NEED Annex C: Update to impact of measures method

27 June 2019 **National Statistics**

This year sees an update to the method used to estimate the energy savings from installing different energy efficiency measures. This analysis is referred to as “impact of measures”. This document sets out what motivated the new method, what the changes are, and the issues not yet resolved.

Main messages

- The estimates generated by the new method are more robust and closer to a “true” estimate of the savings.
- Estimates of savings multiple years after installation (longitudinal savings) and for total energy (gas plus electricity) are now produced.
- The method enables results to be disaggregated by additional property and household characteristics, including EPC ratings.
- The only additional data needed for assessing new energy efficiency measures are the addresses of the properties, the type of measure and the dates of installation. The rest of the data required is held in NEED.
- The amount of work required to estimate the impact of a measure is lower than it was in the past. This means that it may be possible to assess additional measures as and when the data required, as set out above (point 4), becomes available.

In the spirit of continuous improvement, the method may be updated in future years as improvements are made. In such an event the tables published using the new method may be revised.

Contents

Introduction

This Annex is divided into the following sections:

- **Previous Method**: Details the process used for the impact of measures analysis in previous NEED reports. It includes an overview of the difference-in-difference approach used in both the previous and new methods. Readers unfamiliar with the impact of measures method are advised to read this. Users familiar with the previous method are advised to skip to the following section.
- **What prompted the change?** Describes the motivation for updating the method used for assessing the impact of measures.
- **What was changed?** Sets out the changes made, with explanation of the technical processes and the logic for using them. Note that this doesn't include every feature or process which was considered or trialled.
- **Overview of new method**: Gives an overview of the new impact of measures algorithm.
- **New features:** Describes the novel outputs the new method has enabled, specifically estimates for the longitudinal impacts of measures, and the total energy savings (the combined savings in gas and electricity consumption).
- **Outstanding issues:** Highlights known limitations and issues with the new method, including differences in results across different installation years.

Readers with questions or comments are encouraged to get in touch with the NEED team. The team can be reached via email at energyefficiency.stats@beis.gov.uk

The impact of measures analysis using this new method is published in table format[1] as part of the NEED 2019 publication. These also include tables for longitudinal and total energy savings. For in depth commentary of the results please see the NEED 2019 main report[2].

Note on terminology
Where a year number is used in this report it refers to the period covered in by NEED's gas period for that figure. For example, 2015 refers to the 1st of October 2014 – 30th of September 2015. The only exception to this is when discussing the installation of solar photovoltaic panels (solar PV). The savings for solar PV are measured using electricity, for which the electricity year is used

1. All published impact of measures tables can be found here: https://www.gov.uk/government/statistics/national-energy-efficiency-data-framework-need-impact-of-measure-data-tables-2019
2. The 2019 NEED report can be found here: https://www.gov.uk/government/statistics/national-energy-efficiency-data-framework-need-report-summary-of-analysis-2019

(which runs from late-January to late-January, more closely tracking the calendar year than gas).

Property "features" are also referenced in this document. These refer to all property and household characteristics which are held in NEED and are available for use in the impact of measures process.

Previous method

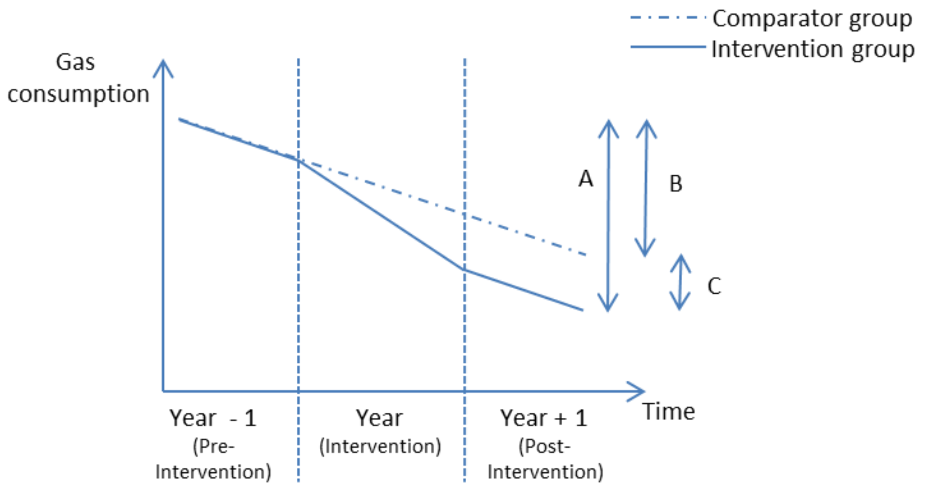
This section describes the impact of measures method used in previous NEED publications, which provided the basis for the new method.

The first step was to create intervention and comparator groups. The intervention group contains properties which have received the energy efficiency measure being considered (and no other measure as recorded in NEED). The comparator group contains similar properties that have not had any energy efficiency measures installed.

Each individual property in the intervention group is randomly matched to a property with the same attributes in the comparator group. This allows comparison of differences in energy consumption (or "savings") for each property, allowing more understanding of the typical difference (median), the distribution and variance of savings. This is known as a difference in difference method.

An illustration of the change in consumption of installing the energy efficiency measures is shown in Figure 1, where 'C' represents the energy saving. This saving is equivalent to 'A minus B' on the diagram, where A is the change in consumption for the intervention group before and after the installation of the measure; and B is the difference in consumption for the comparator group.

Figure 1: Difference in difference approach



Intervention group

A new intervention group was created for each energy efficiency measure considered each year. These properties had to meet the conditions set out in Table 1 below. Note that Table 1 details conditions for measures installed during the periods covered by NEED's 2016 gas period (for all measures apart from solar) or NEED's 2016 electricity year (for solar PV).

Table 1: Summary of intervention group conditions for inclusion, in 2016

Variable	Condition
Date of installation	Energy efficiency measure recorded as being installed between 1st October 2015 and mid-July 2017 and Solar PV recorded as being installed between 30th January 2016 to 30th January 2017 (inclusive) to match the gas and electricity consumption periods for 2016, respectively.
Energy efficiency measures	No record of any other measure available through government schemes or recorded in NEED at any time.
Consumption	Gas consumption in 2015, 2016 and 2017 between 2,500 kWh and 50,000 kWh (excluding estimated readings). Electricity consumption in 2015, 2016 and 2017 between 100 kWh and 25,000 kWh (excluding estimated readings).
Change in consumption	Change in gas and electricity consumption between 2015 and 2017 is between -80 per cent and +50 per cent.
Property type	Flats are excluded due to insufficient address details being available to identify which flat in a block received the energy efficiency measure.

Comparator group

All the conditions applied to the intervention group are also applied to the comparator group, except for having an energy efficiency measure recorded in NEED.

The comparator group was selected using random stratified sampling, stratifying by:

- Starting gas consumption band[3]
- Region
- Property type
- Property age

3: Gas bands are created using gas consumption in the year before the measure is installed, the lowest gas band is 2,500 kWh to 5,000 kWh, then intervals of 5,000 kWh up to 50,000 kWh.

- Number of bedrooms

Once the comparator group has been selected, each property is paired to a property in the intervention group that has all the same values for the characteristics listed above.

As the random stratified sampling involves an element of chance, each time the pairing process is carried out on the same intervention group different pairs are selected, which influences the final savings estimates. This effect on savings estimates is now known to generally be in the region of 0.5 – 1 per cent of absolute savings (with no bias in either direction), with the variance between analyses decreasing with larger intervention groups. For previous years' NEED publications using the method described in this section, the analysis was only carried out once per year.

Since the November 2013 NEED publication, weighting has been applied to the results to mitigate the impact of a biased housing stock in the intervention group. This attempts to correct for the fact that the intervention group may not be fully representative of the full housing stock.

The weighting factor was calculated for each possible group based on property age, property type and number of bedrooms. For example, group one for cavity wall insulation installed in 2010 would be: the total housing stock excluding flats, being built pre-1919, detached and 1 to 2 bedrooms.

The weighting variables used are shown in Table 2 below.

Table 2: Weighting variables

Variable	Categories
Property age	Pre-1919, 1919-44, 1945-64, 1965-82, 1983-92, 1993-99, 2000-2011, 2012 onwards
Property type	Detached, Semi-detached, End terrace, Mid terrace, Bungalow
Number of bedrooms	1 to 2 bedrooms, 3 bedrooms, 4 or more bedrooms

The weighting factor weighted each record in the intervention population based on its frequency - relative to how often it should appear if this group had the same distribution as the total housing stock. For example, if a property type was more common in the intervention group than the housing stock as a whole, then the weighting factor acts to reduce its overall contribution, while if the property type is less frequent in the group than is the case in the housing stock, then weighting factor acts to increase its contribution.

The weighting factor is calculated using the following formula:

$$\text{Weighting factor for record n } (w_n) = \frac{Housing\ stock_{\ g}}{Total\ housing\ stock} \times \frac{1}{Sample\ stock\ g} = A \times B$$

Where:	*n*	*is the record number in the sample*
	g	*is the group number (e.g. group 1 = built pre-1919, detached, with 1 to 2 bedrooms)*
	housing_g	*is the number of properties in group g in the total housing stock (VOA)*
	sample_g	*is the number of properties in group g from the intervention population (NEED)*

Part A is equivalent to the proportion of the total housing stock a group accounts for (i.e. the number of records in group g in the housing stock divided by the total housing stock).

A is multiplied by B; where B the reciprocal of the number of properties in the intervention group in the same group (i.e. one over the number of properties in the intervention group in group g).

The percentage saving from each measure can then be calculated by summing the weighted percentage saving for each record, to give a percentage saving for the population:

$$Population\ \%\ saving = \sum_n (\%\ \text{age saving for record n} \times w_n)$$

While the weighting was an overall improvement in the method, it is only able to weight for combinations of property characteristics which are present in the intervention group. For example, if detached houses built before 1919 with 1 bedroom are underrepresented in the intervention group, then they will get a higher weighting. However, if such a combination isn't represented in the intervention group at all, then there is nothing to weight by and they can't therefore be considered. Therefore weighted results will not necessarily represent the entire housing stock, the risk of which is higher with smaller invention groups.

What prompted the change?

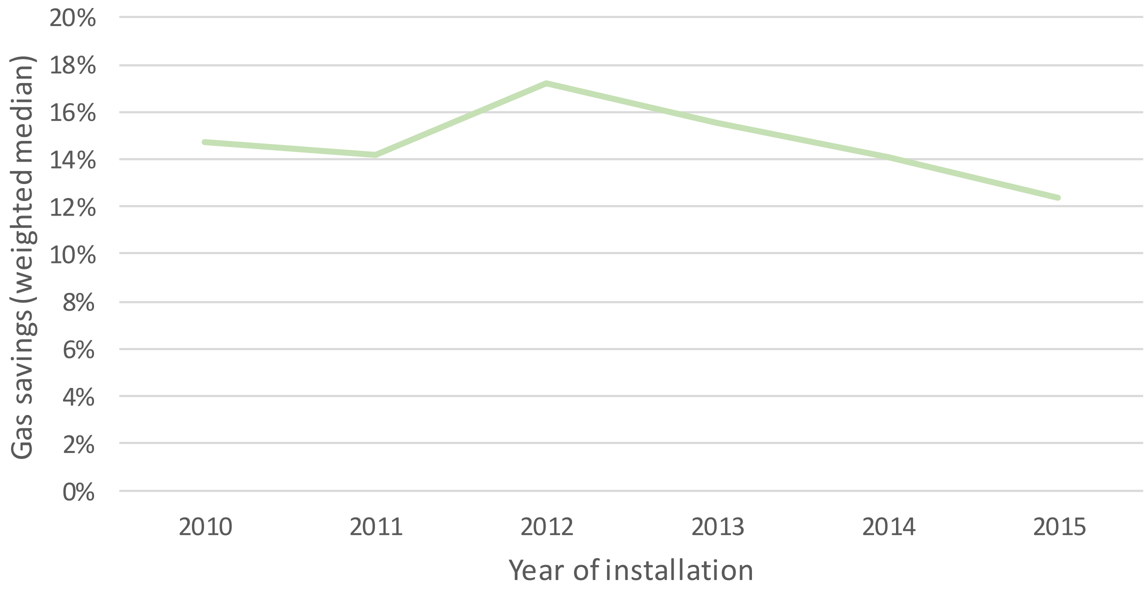
Several factors led to the decision to look for improvements in the impact of measures method.

The first was that in previous years the Valuation Office Agency (VOA) data, which is essential to the analysis, could only be accessed by BEIS staff for a limited time each year. This limited the amount of testing which could be carried out on any changes to the method. This changed in autumn 2018 when BEIS and the VOA signed a data sharing agreement allowing named BEIS staff to hold and access VOA data within BEIS. This enabled the NEED team to make greater use of the VOA data. It also meant that the process used needed to be transformed from the VOA IT system to the BEIS equivalent.

The second was that in the past the full analysis was only carried out once each year. Because the pairing between intervention and comparator involves randomly selecting a comparator property from a pool of candidates, the results varied each time the analysis was carried out. An effective way to deal with this is to carry out the analysis many times and take the mean of the savings estimates. For this to be carried out in a reasonable timeframe use of new technology to handle the multiple analysis was required. This led to the process being migrated from one programming language (SAS) to another (R). The process of moving to a new language brought to light other areas for improvement in the method (e.g. which characteristics the intervention and comparator are best paired by).

Thirdly, the estimates of savings for the same measure varied considerably between years of installation. Figure 2 below illustrates this, showing the weighted median savings of installing solid wall insulation, as published in June 2018[4]. Aside from the effect of properties with measures not in NEED being used in the comparator group and the effects of pairing intervention and comparator groups, there should in theory be little difference in estimated savings between years. It was decided to look more deeply into the impact of measures process to understand what could be causing the differences between years.

Figure 2: Trend in annual savings estimates for solid wall insulation under previous method



4. These figures come from the published table "Impact of Measures Time Series (2005 – 2015)" available at https://www.gov.uk/government/statistics/national-energy-efficiency-data-framework-need-report-summary-of-analysis-2018

What was changed?

Before making any changes, the first step was to replicate the findings of previous years using the new process. The new process was written in the R language, yielding significant reductions in processing time over the older process, which used SAS.

This was done successfully for installations in the 2015 gas period (the most recent year), however for years before this it wasn't possible to replicate those findings exactly.

Replicating the results for 2015 installations gave confidence in the new system. The discrepancies between intervention group sizes and results in previous years are of less concern as there are several factors which likely contribute to this:

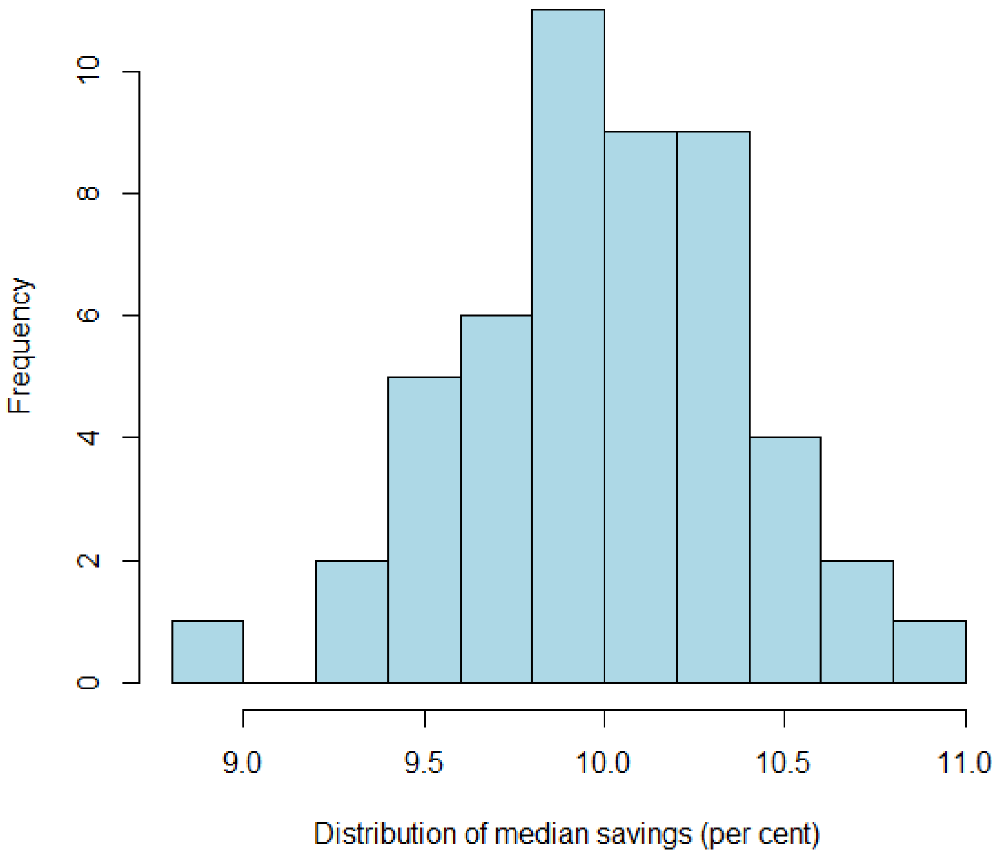
- A change in criteria for a property to be eligible for use in the analysis. This includes the addition of a filter to remove properties with estimated meter readings, which was added for 2015 installs.
- New data in installations in past years being added retrospectively.

Multiple runs

Carrying out the processing within BEIS enabled the full impact of measures analysis to be run many times for each year and technology. Each run generated a slightly different savings figure as there is an element of randomness to pairing intervention and comparator properties.

When the process is run multiple times a histogram can be made of the results. This shows that the estimated savings are normally distributed, and the centre of this histogram provides a "true" estimate of the savings. The mean of the distribution is used for this. Figure 3 below illustrates the distribution of savings with the process being repeated 50 times for solid wall insulation installed in 2015. The more times the process is repeated the more the distributions of savings approaches a truly normal distribution.

Figure 3: Distribution of savings for 50 iterations for solid wall insulation installed in 2015



Pairing intervention and comparator properties

When pairing intervention and comparator properties it is desirable to pair by the property and/or household characteristics which explain the most difference in consumption year on year. However, to ensure that all properties have an adequate number of potential matches available to form a comparator group, the number of characteristics to pair by is limited.

Energy performance certificates

The energy performance certificate (EPC) dataset was joined to NEED so that properties' energy efficiency ratings could be included as a characteristic to pair properties. Roughly half of all domestic properties in England and Wales have had at least one EPC. For properties with more than one EPC, an algorithm was created to determine which would be most appropriate to include. This algorithm is shown is summarised below.

EPC assignment algorithm
If there is one or more EPCs lodged before the beginning of the year of install, of the EPCs lodged prior to the year of installation, the EPC lodged closest to the year of installation is used.

Otherwise, if there is one or more EPCs lodged after the beginning of the year of install, the EPC closest to the year of install is used.

Otherwise, the status is set to "no EPC".

Regression model

To find which of the available characteristics explain the most variation in the change in energy consumption associated with each measure, multiple linear regression models were created. The dependent variable used was the estimated saving of gas consumption for each property (per cent). A model was created for each year of installation from 2011 to 2015 and for each of the following measures: solid wall insulation, cavity wall insulation, loft insulation and condensing efficient boiler. Table 3 below shows all the characteristics included in the models.

Note that while the regression model was attempting to explain a continuous outcome (energy savings), the predictive variables were all treated as categorical. To use these in the model the predictive variables were "dummy coded". Dummy coding involves assigning each of the categories for each variable its own column, populated with a "1" or "0", where "1" is given to the category which is present. For example, there are 7 property types, and a semi-detached property would be given a value of "1" in the "semi-detached" column and a "0" in the other 6 property type columns. All of these dummy coded columns were then input into the linear regression model.

Table 3: All characteristics included in regression model

Characteristic	Description	Data owned by
Consumption band	Banded annual gas or electricity consumption of the property in the year prior to the intervention	BEIS
Region	Region based on former Government office region the property is in	Open
Energy Performance Certificate (EPC)	Energy efficiency rating of the property	Open
Age Group	Banded build year of the property (e.g. 1983 – 1992)	VOA
Adults	Estimated number of adults living in the property	Experian
Income	Estimated total annual income of all adults living in the property	Experian
Bedrooms	Number of bedrooms	VOA

Property type	Type of property (e.g. detached, bungalow, etc)	VOA

Table 4 below shows the 15 categories that have the strongest relationship with the energy savings. This shows that the most important characteristic to pair by is the banded annual gas consumption of the property in the year prior to the installation.

The coefficients were consistent between years and measures. This held true for characteristics not shown in Table 4 (e.g. most of the EPC bands had high coefficients, whereas for Region the coefficients tended to be lower).

Table 4: Weighted average of coefficients for all measures for installations between 2011 and 2015

Category	Coefficient
Gas consumption in band: 42,500 – 45,000 kWh	0.1034
Gas consumption in band: 37,500 – 40,000 kWh	0.1013
Gas consumption in band: 40,000 – 42,500 kWh	0.1011
Gas consumption in band: 30,000 – 32,500 kWh	0.0992
Gas consumption in band: 32,500 – 35,000 kWh	0.0986
Gas consumption in band: 27,500 – 30,000 kWh	0.0985
Build year: 2012 onwards	0.0973
Gas consumption in band: 25,000 – 27,500 kWh	0.0957
Gas consumption in band: 22,500 – 25,000 kWh	0.0947
Gas consumption in band: 20,000 – 22,500 kWh	0.0903
Gas consumption in band: 47,500 – 50,000 kWh	0.0902
Gas consumption in band: 45,000 – 47,500 kWh	0.0896
Gas consumption in band: 17,500 – 20,000 kWh	0.0871
EPC band B	0.0836
Gas consumption in band: 15,000 – 17,500 kWh	0.0802

The results from the regression allowed an informed decision to be made on the best characteristics to pair properties by. To ensure that the majority of properties were used in the analysis while pairing by as many features as possible, an algorithm was created which paired by as many of the below characteristics as possible while meeting the constraint that over 99.9 per cent of all intervention properties be paired. The characteristics, in order of the importance the algorithm assigns to them, are:

- Gas consumption band
- Type of property
- Age band of property
- Number of adults living in the property
- EPC
- Region

Note that some variables are strongly related to other variables not included in the list above. For example, the gas consumption band tends to be higher for properties with a larger floor area or more bedrooms. This means that when gas consumption band is used for pairing, it would be redundant to pair by floor area or the number of bedrooms.

This process is referred to “elastic pairing”, as the characteristic which properties are paired by changes depending on the distribution of characteristics in the intervention group.

Weighting results

When deciding how to stratify the weighting framework, a useful question to ask is what the result should be representative of. For example, if the estimated savings should be representative of the number of bedrooms in the housing stock, then weights should be stratified by the number of bedrooms. Alternatively, if the savings figure should be representative of the number of adults in the home, then that should be incorporated into the weighting framework.

In the case of this analysis it is considered most important to weight by the characteristics which explain the most variation in consumption between years, because this means the results would be most likely to generalise to the entire population. This meant that the characteristics used to pair intervention and comparator groups were taken as a starting point for weighting.

Elastic weighting

For the final weighting process, to ensure that the majority of properties were used in the analysis while weighting by as many features as possible, an algorithm was created which weighted by as many of the below characteristics as possible while meeting the constraint that over 83 per cent of the national housing stock be represented.

For the constraint of 83 per cent, flats are not included in the calculation. The threshold of 83 per cent was deemed a reasonable balance between:

- Weighting the results to represent the majority of the housing stock
- Weighting the results by enough features for the results to be meaningful

The characteristics, in order of the importance the algorithm assigns to them, are identical to those used for pairing:

- Gas consumption band
- Type of property
- Age band of property
- Number of adults living in the property
- EPC
- Region

This is similar to the elastic pairing process, however in this case the process is referred to as “elastic weighting”.

It is possible that the elastic weighting process could be improved in the future by dynamically changing the order in which characteristics for weighting are selected, depending on the distribution of characteristics in the intervention group.

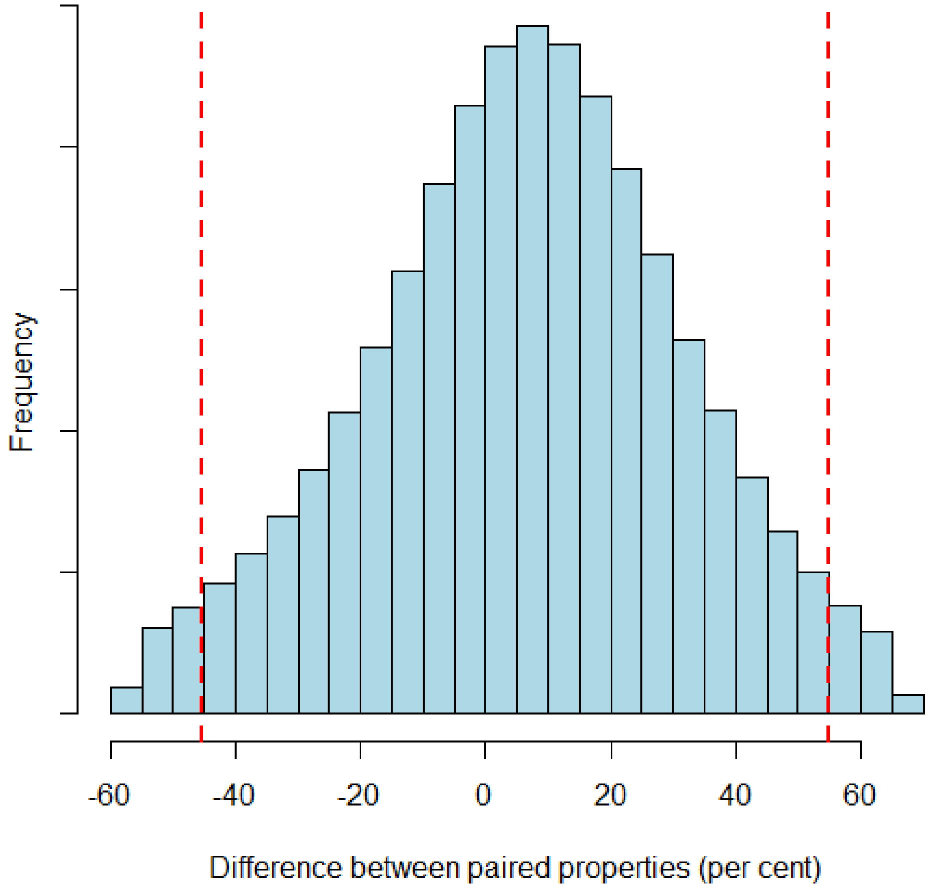
Removing outliers

In the previous method the difference in savings between the intervention and the comparator group were removed if they were less than -80 per cent or over 50 per cent. Values outside of this window were considered to be the result of an inappropriate pairing and the filter prevented these pairs from being included.

While the filter described above was very useful, the fact that the filter boundaries remain static means that measures which have very high savings are likely to be estimated to be slightly lower than they actually are. This is because the distribution will be closer to the -80% figure for the higher saving measure and further from the 50% figure. As such a higher proportion of outliers below -80% can be expected to be cut off and fewer above 50%, relative to a lower impact measure. This will cause the estimated median savings of the high impact measure to be slightly lower and those of the low impact measure to be higher.

To eliminate this problem the filter was calculated for each distribution of savings after the intervention and comparator group were paired. An appropriate method of calculating this was deemed to be the highest density region (HDR). The HDR is set to 95 per cent, which means that the 95 per cent of the data which is most densely populated is included. To illustrate this Figure 4 below shows how the values to filter on are determined using the 95 per cent HDR for boilers installed in 2016. Note that this is different to cutting off the top and bottom 2.5 per cent of the distribution, as such a cut would have no impact on the calculated median.

Figure 4: Filtering boundaries for paired properties using 95 per cent highest density region for boilers installed in 2016



Removing properties with estimated consumption

For properties without a meter reading in a particular year, a reading for that meter is generally estimated in the meter data received by BEIS, and recorded in NEED, rather than being left blank. As actual consumption isn't recorded for these properties, they shouldn't be included in either intervention or comparator groups. There are two scenarios in which meter reads are estimated:

1) When a meter has had consumption recorded in the past, the consumption figure recorded will be carried forward to future years as the estimate. Properties with these estimates are removed by finding properties where annual consumption is identical to the previous year. This filter was introduced in the NEED 2018 publication.

2) When a meter is new it is assigned an estimated consumption figure based on its profile. This can be detected by looking for a large number of properties with identical annual consumption. In practice this is done by rounding the consumption of all properties to the nearest kWh, counting the number of properties by each kWh, ordering the counts by kWh, and looking for changes in counts between sequential kWh values of over 300 per cent. For example,

if 50 properties have a consumption of 12,235 kWh and 345 properties have a consumption of 12,236, all 345 properties with a consumption of 12,236 kWh would be removed from the intervention and comparator groups. Such a change would be a 590 per cent increase in the frequencyof consumption, above the 300% threshold, meaning that it is very likely that most properties with gas consumption of 12,236 kWh in fact have estimated readings. In practice this finds 10 – 15 rounded kWh figures each year. While it is a beneficial filter, is it likely that lower frequency estimated consumption figures remain in the analysis. This filter was introduced in the current publication (NEED 2019).

Overview of new method

The method is presented in algorithmic form below.

Impact of measures algorithm

Select all properties in England and Wales in year n as basis for comparator group, then apply filters:
1) Remove where the consumption value in the year n-1 or year n+1 is estimated
2) Remove where the change in consumption between the year before and the year before that, or the change in consumption between the year after and the year of installation, is either over 80 per cent reduction or 50 per cent increase
3) Apply highest density region filter to remove outliers in change in consumption between year before and year after
4) Remove where consumption value is not between 2500 – 50,000 kWh for gas, or 100 – 25,000 for electricity
5) Remove where one or more measures were installed in the years before, during or after the period in question
6) Remove flats

Create interventions group by selecting all properties in NEED with an installation of each measure during the period in question.

Create intervention groups for combinations of measures by finding properties with multiple interventions during the period in question.

Apply filters to intervention groups:
1) Remove where the consumption value in the year before or year after is estimated
2) Remove where the change in consumption between the year before and the year before that, or the change in consumption between the year after and the year of installation, is either over 80 per cent reduction or 50 per cent increase
3) Apply highest density region filter to remove outliers in change in consumption between year before and year after
4) Remove where consumption value is not between 2500 – 50,000 kWh for gas, or 100 – 25,000 for electricity
5) Remove where one or more measures were installed in the year before or the year after

6) Remove flats
7) If assessing solid or cavity wall insulation, remove where the property was built after 1999 (due to changes in building regulations for properties built after 1999)

Calculate banded gas or electricity consumption for properties in comparator and intervention groups.

Apply EPC assignment algorithm to assign EPC ratings to comparator and intervention groups.

Apply elastic pairing process to find optimal characteristics to pair by.

Apply elastic weighting process to find optimal characteristics to weight by.

The following section is carried out with 50 iterations:

Randomise the order of the comparator property prior to joining the properties

Join the intervention and comparator properties

Calculate the relative changes in consumption

Apply highest density region filter to remove outliers

Create summary statistics (End of iterations)

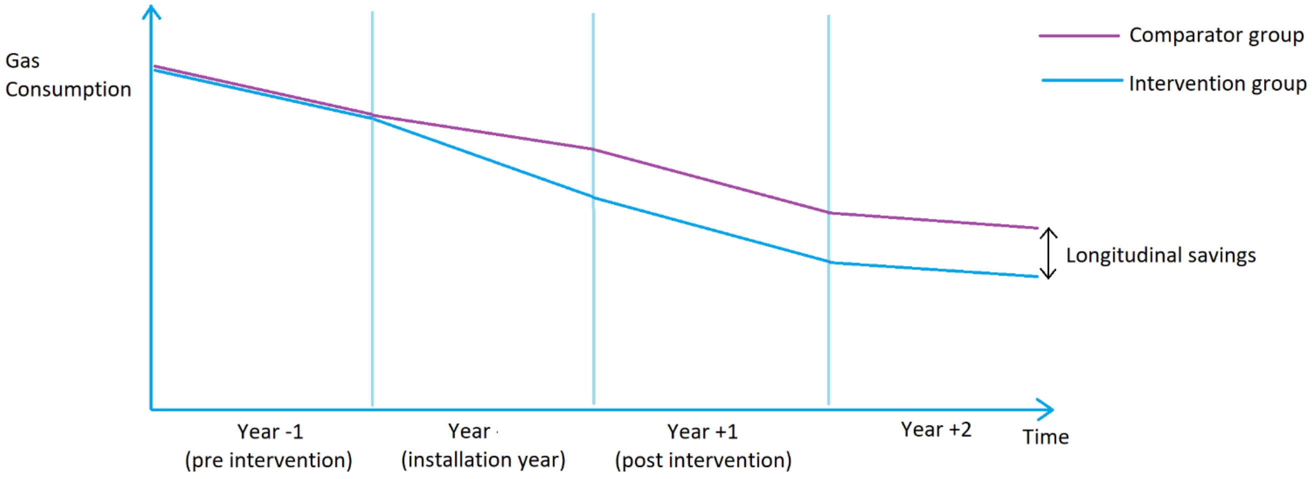
Calculate averages of summary statistics across all iterations.

New features

Longitudinal impacts

The capacity to find the impact of measures over time (longitudinally) has also been added. This uses the same method as the standard method with paired intervention and comparator properties. It uses the same filters, pairing characteristics and weighting characteristics. The change is that rather than comparing consumption in the year before installation to the year after, consumption in the year before is compared to any number of years after. The limitation is the latest year for which consumption figures are held in NEED. This makes it possible to see how the impact of measures changes over time. This is demonstrated for a two year period in Figure 5 below.

Figure 5: Longitudinal difference in difference approach



"Other" energy savings

Some gas heated homes use electric heaters for secondary heating. If this is widespread then only assessing the gas savings of insulation may provide only a partial picture. To assess this, analysis to estimate the electricity savings of primarily gas-saving measures was added. This uses the same method as the standard analysis, assessing electricity use (kWh) in the years before and after the installation, with a comparator group. Similarly, gas savings from primarily electricity-saving measures (such as solar PV) were estimated.

It should be noted that the intervention groups for this were filtered to ensure reasonable levels of electricity and gas consumption in the years of interest, rather than only one energy type. This extra filtering means that the intervention group will be smaller for this analysis than for the standard impact of measures analysis, which only considers one energy type.

Outstanding issues

While the updated method provides several improvements, some issues remain outstanding.

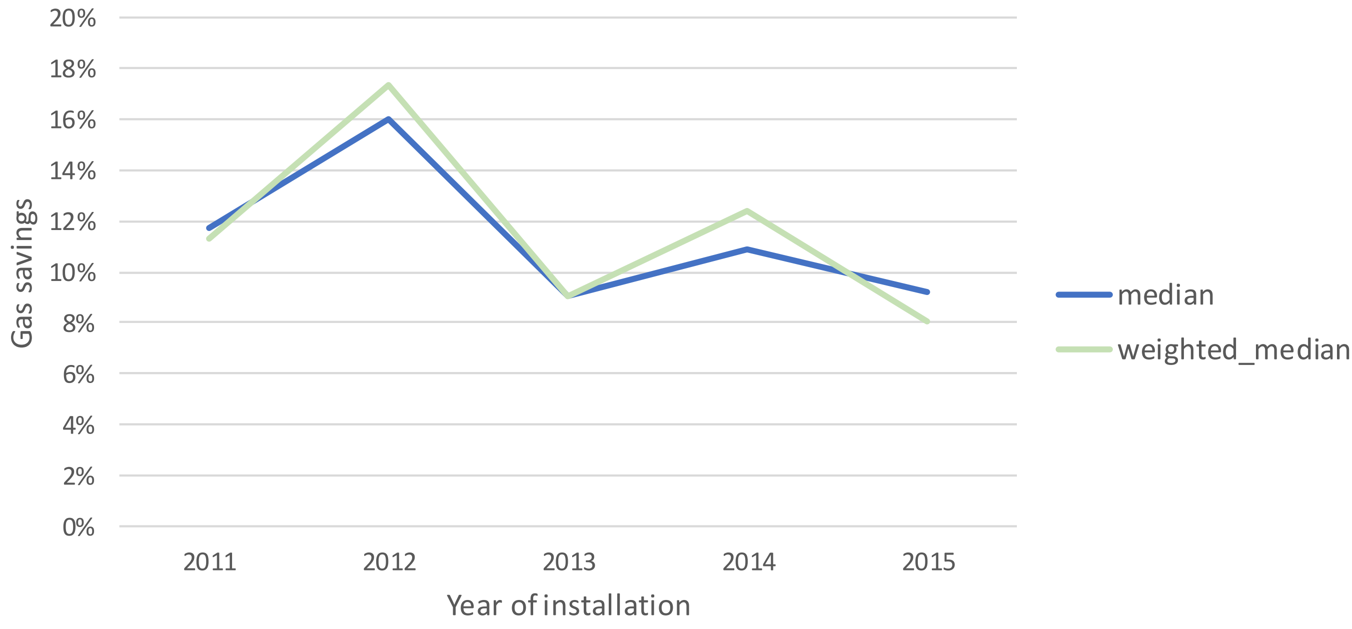
The elastic weighting process could be improved in the future by dynamically changing the order in which characteristics for weighting are selected, depending on the distribution of characteristics in the intervention group.

Installations outside of government schemes or the Gas Safe register remain unknown. As time goes on an increasing proportion of properties will have at least one installation of a measure which isn't included in the impact of measures analysis. Due to the increasing prevalence of these measures it can be expected that the comparator group is becoming less "pure" with each subsequent year, as an increasing proportion of comparator properties include other measures.

Benefits from new measures in the form of comfort taking, rather than bill savings, remain undetectable in NEED. This means that the savings from measures are underestimated, with it not being possible to precisely quantify the underestimation. Estimations can be made, for example by considering the savings for high income properties, which are less likely to take comfort. Another solution to this would be to link data on the temperature inside each property to NEED, which would make it possible to quantify the changes in temperature and combine this with the bills savings, to get a fuller view of the benefits provided by the measure.

There are also differences between years. Figure 6 demonstrates this for solid wall insulation. Possible causes for this are listed in the following section. Changes to the impact of measures method in the future may account for or explain the differences between years.

Figure 6: Trend in annual savings estimates for Solid Wall Insulation under new method



Causes of differences between years

As highlighted in the weighting results section of this document, it is likely that the causes of the differences in estimated savings between years are due to features of the installations which aren't recorded. These features include:

- Not knowing the number of walls in the property covered by solid wall insulation.
- Not knowing any detail about the material of the measure, only it's overall category (e.g. cavity wall insulation is available in multiple forms including bead and mineral wool).
- Not knowing the thickness of loft insulation.
- Not knowing the model or efficiency rating of new boilers.
- Not accounting for the quality of installations.
- Not accounting for the size of the measure (e.g. generation capacity in solar photovoltaic installs).
- The quality of installs may vary between years.
- The results may be different for early adopters of novel measures, as the treated population may consume energy in a different pattern to other consumers.
- Increasing prevalence of measures outside of government schemes. This means that the comparator group is likely to include properties which have had energy efficiency improvements made. All other things being equal, this would lead to a decrease in the savings found using NEED in later years.

This publication is available from: https://www.gov.uk/government/collections/national-energy-efficiency-data-need-framework

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