Energy usage in households with Solar PV installations

Background

The National Energy Efficiency Data-Framework (NEED) is produced and published by DECC to provide detailed information on annual electricity and gas usage, and energy efficiency in domestic and non-domestic buildings in Great Britain. The published consumption figures are broken down by property and household attributes, as well as geographic and socio-demographic characteristics. Analyses conducted on a representative sample of households allow DECC to investigate the impact of installing energy efficiency measures on gas consumption. For more information, visit www.gov.uk/government/collections/national-energy-efficiency-data-need-framework.

The Feed-in Tariff (FiT) scheme is a financial incentive mechanism launched in April 2010. Its aim is to encourage the deployment of small-scale (up to 5MW) renewable microgeneration installations, such as wind turbines and solar photovoltaic (PV) panels. Microgenerators receive guaranteed payments from electricity suppliers based on the kilowatt hours (kWh) of electricity produced, along with export tariffs for electricity not used on site but exported to the grid. For more information, visit www.ofgem.gov.uk/environmental-programmes/feed-tariff-fit-scheme.

Information on households that registered for the FiT scheme, and installed solar photovoltaic (PV) panels to generate electricity, has now been combined with NEED. This article describes initial results from analysis of these data. The analysis of their energy consumption habits will allow DECC to gain a better understanding of how the FiT scheme is performing against its objective of helping consumers become active participants in the transition to a low-carbon economy.

This initial analysis addressed the following questions:

- What are the general characteristics of households with solar PV installations?
- How does the installation of solar PV affect a household's energy consumption? Does the potential for savings vary depending on prior energy usage?
- Do households with FiT installations also employ other energy efficiency measures (e.g. cavity wall insulation)?

The findings presented in this article are based on preliminary analysis which will be developed further during 2015. As a result some of the preliminary results and associated messages may change.

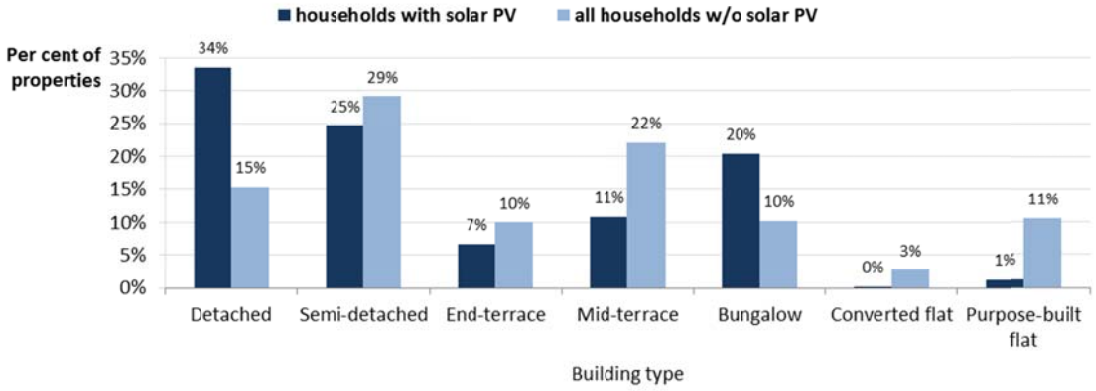
Characteristics of households with FiT installations

A total of 369,700 households in England and Wales that have solar PV installations could be assigned a unique property reference number (UPRN) from AddressBase, which allowed them to be matched with property attribute data from the Valuation Office Agency. This represents approximately 70 per cent of all households in Great Britain with solar PV installations[1]. Based on the sample of data analysed, the comparison of distributions of various property attributes with the entire housing stock revealed that, in general, properties with solar PV installations in this sample tend to be large, relatively new, and have four external walls.

Chart 1 shows that FiT properties are typically detached houses (34%) or bungalows (20%); while flats are underrepresented: only 1.5 per cent of FiT properties are purpose-built or converted flats, even though these two categories make up 14 per cent of the housing stock.

[1] The remaining 30 per cent of properties with a FiT installation which are not included in the analysis will include any installations in Scotland and any properties where address information provided did not allow a match to other information about the property. In particular, flats are often more difficult to match due to the variety of possible ways the address can be written. This means flats – especially converted flats – are underrepresented in the data (both the Fit PV data and the NEED data).

Chart 1: Relative frequency of building types in the whole housing stock and in the subset with solar PV installations



FiT properties are overrepresented among large households: 29 per cent of households with solar PV installations registered on the FiT scheme have 4 or more bedrooms, which is over twice the figure for all properties (14%) (see Chart 2).

Chart 2: Relative frequency of number of bedrooms per property in the whole housing stock and in the subset with solar PV installations

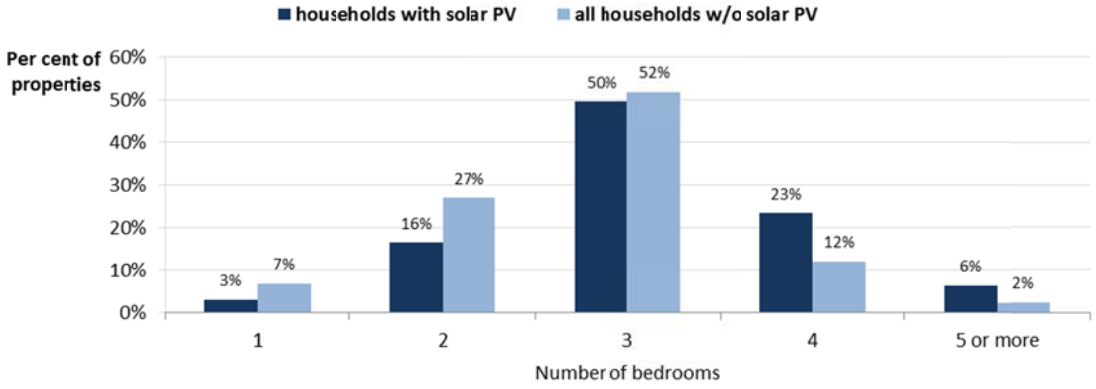
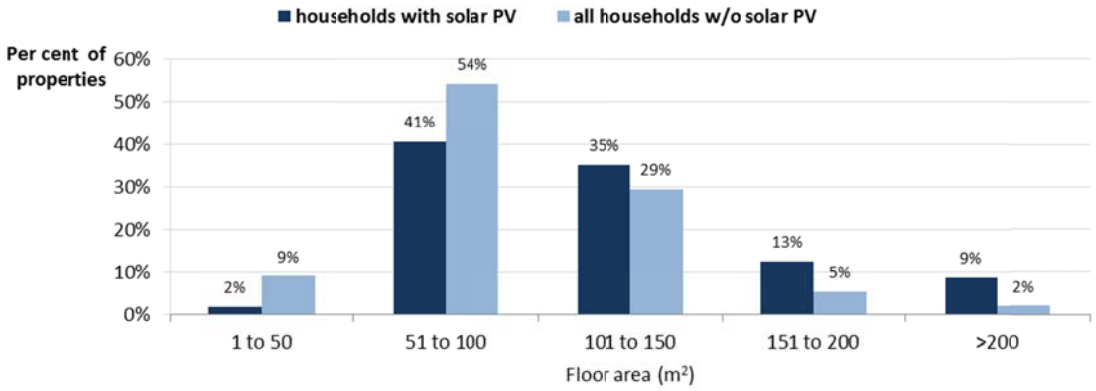


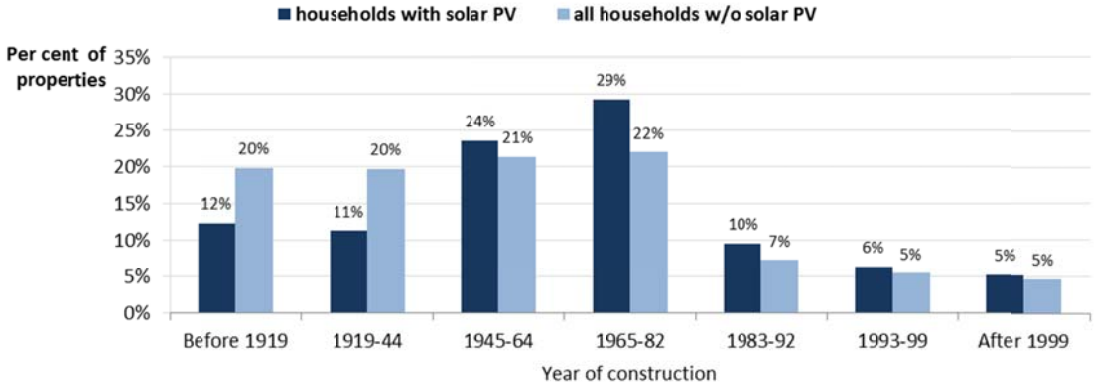
Chart 3 shows that FiT properties are typically large: 56 per cent of them have a floor area of at least 100 m^2, while only 37 per cent of the whole housing stock does. The similar pattern of results is explained by the high level of correlation between floor area and the number of bedrooms in a property.

Chart 3: Relative frequency of floor areas (in m^2) in the whole housing stock and in the subset with solar PV installations



Properties with solar PV installations tend to be relatively new: although nearly four in ten (39%) homes in Britain were built before 1945, these make up less than one in four (24%) of those with solar PVs. The most numerous category is that of buildings erected between 1965 and 1982, which make up 29 per cent of all properties with FiT installations (see Chart 4).

Chart 4: Relative frequency of building ages in the whole housing stock and in the subset with solar PV installations



Overall, these results reveal that households with a solar PV installation registered in the FiT scheme are larger than typical, and are more likely to be detached. Properties of this description generally have higher energy consumption, and also a larger roof area, which might make the installation of solar PV economically more viable.

Electricity and gas consumption in FiT households

In order to gain a better understanding of how the electricity and gas consumption of a household changes as a result of installing solar PV, a subset of properties that had solar PV panels installed in 2011 (181,050 properties or 88 per cent of all solar PV installations in 2011) was selected for further analysis, and their electricity and (weather-corrected) gas usage figures in the full billing years before and after the installation, i.e. in 2010 and in 2012, were compared. In addition, these figures were also compared with the consumption figures for households that do not have solar PV installations registered in the FiT scheme.

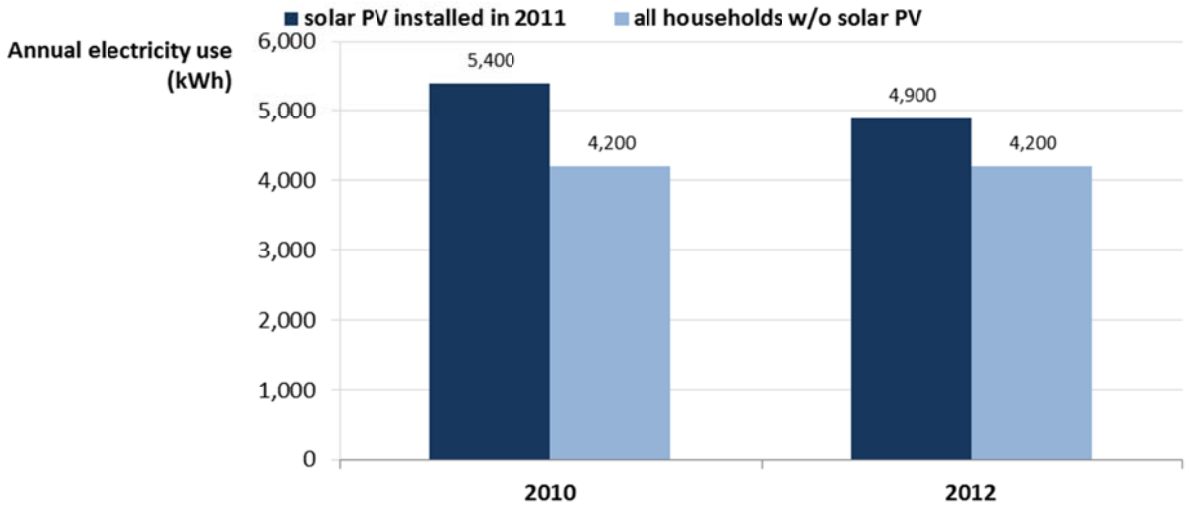
In accordance with NEED methodology, electricity consumption figures below 100kWh or over 25,000kWh, and gas consumption figures below 100 kWh or over 50,000 kWh were deemed invalid, and these records, as well as those with estimated consumption figures were excluded from the analysis. Additionally, consistent with the NEED impact of measures analysis, households whose electricity consumption increased by over 50 per cent or decreased by over 80 per cent between 2010 and 2012 were also excluded, because such a large change is more likely to be the result of something other than the installation of solar PV (e.g. change in occupancy or occupant circumstances). For more details on how electricity and gas usage is calculated in NEED, see www.gov.uk/government/statistics/domestic-national-energy-efficiency-data-framework-need-methodology. The final sample from which electricity consumption was analysed consisted of 129,090 households with solar PV (71% of all properties that installed solar PV in 2011 and were identified with a UPRN).

Households with FiT properties typically use substantially more electricity than those without FiT installations. In 2010, for example, the mean electricity consumption of FiT properties was 5,400 kWh, compared to the national average of 4,200 kWh (i.e. 27% higher). There are several possible reasons for this difference. For example, and as mentioned above, households with solar PV installations tend to be larger and have four external walls, which typically results in a higher electricity use (see Chapter 3 of the NEED Summary of analysis available at www.gov.uk/government/statistics/national-energy-efficiency-data-framework-need-report-summary-of-analysis-2014). There may also be behavioural differences between the occupants of

households that have solar PV installations and those that do not, resulting from socio-demographic characteristics, different attitudes towards energy use, or other factors.

By 2012, i.e. after the installation of solar PV, the gap in electricity consumption between properties with and without solar PV narrowed considerably, to 16 per cent. Between these two years, electricity consumption in FiT households decreased substantially, by an average of 9.5 per cent (median: 13.2 per cent). Although households not registered on the FiT scheme also decreased their electricity usage in the same period, the rate of this decrease was much lower (mean: 1%, median: 5.7%; see Chart 5). In our sample of FiT households, those with higher initial energy consumption achieved a higher reduction in kWh terms, but not as a percentage of initial consumption.

Chart 5. Mean electricity consumption of households that installed solar PV in 2011, and of the entire housing stock

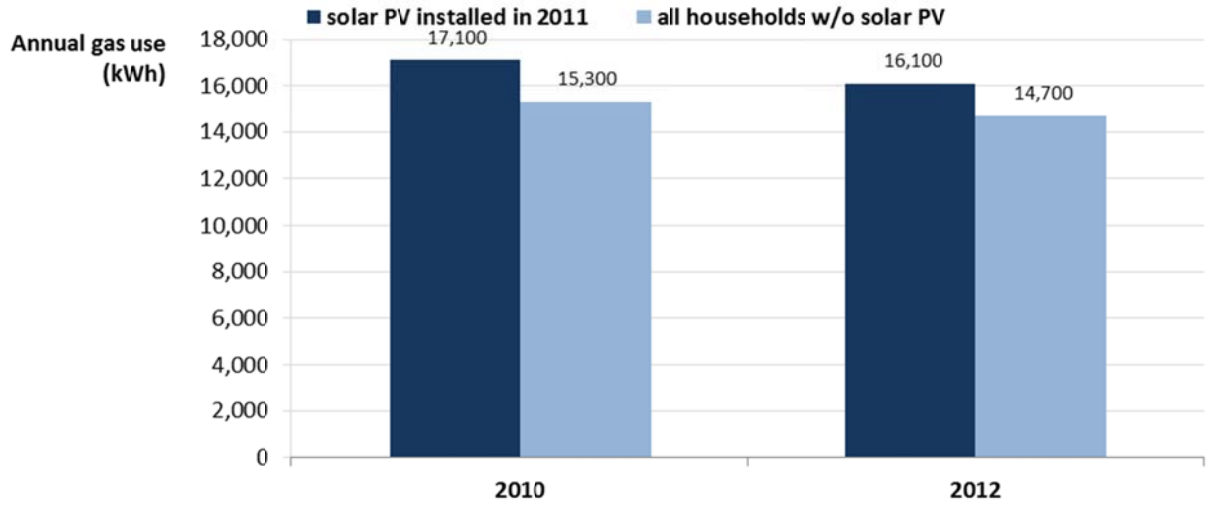


It is important to note that the data used for this analysis does not allow a direct comparison of electricity consumption between households with and without solar PV. As discussed above, the two groups differ substantially on a number of important factors (such as building age and size). Previous analysis of household energy consumption conducted in NEED revealed that property size has an impact on the rate of reduction in consumption: e.g. larger properties had a smaller percentage reduction in consumption between 2005 and 2012 than smaller properties, particularly for gas consumption, but also, to a more limited extent, for electricity. Future work will include drawing up an appropriate comparison group of properties not registered on the FiT scheme to get a better understanding of changes in consumption for similar properties.

The difference between FiT and non-FiT households in terms of gas usage is smaller than for electricity. In 2010, for example, the mean gas consumption of FiT properties was 17,100 kWh (median: 15,600 kWh), compared to 15,300 kWh in the non-FiT group (median: 14,200 kWh), i.e. 11 per cent higher. In 2012, after the installation of PV solar panels in the FiT properties, the gap narrowed slightly to 10 per cent, because gas consumption decreased slightly faster in FiT properties (by 5.5%, compared to 4.5% in the non-FiT group).

Overall, these results suggest that the installation of solar PV panels contributes to a substantial reduction in electricity usage from the grid, in excess of the slight but consistent decreases in year-on-year electricity usage figures that appear in all households. Gas usage, however, did not change to the same extent; it appears that the decrease was electricity-specific, and did not generalise to all forms of energy to the same extent (see Chart 6).

Chart 6: Mean gas consumption of households that installed solar PV in 2011, and of the entire housing stock



Energy efficiency measures installed in properties with a solar PV FIT installation

The next part of this article looks at other energy efficiency measures installed in properties with a Solar PV FiT installation throughout Great Britain (i.e. in England, Scotland, and Wales). The NEED framework contains data on the following energy efficiency measures installed up to the end of 2012: Cavity wall insulation, loft insulation, solid wall insulation, heating management, draught proofing and glazing[2]. The data are based on information from the Homes Energy Efficiency Database and Gas Safe. It includes measures installed through Government schemes, but does not include measures installed when a property is built, or measures people have installed themselves (e.g. DIY loft insulation).

A total of 421,460 properties that had a solar PV panel installed prior to the end of 2013 were successfully matched into the NEED framework (95 per cent) to allow comparison of other energy efficiency measures in the property.

Table 1 shows that just under 60 per cent (245,260) of these properties have at least one other energy efficient measure installed, either before, after or during the year the PV installation was commissioned.

The data were split into FiT cohorts[3] i.e. the year the FiT installation was commissioned. This shows that households who installed solar panels at a later date were slightly more likely to have another energy efficiency measure installed at some point. Table 1 shows that 56 per cent of households that had a solar panel installed in 2010 have an energy efficiency measure compared to 61 per cent of those which had a solar panel installed in 2013.

From December 2012 onwards households needed to have an EPC rating of D or above in order to qualify for the higher solar PV tariffs. As noted earlier the data on energy efficiency measures only goes up to the end of 2012, which may explain why households in the 2013 FIT cohort do not have significantly higher levels of energy efficiency measures.

[2] Some data ends earlier than 2012.
[3] FIT years run from April to March, but for this analysis DECC has used calendar years.

Table 1: Number of properties with a PV installation and at least one other energy efficient measures or PV installation only

FiT Installation Year	Property has both	Property only has a FiT measure	Total	% properties that have both
Pre 2010[4]	1,770	1,660	3,430	52%
2010	11,360	8,870	20,230	56%
2011	101,170	79,340	180,510	56%
2012	83,890	56,550	140,440	60%
2013	47,070	29,780	76,850	61%
Total	**245,260**	**176,200**	**421,460**	**58%**

Table 2 looks at each energy efficiency measure individually. Of the 140,440 properties that adopted a PV installation in 2012, 28 per cent (39,210) had cavity wall insulation, 88 per cent (34,380) of which were adopted before the PV installation was commissioned on the property. For all cohorts the majority of energy efficiency measures were installed before the FiT solar PV installation. However, solid wall insulation was more commonly installed in the same year as the PV installation.

Table 2: Percentage of properties by FiT cohort, non-FiT measure year & type of energy efficiency measure

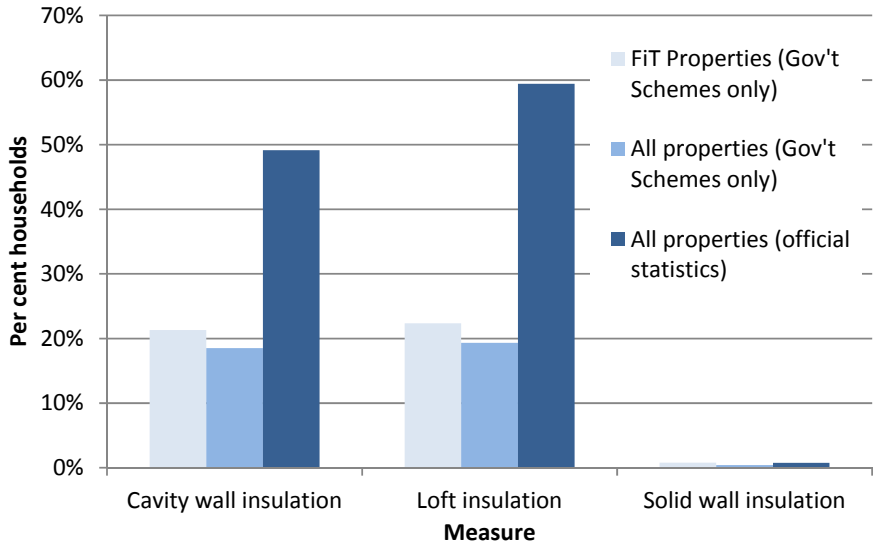
FiT Installation Year	Year non-FiT measure installed	Type of Energy Efficiency Measure				Total FiT installations matched to NEED
		Cavity Wall Insulation	Loft Insulation	Solid Wall Insulation	Other measures*	
2010	Before 2010	20%	15%	0.0%	31%	20,230
	2010	2%	4%	0.4%	4%	
	After 2010	2%	6%	0.2%	2%	
	Total	**24%**	**24%**	**1%**	**38%**	
2011	Before 2011	20%	17%	0.2%	32%	180,510
	2011	3%	5%	0.4%	3%	
	After 2011	2%	4%	0.4%	0%	
	Total	**25%**	**26%**	**1%**	**35%**	
2012	Before 2012	24%	22%	0.2%	36%	140,440
	2012	3%	8%	0.8%	0%	
	Total	**28%**	**30%**	**1%**	**36%**	

*heating management, glazing and draught proofing

The table is based on properties with measures installed through Government schemes, it does not reflect the total number of properties with each measure. In Great Britain as a whole 19 per cent of properties had cavity wall insulation installed through Government schemes (the figure for loft insulation was also 19 per cent). The total percentage of households that had cavity wall insulation in Great Britain (i.e. including an estimate for that installed in new build housing and that installed outside of government schemes) was 49 per cent in 2012 and the percentage of households in GB with insulated lofts was 59 per cent in 2012.

[4] The FIT scheme went live on 1st April 2010. Any properties that had a PV installation commissioned between 15th July 2009 and 31st March 2010 were eligible to apply under the FiT scheme.

Chart 7: Percentage of FiT properties with cavity wall and loft insulation in 2012 compared to Great Britain



Both heating management and glazing are the next biggest energy efficient measure adopted by households, with around 18 per cent of FIT properties having one of these measures, again the majority of these properties adopted them before the PV installation was commissioned.

The percentage of FiT properties with solid wall insulation and draught proofing are small, around 1 per cent, in comparison to other measures that have been analysed. This percentage is in line with non-FIT properties. Ninety per cent of FiT properties implementing the draught proofing measure, did so before they installed a PV installation. FiT properties with solid wall insulation is the only energy efficiency measure, where the majority of properties have been insulated either during the same year as the PV installation or after.

Table 3: Number of non-FIT measures installed in a FIT property

FiT Installation Year	Number of non-FiT measures installed in each property			
	1 non-FiT measure	2 non-FiT measures	More than 2 non-FiT measures	Total
2010	**6,550**	**3,510**	**1,290**	**11,360**
	58%	*31%*	*11%*	*100%*
2011	**58,520**	**31,280**	**11,370**	**101,170**
	58%	*31%*	*11%*	*100%*
2012	**45,850**	**27,510**	**10,520**	**83,890**
	55%	*33%*	*13%*	*100%*

Generally, FiT properties have adopted one other energy efficient measure. Table 3 shows that this is 58 per cent of FiT properties in the 2010 and 2011 cohorts and 55 per cent in the 2012 cohort. Around 30 per cent of FiT properties in 2010, 2011 and 2012 have a combination of 2 non-FiT measures.

Table 4: Percentage of FiT properties adopting a combination of two non-FIT measures

FiT Installation Year	% FiT properties adopting a combination of two non-FiT measures			
	Cavity & Loft Insulation	Loft Insulation & Glazing	Cavity Insulation & Heat Management	Cavity Insulation & Glazing
2010	28%	15%	15%	14%
2011	33%	12%	13%	14%
2012	37%	12%	12%	12%

In the 2010 cohort, 28 per cent of the FiT properties have cavity and loft insulation. This increased by 5 percentage points, to 33 per cent for the 2011 cohort and a further 5 percentage points, to 37 per cent for the 2012 cohort. Some of the other combination of measures that are quite common, are presented in Table 4.

Future directions

This article presents the first findings of a long-term project that will continue to expand the value of NEED, and utilise this unique tool for analysing energy consumption data to evaluate the impact of various DECC policies on consumer behaviour in terms of energy use and energy efficiency.

In the coming months, this work will be taken forward in several ways. For example, this early analysis revealed substantial variation across households in the change in electricity usage from the grid following the installation of solar PV. Further analysis of household-level property attribute information will make it possible to identify the household characteristics that are associated with higher energy usage reduction potential. In addition, this will allow the drawing up of appropriate comparison group of households with no microgeneration installations registered on the FiT scheme so that energy consumption trends can be directly compared between these two groups.

Importantly, the usage figures presented above cover only consumption from the grid, and do not include electricity generated from the solar PV installation that is used on site, by the household itself. Current development work at DECC aims to improve estimates of generation and export meter readings, which would make it possible to investigate the pattern of electricity usage changes more fully.

Feedback on this article is warmly welcomed, and readers are invited to contribute their suggestions on how to develop this research project further, in addition to the planned work outlined above. DECC is also keen to learn about related investigations and research into the impact of microgeneration on energy-related consumer behaviours and attitudes.

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