# Powering the Nation 2:

## Electricity use in homes, and how to reduce it

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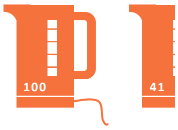
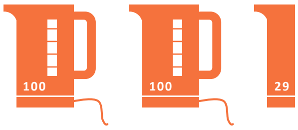
## Average energy savings per household, in kettles, from

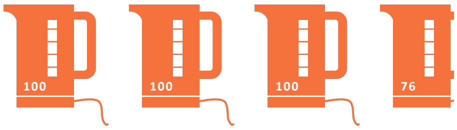
Washing clothes at 40°C or less
24 kWh/year
**141 kettles***



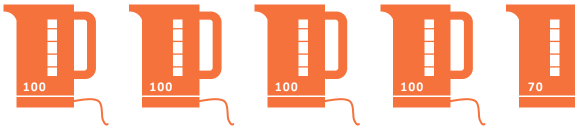

Not overfilling the kettle
39 kWh/year
**229 kettles**




Turning off standby appliances
64 kWh/year
**376 kettles**

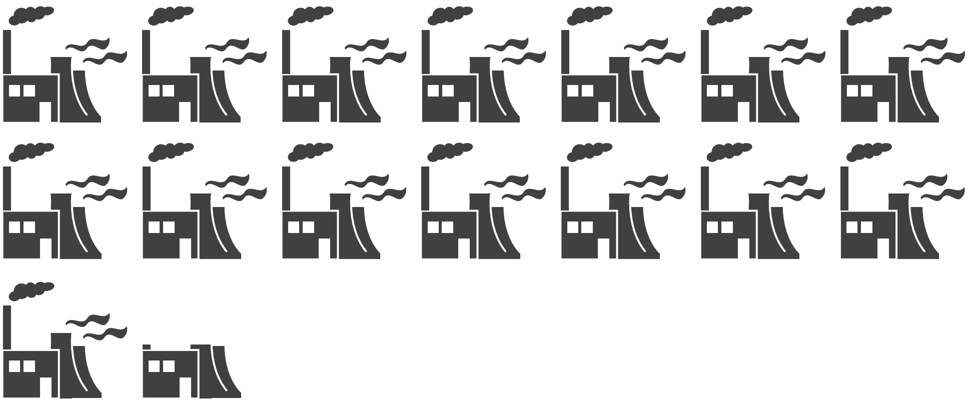



Not leaving PCs on
80 kWh/year
**470 kettles**

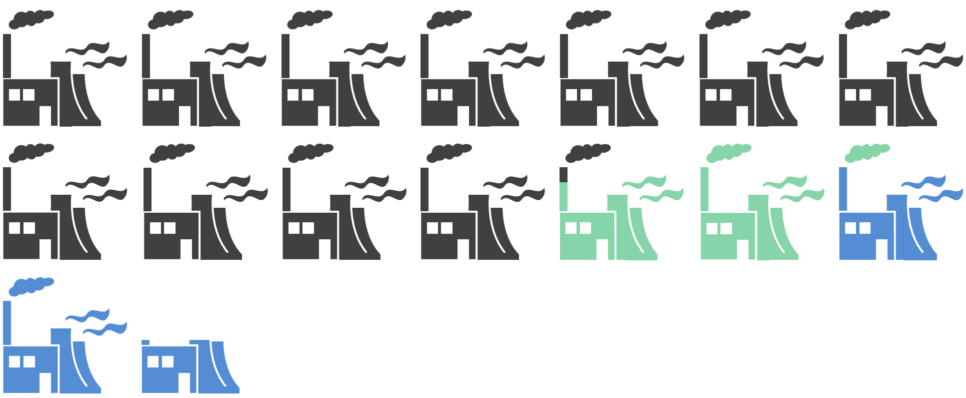



*boiling 1 full kettle=170 Wh

## Potential savings from energy efficiency and heating upgrades



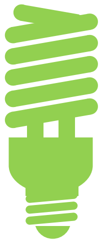
Current UK household demand*



UK household demand with fuel switching and energy efficiency savings

*Assuming large power stations with a capacity of 1.5 GW, a load factor of 52%, generating 6,800 GWh a year.

'Never leave lights on'
**490 kWh/year**



Average among 2+ households
**613 kWh/year**

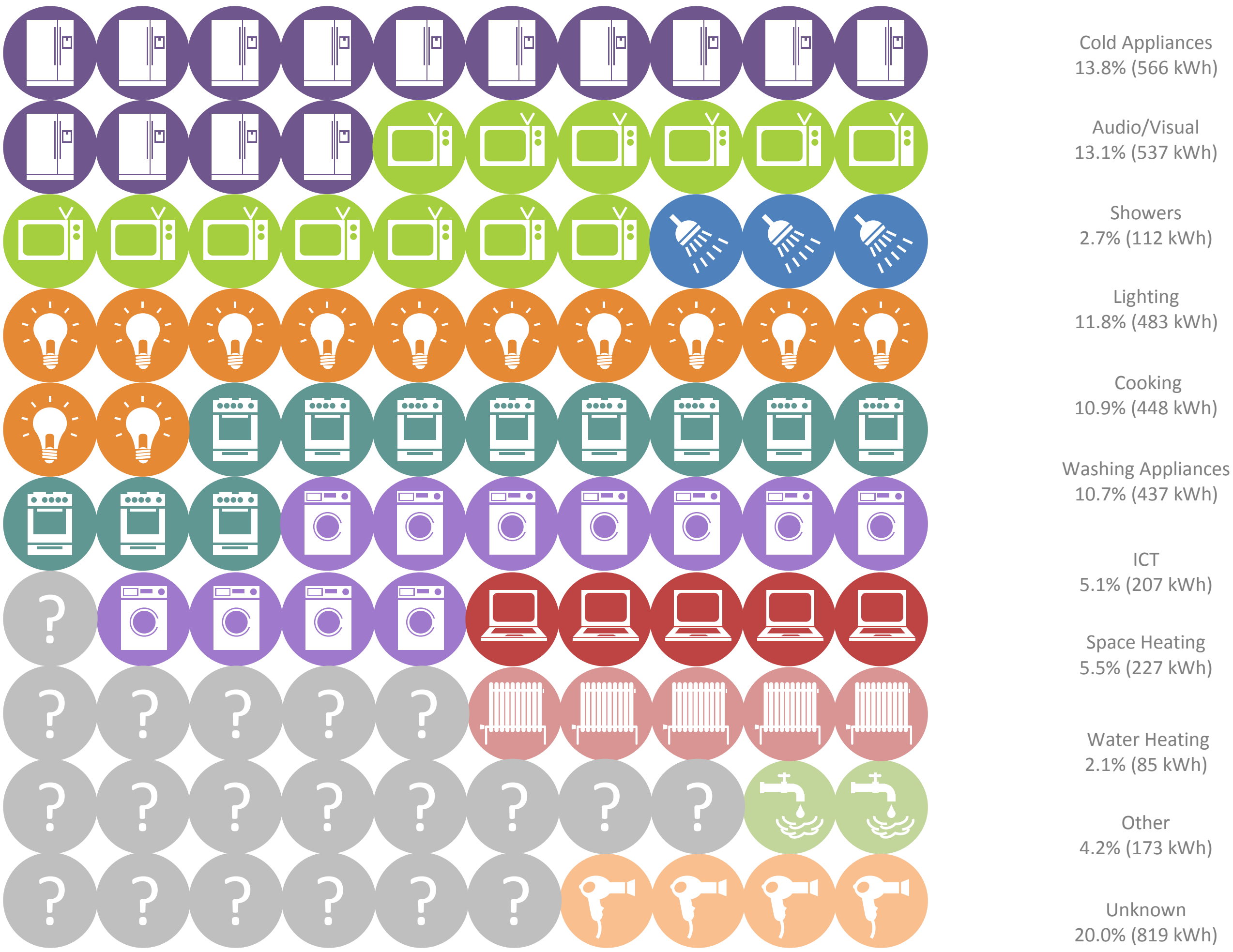
'Often leave lights on'
**840 kWh/year**

## Range of lighting use

(averages, households of two or more)

## Highest and lowest users


## Average electricity breakdown over year



# Contents



This report summarises work carried out for DECC and DEFRA by Peter Armitage, Ian Cooper, Daniel Godoy-Shimizu, David Knight, Jason Palmer, Peter Pope, Nicola Terry, Amy-Alys Tillson and Jake Young at Cambridge Architectural Research; Mark Hughes, Alvin Chan, Jorge Garcia Moreno and Alex Stewart at Element Energy; Steven Firth and Tom Kane at Loughborough University. The work was supervised by Penny Dunbabin, Oliver Sutton, Mike Walker and Michael Harrison at DECC, and Lee Davies at DEFRA. June 2014.

# Executive Summary

The Household Electricity Survey (HES) was the most detailed monitoring of electricity use ever carried out in the UK. Preliminary findings were published in 2012, and provided unparalleled insights about energy use in the home. This is a summary of more thorough analysis of the survey data, structured around 30 questions drawn up by DECC and DEFRA. The work was carried out in 2013 and 2014, and more detailed reports are available here[1].

The opportunity to glean more from this data could hardly be more timely. We are at a critical juncture in planning electricity generation, where the UK must invest £110bn in energy infrastructure[2] – partly to replace the power stations built in the 1960s and 70s, now reaching the end of their useful lives. We must meet the Government's target of an 80% reduction in greenhouse gas emissions by 2050, and at the same time balance the necessities of maintaining the country's fuel security and allocating resources wisely for the long-term. We cannot make informed decisions about electricity generation without also understanding the potential for efficiencies and savings from households (and other sectors). This relies on robust data and analysis.

At the same time, the UK Government is committed to the most complex smart metering and consumer engagement project in the world – the vision of a smart grid, where data becomes the prime commodity to manage consumption and demand. The Green Deal is also changing the landscape for cutting energy use in homes.

**Only a tiny proportion of households owned the most efficient appliance currently available, and for cold appliances, washing machines, tumble dryers and dishwashers, almost 100% could be replaced with more efficient models**

In this report we present our answers to four questions about household electricity use: what it is used for, when it is used, who uses it, and how this might change over the next few decades.

## Findings

Our findings span five themes, addressing different aspects of electricity use in homes. First we look at appliances: what appliances householders own, what energy labels they have, how old they are, and when they tend to replace them. Then we examine how much electricity could be saved in different ways and how much could be trimmed from the peak load. Finally we look at the scope for improving the modelling of electricity use in homes, and social studies that were carried out under the project.

## Appliances

We found enormous variation in the ages of appliances the HES households owned, with one fridge-freezer 41 years old. The average appliance age across all households varied from 3.8 years for kettles to 8.4 years for fridge-freezers. Only a tiny proportion of households owned the most efficient appliance currently available, and for cold appliances, washing machines, tumble dryers and dishwashers almost 100% could be replaced with more efficient models. The most efficient models available are at least 20% more efficient than the most commonly owned ones.

Cold appliances and washing machines are also getting bigger: fridges purchased by HES households got two-fifths bigger, on average, from 1985 to 2011, while freezers and fridge-freezers grew by one fifth. On average, this increase in size is partially offsetting the efficiency gains made by appliance manufacturers.

1. https://www.gov.uk/government/publications/household-electricity-survey--2 (accessed 6 June 2014)
2. https://www.gov.uk/government/policies/maintaining-uk-energy-security--2/supporting-pages/electricity-market-reform (accessed 20 May 2014)

A surprising number of homes had very high electricity use for cold appliances, and especially older freezers (15 years old or more). We found evidence suggesting around a fifth of older freezers are faulty and the thermostat does not cycle on and off as normal. These freezers consume 330 kWh a year more than they should[3].

Readers might anticipate that households expressing concern about the environment would own more efficient appliances, but they did not – apart from refrigerators. We also found that very few households had A+ or A-rated washing machines and tumble dryers, so there are major opportunities to improve the efficiency of these appliances.

We also found that – contrary to Energy Label assumptions – 80% of washing cycles were at 40°C or less. On average, households that always run washing machines at 40°C or less save 85 Wh per washing cycle, or around 24 kWh a year.

More generally, we identified a rising trend in size for all major appliances except dishwashers. This increasing size is often more important than the energy rating in shaping the overall energy use of an appliance.

## Potential savings

We identified total potential savings from efficiency gains of 15,400 GWh a year for the whole UK – an average of 570 kWh per household. This is more than the annual output of two large (1.5 GW) power stations[4]. More than half of the potential savings could come from energy efficiency improvements, with the remainder coming from switching from electric heating to other forms of heat.

**More efficient appliances would make a bigger difference to the peak load than 'load-switching' per se**

We also calculated the electricity savings that could be achieved from replacing individual appliances of the most common rating with the best now available on the market. This suggested savings of more than a fifth from the main white appliances:

- Tumble dryers 39%
- Cold appliances 24%
- Washing machines 23%, and
- Dishwashers 21%.

Focusing on lighting, we identified potential savings of 230 kWh per house a year, on average, from replacing the remaining traditional (incandescent and halogen) bulbs with low energy bulbs. This factors up to 6,200 GWh a year for the whole UK. On top of this we found that some households have very high power demands for external halogen lights – up to 1500 W – and these will be replaced through the EU Eco-Design Directive.

## Reducing peak load

We found that the average peak demand for power in HES homes came from 6pm to 7pm, at an average of 720 Watts per home, rising to more than a kilowatt in cold weather. It is relatively easy to change the time of use of some appliances, like washing appliances and electric water heating. For the HES households, we found these made up 9% of the peak load (not including non-domestic electricity use). With the right incentives, it should be possible to trim this from the national peak load. However, we found that increasing the efficiency of non-switchable appliances would make a bigger difference to the peak load.

Looking to the future, we also found that higher take-up of low carbon technologies like photovoltaic solar panels and micro wind turbines will reduce electricity drawn from the grid (about 5,000 GWh by 2050), but these savings will be swamped by increased electricity use for heat pumps

3. This is based on a small sample, and DECC is considering further work in this area.
4. Assuming a load factor of 52%, generating 6,800 GWh a year each.

(27,000 GWh by 2030) and to charge electric vehicles (3,000 GWh by 2030). Overall peak electrical demand is expected to increase by around 6.5 GW even with measures to reduce the impact on peak load.

### Electricity modelling

DECC publishes household energy statistics each year based on computer models. We compared model outputs against measured electricity use in the HES homes, and found a good match overall. However, the models over-estimated electricity use for appliances (by a third), and for lighting (by a quarter), but under-estimated electricity use for cooking (by a third).

We proposed a new way of modelling electricity use for appliances, lights and cooking, but even this does not account for the large variability in electricity use between households. We recommend using adjustment factors in models when they are applied to individual dwellings – to account for high or low-use patterns, when this information is available.

### Social studies

We ran a series of different tests to analyse electricity use in high and low use households. We found that low use households tended to be single people living in small dwellings, and often retired. The size threshold for significance was a floor area less than 75m$^2$. Conversely, high-use households were often in social grade A, with three or more people, not working (but not retired), aged 45-54, or living in a large home. Here, the size threshold was more than 130m$^2$.

We found some correlation between high electricity use for appliances and space heating. Households saying that they left a TV or computer on when they were not using them, or mobile phone chargers switched on, or those claiming to buy energy efficient appliances, all also had above-average electricity use.

However, more broadly, what householders said about how they used electricity at home was often at odds with their actual electricity use. For example, there were no significant links between householders claiming they turned off unused appliances and reduced electricity use for TVs. And a quarter of the households using *most* electricity for lighting said they "never left lights on when they were not in the room".

We used data from the survey to estimate how electricity use will change purely as a result of demographic change. We found that if today's energy use patterns persist, electricity consumption will rise by 9% over ten years – slightly less than the expected 10% rise in the number of English households.

## Introduction

The Household Electricity Survey monitored a total of 250 owner-occupier households across England from 2010 to 2011. Twenty-six of these households were monitored for a full year. The remaining 224 were monitored for one month, on a rolling basis throughout the trial. The survey was geared to finding out more about the range and quantity of electric appliances in typical homes, and to understand how these appliances were used.

The households had between 13 and 85 appliances in their homes, with about a third of households owning between 30 and 40 appliances. Preliminary analysis was summarised in Powering the Nation[5], published in 2012. This report summarises more detailed analysis carried out in 2013 and 2014, focusing on specific questions drawn up by DECC and DEFRA.

5. Owen P (2012) Powering the Nation: Household energy-using habits revealed. London: EST/DECC/DEFRA.

This summary draws out the most important findings from ten reports written by Cambridge Architectural Research, Loughborough University and Element Energy. More detailed reports are available online[6].

The sample of homes in the survey was not perfectly representative – partly because only homeowners were included and partly because they were more energy-conscious than average households. However, they were fairly typical in terms of social grade, number of residents, life stage, and property age.

## Seasonal adjustments

Most of the households in the survey were only monitored for a month, and these figures were unduly affected by the time of year when they were monitored. As a result, we had to adjust the data for these homes to account for seasonal differences for some questions. For example, fridges and freezers use more energy in the summer, but lighting is used more in the winter.

We used data from the 26 households monitored over a whole year to generate seasonality factors for each appliance type – cold appliances, electric cooking, lighting, washing, audiovisual, ICT, water heating and space heating.

We calculated the electricity use on each day for each appliance type, and normalised by dividing by the total use over the year. The results were very noisy, so we used regression analysis and least squares to find a best fit curve. We generated a separate adjustment curve for each of the eight appliance types where there was a link between energy use and the time of year.

## Limitations of the data

Studies like the Household Electricity Survey are unusual because they are difficult to organise and very expensive. Inevitably, there are compromises – largely due to the modest sample size. Ideally, there would have been thousands of households participating in the study, including both rented and privately-owned homes. Ideally, all homes would have been monitored for the full 12 months rather than having some of them monitored for just one month.

There was another limitation because not all appliances had plug-in meters, so around 20% of energy use for each household was 'unknown'.

The Departments asked us to summarise the main findings of this study, to compare with other sources of empirical data and to draw out implications for policy. The report indicates a number of areas which require more detailed study, perhaps with larger sample sizes, before robust policy recommendations can be made.

There were also fewer than average households with primary electric heating: nine of them, or 3.5%, against an average across the population of 8%[7]. The rest had gas or oil for their heating system, although 24 had backup electric heating. Flats were under-represented (4% against 20% nationally[3]). Average (mean) electricity use across homes in the sample was 4,093 kWh/year, against a mean of 4,154 kWh across all UK homes[8]. The location of households that participated was spread evenly across England.

6. https://www.gov.uk/government/publications/household-electricity-survey--2 (accessed 6 June 2014).
7. Palmer J, Cooper I (2014) UK Housing Energy Fact File 2013. London: DECC. https://www.gov.uk/government/publications/united-kingdom-housing-energy-fact-file-2013 (accessed 6 June 2014).
8. DECC (2012) Energy Consumption in the UK. London: DECC. (Tables 3.1 and 3.3.)

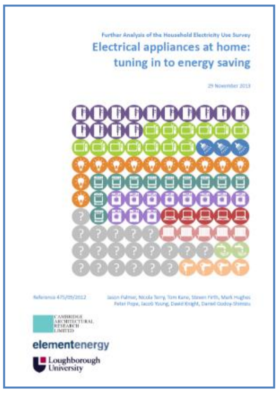
This data offers an unparalleled source of very detailed electricity profiles. It has already provided unmatched insights into the way electricity is used in English homes. This report covers a range of topics – from reducing peak demand to the age and efficiency of appliances, and whether an exchange scheme would be viable.

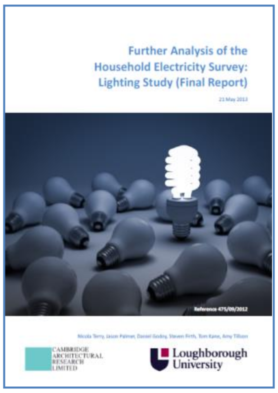
We scrutinised and analysed the data in a variety of different ways to explore specific questions. We used tools including SPSS, R (both specialist statistics packages), Excel and SQL (structured query language) for analysis. We carried out standard statistical tests (t-tests and others), and we focused quite explicitly on uncertainty in the data and the analysis.

This report is structured around five themes:

1. Appliances
2. Potential savings
3. Reducing peak load
4. Electricity modelling
5. Social studies

We draw the project together at the end of this summary with signposting to ten more detailed reports, where readers can find full details of our methods, findings from all parts of the analysis, and policy recommendations:

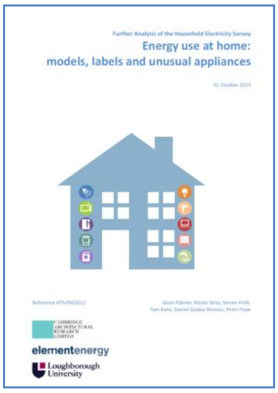



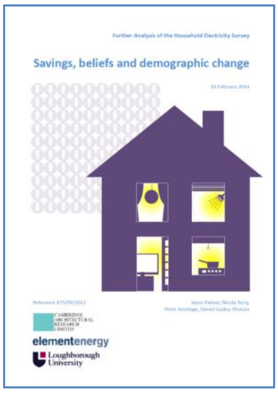



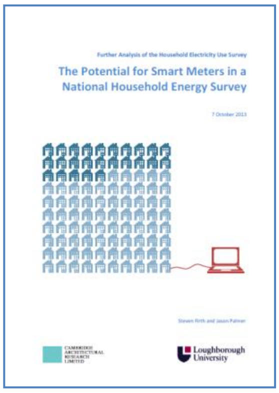


Correlation of consumption with low carbon technologies


Increasing insight and UK applicability





Electricity price signals and demand responses


Consumer archetypes

# 1. Appliances

There is enormous variation in the ages of appliances owned. One fridge-freezer in the survey was reported to be 41 years old, and pensioners tend to have older appliances. However, the average appliance age across all households varied from 3.8 years for kettles to 8.4 years for fridge-freezers (see table). The average age of appliances can be used to indicate their lifespan (when they will need to be replaced). Here we estimated that the approximate average lifespan of a product is twice the average age of the stock of appliances. For the HES sample the estimated lifespans of dishwashers, washing machines, tumble dryers, refrigerators and freezers are consistent with lifespans reported in other studies.

Some appliances are more likely to be owned by certain social demographic groups. For example, we found people in social grade A are more likely to have a dishwasher and tumble dryer, and older people are likely to own significantly older cold appliances, washing machines and televisions.

Purchasing TVs appears to be different from other appliances, which are usually replaced when they break. It appears to be more common to retain old TVs and continue using them after buying a new one, which means the 'replacement rate' for new energy efficient TVs is lower than sales data suggests.

We also found that people in part-time employment were more likely to own a dishwasher (80% of them did), while retired people were less likely to own a dishwasher (only 42%). Those aged from 65 to 75 owned older washing machines on average (mean 7.5 years old), whereas people from 19 to 34 had newer washing machines, on average (mean 3.5 years old). We found similar results for cold appliances and televisions.

Household size was also a significant factor: households with one person were less likely to own dishwashers (34% compared to 59% for all homes), tumble dryers (31% compared to 55%), refrigerators (40% against 51%) and microwaves (86% compared to 91%). Conversely, households with four or more people are more likely to own dishwashers, tumble dryers and refrigerators.

| | Household Electricity Survey sample | | | | Comparison data | |
|---|---|---|---|---|---|---|
| **Appliance type** | Percentage appliance ownership in HES (%) | Mean appliance age (years) | Estimated lifespan (years) | Age of oldest appliance | National ownership[9] (%) | Appliance lifespan[10] (years) |
| **Kettle** | 99 | 3.8 | 8 | 26 | - | - |
| **Television** | 99 | 5.3 | 11 | 27 | 99 | - |
| **Dishwasher** | 59 | 5.5 | 11 | 18 | 40 | 8-11 |
| **Washing machine** | 91 | 5.7 | 11 | 22 | 96 | 12-14 |
| **Microwave** | 91 | 6.2 | 12 | 31 | 92 | - |
| **Tumble dryer** | 53 | 6.7 | 13 | 26 | 57 | 13-17 |
| **Refrigerator** | 50 | 6.8 | 14 | 21 | - | 16-19 |
| **Freezer** | 48 | 6.8 | 14 | 30 | - | 11-19 |
| **All cold appliances** | 100 | 7.4 | 15 | 41 | 97 | - |
| **Fridge-freezer** | 74 | 8.4 | 17 | 41 | - | - |

9. ONS (2011) Ownership of consumer durables increases into 2010 http://www.ons.gov.uk/ons/rel/family-spending/family-spending/family-spending-2011-edition/sum-consumer-durables-nugget.html (accessed 2nd October 2013 ).

10. Young, D. (2008) When do energy-efficient appliances generate energy savings? Some evidence from Canada. Energy Policy, 36(1) 34–46.

Households typically purchase new appliances when their existing appliances stop working. However, the energy consumption profiles for cold appliances revealed that 6% had faults that meant they used much more energy than they should. (See *Faulty cold appliances*, page 10.)

## Do certain households buy more efficient appliances?

We explored whether there was any link between household characteristics – the age of the oldest person, employment status, the size of the household, how concerned they are about the environment, and their social grade – and the energy efficiency of the appliances they acquired. We looked at all the large electricity-using appliances covered by EU energy label legislation (see table below).

Actual energy use was affected by how much each household used the appliances, so we used energy label ratings to see which appliances were rated best. Not all of the appliances in the survey had energy labels recorded, but at least 30% of appliances did have label data.

We found high ownership of A-rated appliances or better for all except for washing machines, where 68% of appliance in the sample were B-rated, and tumble dryers, where 75% of the appliances were C-rated. However, there were very few significant links between energy labels and household characteristics. This may be because a single energy rating dominated for each appliance type (a single rating accounts for at least 65% of the machines in each appliance type).

You would expect households that are ‘Very concerned’ and ‘Fairly concerned’ about the environment to own more efficient appliances. However, the analysis showed little difference between these households and other households (refrigerators are the only exception, where all owners of A+ rated machines were ‘Very concerned’ about the environment). This may be partly related to the cost of more efficient appliances. Households that are more concerned about the environment may prefer more efficient appliances, but higher cost appears to deter them.

| Appliance type | Number of appliances in HES sample | Number of appliances with an energy rating | Percentage of appliances according to energy label* | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | A+ | A | B | C | D | E |
| All cold appliances | 398 | 122 | 2% | 75% | 18% | 4% | - | - |
| Washing machines | 227 | 149 | 1% | 15% | 68% | 9% | 7% | - |
| Fridge-freezers | 149 | 77 | 1% | 79% | 14% | 5% | - | - |
| Freezers | 143 | 46 | 2% | 65% | 17% | 9% | 2% | 4% |
| Dishwashers | 111 | 61 | 3% | 74% | 7% | 13% | 3% | - |
| Tumble dryers | 111 | 64 | - | 2% | 8% | 75% | 13% | 3% |
| Refrigerators | 106 | 44 | 5% | 70% | 23% | 2% | - | - |

*Rows sum to 100%, apart from rounding errors

There were few A+ or A-rated washing machines and tumble dryers in HES households, suggesting that encouraging households to purchase more efficient models – perhaps emphasising the ongoing savings – would lead to energy savings.

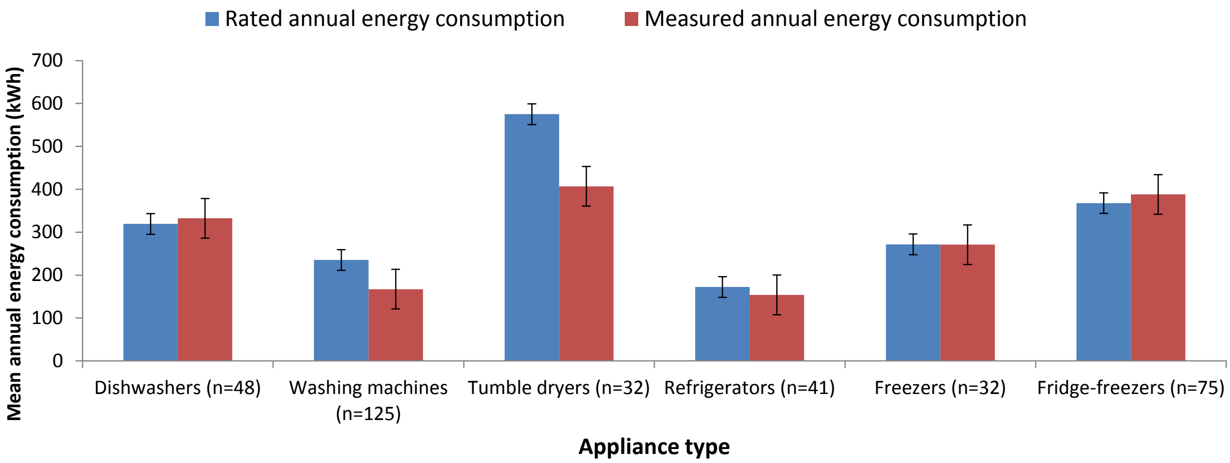
Comparisons with national sales data showed that over time most appliances sold are getting more efficient. However, the energy ratings of tumble dryers currently lag behind other appliances. The uptake of cold appliances rated A+ or better is also surprisingly slow.

## How does actual energy use compare to energy label estimates?

The energy use of many appliances varies according to how they are used. Dishwashers and washing machines, for example, use more or less energy per cycle depending on the temperature setting and program selected – and overall consumption also depends on how often they are used. Manufacturers publish estimates of actual electricity use for many appliances, based on lab experiments and simple assumptions about how they will be used.

We looked at the big ticket appliances – dishwashers, washing machines, tumble dryers, refrigerators, freezers and fridge-freezers.

For dishwashers, refrigerators, freezers and fridge-freezers the average rated annual electricity use (based on manufacturers' estimates) was closely matched to the average measured electricity use. The rated electricity use was based on the EU Energy Label calculation method and this showed that, overall, these appliances appeared to be operating as expected in Energy Label assumptions. However, for washing machines and tumble dryers, the mean measured annual electricity consumption is lower than the mean rated annual energy consumption (29% lower in both cases). This is due to much lower average energy use per cycle, seemingly the result of lower temperature washing programmes (30 or 40°C washes rather than 60°C assumed in the rated annual electricity use calculations). In fact there were more washing cycles a year in the HES households than assumed in Energy Labels (284 cycles per year for washing machines and 260 for tumble dryers, compared to 220 and 160 in the Energy Label assumptions).




### Energy Label assumptions over-estimate English use of laundry appliances

Comparing the Energy Label estimate against measured annual energy use of the six major appliance types shows a good match for dishwashers and cold appliances. However, washing machines and tumble dryers use much less electricity than estimates based on 'standard' cycles. (Error bars show the 95% confidence interval for the mean.)

The Energy Saving Trust, detergent manufacturers and retailers have run 'Wash at 30°C' campaigns for several years, and this could be evidence that the message is getting through.

We looked in more detail at washing machines and tumble dryers, focusing on energy use per cycle – which is not affected by different assumptions about how often the appliances are used. Again, we found the average rated energy use estimates (based on a standard 60°C wash or a full tumble dryer load) for a single washing cycle were consistently higher than the average actual energy use recorded over the year for each HES household. (If the estimate matched reality the points would fall on the black 'lines of parity' shown on the graphs below.)

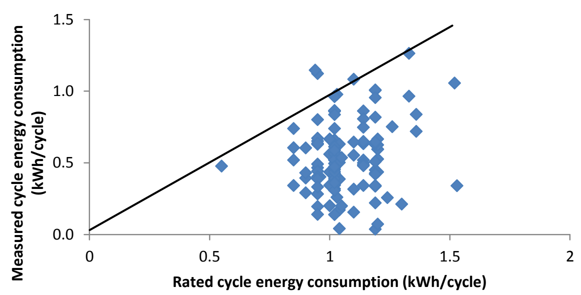
Somewhat surprisingly, we found a gradual rising trend in the *annual* energy use of dishwashers, washing machines and tumble dryers: appliances purchased more recently showed higher annual energy use, on average. However, energy use *per cycle* is falling somewhat over time for washing machines, and flat for dishwashers – indicating that newer appliances see more use than old ones. Energy use per cycle is rising over time for tumble dryers, partly because they are getting gradually larger over time (see next section).

Overall we found no clear link between energy efficiency rating and annual energy use for any of the appliance types in the HES sample. There are simply too many other factors involved: the location of cold appliances, the dampness of clothes put into a tumble dryer, the program selection and temperature for washing cycles, and so on. These factors are more important than the energy rating in determining energy use. Further, less efficient appliances tend to be older and used less often, and for some appliance types larger sizes undermine the savings from increasing efficiency – see next section.

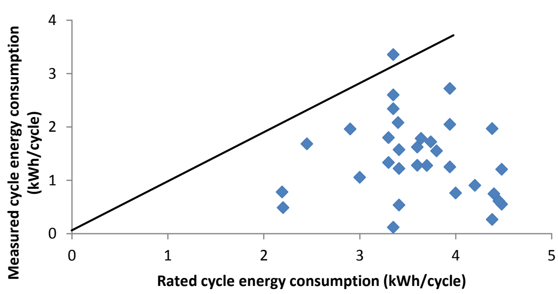
## How does energy use relate to appliance size?

Our analysis found that nearly all appliances are getting bigger over time, with the exception of dishwashers – see table below. Larger size is usually accompanied by increased energy consumption and, in many cases, size is more significant than the energy rating. For example, a large (52") A+ television would typically use more electricity when on than a medium (42") A-rated television.

### Washing machines




### Tumble dryers



| Appliance type | Rising trend in size? | Strength of trend |
|---|---|---|
| TV | Yes | Medium |
| Washing machine | Yes | Low |
| Tumble dryer | Yes | Medium |
| Dishwasher | No | - |
| Fridge | Yes | Medium |
| Freezer | Yes | Low |
| Fridge-freezer | Yes | Low |

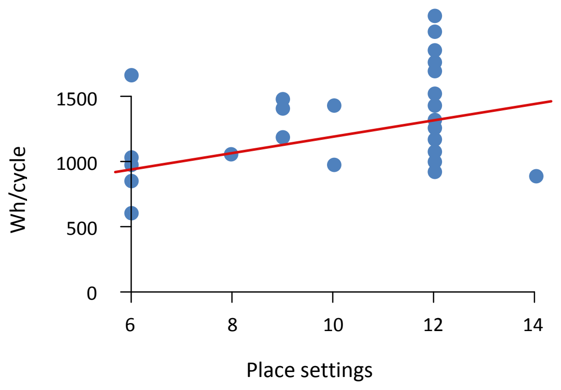
The average size of all cold appliances purchased by HES households rose from 1985 to 2011 (fridges got two-fifths bigger, on average, while freezers and fridge-freezers grew by one fifth). On average, this increase in size has undermined the efficiency gains made by appliance manufacturers.

Washing machines purchased since 2004 used a little less energy per wash, on average, than older machines in the survey – in spite of increased drum sizes. However, only a tiny proportion (2.3%) of household washing cycles used an 'economy' setting. However, there was no evidence that 'economy' settings actually saved energy relative to non-economy washes, so encouraging more households to use 'economy' settings may not save any electricity.

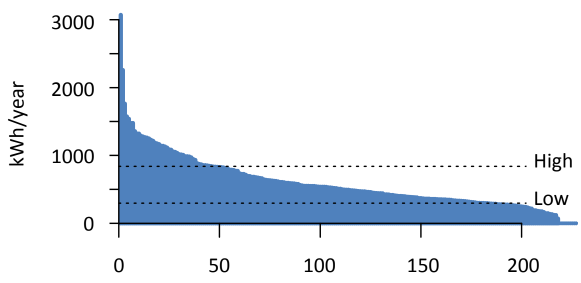
## Faulty cold appliances

A surprising number of homes had very high electricity use for cold appliances, and particularly households with old freezers (15 years old or more). We found evidence suggesting around a fifth of old freezers are faulty, with the thermostat not cycling on and off as normal. In the survey, these freezers consumed 330 kWh a year more than they should. Fridges seemed to be less likely to fail in this way, but there were still nine drawing about 150 kWh a year more than they should. Note that there was a small sample of old freezers, so the figures should be treated with caution, and we recommend further study in this area.

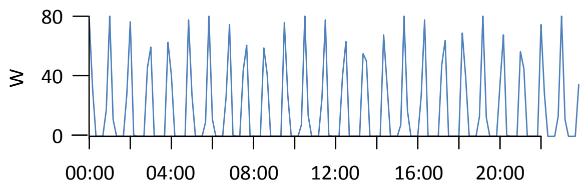
### Dishwasher electricity use and place settings



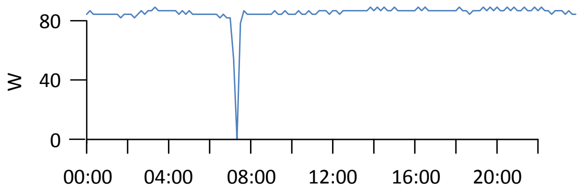

### Refrigeration consumption for all households



**Daily profile for a normal chest freezer**




**Daily profile for a malfunctioning chest freezer**




Correctly functioning cold appliances cycle on and off, with the compressor pumps running intermittently, like the profile at the top. However, 21 cold appliances had strange electricity use profiles, like this one at the bottom, which uses about 85 Watts continuously – apart from cutting out briefly just after 7am.

Most households used between 300 and 840 kWh a year to run cold appliances. However, 19 households used more than double the average (see *Refrigeration* chart, p10). Overall we found that 21 out of 380 appliances (6%) appear to be malfunctioning. Almost a quarter of households with high energy use for refrigeration had at least one malfunctioning appliance, and two of them had two faulty appliances.

We inspected the electricity profiles and saw that some of the high consuming fridges and freezers had probably failed – perhaps due to poor seals or a failed thermostat. The appliances did not cycle on and off normally. The charts below show a sample 24-hour profile from a normal freezer and one with a fault. Householders would not normally be aware of these faults.

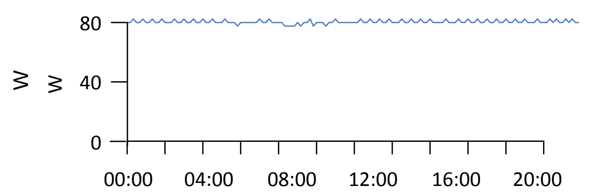
| Appliance | Sample Size | Proportion malfunctioning | Extra usage for failed appliances kWh/year[11] |
|---|---|---|---|
| Fridge | 99 | 2% | 180 |
| Freezer | 129 | 9% | 331 |
| Fridge-freezer | 148 | 4% | 120 |

11. The sample size was too small to test significance for fridges, and 'faulty' fridge-freezers showed a non-significant difference in energy consumption (p=0.15), but there was a significance difference for faulty freezers (p<0.01).

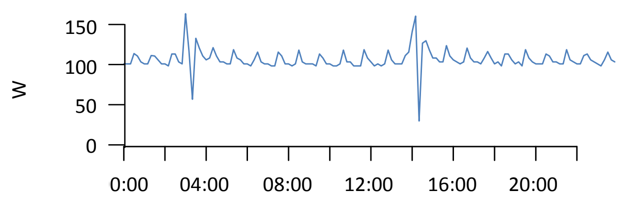
Faulty appliances tended to be older: 20% of cold appliances bought before 1995 were faulty, compared to 3% of newer appliances (see table below, and note the small sample size for older appliances). However, it is remarkable that some appliances less than two years old still appeared to be faulty. Profiles from two such appliances are shown below.

### Daily profiles for two malfunctioning appliances less than two years old

#### Upright freezer




#### Fridge-freezer




## Standby power

Our analysis suggests that standby power accounted for an average of 200 kWh per household per year, or 5% of total electricity use. (Note that most of the appliances in the survey were bought before the EU Standby Directive came in, which required standby power use below 1 Watt, and in time will fall to below 0.5W.)

This figure includes devices such as computer routers that may be left on all the time but do not have a true ‘standby’ mode because they are always active. Modems and routers were recorded with much higher continuous power use than the true standby for other computer equipment – around double the next-highest device. Continuous use means there may be opportunities for using timers on modems and routers.

| Age of appliances, where known | Proportion malfunctioning | Sample size |
|---|---|---|
| > 15 years | 20% | 15 |
| 11 to 15 years | 3% | 31 |
| 6 to 10 years | 3% | 69 |
| 5 years or less | 4% | 167 |

| | Best available rating | Most common rating | Efficiency improvement from most common to best available | Proportion of appliances that could be upgraded |
|---|---|---|---|---|
| Cold appliances | A+ | A | 24% | 98% |
| Washing machine | A++ | A | 23% | 99% |
| Tumble dryer | A | C | 39% | 98% |
| Dishwasher | A++ | A | 21% | 100% |

## What scope is there for improved efficiency of appliances?

Many of the appliances monitored in the survey were not the most efficient ones available, based on energy labels. For example, 75% of the cold appliances monitored were rated A, whereas A+ appliances and better are now available. Of course, the better-rated appliances tend to be more expensive, and have not been available for very long – two reasons why most households have less efficient appliances.

We explored the potential for improving appliance efficiency by replacing appliances with the most efficient ones currently on the market. On average, at least a 20% improvement in energy efficiency was possible for cold appliances and washing appliances, see table below. We also found that almost all of these appliances were not as good as the best ones available.

## How could we encourage households to buy more efficient appliances?

Scotland, Austria, Germany, Belgium and Spain have all experimented with rebate schemes to provide financial incentives for households to replace appliances with more energy efficient models. We examined the optimum levels for a possible rebate scheme covering England – based on how much energy would be saved per pound invested in new appliances for the HES households.

We used the actual energy use per appliance for each HES home to estimate the savings from switching to successively better-rated appliances. Unsurprisingly, appliances with better energy ratings tend to me more expensive. There is also a law of diminishing returns, and sometimes, beyond a certain point, better performance only comes with a major jump in cost.

Assuming that a rebate scheme covers the full cost of a new appliance, and old appliances have to be withdrawn from use, we found the optimum rebates ranged from £350 to £450, depending on the appliance, to the nearest £50 – see table. Tumble dryers and fridge-freezers would bring the biggest savings in annual energy use, mainly because existing appliances are much less efficient than those now on the market.

We also used the Treasury's Green Book approach to generate the Net Present Value of future energy savings and carbon impacts. We found future savings would not meet the cost of the rebates for any of these appliances.

| | Optimum rebate level | Corresponding Energy Rating | Mean Appliance Energy Saving (%) | Mean Annual Household Saving (kWh) |
|---|---|---|---|---|
| **Washing Machine** | £350 | A+++ | 46% | 87 |
| **Fridge** | £400 | A++ | 33% | 51 |
| **Freezer** | £450 | A++ | 27% | 72 |
| **Fridge Freezer** | £450 | A++ | 33% | 146 |
| **Tumble Dryer** | £450 | A+ | 60% | 225 |

## 2. Potential savings

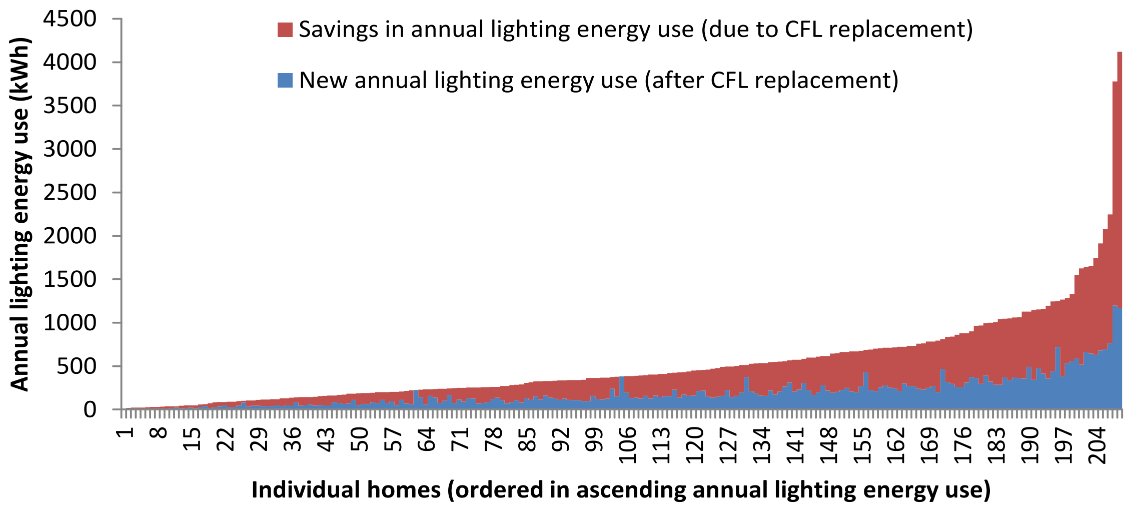
We examined potential savings from making simple changes to the way lights and appliances are used in homes. Let's start with lighting. We found that only 30% of the lightbulbs in HES households were low energy bulbs (compact fluorescent, LED or conventional fluorescent tubes). The rest were traditional (incandescent) bulbs, or halogens, which use considerably more power.

The Market Transformation Programme, which supports Government policy on sustainable products[12], projects 80% take-up of low energy lights by 2024. Using this uptake rate, we estimated the savings across all HES households, and found that moving from 30% to 80% low energy lights would save an average of 230 kWh a year per household, or 6.2 TWh across the UK[13]. Naturally, the actual saving per household depends how much they use their lights, how many lights are installed, and what proportion are already low-energy lights. The 'before' and 'after' lighting energy use figures are plotted household-by-household in the graph below.

We also examined outdoor lighting in the HES households. We found that 58% of them had at least one outdoor light, and the vast majority of these use traditional incandescent bulbs (49%) or halogens (30%). Households with traditional bulbs had an average installed load of 66W, while those with halogens had much higher installed loads – an average of 350W, and 1500W was the highest recorded.

These low efficiency lamps also represent a good opportunity to reduce electricity use. The EU Eco-Design Directive[14,15] banned the entry of these lamps into the supply chain, so electricity use for outdoor lights will come down sharply over time with no further intervention. (Some retailers have stockpiled the old lamps, which is why they are still available in the short-term.)

**Current electricity use for lighting, and potential savings**




12. See http://efficient-products.ghkint.eu/
13. 230 kWh x 27 million homes = 6.2 TWh. More detailed analysis is given in Terry N et al. (2014) Further Analysis of the Household Electricity Survey: Lighting Study. London: DECC. pp69-71.
14. European Commission (EC) (2009) No 244/2009 of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for non-directional household lamps. Brussels: EC.
15. European Commission (EU) (2012) No 1194/2012 of 12 December 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for directional lamps, light emitting diode lamps and related equipment. Brussels: EC.

Moving from lighting to savings from appliances, which we touched on in Section 1 above, we examined the potential savings from four different interventions that could reduce energy use by appliances, following the approach used in the original *Powering the Nation* report. We explored:

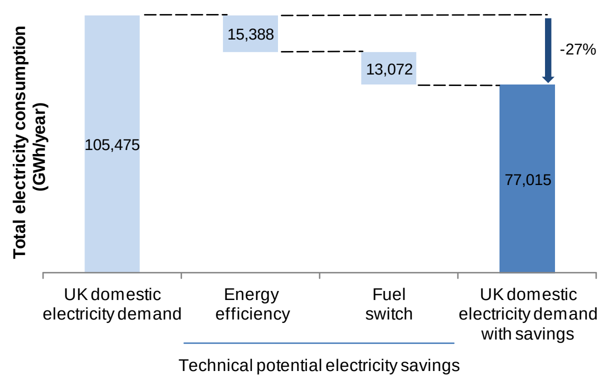
- replacing cold appliances with A+ or A++ energy-rated appliances
- reducing standby power for audiovisual and computer sites
- replacing existing washing machines, clothes dryers and dishwashers with energy efficient alternatives, and
- replacing desktop PCs with laptops

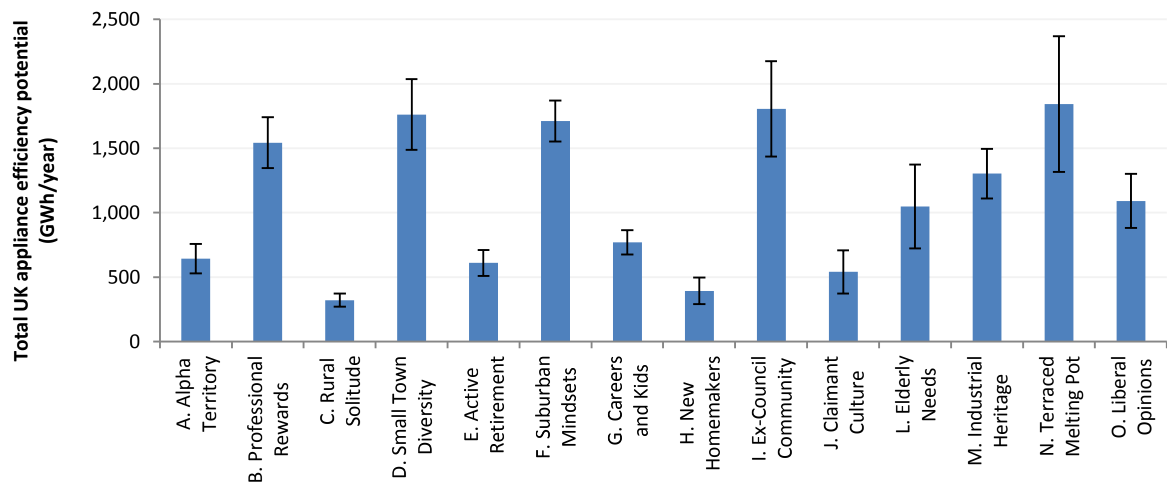
We also considered potential savings from switching to non-electric fuels for heating, or more efficient electric heating systems, for water heating and primary or secondary heating. The estimated average saving per household was 584 kWh a year.

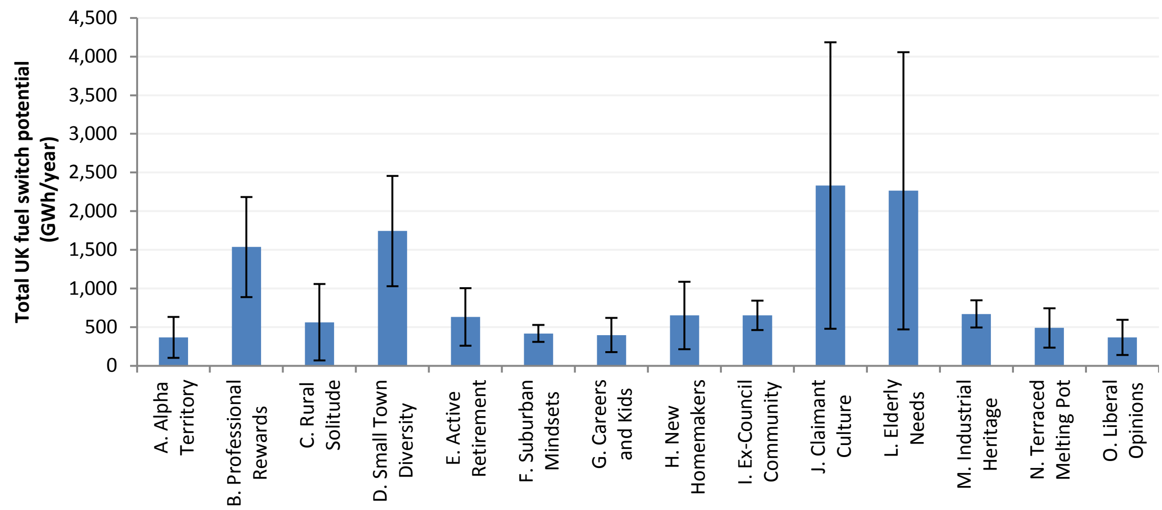
The Departments wanted to know which households had the greatest potential for efficiency savings, so we broke down potential savings into different demographic groups, using Experian's 15 Mosaic Groups. These are commonly used by industry and Government to define the distribution of household types in a given region. **The group names come from Experian and were developed for marketing purposes. They do not reflect Government naming conventions**.

In total, we estimated potential savings from upgrading to more efficient appliances, across all UK homes, of 15.4 TWh a year, or 14% of household electricity use. The potential savings are shared across household types as shown in the graph below (bars show uncertainty ranges).

## Potential savings from energy efficiency and heating upgrades






The greatest opportunity for savings from upgrading to efficient appliances exists in the 'Ex-Council Community' and 'Terraced Melting Pot' Experian groups, which offer possible savings of over 1.8 TWh a year each, nationally.

The 'Small Town Diversity', 'Suburban Mindsets', and 'Professional Rewards' groups also offer big potential savings: 1.76, 1.71, 1.54, and TWh a year, respectively. The big savings are not because these groups own particularly inefficient appliances, but because they tend to have high electricity use combined with a strong representation in the UK.

Similar work on potential savings from replacing electric primary or secondary heating with non-electric heating, or more efficient electric heating like heat pumps, found total potential savings of 13.1 TWh a year, or 12% of total electricity use. This broke up into the Experian groups as shown above.

**Replacing electric heating with non-electric heating or more efficient electric heating could save 12% of electricity use**

For electric heating, the biggest potential savings could come from 'Claimant Culture' and 'Elderly Needs' Experian groups. These two segments only account for 6% of UK households each, but together they offer 4.6 TWh a year of savings potential (over a third of the total).

For both groups, electric space heating contributes almost 80% of the savings opportunity, with water heating making up the remainder.

## 3. Reducing peak load

The margins between electricity generating capacity and the demand for electricity in the UK are falling – due largely to reduced generation using coal and oil. This trend is set to continue, with around a fifth of generation capacity being withdrawn by 2020. Ofgem, the electricity regulator, says[16] that the risks to security of supply are increasing, as is the risk of disconnections due to inadequate supply (admittedly from near zero).

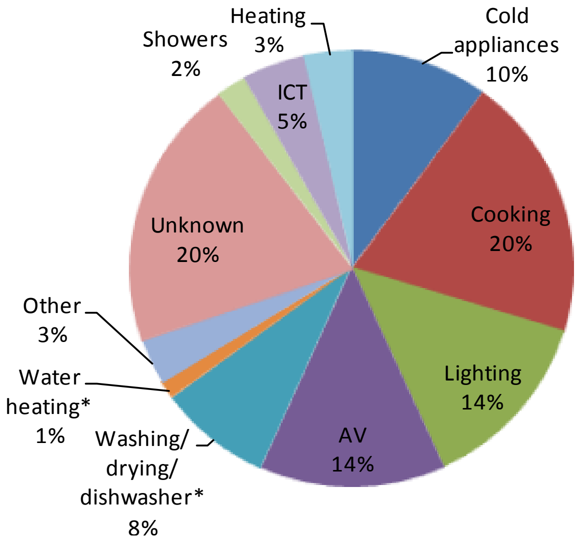
16. Ofgem (2013) Electricity Capacity Assessment Report 2013. London: Ofgem. https://www.ofgem.gov.uk/ofgem-publications/75232/electricity-capacity-assessment-report-2013.pdf (accessed 13.03.14)

| Switchable | Partially switchable | Non-switchable |
|---|---|---|
| Washing machine | Ovens | Lights |
| Tumble Drier | Space heating | TV |
| Dishwasher | Cold appliances | Audio equipment |
| Water heating | | Computers |
| | | Hobs |
| | | Microwave |

Ofgem is particularly concerned about winter demand and periods of peak demand – currently a peak of up to 60 GW across both housing and non-domestic users. DECC and DEFRA asked us to quantify the potential for shifting demand away from the peak period – to move towards a more even demand for energy.

We saw above that the average peak demand for power in HES homes came from 6pm to 7pm, at an average of 720 Watts per home, rising to more than a kilowatt in cold weather, and 1.6 kilowatts on the coldest day of 2010, the 20th of December.

Some appliances are less time-sensitive than others. For example, households need electric lighting when it is dark outside and occupants are active: they cannot choose to use lights at some other time. Conversely, households have more discretion about when they run their washing machines or tumble-driers. Given the right incentive, householders might be persuaded to use such appliances during periods of low electricity demand. The table above shows which appliances are 'switchable' to periods outside the peak in demand. The switchable appliances add up to about 9% of peak household demand. We worked out that increasing the efficiency of non-switchable appliances would make a bigger difference to peak load.




### Share of peak load for different uses

Nearly 60% of the known peak electricity demand (6-7pm) is used for cooking, lighting and audio-visual appliances. These are hard to move to other periods, but offer potential for improved efficiency – which would cut the peak load. (Appliances that are easier to move to other periods are marked with an asterisk in the chart.)

Our work showed the savings from better efficiency make a bigger difference to peak load than load-shifting per se.

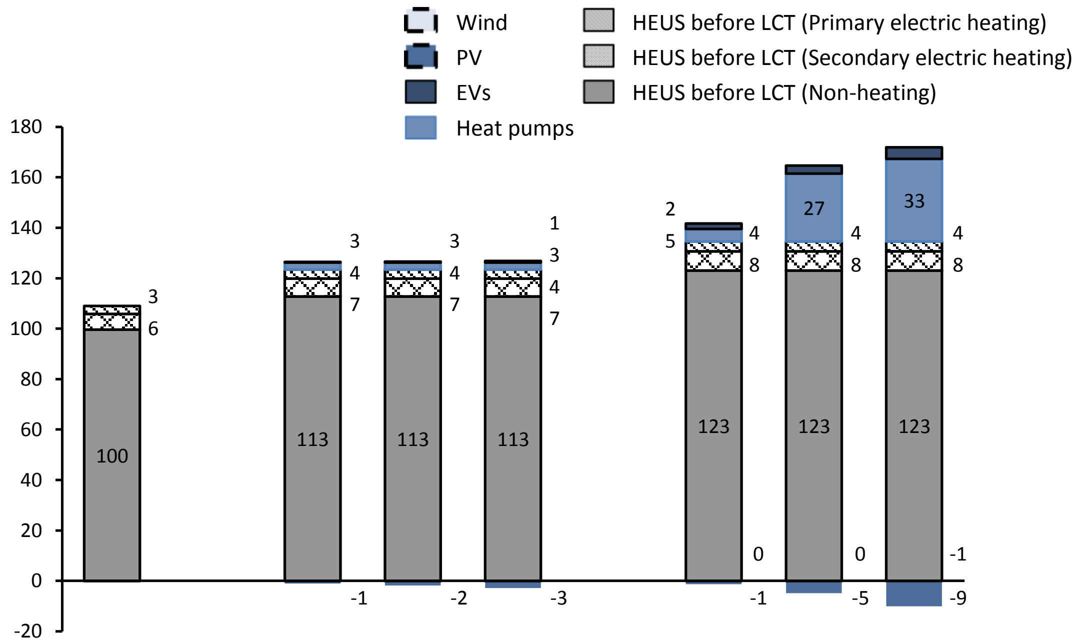
## Low carbon technologies

As part of the further analysis, Element Energy looked at future uptake rates for electric vehicles (EVs), heat pumps, photovoltaics (PV) and small-scale wind turbines, focusing on how these will affect household demand for electricity[17]. They found that nationally, electricity demand on the grid in 2020 is expected to increase by up to 16% as the increased demand for heat pumps and electric vehicles is more than the extra generation from PV and household scale wind. Similar demand per household is forecast (with renewable generation offsetting increased demand), but rising numbers of households will push up total demand.

The demand for electricity is forecast to grow still further by 2030, mainly due to increased use of heat pumps. (For simplicity, this analysis assumed no improvements in energy efficiency compared to today, so these figures are pessimistic). Element's 'high', 'central' and 'low' estimates were based on DECC uptake projects as shown in the graph below.

Changes in the deployment and use of low carbon technologies will also affect the profile of electricity demand through the day, with different implications in the summer and winter, and depending what strategies are used to manage demand (so-called 'demand-side response'). The graph on the following page shows the overall effect on average electricity use of the 'high' estimate by 2030.

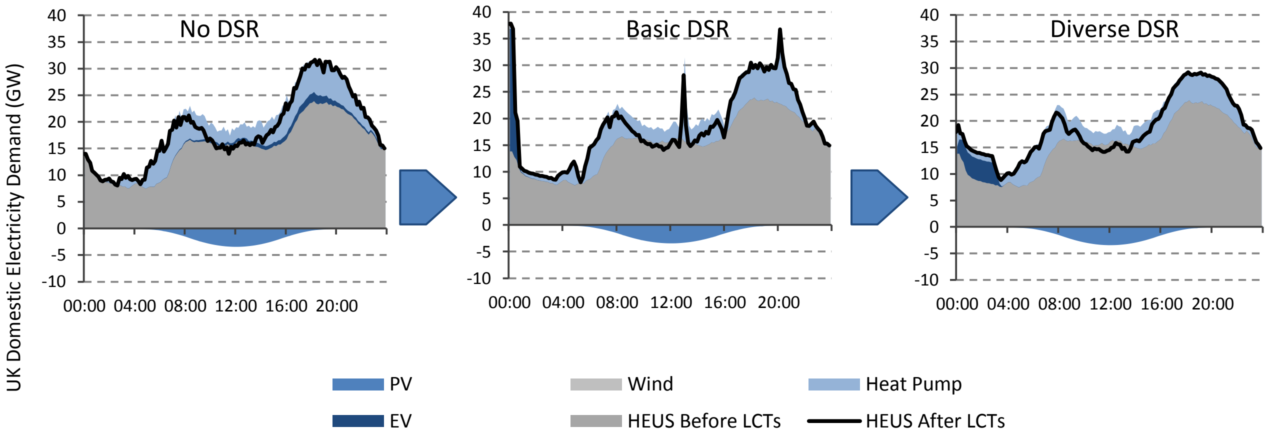
### Significant factors for high or low electricity use




In the 'central' estimate, residential electricity demand could increase by around 47% by 2030, due to population increase and greater use of heat pumps and electric vehicles.

17. Element Energy (2014) Further Analysis of Data from the Household Electricity Usage Study: Correlation of Consumption with Low Carbon Technologies. London: DECC.

## 24-hour profile of electricity demand under a 'high' estimate of low carbon technologies take-up, 2030




The graph shows that heat pumps and electric vehicles could increase the typical morning and evening residential peaks from 16 and 25.5 GW to 22.5 and 31.5GW, respectively. Staggered demand side response (DSR) could reduce these increases by around 2.5 GW, but for heat pumps this depends on sufficient space being available in homes for heat stores.

The graph also illustrates the difficulty of implementing demand-side-response measures (like time-of-use tariffs) for low carbon technologies without affecting diversity in consumption patterns. For example, if electric vehicles are charged and heat pumps come on all across UK at the same time (say, the start of a low-tariff period), then big new demand peaks could be formed. We recommend strategies to promote diversity: locally and nationally staggered time-of-use tariffs, and other measures to spread vehicle charging and heat-pump use evenly overnight.

## Savings from secondary heating

Space heating accounts for a significant proportion of electricity use even when the main heating system is gas or oil. In this survey, households using electricity in addition to a gas or oil main heating system used an average of 590 kWh of electricity a year for this. (For comparison, households using electricity for their main heating used 4,860 kWh a year, on average.) Households only using electric heating as a backup may be able to use their main heating instead, or to shift this demand away from peak periods by heating their home at other times. The Departments asked us to work out how much electricity use this could save.

We found a very wide range in energy use for backup electric heating in the 24 homes in the survey that had it: from well under 1kWh a day up to 16 kWh a day. The average was 4 kWh a day. Backup heating used an average of 20% of the total electricity use during the heating season for these households, rising to 30% during the peak period from 6-7pm, and much higher on very cold days. On the coldest day of the year in 2010 these households used an average of 570 Watts for backup heating during the peak hour – an astonishing 84% of their total electrical power demand at this time.

There are approximately 4.2 million homes using electric backup heating in England (19%, based on CAR's analysis of the English Housing Survey 2010[18]). If the HES survey is representative then, by avoiding secondary heating in peak periods, they could save between 680 MW and 820 MW during the peak hour 6-7pm on average, and up to 2.0 GW in cold periods.

## Could we use timers?

Washing machines, tumble driers and dishwashers are eminently switchable. On paper at least, householders could avoid using these appliances during the evening peak, even without any new controls. If they wished, they could use built-in or plug-in timers to automatically delay the start of washing cycles until the end of the peak period.

The monitored homes used an average of 57 W (21 kWh a year) for washing appliances during the evening peak period from 6-7pm. Potentially, switching this load to periods of low electricity demand could bring small but worthwhile reductions in the peak load.

One approach to persuading householders to use their washing appliances outside the peak load periods is to charge more for electricity in peak times – so there is a financial incentive to run these appliances at different times. To give some idea of the savings that might be possible, if all households in England with washing appliances refrained from using them during the evening peak, this would cut England's peak load by up to 1.3 GW (the equivalent of one fairly large power station).

If timers are used on washing appliances, they must do so safely. Mark Cashin, home safety expert at The Chief Fire Officers Association, was quoted in the Guardian in January 2014: "Every year we have numerous fires caused by dishwashers, washing machines and tumble driers. We would strongly advise people not to put them on when they go to bed, or before they leave the house."[19]

Potentially, timers could also be used to suspend fridges and freezers for 30 minutes during the peak period, or 'smart' controls in the appliance, activated by frequency response or other signals from the grid, could automatically suspend cold appliances for part of the peak period. Smart controls would mean appliances (or their controls) would have to be upgraded.

In the best case scenario (and putting efficiency savings aside), if all power to cold appliances could be suspended, it would be possible to trim 10% from peak power demand for 30 minutes, or an average of 35 W for each household in our sample that replaced its cold appliances. It is hard to scale this to a national level because of uncertainty about how many households could change their controls, but if half of all England's households did this it would cut the peak load by 0.4 GW.

Although timers are not mandatory on washing appliances now, and cold appliances do not currently have timers or smart controls, scaling the Household Electricity Survey data to the national level suggested that time of use tariffs could reduce England's evening peak by around 2.3 GW.

There is good evidence that, in most cases, UK households engage well with 'time of use tariffs' (where households pay more per unit of electricity at peak times, and less when demand is lower).[20,21]

18. Department of Communities and Local Government (2013) *English Housing Survey* Available at: https://www.gov.uk/government/organisations/department-for-communities-and-local-government/series/english-housing-survey (accessed 15.05.14).
19. Brignall M (2014) Is your kitchen about to go up in flames? London: The Guardian. http://www.theguardian.com/money/2014/jan/11/kitchen-flames-domestic-appliances (accessed 15.05.14)
20. Element Energy (2013) Further Analysis of Data from the Household Electricity Usage Study: Electricity Price Signals and Demand Response. London: DECC.
21. Bulkely H et al (2013) Customer-Led Network Revolution: Social Science Interim Report 2. Houghton-le-Spring: Nothern Powergrid.

As well as washing, drying and water heating loads (which can often be scheduled with minimal lifestyle impact using timers), there is evidence that some cooking consumption and other loads closely linked to lifestyle patterns can be shifted in response to these tariffs.

The Customer-Led Network Revolution trial indicated that it was possible to shift around 100W per home, on average, during the 4pm-8pm period. Similar trials by SSE and EDF in the Energy Demand Research Project also identified peak load savings from around 1% to 5%, although the incentives and implementation of trials was varied. As well as switching the time of use, there is evidence that these tariffs result in lower overall electricity use – perhaps as households become more aware of their energy use and how much it costs.

### Motivating clusters of homes

Element Energy identified seven ‘clusters’ of energy-use behaviours. One of these clusters, accounting for around 10% of survey households, had particularly high electrical demand at peak times. Element called this cluster ‘Peak-time users’, and found that they offered much higher potential for reducing the peak load than other households – mainly because of very high use of washing appliances and water heating from 6-7pm.  On paper, if all ‘Peak-time user’ households in England acted to reduce their peak demand as described above, they offer a technical potential to shift 0.8 GW (almost half the total for all homes) – although the achievable shift may be much less.

## 4. Modelling electricity use

Many of DECC’s published statistics[22,23] on household energy use are based on computer models[24]. We compared the model estimates for electricity use in each HES household against the actual, measured values. Overall, the models came very close to total electricity use in these homes: 5% under. However, the split between appliances, lights and cooking was different.

The model estimate of electricity use for appliances and lighting, averaged across all HES homes, was too high (33% over for appliances, 25% for lighting), whereas the model estimate for cooking was 33% too low. We used the HES data to derive an alternative model that matched the HES data better, but even this did not account for the large variability in electricity use between households (and particularly very high use households). We recommend using adjustment factors in models to account for high or low-use patterns, when this information is available, for modelling individual homes or small groups of homes.

As well as our analysis work for the Departments, we tried to make data from the survey available to policymakers and the research community in simple interactive spreadsheets. We developed three such spreadsheets. The first, the ‘Model Tester’, allows users to compare the model estimates and actual electricity use figures for HES homes in graphs. The second tool, the ‘Lighting Tool’ allows similar comparisons, but focuses specifically on energy use for lighting. And the third tool, the ’24-Hour Chooser’ shows a profile of HES electricity use through an average day, with users selecting different household types and periods to plot in the profile.

All three tools are available to download here.[25]

22. DECC (2013) Energy Consumption in the UK. DECC: London https://www.gov.uk/government/collections/energy-consumption-in-the-uk
23. Palmer J, Cooper I (2013) United Kingdom Housing Energy Fact File. London: DECC
24. The Cambridge Housing Model and the National Household Model both use electricity use algorithms from SAP, the Standard Assessment Procedure, which is used to check compliance with the Building Regulations.
25. https://www.gov.uk/government/publications/household-electricity-survey--2

# 5. Social studies

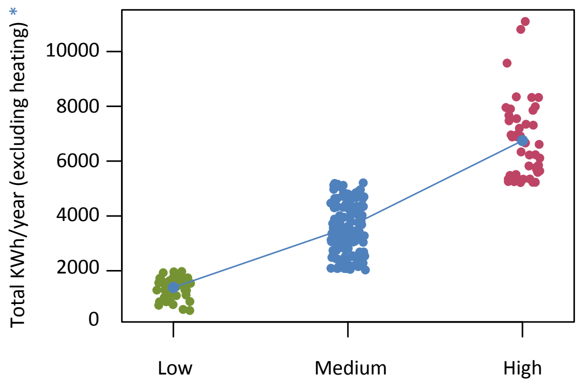
Many aspects of energy use in the home cannot be understood by looking solely at technical and technological factors. This study was mainly *quantitative* – in that it focused on measuring electricity use over time – and more limited data was collected about 'soft' factors affecting energy consumption. However, we explored a number of research questions intended to draw as much as possible from the limited social, demographic and *qualitative* (descriptive) information that was available.

This part of the report gives a summary of our findings about high and low-use households, single-person households, how stated behaviour compares to monitored electricity use, and the effect of demographic change on electricity use in the home.

## Why do some households have very high or very low electricity use?

We sought to find out whether there are social or demographic factors that help to explain high or low use. We classified the households as 'low' (bottom 20%), 'high' (top 20%) and 'medium' (the rest). The strip chart, right, shows the ranges in each category. There are 46 households in the top and bottom categories, and 136 in the medium category.

### Why do some households have very high or very low use?

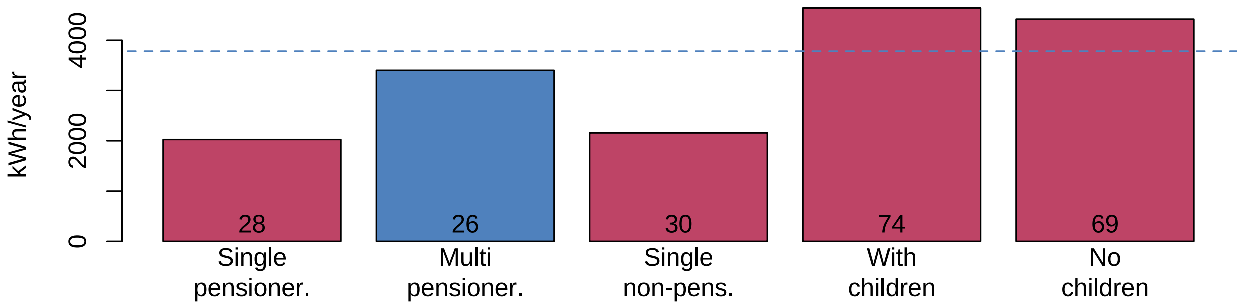


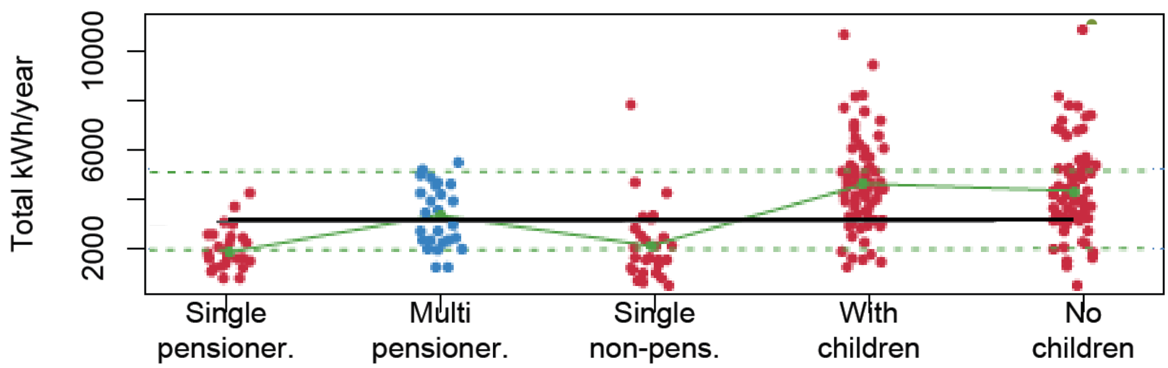

We tried to look for social or demographic factors that help to explain high or low use. We classified the households as 'low' consumption (bottom 20%), 'high' consumption (top 20%) and 'medium' (the rest). The strip chart shows the ranges in each category.

*This analysis was restricted to the 228 households where we could identify at least 60% of the electricity use, and excludes space heating.

## Household types and average energy use

We found that people living alone used much less electricity, on average (red columns and points in the charts below show significant relationships). Both single pensioners and singles of working age used just over half as much energy as the average. Households of working age with children used about a fifth more than average, while households of working age without children used about an eighth more.



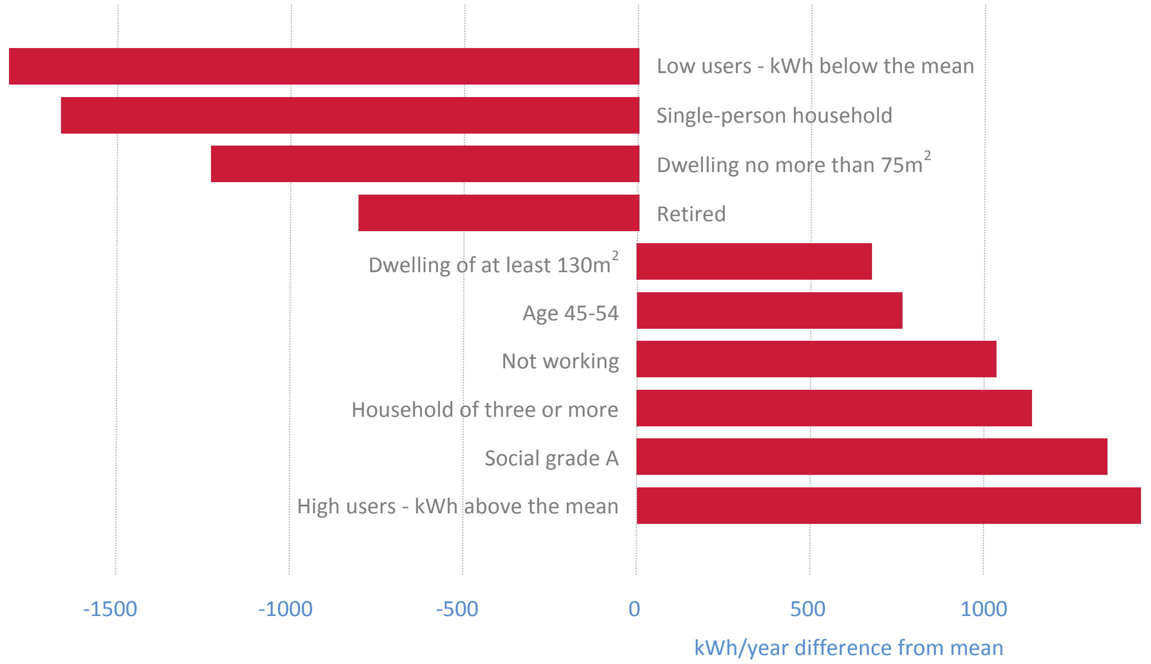

Analysis revealed significant relationships between household type and overall energy use: single-person households used less than the mean, while multi-person households tended to use more (see charts). However, in households with more than two people, each successive person added less to energy use, on average.

Similar examinations of other factors showed that age was also significant: households aged 45-54 used about a fifth more than average, while households over 65 used from a quarter to a third *less* than average. Working status was also significant, and it is interesting to note that retired households used a fifth less – whereas people out of work but in working age used a quarter *more* than average.

There were some other indicators of high energy use for particular types of appliance: four of the five households with highest energy use for audio-visual appliances had at least three TVs, and there was a link between high appliance ownership and high energy use. There was also a link between using tumble dryers and having high electricity use. No households were identified as being in the top 20% usage for all appliance categories.

### Significant factors for high or low electricity use

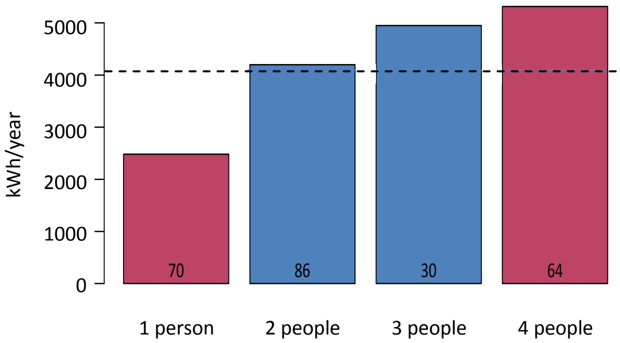
This chart brings together all of the factors we found to correlate to total energy use in these homes. The bars to the left show drivers linked to low average use, while those on the right show drivers linked to above-average use. The biggest drivers are living alone (more likely to use less energy) and being in social grade A (more likely to use more energy).




Focusing on energy use for lighting, dwelling size is a fairly good indicator of electricity consumption for lights. The largest homes use most electricity for lighting, while the smallest ones use least. Pensioners and singles typically use less electricity for lighting too – suggesting that they may be more careful in turning off lights in unused rooms and installing low energy lights. The data showed that house type (detached, semi-D, flat etc.) was not as important as dwelling size.

## Could single-person households save electricity by using smaller appliances?

Between 1970 and 2010 the number of people living alone in the UK increased from 6% to 13% of the population, although this percentage has been stable since 1998 (29% of households are now single person households). Single-person households use above-average energy per person, as single person households use more than half as much as couples. In this study couples used 2100 kWh a year per person, whereas single people used 2480 kWh a year: 18% more. A comparison of total annual electricity use against number of occupants is shown in the graph on the following page.




**Total electricity use by number in household**

The dashed line shows the overall mean. Red bars are significantly different from the average. The numbers at the bottom of the bars are sample sizes. Overall the graph shows how the extra electricity use of each additional household member falls as household size rises. This is an 'economy of scale': larger households have lower electricity use per head, on average.

We explored whether single people could use smaller appliances and so save energy. Our analysis showed that a smaller dishwasher with six instead of 12 place settings would save 78 kWh a year (27%) on average, but there would be no significant saving from a smaller washing machine. Singles already have smaller cold appliances, and fewer of them than couples, so there would again be no saving potential for refrigeration.

We found that running dishwashers at a lower temperature would save more electricity overall. Running one at 55 instead of 70°C could save 64 kWh a year, or 22% of dishwasher energy, on average – and this saving could be extended not only to singles, but all households with dishwashers.

## What did the survey reveal about household beliefs?

The HES survey included questions for householders about their beliefs and attitudes, particularly in relation to the environment and their energy efficiency habits. For example, it asked how concerned they were about climate change, whether car users should pay higher taxes, and how often they left lights on when they were not in the room.

We cannot be sure who in each home answered these questions, but there was some evidence interviewees tried to represent the whole household in their answers, and answers were consistent with a similar survey by DEFRA in 2009[26].

There was a link between household size and interviewees saying they left appliances on unused, with single-person households rarely saying they did this, whereas a third of households with more than two people did. However, analysing electricity use profiles alongside the survey data showed little link between TV use and what people said about leaving appliances on (see chart).


**What they say may not match what they do**

Households that said they 'never' or 'occasionally' left appliances on unused had their TVs on just as long as those saying they left appliances on. (The green bar for one occupant and 'more' is omitted because there were only four such households, not enough for a significant average.)

26. Alex Thornton (2009) Public attitudes and behaviours towards the environment - tracker survey: A report to the Department for Environment, Food and Rural Affairs. London: TNS/Defra.

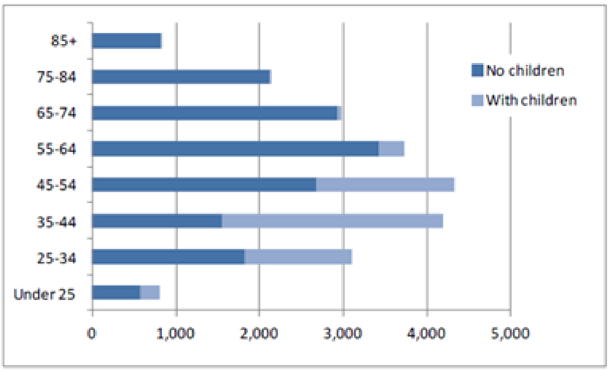
## How will demographic change affect energy use?

Some energy use patterns are related to household age. For example, we calculated that households over 75 use a third less electricity than the average for all households. Conversely, middle-age households (35-54) tend to use more electricity. Government projections[27] of household ages through to 2021 suggest that the number of middle-age households and the number of older households will increase – see charts.

Considering the effect of age alone, and assuming that current patterns of energy use endure with no major changes in electricity use in the home, the HES suggests that electricity use will increase by 9% because of demographic change alone.

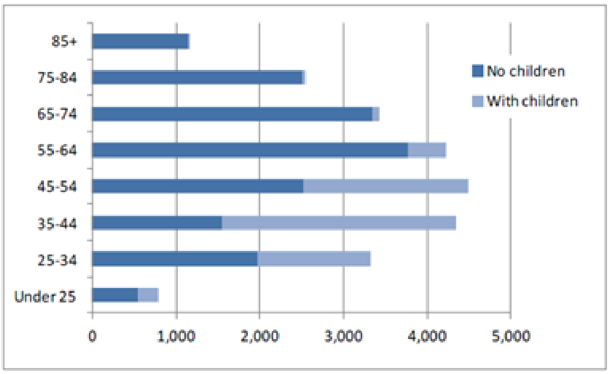
### Households in different age bands:

**2011**




Number of households (thousands)
Source: DCLG (2013)

**2021**




Number of households (thousands)

| With children | 2011 consumption (MWh) | Projected 2021 consumption |
|---|---|---|
| 19-24 | 1,166,672 | 1,143,872 |
| 25-34 | 5,439,772 | 5,801,939 |
| 35-44 | 12,398,624 | 13,110,391 |
| 45-54 | 9,162,979 | 10,908,561 |
| 55-64 | 1,687,528 | 2,524,902 |
| 65-74 | 228,343 | 347,034 |
| 75+ | 113,817 | 204,480 |
| TOTAL | 30,197,736 | 34,041,180 |
| **Increase** | | **12.7%** |

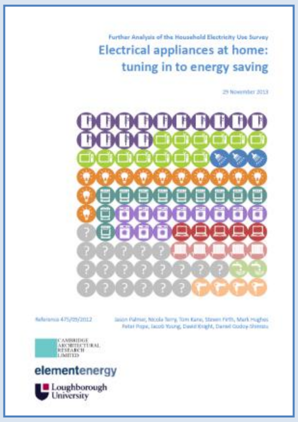
| No children | 2011 consumption (MWh) | Projected 2021 consumption |
|---|---|---|
| 19-24 | 2,205,273 | 2,127,865 |
| 25-34 | 3,594,080 | 3,880,026 |
| 35-44 | 6,462,309 | 6,451,982 |
| 45-54 | 12,917,656 | 12,241,303 |
| 55-64 | 12,529,271 | 13,795,165 |
| 65-74 | 10,742,173 | 12,325,453 |
| 75+ | 8,060,373 | 9,991,304 |
| TOTAL | 56,511,135 | 60,813,099 |
| **Increase** | | **7.6%** |

27. DCLG (2013) Table 418 Household projections: by age and number of dependent children, England, 2011 & 2021. London: DCLG. https://www.gov.uk/government/statistical-data-sets/live-tables-on-household-projections (last accessed 5 February 2014).

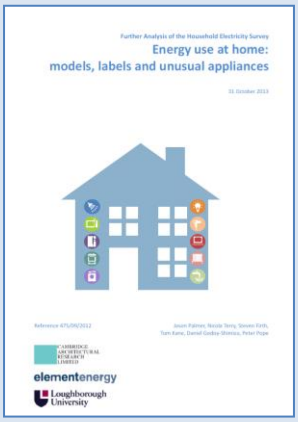
# Where to find out more

There are ten published reports apart from this one available on GOV.UK, here. The first four shown below cover a series of very specific questions that were drawn up by DECC and DEFRA. A summary of the questions covered in each report follows its cover below, and readers working electronically can find them easily by searching for the titles at WWW.GOV.UK.

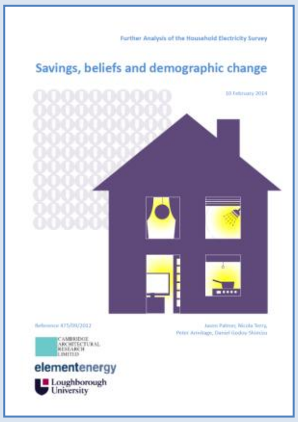

- Daily demand profiles
- Potential for demand shifting
- Baseload demand
- Standby energy use
- 24/7 appliances
- Back-up electric heating



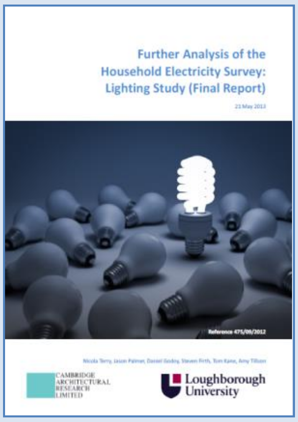

- Age of appliances
- Purchase rates
- Energy ratings
- Cluster analysis
- Single-person households
- Appliance use associations
- Products with high agency
- Smaller, simpler appliances
- Washing appliances
- Heated conservatories
- Rebound effects
- Seasonality trends



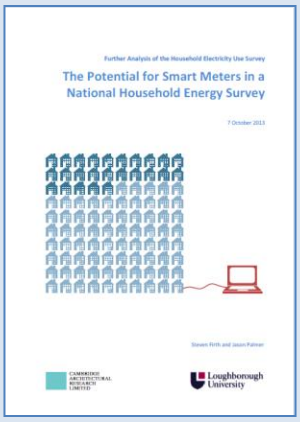

- Actual and modelled energy use
- ‘Unusual’ appliances
- Air conditioning
- Electricity use of major appliances
- Energy Consumption in the UK and the Energy
- Follow-up Survey
- Secondary heating




- Electricity use and environmental beliefs
- Potential energy savings in social groups
- Pensioners by socio-economic group
- Demographic change
- High and low use households
- An exchange scheme for inefficient appliances




- High-low lighting users
- Daytime & night-time lighting
- Baseload lighting
- Rebound effects
- Lighting activities
- Lighting modelling
- Lighting projections
- Household Type




- Potential applications of smart meter data
- Collecting & disaggregating data
- National Household Energy Survey
- Estimated costs of a national survey


### Correlation of consumption with low carbon technologies

- HES demand profiles
- Low carbon technologies for one households
- LCTs and electricity use
- Load shifting potential
- National implications


### Electricity price signals and demand response

- Overview of trials
- EDRP trials
- Customer-led revolution
- NI keypad meters study
- National peak shift potential appliances


### Increasing insight and UK applicability

- Experian Mosaic UK dataset
- HES households into Mosaic
- Electricity use of Mosaic groups
- Technical potential for savings per group


### Consumer archetypes

- Profiles of the household archetypes
- Occupant characteristics
- Building details
- Electricity use
- Technical potential for electricity savings

Prepared by Cambridge Architectural Research, Cambridge Energy, Loughborough University and Element Energy under contract to DECC and DEFRA. Views are the authors', not the Departments'. June 2014.