The development of a National Energy Efficiency Data-framework and its use in evaluating energy efficiency policies

Mary Gregory, Statistician, Department of Energy and Climate Change, London, UK.
Julian Prime, Statistician, Department of Energy and Climate Change, London, UK.

Abstract

The UK have developed a National Energy Efficiency Data-framework to help inform policy evaluation. The framework builds on the progress made in producing sub-national energy consumption statistics, a project which collects and analyses data on the gas and electricity consumption recorded by meters installed in homes and businesses. Data from around 30 million electricity meters and 25 million gas meters are utilised each year. The innovative approaches used to produce sub-national estimates of consumption were recently awarded the first "innovation and development" award from the Royal Statistical Society.

The National Energy Efficiency Data-framework takes this a step further. Gas and electricity consumption data are matched, at an individual property level, with information about energy efficiency measures installed in households and household characteristics. This enables analysis to help improve our understanding of energy consumption and the impact of energy efficiency measures. Analysis from these matched data have been used to inform policy development and will be used to support policy evaluation of a number of energy efficiency policies in the UK. Work so far has focused on the domestic sector, but there is also potential to undertake work relating to the non-domestic sector.

This paper will explain the methods used to get energy consumption data and how these are used alongside other data to understand more about energy consumption and the impacts of energy efficiency measures. It will cover some of the results from the analysis so far and how the data might be used in policy evaluation in future.

Background

The UK has collected and published energy consumption data within the Digest of UK energy Statistics since 1948. This has been produced at a national level based around aggregate information from energy suppliers and produced in compliance with international reporting guidelines for energy statistics. Whilst these data are still used, the development of UK energy policy has required more detailed data to help deliver and monitor reductions in energy use and emissions. One requirement for more disaggregated data came from the 2003 Energy White Paper which encouraged regional and local bodies to have greater engagement in improving energy efficiency. However as no such data was available, the energy statistics team within the UK Department of Trade and Industry (now within the UK Department of Energy and Climate Change) began a project to deliver to users a more disaggregated breakdown of energy data.

This paper will outline the methods used to produce sub-national energy consumption data and how this is used alongside other data to understand more about energy consumption and the impacts of energy efficiency measures. It will cover some of the results from the analysis so far and how the data might be used in policy evaluation in future.

Collecting and analyzing metered energy use data

Data at individual meter point was first obtained in 2004. The project involved obtaining consumption of gas and electricity for all homes and businesses within England, Scotland and Wales, at individual energy meter level. This equates to around 30 million electricity meters and 25 million gas meters. The Department wanted to introduce a low-cost solution, thus reducing the burden on data suppliers. Following formal consultations with energy industry partners and a large number of users, it was concluded that the consumption data obtained from the existing administrative systems of the energy companies would meet the requirements. These meter data and the related consumption information [Meter Point Administration Number (MPAN) for electricity use and the Meter Point Reference Number (MPRN) for gas] were geo coded using the address information provided. To protect the confidentiality of the data initial outputs from the meter analysis were initially limited to Local Authority level, but following further engagement with energy suppliers, analysis at the Middle Layer Super Output Area (MLSOA) and Lower Layer Super Output Area (LLSOA) (both UK Census based areas, covering around 5,000 and 1,000 people (2,000 and 400 homes) respectively) was agreed. Data are currently collected on an annual basis with the introduction of smart metering we will be reviewing the frequency of the data collection and subsequent analysis.

Datasets, commentary, maps, and analytical tools have all been developed in conjunction with key users and stakeholders, and are updated regularly on the Department of Energy and Climate Change (DECC) website. In addition, the LLSOA data were also added to a number of other analytical databases (including Neighbourhood Statistics) enabling users to investigate trends in energy use with some of the key drivers (including population, housing and income). The work was recognized by the Royal Statistical Society in its 2010 annual awards, winning the prestigious “Innovation and Development in Official Statistics” award.

Future utility of the data was considered at an early stage, and working closely with the energy industry and other key energy efficiency stakeholders in the UK, plans were established at an early stage for a future data architecture suitable for matching with additional data sources. By doing such matching and analysis, it was hoped that a greater understanding of the drivers of energy use would be developed, which would help to monitor and evaluate the real life impact of energy efficiency measures in different types of buildings.

Development of the National Energy Efficiency Data-framework

The National Energy Efficiency Data-framework (NEED) is the means to match the electricity and gas meter point consumption data with additional data sources. Gas and electricity consumption data are matched, at an individual property level, with information about energy efficiency measures installed in households and household characteristics.

Datasets are combined within the framework using the National Land and Property Gazetteer (NLPG) Unique Property Reference Number (UPRN) as a spine. Address data from each of the datasets included in NEED is used to assign a UPRN to the records in the dataset, the UPRN is then used to match the datasets to each other and form NEED.

Data in NEED cover the residential and business sectors across the whole of Great Britain. However work to date has focused on the residential sector in England. Four key data sources have been used in this work: meter point gas and electricity consumption data as described above; the Homes Energy Efficiency Database (HEED) which includes information on energy efficiency measures installed; Valuation Office Agency (VOA) property attribute data; and Experian modelled data on household characteristics.

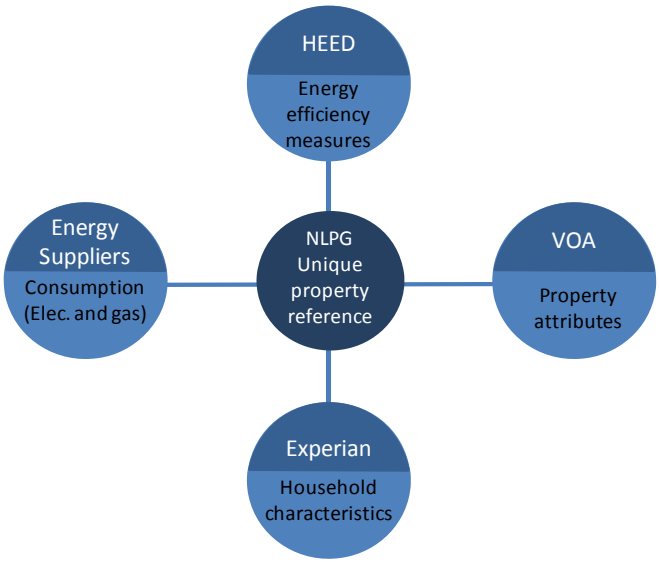


Figure 1. Residential data in NEED

Homes Energy Efficiency Database (HEED). HEED is a national database developed by the Energy Saving Trust. It was set up to help monitor and target carbon reduction and fuel poverty work. It contains details of energy efficiency and micro-generation installations such as cavity wall insulation and solar hot water, including the date of installation. Data have been recorded in HEED since 1995 including activity reported from Government programmes, such as the Energy Efficiency Commitment (EEC) and Carbon Emissions Reduction Target (CERT), and activity reported by trade associations such as Gas Safe and FENSA. Approximately 50 per cent of UK homes have a record in HEED[1].

Valuations Office Agency (VOA). The VOA are responsible for allocating homes in England and Wales to the appropriate Council Tax band. In order to do this it maintains a property database covering all properties in England and Wales. It includes information on the age of dwelling, dwelling type, number of bedrooms and floor area.

Experian. Experian is a commercial organisation which produces modelled data of household characteristics at address level. Variables include income group, number of adults, age of household reference person and length of residence. DECC purchased a sample of these data for England.

Creating an analytical dataset. Each of the four datasets described above were matched to the NLPG at property level - sub-building or building shell level. Match rates were high for all the datasets and well above expectations**.**

Data source	**Match Rate**
Electricity Consumption	94% (87%)
Gas Consumption	97% (93%)
HEED	99% (98%)
Experian	82% (69%)
VOA	100%

Table 1. Matching statistics (sub-building match rates in brackets)

1 There are records for approximately 50 per cent of homes in the UK, however there may not be full information for each of these records. Data include activity delivered through Government schemes and activity reported from trade associations including, Gas Safe (formally CORGI) and FENSA. There is no information on measures that a household have installed themselves (DIY).

The matching statistics in Table 1 cover the residential sector (and business sector for consumption data). When considering the match rates set out in Table 1 it should be noted that the matching statistics are calculated based on the number of records in each of these sources rather than the number of UPRNs in England and Wales. For example, not all properties have a gas meter and DECC only leased Experian data for a representative sample of about 3 million properties; the match rate shows how many of the records in each of these sources could be matched to the NLPG. The figure quoted for HEED excludes flats which were excluded from the analysis of impacts of energy efficiency measures due to difficulties with matching.

In order to help data confidentiality, increase processing speed and reduce cost it was decided that a sample would be used for analysis. A representative random sample of approximately 3.8 million records was selected from the VOA data. The match rate for VOA data is 100 per cent as only VOA records that could be matched to the NLPG were included in the sample. In order to create the analytical file, data from all sources were matched to the VOA sample via the UPRN.

Results from NEED

Analysis undertaken to date has been intended to test the value of this framework approach. However, results from NEED have already been used to inform policy development within DECC, most significantly for the Green Deal, which is the UK Government's initiative to support the implementation of energy efficiency measures in households and businesses. Initial results from NEED cover electricity and gas consumption for different properties and households, and the impact of energy efficiency measures.

Summary consumption statistics. A key benefit of NEED is the ability to be able to analyse energy consumption by property and household information. Initial analysis made use of 2008 consumption data and compared this with property and household attribute data.

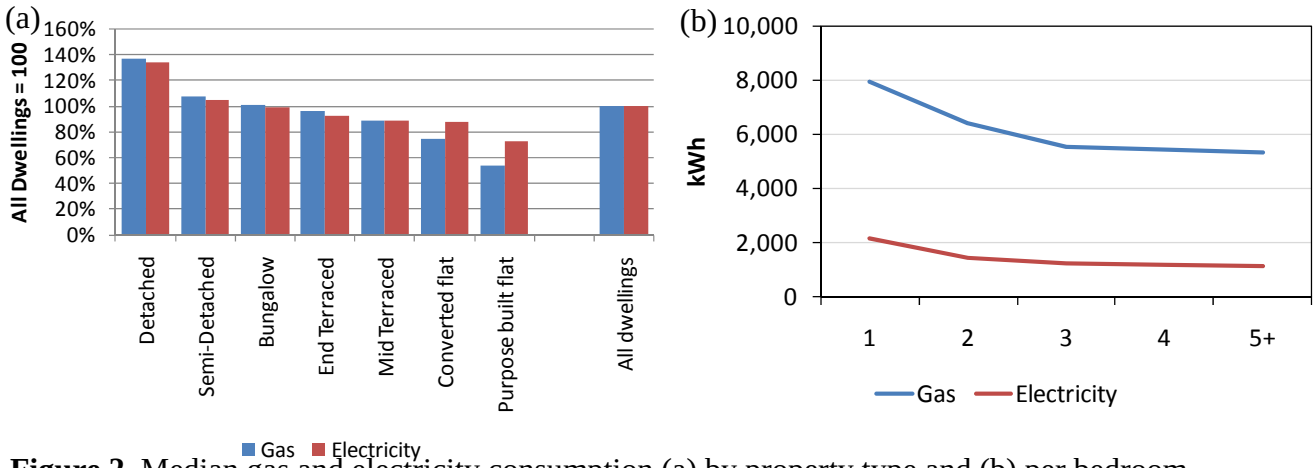


Figure 2. Median gas and electricity consumption (a) by property type and (b) per bedroom.

Figure 2(a) shows that detached houses have the highest median consumption and purpose built properties have the lowest median consumption. The median consumption for bungalows is the most similar to the whole population median at 101 per cent and 99 per cent of the all dwelling median for gas and electricity respectively. Figure 2(b) shows the consumption by number of bedrooms, demonstrating that the consumption per bedroom decreases as the number of bedrooms increases, dropping sharply up to three bedrooms and then flattening out.

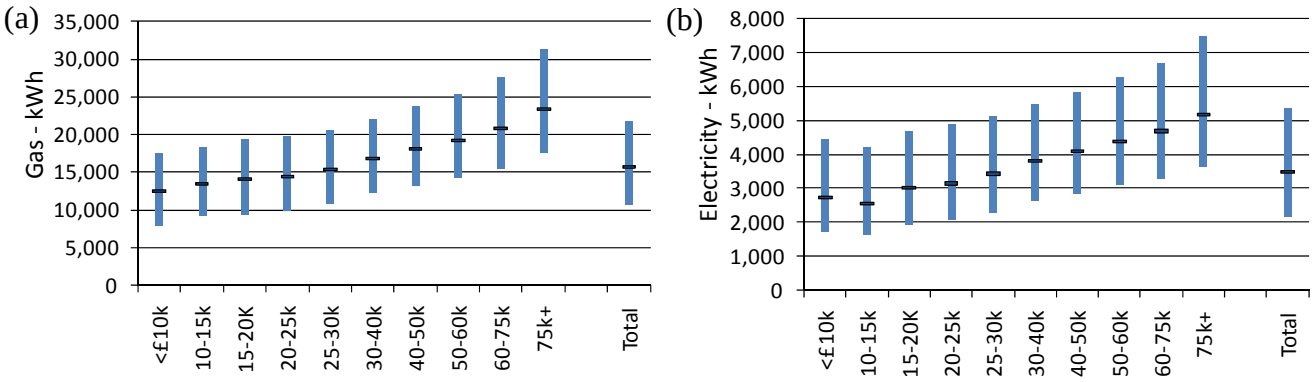


Figure 3. Consumption by income group, median and inter-quartile range, (a) gas and (b) electricity.

As would be expected, Figure 3 shows that the median consumption is higher for households with a higher income. For both gas and electricity the median consumption for the highest income group is 1.9 times higher than the median for the lowest income group. It is likely that some of the results seen here are due to a correlation between variables. For example, based on the data in this analysis, the correlation between income and property type is 0.30. It is likely that households on higher incomes have larger properties and this may be the main driver for the higher consumption observed for this group. Figure 4 shows the results of initial analysis of the correlation between a number of key variables and the consumption of gas and electricity.

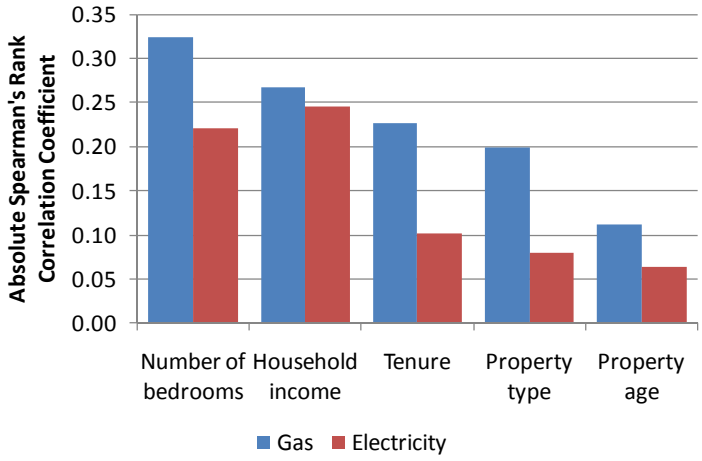


Figure 4. Correlation coefficients for explanatory factors of 2008 energy consumption

The most significant single factor in determining gas consumption is number of bedrooms (which is very closely associated with the size of the property); properties with more bedrooms consume more gas. For electricity consumption household income is the highest single determinant, with a coefficient of 0.25. In all cases, Figure 4 shows a lower correlation between the property attribute and electricity consumption than for gas. This is likely to be because gas use is dominated by heating while electricity is used for a wider range of purposes.

Impact of energy efficiency measures. NEED has also been used to estimate the impact of installing energy efficiency measures in households in England. Analysis undertaken to date looks at measures installed during 2006 including; cavity wall insulation, loft insulation (including top-up), replacement boilers, double glazing and lighting. An assessment of the saving was made using a difference in difference approach looking at the energy consumption before and after a measure had been installed and comparing this with changes in consumption observed in a comparator group, i.e. a group who had not had any measure recorded as installed, over the same period. The comparator group was

made up of 910,910 households which did not have a record in HEED. Mean and median savings for measures are reported due to the policy necessity to understand the impact of measures on a typical house (from the median) and total savings from installation of measures (from the mean).

Analysis undertaken so far in NEED focuses on savings in gas; as the main fuel used to heat homes in Great Britain, with the exception of lighting where the saving in electricity consumption was assessed. As referred to previously, due to difficulties matching flats in HEED meaning it was difficult to identify which flat or sub-building within a building shell had received the measure stated, flats were excluded from this analysis. Properties with an estimated electricity or gas reading during the period were also eliminated from the analysis where possible. To do this it was assumed a consumption value was an estimate if a property had the same value in consecutive years.

It is likely that some measures had been installed but not recorded in HEED, for example do-it-yourself loft insulation and some boiler installations. Therefore the comparator group savings may be bigger than it would have been if designed as a controlled experiment. Therefore, the results reported below may underestimate the actual saving. Based on sales figures during the period considered (2005-07), the impact of this is estimated to be around 170kWh per year.

Results for cavity wall insulation are shown in detail below. Figure 5(a) shows mean gas consumption in 2005 and 2007. The mean consumption in 2005 was higher for properties with cavity wall insulation installed in 2006 (20,830 kWh) than for the comparator group (19,888 kWh). There are a number of factors which may contribute to this, including the inclusion of more modern properties, which are likely to be more energy efficient as new properties have probably had energy efficiency measures installed when built, in the comparator group.

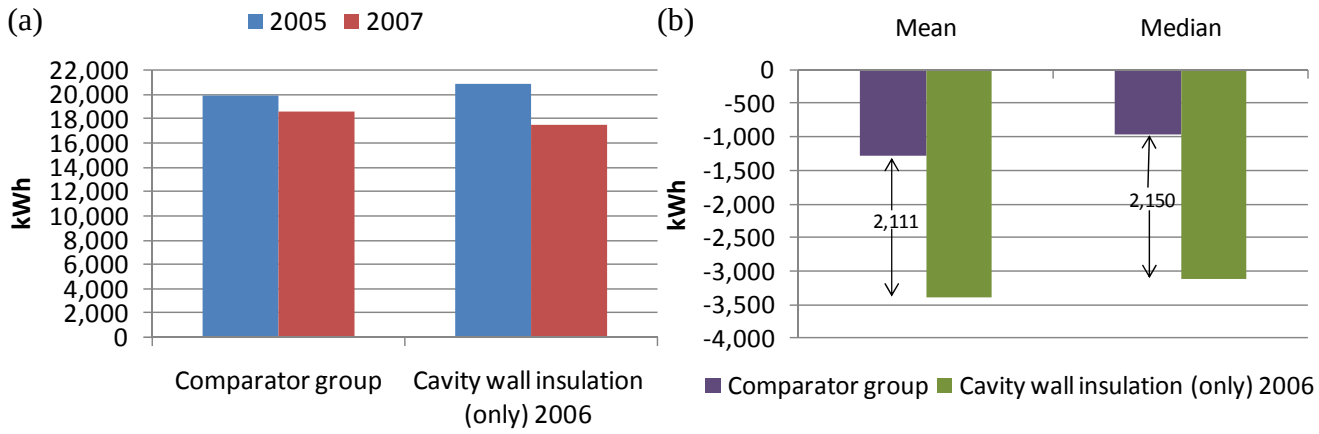


Figure 5. (a) Mean gas consumption 2005 and 2007 for comparator group and properties with cavity wall insulation installed in 2006. (b) change in annual consumption between 2005 and 2007, comparator group and cavity wall insulation 2006.

Figure 5(b) shows the saving observed in properties with cavity wall insulation installed in 2006 compared with the saving in the group with no insulation measures installed in any year. Despite uncertainty in the similarity of the properties in the comparator group and properties with cavity wall insulation, raised by the differing levels of consumption in 2005, it is clear that there is a significant saving from the installation of cavity wall insulation. There is also considerable variation in the saving observed. The median saving for properties with cavity wall insulation installed in 2006 (intervention group), before adjustment for the comparator group is 3,110kWh, the 10th percentile saving is 8,260kWh while at the 90th percentile there was an increase in consumption (860kWh). Figure 6 shows the distribution of the reduction in gas consumption between 2005 and 2007.

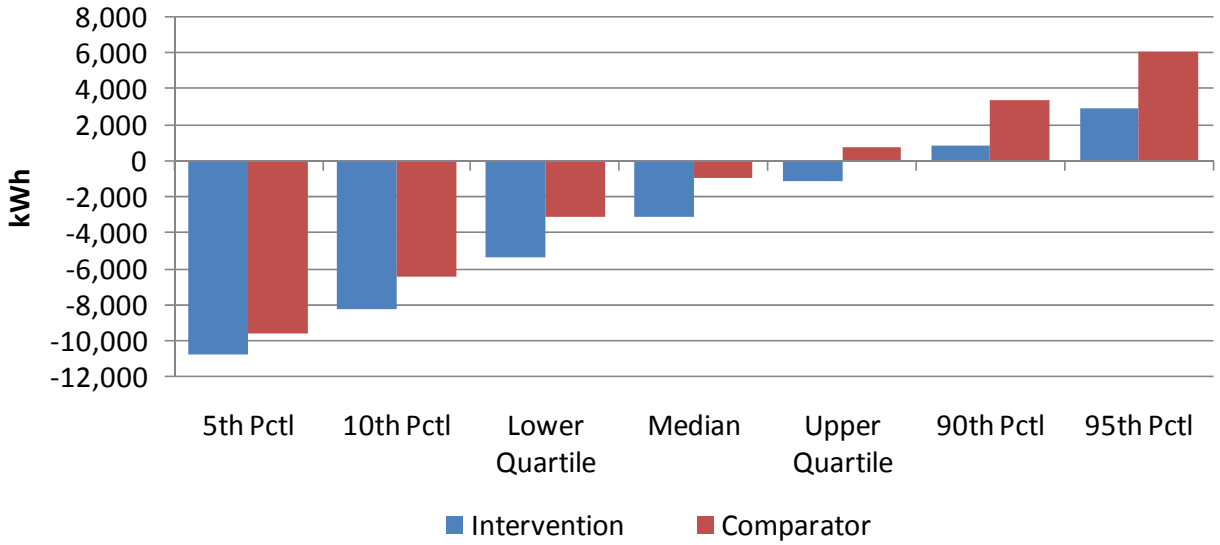


Figure 6. Change in annual gas consumption between 2005 and 2007.

Similar analysis was also undertaken for other measures. Table 2 shows the savings for cavity wall insulation alongside four other energy efficiency measures; replacement boilers, loft insulation (including top-up), glazing measures and lighting measures. Of the five measures considered, cavity wall insulation and condensing boilers had the greatest potential to save energy, with median savings of 2,150 kWh and 2,180 kWh respectively.

Measure	Sample size	Mean	Median
Cavity Wall Insulation	15,750	-2,110 kWh	-2,150 kWh
Condensing Boiler	35,200	-1,660 kWh	-2,180 kWh
Loft Insulation (including top-up)	11,170	-620 kWh	-590 kWh
Glazing Measures	40,000	-390 kWh	-450 kWh
Lighting Measures	59,000	-60 kWh	-60 kWh

Table 2. Mean and median change in consumption between 2005 and 2007 for properties with measure installed in 2006.

Figure 7 shows the median percentage change for the three measures demonstrating the greatest savings (cavity wall insulation, loft insulation and replacement condensing boilers), along with the lower and upper quartiles. These figures do not include any adjustment to control for the changes that may have been observed even if no measure had been installed, but can be seen alongside the equivalent changes for the comparator group. From the chart it can be seen that the inter-quartile range for boilers is greater than for cavity wall insulation despite the median saving being very similar (-16 per cent for cavity walls and -17 per cent for condensing boilers). One cause of this is likely to be the variation in efficiency of the boilers being replaced.

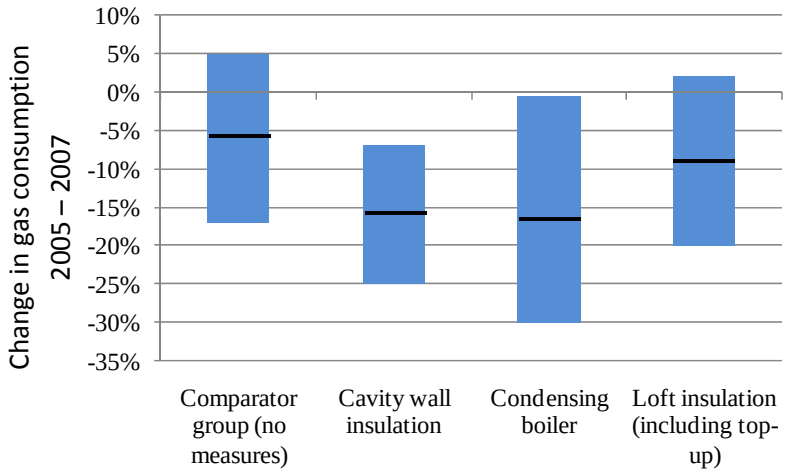
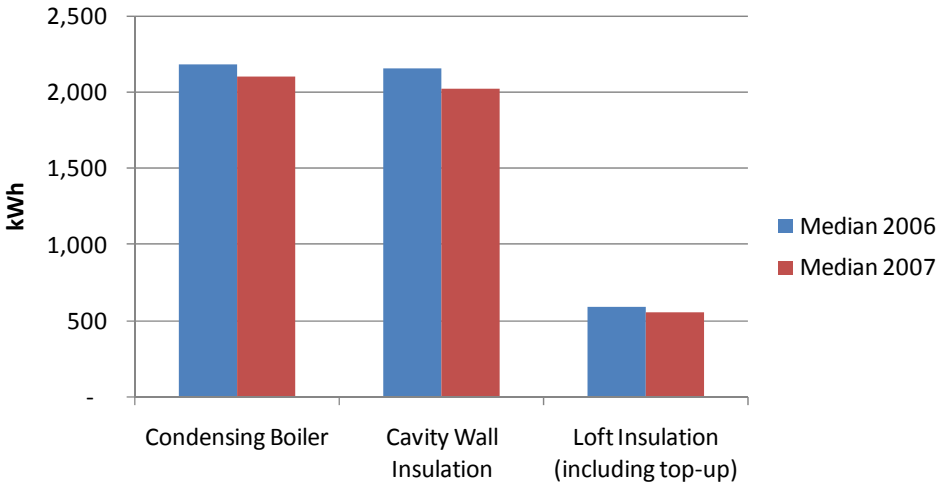


Figure 7. Median, lower and upper quartile percentage change in gas consumption between 2005 and 2007.

To validate the findings observed in the analysis of measures installed in 2006, analysis was repeated for measures installed in 2007. Change in consumption over the period 2006 to 2008 was used to assess the impacts for the three major measures; cavity wall insulation; loft insulation; and condensing boilers. Figure 8 shows that the results for measures installed in 2007 are consistent with the savings observed for measures installed in 2006 and gives confidence in the findings.



Measure	Median 2006	Median 2007
Condensing Boiler	-2,180 kWh	-2,100 kWh
Cavity Wall Insulation	-2,150 kWh	-2,030 kWh
Loft Insulation (including top-up)	-590 kWh	-560 kWh

Figure 8. Median saving for major measures installed in 2006 and 2007.

Conclusion

The development of NEED has demonstrated the potential of utilising administrative data to inform development and evaluation of important policies. Many of the results described in this paper are not unexpected, however this work has enabled impacts to be quantified in a way that had not previously been possible. It has allowed DECC to understand more accurately the impacts of past and current policies, such as the Energy Efficiency Commitment (EEC) and Low Carbon Communities Challenge (LCCC), and help inform expectations for future policies, such as the Green Deal and the Energy

Company Obligation (ECO). The large samples available through the innovative use of administrative data have enabled detailed analysis which brings new insights, for example enabling a better understanding of consumption in very small geographical areas and of the impacts of energy efficiency measures in different types of property.

The work described above was carried out in order to test whether this approach to looking at energy consumption and impacts of energy efficiency measures had value. DECC has been encouraged by the outputs from the work and the value that has already been gained from the results. Given this success, DECC plans to use these data to carry out further analysis in a number of areas. This will build on the results presented in this paper including refining some of the methods, repeating analysis for additional years and looking at the impact of solid wall insulation. It is also intended that NEED will be used in a number of key evaluations over coming years, including to evaluate the impact of the Green Deal. Further work will also include analysis in the business and industrial sectors and development of a model of energy consumption.

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