saving - actual	Average saving - modelled	Realised SAP savings	Didn't realise SAP savings
Gas heated properties	47	27	20	£49	£217	10	37
Electrically heated properties	7	7	0	£557	£364	4	3
Weighted average (as per stock prevalence)	NA	61%	39%	£90	£229	24%	76%

5.1.4 Potential reasons for unrealised SAP energy savings

Considering the weighted average combination of properties, for the majority the modelled saving were higher than the actual savings. There is likely to be a combination of reasons for this:

- SAP modelling overpredicts baseline energy use in a household and therefore the proportion of energy saved will be greater in absolute terms
- Implementing energy efficiency measures in reality does not result in as high energy savings as SAP predicts.
- For the FutureFit properties, the proposed in-use factors that aim to reduce the SAP modelled energy savings for specific measures account for less than half of the unrealised SAP energy savings
- There was evidence of underheating for some properties. When the tenants are underheating their homes, the works carried out will bring smaller energy bill savings in absolute terms than SAP estimates.
- Based on tenant surveys, one likely reason for the unrealised space heating savings could be the difficulty experienced in using some of the installed equipment (e.g. zoned heating).

5.2 Further findings

Lifestyle advice

It appears that lifestyle advice may have had a positive consequence on total energy savings for the FutureFit properties as indicated in the table below. The 'Advice' group reduced energy c consumption by 5% saving £12 on average. Furthermore, the 'works only' reduced their energy consumption by 8% compared to 13% or 'works and advice' group. This trend in the numbers indicates the positive effect of lifestyle advice.

Table 5-4: Impact of lifestyle advice on total energy savings

	Advice (Group 3) sample size: 25	Works only (Group 1) sample size: 25		Works and advice (Group 2) sample size: 22		All works properties sample size: 47	
	Actual	Actual	Modelled	Actual	Modelled	Actual	Modelled
Average saving (kWh)	646	1,108	4,064	2,073	3,961	1,560	4,016
Average pre actual (kWh)	13,290	13,761	19,681	15,403	20,679	14,529	20,148
Average saving (% kWh)	5%	8%	21%	13%	19%	11%	20%
Average cost saving (£)	£12	£20	£216	£82	£219	£49	£217

Low and medium package of works

There appear to be no higher gas savings associated with the medium package of works compared with the low package of works. At the same time, tenants in a property with medium retrofit package did not report feeling warmer than those living in a home where low package of measures was installed. This highlights the diminishing returns on additional works and questions the value of the extra investment.

Archetypes

Examining the gas savings on a per archetype basis showed no obvious pattern. Most archetypes had a proportion of properties that didn't save on their gas bills. However, older and larger properties (archetypes 7 and 13) look to be the 'best performing'. Archetype 7 was the only archetype to show a positive NPV for a low carbon package of works in the Green Deal financial analysis conducted previously. Archetype 7 is a house built between 1930 and 1949 with cavity walls. The retrofitting works were installed included cavity wall insulation, airtightness improvements, heat recovery fan, pipework and cylinder insulation.

Tenant perceptions

The survey responses for the properties that increased their gas bill the most revealed that these tenants tended to agree with the statement that they saved money post intervention. Given the trend of negative electricity bills savings, it is unlikely that these properties would have saved on their combined energy bills. Their response highlights a key point: a tenant's perception of their energy consumption pattern can be very different from reality. With direct debit payments, estimated bills, increased energy prices and differences in weather from year to year, it can be very hard for a tenant to have an accurate feel for their energy consumption trends.

5.3 Carbon emission reductions

5.3.1 Average carbon reductions

Annual carbon dioxide emission reductions for the 47 gas-heated properties were 245 $kgCO_2$/year. Close to 30% of the carbon emission savings from reduced gas consumption were lost due to the increase in electricity consumption. For the 7 electrically heated properties, the average carbon reduction was 1873 $kgCO_2$/year.

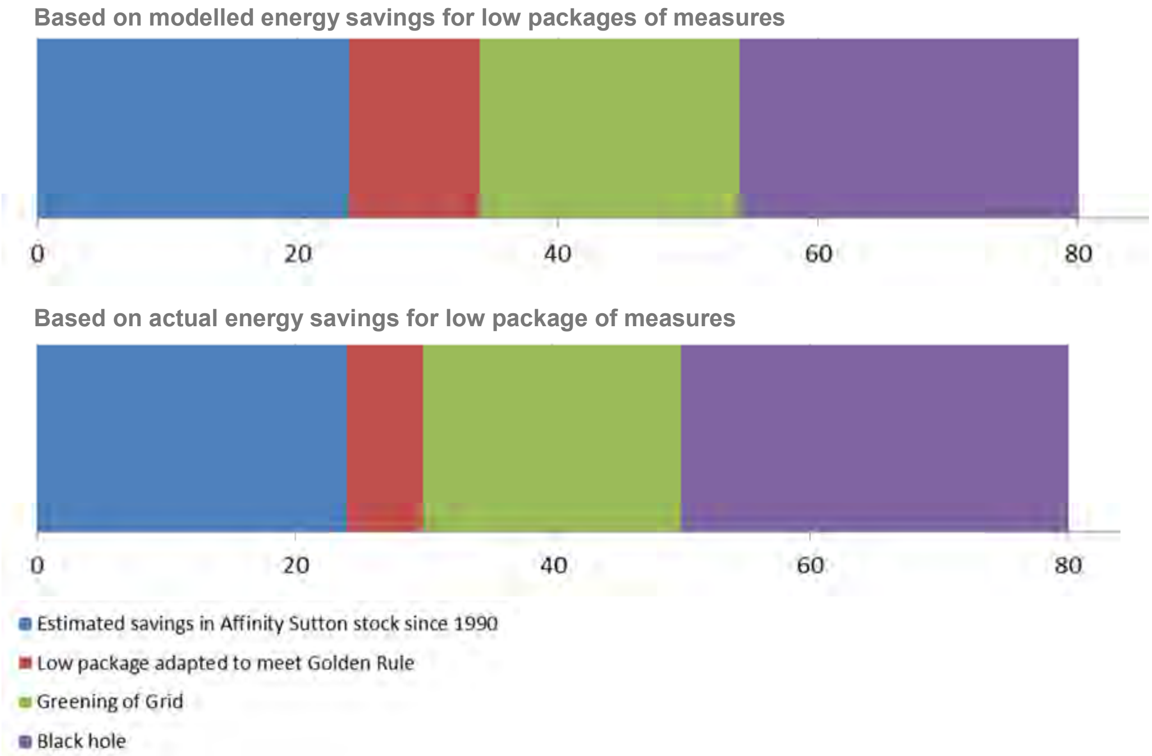
Extrapolating from these two samples, it is estimated that retrofitting the 101 FutureFit properties saved 44,275 kgCO_2/year.

5.3.2 The carbon black hole

The FutureFit Phase 1 report[6] identified a substantial 'carbon black hole' when evaluating the long term impact of Green Deal in the context of the national target of 80% carbon reduction by 2050. Based on modelled energy savings for a low package of works that has been adapted to meet the Golden Rule, it was estimated that a 10% reduction would be achieved relative to the current baseline. Taking into account this plus the carbon savings already made in its stock and an estimate for the effects of grid decarbonisation, it was found that there was still a significant gap in terms of delivering the 80% target.

The monitored FutureFit data indicates that 59% of this modelled savings will be realised in actual. The figure below compares the progress made towards the 80% target based on the modelled and monitored datasets.

Figure 5-1 Implication for the carbon black hole



5.4 Green Deal implications

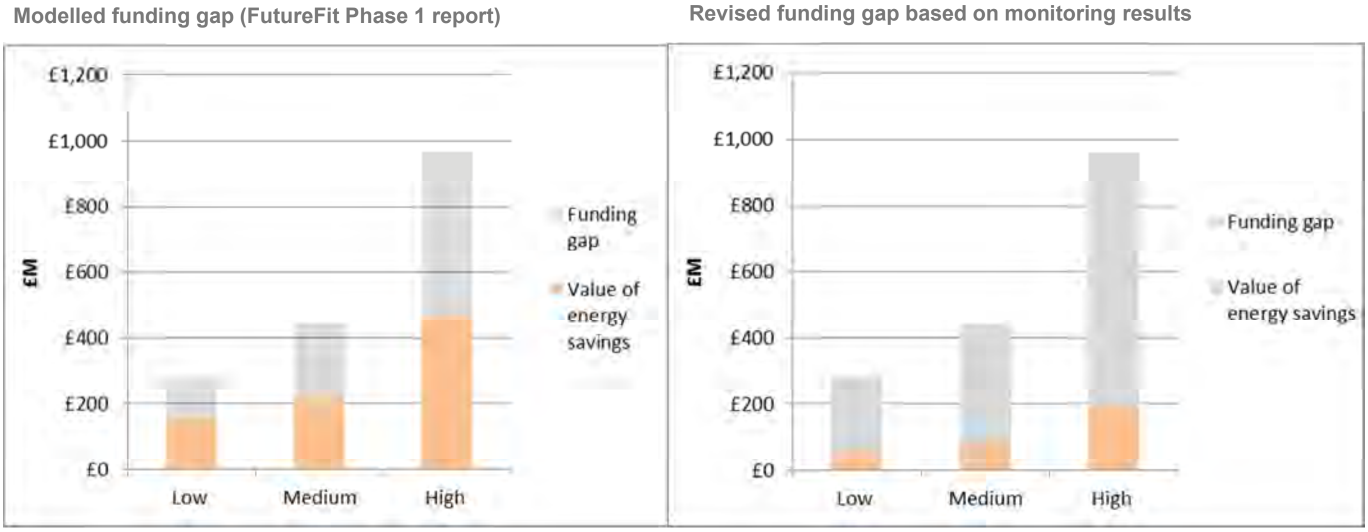
The previous technical and financial study carried out my Verco[7] demonstrated that the net present value of modelled energy savings across the Affinity Sutton housing stock is significant in magnitude, but it only covers about half of the capital costs of energy efficiency measures. The findings from this

[6] http://www.affinitysutton.com/PDF/6416_futurefit_report_web.pdf

[7] Report available at www.affinitysutton.com/PDF/FutureFit%20Finance%20Programme_Final%20report.pdf

study indicate that only 40% of the modelled savings was realised on average for the FutureFit properties. This will widen the funding gap further as illustrated in the figures below.

Figure 5-2 Implications of unrealised SAP savings to the retrofit investment funding gap



However, on an individual property basis the picture is not quite homogeneous. The inconsistency in modelled versus actual savings highlights a key issue: while averages indicate an overall trend, the range of the underlying data points is also important. Whilst overall the SAP modelled savings were higher, the consequences of signing up to the Green Deal based on modelled savings is very different for the properties that didn't achieve the level of savings SAP predicted compared to the ones that overachieved.

Figure 0-1 Pre-works actual and modelled gas bill (£)

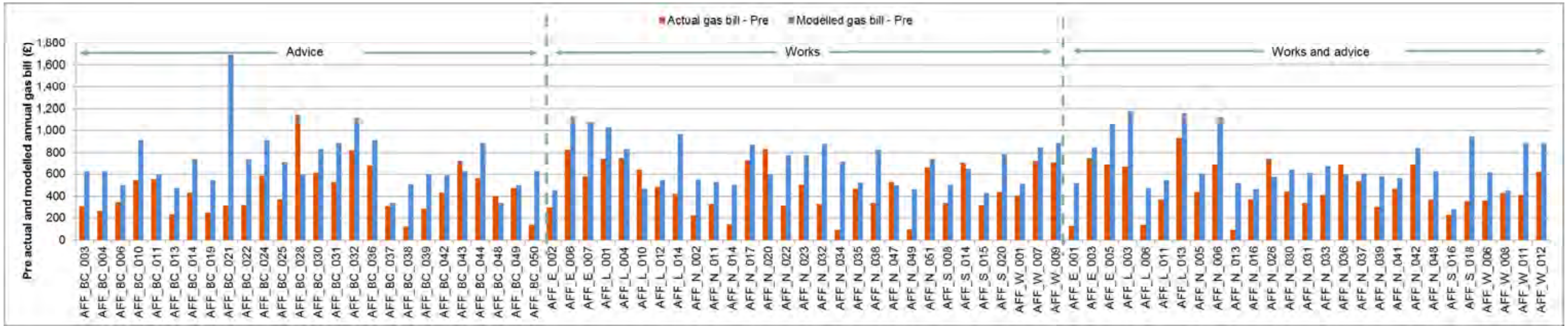


Figure 0-2 Survey responses for all the properties which did not save on their gas bills post intervention

		Survey 1 Q1 (Groups 1&2)	Survey 1 Q4 (Groups 1&2)	Survey 1 Q5 (Groups 1&2)		Survey 1 Q10 (Groups 1&2)		Survey 1 Q9 (Groups 1&2)		Survey 2 Q7 (Groups 2&3)	Survey 2 Q6 (Groups 2&3)
Property	Gas saving - %	Warmer home since the works?	Saved money?	Has there been a change in behaviour due to works?	If yes, how?	Were there issues with some of the installed works?	If yes, which?	Were some of the installed works hard to use?	If yes, which?	Able to increase use of heating since advice delivered to a more comfortable temp?	Have you saved money?
AFF_N_013	-131%										
AFF_BC_050	-118%									4	3
AFF_N_049	-93%										
AFF_L_011	-51%	4	3	Yes	Use less heating	Yes	Fans	Yes	Zoned heating	3	4
AFF_N_034	-49%										
AFF_L_004	-34%	3		Yes	use less electricity	No		No			
AFF_BC_039	-21%									5	1
AFF_BC_037	-20%									1	5
AFF_S_018	-17%										
AFF_BC_013	-15%									4	5
AFF_N_023	-12%	5	4	No							
AFF_L_003	-10%	5	4	No		Yes	Zoned heating	Yes	Zoned heating	5	4

5 = strongly agree, 1 = disagree

Figure 0-3 Residential survey – Does your home feel warmer?

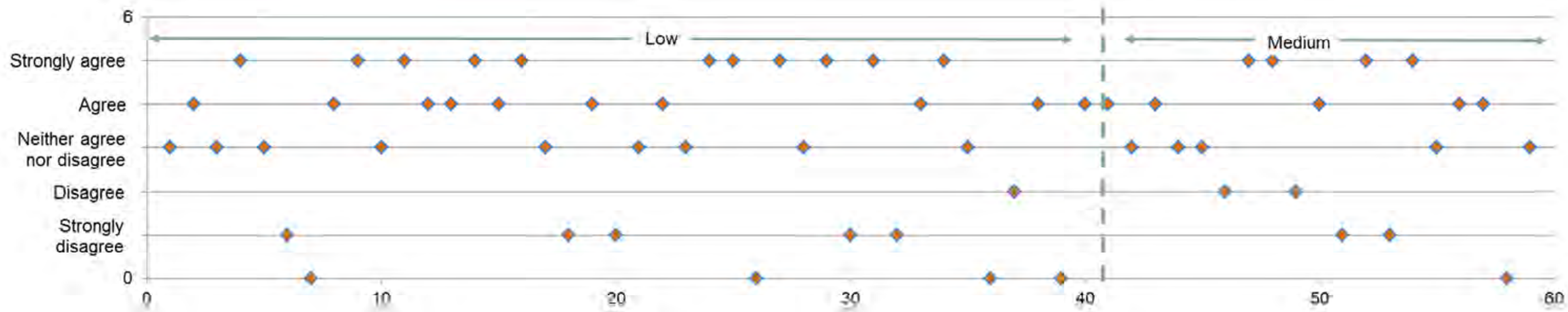


Figure 0-4 Actual gas savings (£) by archetype

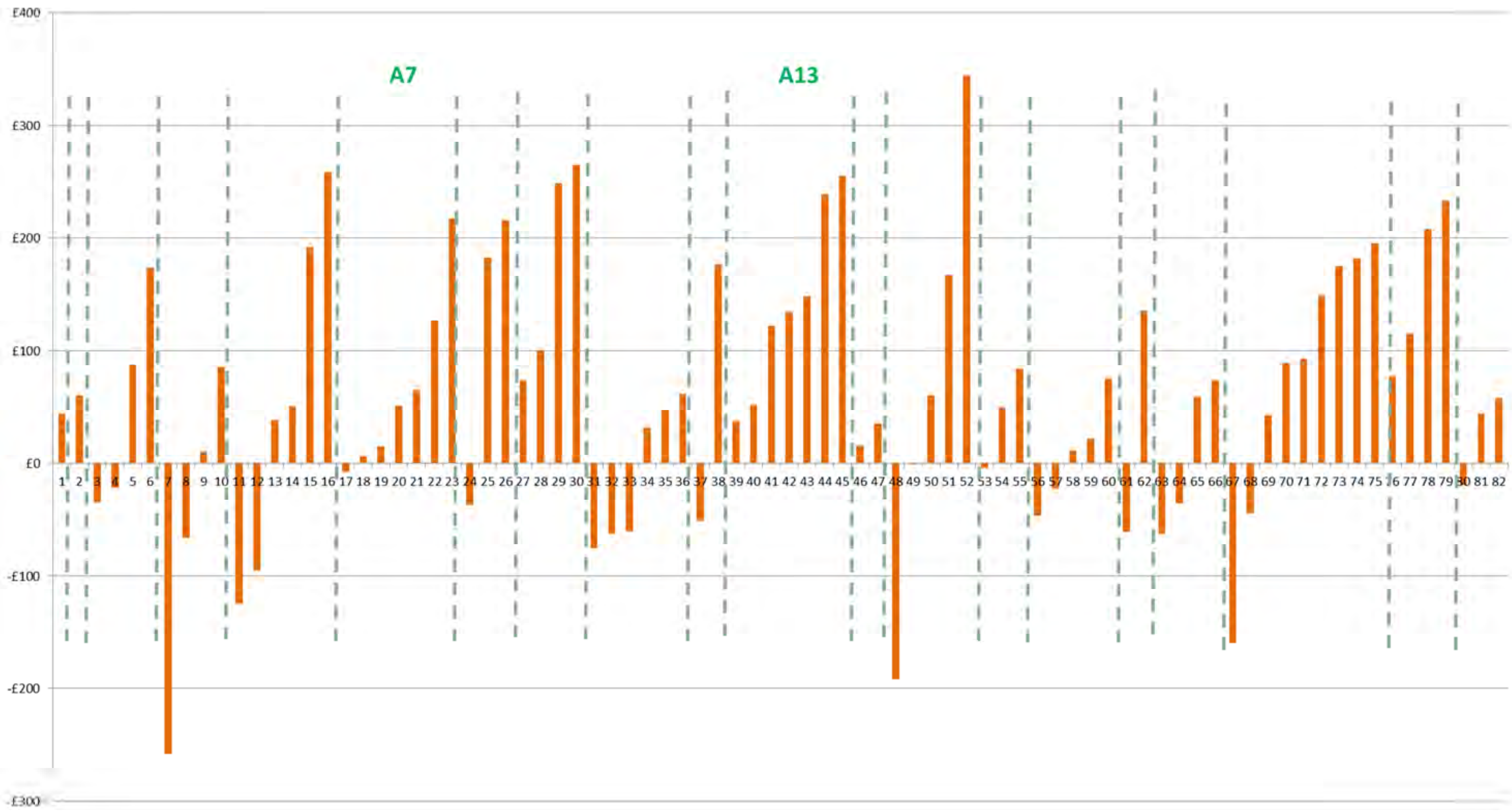
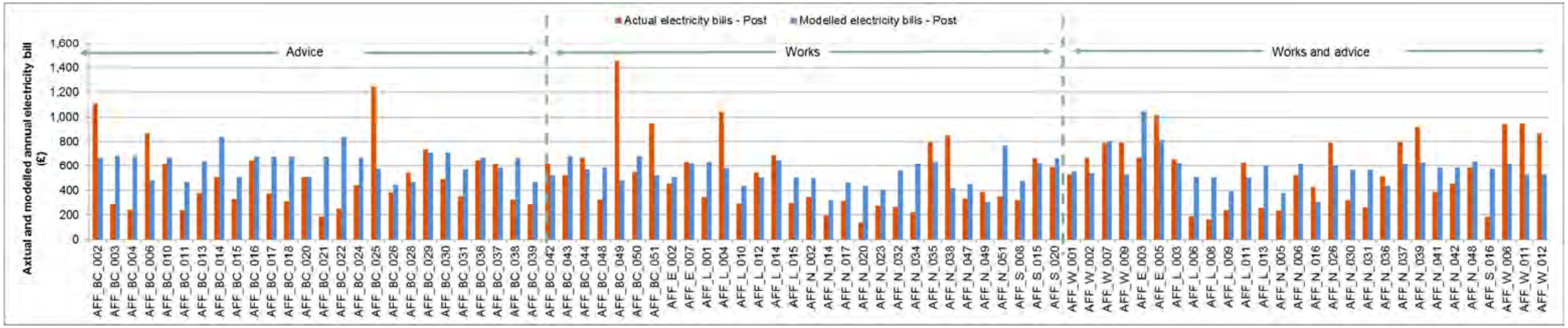


Table 0-1 Archetype description

Archetype	Age	Type	Built form	Wall type
1	1983-1990	Flat		Cavity
2	1900-1929	Flat		Cavity
3	1900-1929	House	Mid-terrace	Cavity
4	1900-1929	House	End-terrace/ semi	Solid Brick
5	1930-1949	Flat		Cavity
6	1991-1995	Flat		Cavity
7	1930-1949	House	End-terrace/ semi	Cavity
8	1930-1949	House	End-terrace/ semi	Solid Brick
9a	1996-2002	Flat		Cavity
10	1930-1949	House	End-terrace/ semi	System Built
11	1950-1966	Flat		Cavity
12	1950-1966	Flat		Solid Brick
13	1950-1966	House	End-terrace/ semi	Cavity
14	1983-1990	House	End-terrace/ semi	Cavity
15	1967-1975	Flat		Cavity
16	1967-1975	House	Mid-terrace	Cavity
17	1976-1982	House	Mid-terrace	Timber Frame
18	1967-1975	Maisonette		Cavity
19	1976-1982	Flat		Cavity
20	1976-1982	House	Mid-terrace	Cavity
21	1991-1995	House	End-terrace/ semi	Cavity
22	1996-2002	House	End-terrace/ semi	Cavity

Appendix 2

Figure 0-1 Pre actual and modelled electricity usage (£)



Appendix 3

Summary of sample size by different categories

Total energy (Section 5)

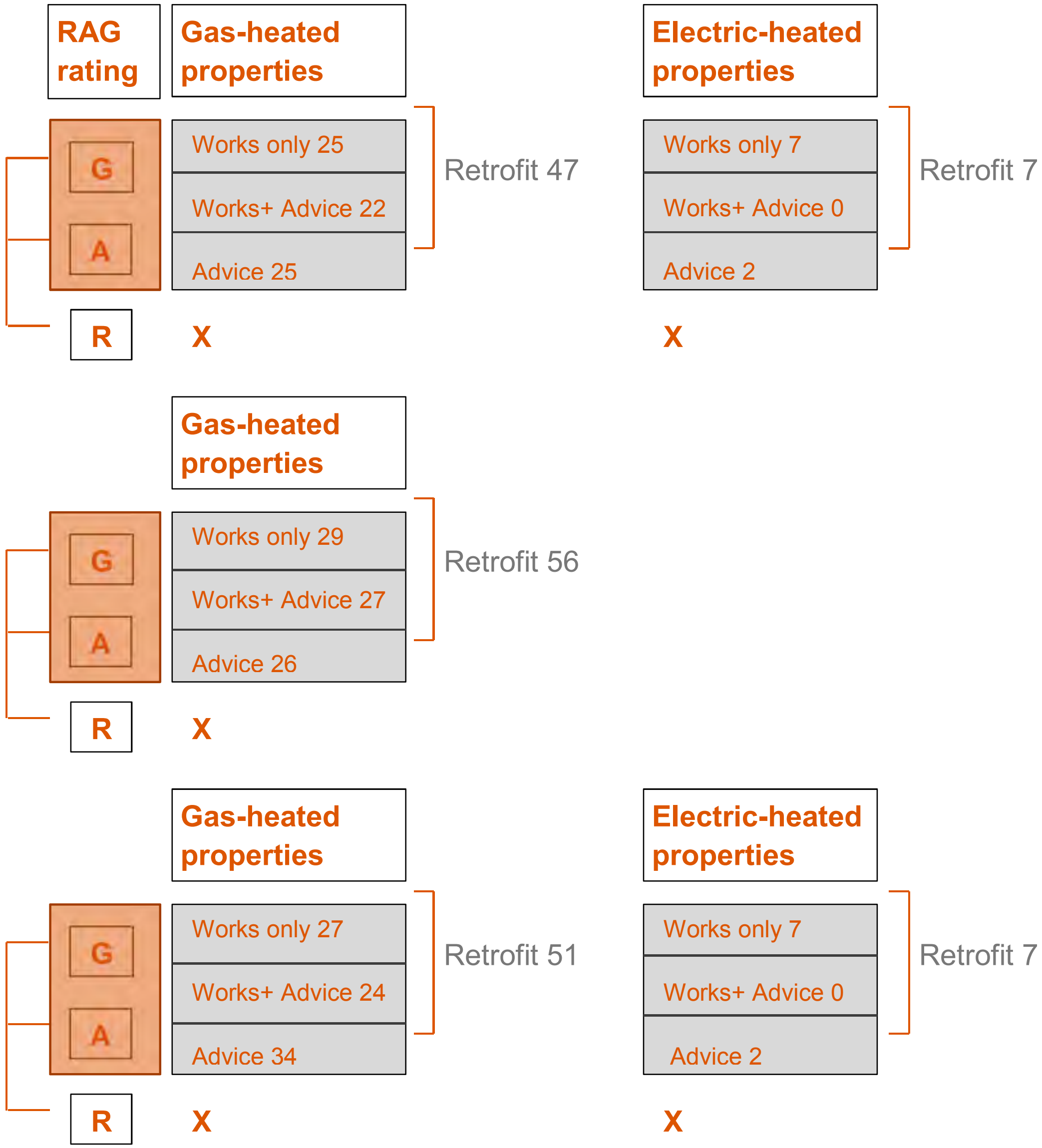
FutureFit sample – 150 properties

Gas consumption (Section 3)

FutureFit sample – 150 properties

Electricity consumption (Sec. 4)

FutureFit sample – 150 properties



Verco

43 Palace Street, Victoria,
London SW1E 5HL, United Kingdom

Email: Pratima.washan@vercoglobal.com
www.vercoglobal.com

Affinity Sutton Group Limited

Level 6, 6 More London Place,
Tooley Street, London SE1 2DA

Telephone: 0300 100 0303
Email: future.fit@affinitysutton.com

www.affinitysutton.com/futurefit

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