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Demand-Side Flexibility for Household Electricity Bill Reduction in Ireland for Cooking, Dishwashing, Tumble-drying and Electric Ovens

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Case Report

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Abstract

Demand-side flexibility (DSF) is increasingly promoted as a means of reducing peak electricity demand and household electricity bills. This study examines the potential financial benefits of household appliance load shifting for Irish consumers using Time-of-Use (ToU) electricity tariffs. Data from the Sustainable Energy Authority of Ireland's Behavioural Energy and Travel Tracker (BETT) survey were combined with current supplier tariff rates and appliance energy consumption data to model a series of load-shifting scenarios. Four household appliances were analysed: electric ovens, dishwashers, washing machines, and tumble dryers. Results indicate that shifting peak-time appliance usage to off-peak periods once a week could yield annual savings of €5 to €44 per household in an ideal scenario and €0.63 to €5.43 in a representative scenario, suggesting that current Time-of-Use electricity tariffs provide limited financial motivation for behavioural change. While strong participation could reduce national peak demand by 0.5% to 2.0%, the overall impact remains modest relative to an annual electricity bill of approximately €1,600 and Ireland's electricity system requirements. The findings suggest that stronger incentives, enabling technologies, or alternative flexibility mechanisms may be required to increase household participation in DSF programmes.

1. Introduction

The demand for electricity in Ireland is increasing, as is the need to build the grid infrastructure required to deliver it. Ireland’s electricity demand in 2025 was just under 34 TWh, up 3.7% on the previous year. The three largest electricity demand sectors in 2025 were commercial services (42%), residential (25%), and industry (21%)[1]

Peak electricity demand (measured in MW), rather than annual electricity consumption (measured in MWh), is particularly important because it is a key determinant of the generation capacity and grid infrastructure required by a country. These costs ultimately feed through to consumer electricity bills via a range of network and system charges. If two regions have the same annual electricity demand but one has a lower peak demand, then, *ceteris paribus*, the region with the lower peak demand will generally have lower electricity costs.

System data from EirGrid shows that peak demand in Ireland for 2025 was 6,011MW however this was a very brief period and system demand across the full year only exceeded 5,850MW for 3 hours in 2025[2]. Demand peaks are expensive to provide for and there should be system benefits in reducing peak. Ireland’s Transmission System Operator (EirGrid) forecasts that peak demand will increase by 19% by 2035 compared with 2024 levels, primarily driven by growth in data centre and new technology loads, along with the electrification of heat and transport[3]. The residential sector also remains a key area of focus for electricity demand growth as the Irish Government progresses towards the housing targets set out in the National Planning Framework.

The practice of Demand-Side Flexibility (DSF) refers to a suite of measures taken to shift or alter electricity demand to better match electricity supply, particularly to move demand from the peak to times with lower demand.

DSF measures may be classified as either intrinsic or extrinsic[4]. Intrinsic measures are those that incentivise electricity users to adapt their own consumption patterns, for example through tariff structures such as Day/Night tariffs, Time-of-Use (ToU) tariffs, or the dynamic tariffs that are now available in Ireland. Under these tariff structures, customers are encouraged to shift their electricity consumption away from periods when electricity is more expensive, thereby reducing peak demand.

In contrast, extrinsic measures involve the direct control of electricity demand and are commonly referred to as Direct Load Control (DLC)[5]. Under this approach, electrical appliances are controlled remotely to increase or decrease demand as required. Groups of appliances across multiple households may be coordinated by an aggregator and operated collectively as a form of virtual power plant. Customers may be provided with the option to opt out of such schemes. However, these programmes are not yet widely available to residential customers in Ireland and are more likely to focus on electric vehicles and electric heating rather than appliances.

ESB Networks has been promoting intrinsic DSF in Ireland, most notably through its ongoing 'Is This a Good Time?' pilot programme[6]. Approximately 40,000 participating customers receive notifications indicating when it would be beneficial to increase or decrease their domestic electricity consumption. For example, customers may be encouraged to increase demand during periods of high wind or solar generation, or to reduce demand during periods of elevated evening peak demand. Participants receive modest incentives, such as gift cards, for taking part.

In this paper, we distinguish between essential and discretionary residential electricity demand throughout the day. Discretionary demand refers to electricity-consuming activities such as clothes washing, dishwashing, and tumble drying, which can generally be shifted from one time period to another with limited disruption to household routines. In contrast, essential demand relates to activities such as medical care, meal preparation, eating, and showering, which are typically linked to specific daily schedules and therefore offer less flexibility for temporal shifting.

The distinction between essential and discretionary electricity use is not universal and is likely to vary across countries and cultures. Differences in social norms, lifestyles, household practices, and expectations regarding energy services can all influence how particular electricity-consuming activities are classified and the extent to which they can realistically be shifted in time.

DSF has the potential not only to reduce the unit-rate component of household electricity bills, but also to deliver wider system benefits by reducing peak electricity demand[7]. The international literature on DSF relating to large flexible loads, such as electric vehicles (EVs)[8] and electric heating systems[9], is relatively well established. In contrast, there is less recent research[10] quantifying the savings that households can

realistically achieve through the shifting of everyday electricity use, particularly when moving consumption away from peak-demand periods. Examples of such discretionary activities include clothes washing, dishwashing, tumble drying, and, in some cases, cooking. This represents an important research gap, particularly where financial savings are the primary motivation for household participation in demand-side flexibility measures.

The Sustainable Energy Authority of Ireland (SEAI) has conducted several *Behavioural Insights for Policy* studies[11] examining electricity use in households across the Republic of Ireland. These studies draw on data collected through the Behavioural Energy and Travel Tracker (BETT) survey programme[12]. Within this research, SEAI assessed user engagement with demand-side flexibility and smart energy services[13].

The findings provide valuable insights into electricity-use patterns within Irish households. During peak-demand periods, cooking was found to be the most common household activity. Specifically, 29% of the overall survey sample reported cooking during the peak period on the day surveyed, accounting for 46% of all appliance-use instances recorded at that time. Furthermore, cooking represented 47% of estimated domestic peak electricity demand across all measured household activities. The percentage contribution of each activity to estimated peak demand is presented in Figure 1.

The study also found that cooking is more likely to occur during peak periods in the winter months and in larger households with more residents. This finding suggests that, although cooking represents a significant proportion of peak residential electricity demand and therefore appears to offer substantial flexibility potential, its practical ability to be shifted may be limited. In particular, meal preparation is closely tied to established household routines and is likely to become even less flexible during the colder and darker months of the year, when electricity demand tends to be at its highest.

Figure 1: SHARE OF PEAK RESIDENTIAL ELECTRICITY DEMAND PER APPLIANCE TYPE[13]

Saving money was the primary motivation for shifting electricity usage, with approximately 75% of survey respondents identifying financial savings as their main reason for moving consumption away from peak-demand periods. This finding is reinforced by the survey's self-reported concern ratings, in which the cost of living received the highest average score, at six out of seven. In comparison, concerns relating to climate change and energy security were found to be of lesser importance.

Using the total number of daily activity instances recorded by respondents, the proportion of activities occurring at each time of day was calculated across all relevant waves of the BETT dataset. This enabled the identification of temporal patterns in household electricity use and provided insights into the potential for demand-side flexibility across different periods of the day.

Table 1: Time of Day for Appliance Usage[11]

Time of Day	Cooking	Washing Machine	Tumble Dryer	Dishwasher
00:00-08:00	5%	10%	5%	6%
08:00-17:00	38%	60%	47%	29%
17:00-19:00	**39%**	**12%**	**19%**	**18%**
19:00-23:00	17%	13%	23%	33%
23:00-00:00	1%	5%	6%	14%

Table 1 illustrates the percentage of total usage instances for each appliance that occur during different times of the day, corresponding to the Time-of-Use (ToU) tariff periods. The results show that, of the four appliances considered, cooking is the activity most likely to occur during peak periods, with 39% of all cooking instances taking place at these times. In comparison, 12% of washing machine usage instances occur during peak periods, while the corresponding figures for tumble dryers and dishwashers are 19% and 18%, respectively.

The SEAI research[14] also assessed consumers' willingness to adopt DSF measures and found that participants expressed an interest in shifting the use of certain appliances to off-peak periods. Dishwashers, washing machines, and tumble dryers were the appliances that respondents were most willing to shift, based on the proportion of their weekly usage that they indicated could be moved. In contrast, only 43% of cooking instances were considered suitable for shifting. Nevertheless, respondents reported a high level of interest in alternative approaches such as batch cooking and using air fryers more frequently as a means of reducing peak-period electricity consumption. Similarly, many participants expressed a willingness to air-dry clothes instead of using tumble dryers. However, intentions expressed in surveys should not be assumed to translate directly into real-world behaviour. Indeed, the study noted that *"time-shifting information can backfire; reported intentions to reduce overall peak consumption were slightly lower among those who read information compared to those who did not. It is possible that knowing the benefits of time shifting can somewhat reduce the perceived importance of overall consumption reduction."*

In terms of electricity pricing structures, suppliers in Ireland offer Time-of-Use (ToU) tariffs (which are distinct from dynamic tariffs) comprising day, night, and peak rates. The night-rate period typically runs from 23:00 to 08:00, when overall demand for electricity is lower. Peak-rate periods generally correspond to the evening demand peak and typically occur between 17:00 and 19:00. Day rates apply during the remaining hours. ToU tariffs are intended to incentivise consumers to shift electricity consumption from peak to off-peak periods and therefore represent the most common form of intrinsic DSF currently available in Ireland.

According to the CSO's *Household Environmental Behaviours – Energy Use 2024* publication[15], 48% of Irish households reported that they were on a standard flat-rate electricity tariff. A further 21% reported using a Day and Night tariff, while only 12% indicated that they were on a smart ToU tariff. The

proportion of households using smart tariffs is likely to increase as the rollout of smart meters continues across Ireland. However, the relatively low uptake may also indicate the presence of behavioural inertia or other barriers to the adoption of more complex tariff structures.

In this context, this paper addresses an identified research gap by quantifying the potential monetary benefits of load shifting as a form of demand-side flexibility for Irish households. It also examines the extent to which increased participation in load-shifting activities could reduce national electricity demand during peak periods.

2. Methods & Data

Electricity unit rates for Time-of-Use (ToU) tariffs were obtained from the websites of the largest electricity suppliers in the Republic of Ireland. The three suppliers with the greatest market share were selected for this analysis. It was assumed that the published tariff rates would remain unchanged for the duration of the study.

All unit-rate values were inclusive of Value Added Tax (VAT), as this reflects the actual price paid by consumers and is therefore relevant when estimating potential household cost savings. The ToU tariffs considered in this study are shown below.

Table 2: Supplier Time of Use Tariff Rates

Supplier	Day (€/kWh)	Peak (€/kWh)	Night (€/kWh)
Supplier 1	0.3703	0.395	0.1946
Supplier 2	0.4352	0.4874	0.2797
Supplier 3	0.4445	0.5411	0.3281

Four appliances were selected for examination in the case studies. These appliances were chosen because they are known to have a degree of flexibility, or *load-shifting potential*, and represent notable contributors to peak-time household electricity demand. Furthermore, a significant proportion of their usage instances could potentially be shifted to off-peak periods. The appliances selected were electric ovens (for cooking), dishwashers, washing machines, and tumble dryers.

Electric vehicles (EVs) were not considered in this study, as it was assumed that most EV owners already charge their vehicles during off-peak night-rate periods and therefore have relatively limited additional load-shifting potential away from peak times. Domestic heating was also excluded from the analysis due to the wide variety of heating systems used across Ireland and the associated complexity in estimating representative energy consumption values.

Suitable energy consumption values for each of the four selected appliances were required for the calculator developed as part of this study. These values were derived from the European Product Registry for Energy Labelling[16] (EPREL). EPREL is a publicly accessible database established by the

European Union that provides energy performance information for a wide range of domestic appliances, enabling consumers to make informed purchasing decisions. All relevant products manufactured or sold within the European Union and European Economic Area are required to be registered in the EPREL database.

Each appliance listing contains key information, including dimensions, water consumption, programme duration, noise emissions, energy consumption per 100 cycles, and the appliance's energy efficiency rating, ranging from A to G, with A representing the highest efficiency. The published energy consumption values per 100 cycles were divided by 100 to determine the average electricity consumption per cycle, expressed in kWh.

While EPREL provided a useful and consistent reference source for appliance energy consumption, the resulting average values were cross-checked against products currently available on the Irish market. Information from appliances sold by Irish retailers was reviewed to ensure that the selected values reflected products commonly available to consumers. Consideration was also given to the fact that newer appliances available for purchase today are likely to be more energy-efficient than many older appliances that remain in use. The final energy consumption values selected for each appliance are presented in Table 3.

Table 3: Average Electricity Consumption per Cycle

Appliance	kWh per cycle
Washing Machine	0.6
Dishwasher	0.8
Tumble Dryer	1.4
Electric Oven*	1.2

* The value for an electric oven was adjusted to 1.2 kWh from 0.9 kWh as the original value was judged too low. Authors own judgement.

2.1. Load Shifting Savings Model

The calculation of energy use and potential cost savings was based on the Time-of-Use (ToU) tariff rates offered by electricity suppliers and the average energy consumption per cycle for each appliance, as discussed previously. This approach allows users to estimate appliance operating costs and potential savings using actual supplier tariff rates in conjunction with representative appliance energy consumption values, as presented in Tables 2 and 3.

The scenarios examined in this study to determine the potential annual monetary benefits for households, as well as the wider benefits to the electricity grid, were as follows:

Scenario 1: One Action per Week-Ideal

This scenario assessed a maximum level of engagement with demand-side flexibility. It assumed that a household shifts one full operating cycle of each of the four selected domestic appliances per week from a peak period to an off-peak period.

Scenario 2: One Actions per Week-Representative

This scenario utilised data from SEAI's Behavioural Energy and Travel Tracker (BETT) survey to model a more representative household load-shifting pattern in Ireland. The analysis estimated the weighted average frequency of usage that occurs during peak-demand periods and assumes that households shift one full operating cycle of each of the four selected domestic appliances per week from a peak period to an off-peak period.

Scenario 3: Battery Storage to Support Load Shifting

This scenario examined battery storage as a technology that can facilitate demand-side flexibility. The objective was to estimate the weekly and annual savings that a household could achieve through the effective use of a domestic battery storage system. Such systems have become increasingly common in Irish households alongside the growing deployment of rooftop solar photovoltaic (PV) installations. By charging during low-cost periods or from excess solar generation and discharging during peak-price periods, battery storage can enable households to reduce electricity costs while also contributing to peak-demand reduction on the wider electricity system.

3. Results

Scenario 1: One Action per week (Ideal household)

Scenario 1 examined the potential annual savings that could be achieved by shifting one instance of each of the four selected appliances per week from peak to off-peak periods. This equates to 52 instances of each appliance being shifted annually. This is a highly idealised scenario, and an important assumption is that the household is using the appliance at peak but assumes to shift it from the peak to either daytime or nighttime. The resulting savings are presented in Table 4. These results should be understood in the context of an annual electricity bill of €1,600/yr[17]

The results indicate that shifting appliance use from peak periods to daytime periods yields modest monetary savings for households. While some financial benefit is achieved, the difference between peak and daytime electricity rates is generally insufficient to generate substantial savings from occasional load-shifting activities alone. This suggests that households may need to engage in more frequent load shifting, make use of night-rate tariffs, or adopt additional flexibility measures in order to realise more significant reductions in their electricity bills.

At a national level, it is difficult to estimate how many households can, or will, reduce their electricity consumption during the period when Ireland's annual system peak demand occurs, which is typically on a winter evening. For illustrative purposes, this analysis assumes that 5% of households are able to shift electricity consumption away from the peak period. Under an idealised scenario in which the electric oven, assumed to be the largest source of household appliance demand, is deferred to a later time, the resulting reduction in national peak demand would be approximately 126 MW. This corresponds to a reduction of around 2% in peak demand and would represent a meaningful contribution to overall national system flexibility. However, this estimate should be regarded as an upper-bound scenario, as it assumes both high participation and perfect behavioural response

Table 4: Scenario 1 Results – Annual Savings

Scenario 1: One Action per Week for all appliances-Sample House	**Annual Saving (€) Shifting Peak to Night**	**Annual Saving (€) Shifting Peak to Day**
Supplier 1	€41.68	€5.14
Supplier 2	€43.20	€10.86
Supplier 3	€44.30	€20.09
Average	€43.06	€12.03

Scenario 2: One Action per Week (representative household)

This scenario was designed to be representative of an average Irish household that regularly uses the four selected appliances. Using data from SEAI's Behavioural Energy and Travel Tracker survey, the average frequency of use for each appliance was determined. Data from the BETT survey indicated that 72% of households own a tumble dryer, 99% own a washing machine, and 70% own a dishwasher. For cooking appliances, it was not possible to determine directly the proportion of households that own an electric oven, as the survey questions grouped together a range of cooking appliances rather than asking specifically about electric ovens.

However, the survey data indicated that 27% of all recorded cooking instances were undertaken using an electric oven therefore these results also examine a scenario with a household with and without an electric oven.

Using the time-of-use information from the BETT survey the annual number of peak-time appliance usage instances was estimated by weighting ideal usage by actual percentage reported use at peak (Table 1). This enabled the potential savings associated with shifting appliance use from peak to off-peak periods to be estimated for a household exhibiting typical appliance-use patterns.

Table 5: Scenario 2a Results – Annual Savings

Scenario 2a: One ACTION PER Week - Representative House	Annual Saving (€) Shifting Peak to Night	Annual Saving (€) Shifting Peak to Day
Supplier 1	€5.11	€0.63
Supplier 2	€5.29	€1.33
Supplier 3	€5.43	€2.46
Average	€5.27	€1.47

For the average representative household and across the four appliances, shifting time of usage could save between €0.63, and approximately €5.43 per year.

A further scenario was examined but this time assuming the household doesn't use an electric oven. The results show smaller savings. This is unsurprising, given that 39% of all cooking activity occurs during peak periods. Despite the relatively frequent use of electric ovens and the assumptions regarding household behaviour and appliance usage patterns, the resulting annual savings remain modest. This suggests that households would be required to make significant changes to their daily routines in exchange for relatively limited financial rewards.

Table 6: Scenario 2B Results – Annual Savings

Scenario 2B: One ACTION PER Week - Representative House-No Electric Oven	Annual Saving (€) Shifting Peak to Night	Annual Saving (€) Shifting Peak to Day
Supplier 1	€3.79	€0.47
Supplier 2	€3.93	€0.99
Supplier 3	€4.03	€1.83
Average	€3.91	€1.09

At a national level, SEAI's Behavioural Energy and Travel Tracker survey suggest that outside of the oven, 19% of household use a tumble dryer between the hours of 5pm and 7pm. Assuming that a weighted portion of 5% of homes are able to take action this would lead to a 24MW or 0.5% reduction in peak national for this appliance.

Scenario 3: Battery storage

The final scenario examined the possible annual savings from utilising the 4-kWh (nominal capacity) domestic battery storage system with an assumed depth of discharge (DoD) of 90% and assumed round trip efficiency 'μ' of 92%. This resulted in a usable capacity of 3.3 kWh, including losses, as seen in Equation 1 below.

E = Capacity × Depth of Discharge × Efficiency

E = (4)(0.9)(0.92) = 3.3 $kWh\ per\ cycle$

(eq 1)

In this scenario, the battery would be charged at night when electricity rates are lower and discharged during day or peak times. The savings from this scenario were calculated based on the tariffs for the three suppliers. If averages were taken for the values from the three suppliers, this would result in savings of approximately €0.50 per day, equivalent to approximately €150 per year (assuming 300 days rather than 365 days of annual use to allow for lower electrical load in summer).

While battery storage systems provided higher annual savings, the upfront cost and payback periods on these systems may be an issue for households. For an estimated cost of between €2,000 to €4,000 (noting that costs would are lower if fitted as part of solar PV installation), this would be a payback period of between 12 - 28 years, ignoring system maintenance and inflation.

The exact savings as per supplier can be found in the tables below.

Table 7: Annual Savings from 4 kWh Battery System

	Annual Savings (€/yr)	**Simple Payback- Low-Cost Installation (yrs)**	**Simple Payback- High-Cost Installation (yrs)**
Supplier 1	159	12.6	25.2
Supplier 2	148	13.5	26.9
Supplier 3	143	13.9	27.8

Again, at a national level, it is difficult to estimate how many households can, or will, adopt battery technology. Aligning assumption with the previous scenarios of 5% of households shifting electricity consumption for cooking (electric oven) away from the peak period using batteries would deliver similar results to Scenario 1 of approximately 126 MW. This estimate should be regarded as an upper-bound scenario, as it assumes both high participation and perfect behavioural response

4. Conclusion

The study aimed to quantify the potential savings available to an average Irish household through the use of Time-of-Use (ToU) tariffs and load-shifting measures, while also assessing the impact that widespread adoption of such measures could have on reducing national peak electricity demand. The results indicate that the financial benefits are modest, even when a substantial amount of electricity consumption is shifted. Given these relatively small savings, it is unlikely that many households would be willing to make significant changes to their daily routines solely for financial reasons.

At the national level, a meaningful reduction in peak electricity demand was observed even when only 5% of households took action to move demand outside of peak times. Under a theoretical case, peak

demand was estimated to decrease by 126 MW and a more realistic scenario based on current usage resulted in an estimated peak-demand reduction of just 24 MW. Relative to Ireland's overall peak electricity demand, this represents only a small but meaningful reduction.

These findings suggest that while residential load shifting can contribute to peak-demand reduction, its overall impact may be limited when driven solely by existing ToU tariff incentives. Consequently, greater peak-demand reductions may require either stronger financial incentives, wider adoption of enabling technologies such as home energy management systems and battery storage, or a greater focus on larger flexible loads such as electric vehicles and heat pumps. While the aggregate benefits of demand-side flexibility to the electricity system remain valuable, the direct financial incentives currently available to households may not be sufficient, on their own, to drive widespread behavioural change.

The use of complementary technologies, such as battery storage produced substantially greater savings. For example, a household equipped with a 4-kWh battery storage system could achieve annual savings of up to €150 by charging the battery using nighttime electricity rate and discharging it during peak-price periods.

These findings indicate that intrinsic Demand-Side Flexibility (DSF) measures alone may not provide a sufficiently strong financial incentive to address the challenges of reducing household electricity bills and lowering evening peak demand.

The findings of this study are likely to be relevant to a range of stakeholders. For households, the results suggest that shifting everyday activities away from peak periods may not be as financially beneficial as many consumers assume. The study provides quantified estimates of potential savings that have not previously been widely reported for Irish households. For electricity suppliers, the findings suggest that existing tariff structures may need to be redesigned if greater levels of load shifting are to be encouraged. Finally, the results provide evidence for policymakers and organisations such as the Sustainable Energy Authority of Ireland (SEAI) and ESB Networks that financial savings associated with Time-of-Use tariffs alone may not be sufficient to drive widespread participation in DSF initiatives. This consideration is particularly relevant in advance of the planned rollout of dynamic tariffs.

Declarations

AI Declaration

The initial and final drafts of this paper was written by the authors. This work was in based on preliminary analysis done by Daniel O'Reilly in his 5th Year ME Energy Engineering Project. An AI tool was used with the following prompts on the final version "Please review this paper for spelling and grammar without making changes to text and "please provide a critical review of this paper and point out any errors in the text or calculations"

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Figures

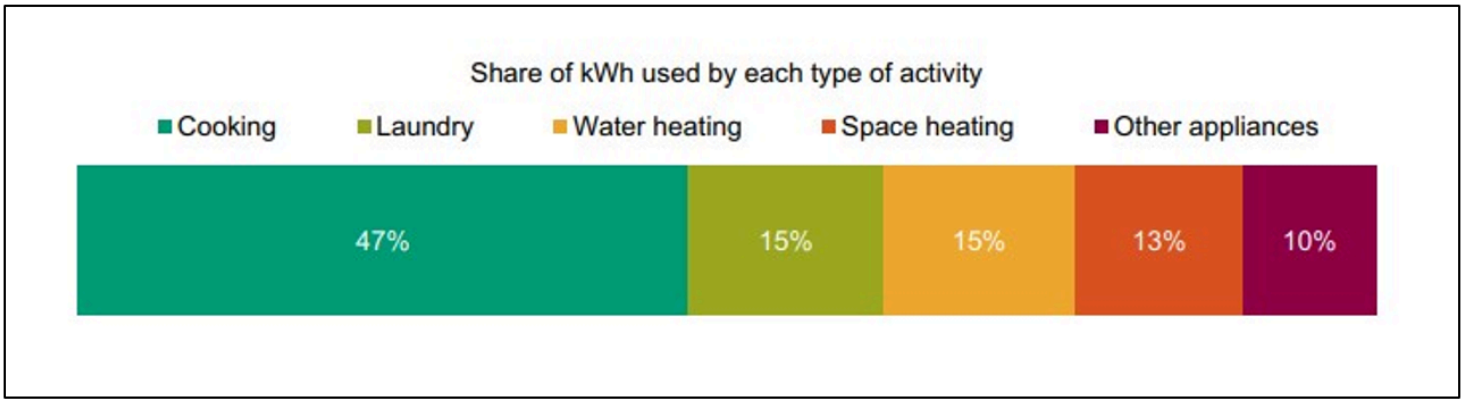


Figure 1

SHARE OF PEAK RESIDENTIAL ELECTRICITY DEMAND PER APPLIANCE TYPE[13]