Appliance monitoring for energy advisers

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Background

National Energy Action is the national fuel poverty charity working across England, Wales and Northern Ireland, and with sister charity Energy Action Scotland (EAS), to ensure that everyone can afford to live in a warm, dry home. In partnership with central and local government, fuel utilities, housing providers, consumer groups and voluntary organisations, NEA undertakes a range of activities to address the causes and treat the symptoms of fuel poverty. Its work encompasses all aspects of fuel poverty, but in particular emphasises the importance of greater investment in domestic energy efficiency.

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1. Introduction

1.1 Context

Wholesale prices for gas and electricity rose from summer 2021 due to supply issues following the COVID pandemic. Tensions and the later war between Russia and Ukraine caused a rise in energy prices not seen since the energy crises of the 1970s.

The energy price cap for customers on the standard variable or default tariff ensured that customers paid a fair price based on the actual costs of energy companies. This rose from £1,277 in October 2021 for the average annual dual fuel domestic energy bill to £1,971 in April 2022. The energy price cap was due to rise to £3,549 in October 2022 and later to £4,279 in January 2023. However, due to concerns about such large price rises being unaffordable for many households, the UK Government introduced the Energy Price Guarantee for domestic customers. This was set at £2,500 from 1 October 2022 and rose to £3,000 from 1 July 2023[1].

With average domestic energy bills approximately doubling in a year, many more households were suffering from fuel poverty and having to choose between heating and eating. There were frequent articles in the media with energy saving tips and there was a much greater focus on the running costs of electrical appliances and more efficient ways of cooking. Many manufacturers highlighted savings could be made using their technology. Comparing the performance of technologies is not always straightforward and advice provided on savings or running costs can be simplistic. This was often based on the rated power for the appliance and in some cases the consumption of the device can vary while being used.

During the energy crisis, NEA produced an advice leaflet indicating approximate running costs for a range of different electrical appliances based on the Energy Price Cap/Guarantee at the time. This project aims to obtain more accurate data based on a combination of investigating published information from manufacturers and testing of appliances directly using electricity monitors. It investigates not only the consumption but also the patterns of consumption of appliances. It also discusses factors which will affect the level of consumption of appliances. In addition to this report, an updated advice leaflet has been published and a spreadsheet with consumption data for different appliances which were currently on the market.

1.2 Household Electricity Survey

The Household Electricity Survey (HES) was a project with UK Government funding which monitored the electricity consumption of 251 owner-occupier households in England. Out of these, 26 households were monitored over a year while the other households were each monitored for a month during the period of the study from May 2010 to July 2011[2].

The report provided data on the variation in consumption profiles by property type, household

[1] Bolton (2024), Gas and electricity prices during the 'energy crisis' and beyond, Research Briefing, House of Commons Library, https://researchbriefings.files.parliament.uk/documents/CBP-9714/CBP-9714.pdf (Accessed 22 May 2024)
[2] Household Electricity Survey – A study of domestic electrical product usage, Intertek Report R66141, https://www.gov.uk/government/publications/household-electricity-survey--2 (Accessed 23 May 24)

makeup and appliance type. For example, figure 1.1 shows the average hourly consumption across all the households in the study without electric heating and how this was made up by different appliance types. Table 1.2 shows the relative contribution of different appliance types to the overall electricity consumption for all the households in the project.

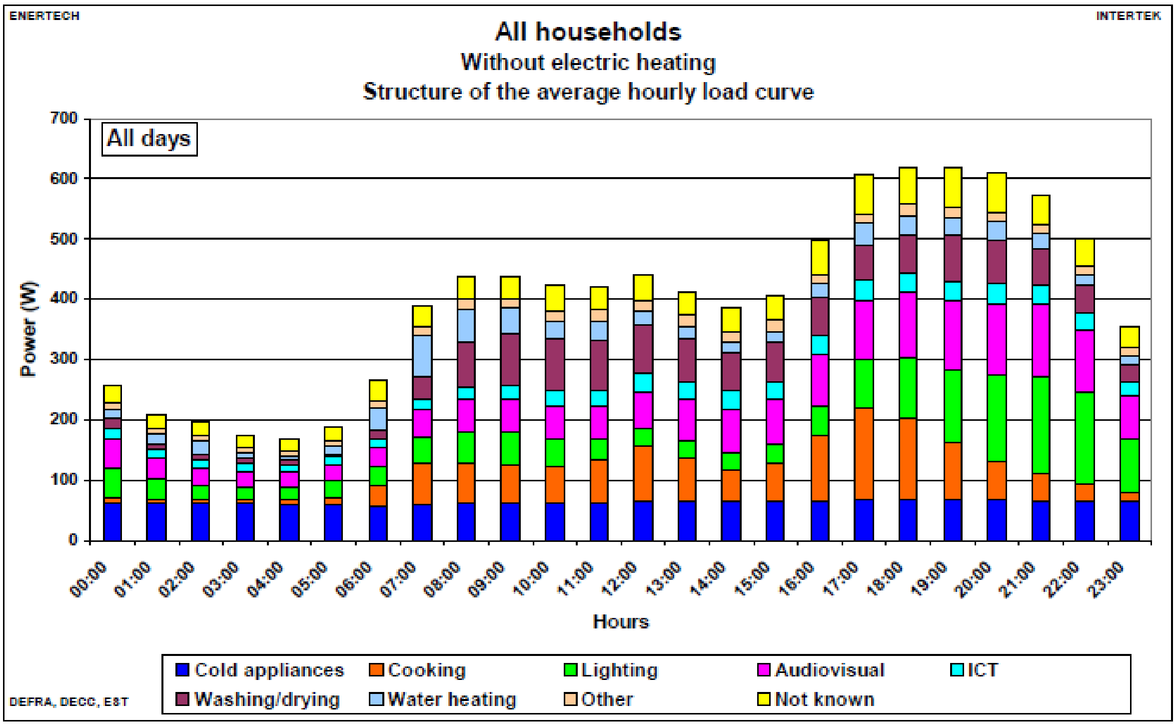


Figure 1.1 Average hourly load and the appliances which contribute towards it from HES [2]

	All households								
	Without electric heating			With additional electric heating			With primary electric heating		
	All days	Holidays	Workdays	All days	Holidays	Workdays	All days	Holidays	Workdays
Cold appliances	16.2%	15.9%	16.3%	13.4%	12.8%	13.6%	4.7%	5.0%	4.6%
Cooking	13.8%	14.1%	13.6%	11.7%	11.9%	11.5%	7.2%	8.3%	6.8%
Lighting	15.4%	14.3%	15.8%	10.0%	9.0%	10.3%	5.8%	6.4%	5.5%
Audiovisual	14.4%	14.5%	14.4%	10.4%	10.6%	10.2%	3.4%	3.2%	3.5%
ICT	6.1%	5.9%	6.1%	3.6%	3.5%	3.7%	2.6%	1.5%	3.0%
Washing/Drying	13.6%	14.7%	13.2%	10.7%	12.1%	10.0%	3.1%	3.1%	3.1%
Heating				22.5%	20.8%	23.0%	64.2%	59.1%	65.8%
Water heating	7.1%	7.0%	7.2%	4.0%	4.5%	3.8%	6.3%	7.6%	5.8%
Other	3.7%	3.6%	3.7%	5.8%	7.3%	5.1%	1.5%	1.0%	1.7%
Not known	9.7%	10.0%	9.8%	7.9%	7.4%	8.7%	1.2%	4.8%	0.2%

Table 1.2 Relative contribution from different loads for households [2]

The study also assessed the consumption in more detail for the different appliance types including cold appliances, washing machines, dishwashers and cookers. This included the range in annualised consumption by household type and the daily average load curve.

It was noted that electricity consumption for cold appliances was seasonal, consuming more in the summer when external temperatures were warmer than the winter. The average annual consumption for all households was 162 kWh for a refrigerator, 427 kWh for all households with a fridge-freezer, 327 kWh those with an upright freezer and 362 kWh for those with a chest freezer. Figure 1.3 shows the average hourly load curve for fridge freezers in the study, with fairly consistent consumption through the day and a peak in the early evening at times when the fridge might have been opened after preparing an evening meal.

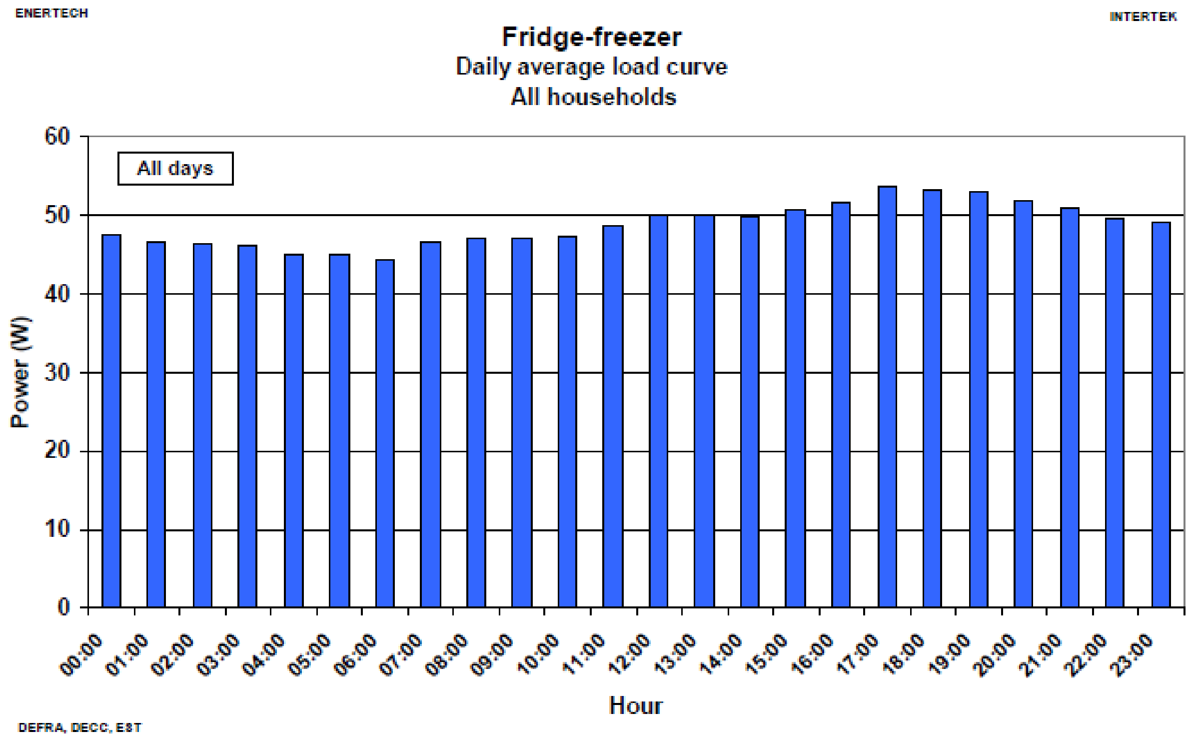


Figure 1.3 Daily average load curve for all households with a fridge freezer on the HES [2]

The average annual consumption for washing machines was 166 kWh. The average number of cycles per year was 284 and ranged from an average of 237 for single pensioner households to 317 for multiple person households with no dependent children. The average number of washing cycles per person was 174 per year. Data on the consumption per cycle indicated that 90% of washing cycles used less than 1 kWh and 50% used less than 0.5 kWh.

For dishwashers, the average annual consumption among all households with the appliance was 294 kWh. Analysis of the consumption per cycle showed that the electricity consumption was less than 1.5 kWh for 80% of cycles and under 1 kWh for 30% of cycles. On average there were 254 cycles per year and 132 cycles per person per year.

Cooking was again shown to vary seasonally, with higher consumption in the colder months. Figure 1.4 shows the average annual consumption of ovens without hobs among households on the Household Electricity Survey was 290 kWh/year. The ovens for some households used more than 700 kWh/year while others used less than 100 kWh/year. The time for peak electricity consumption by the ovens for all households was between 5pm and 7pm.

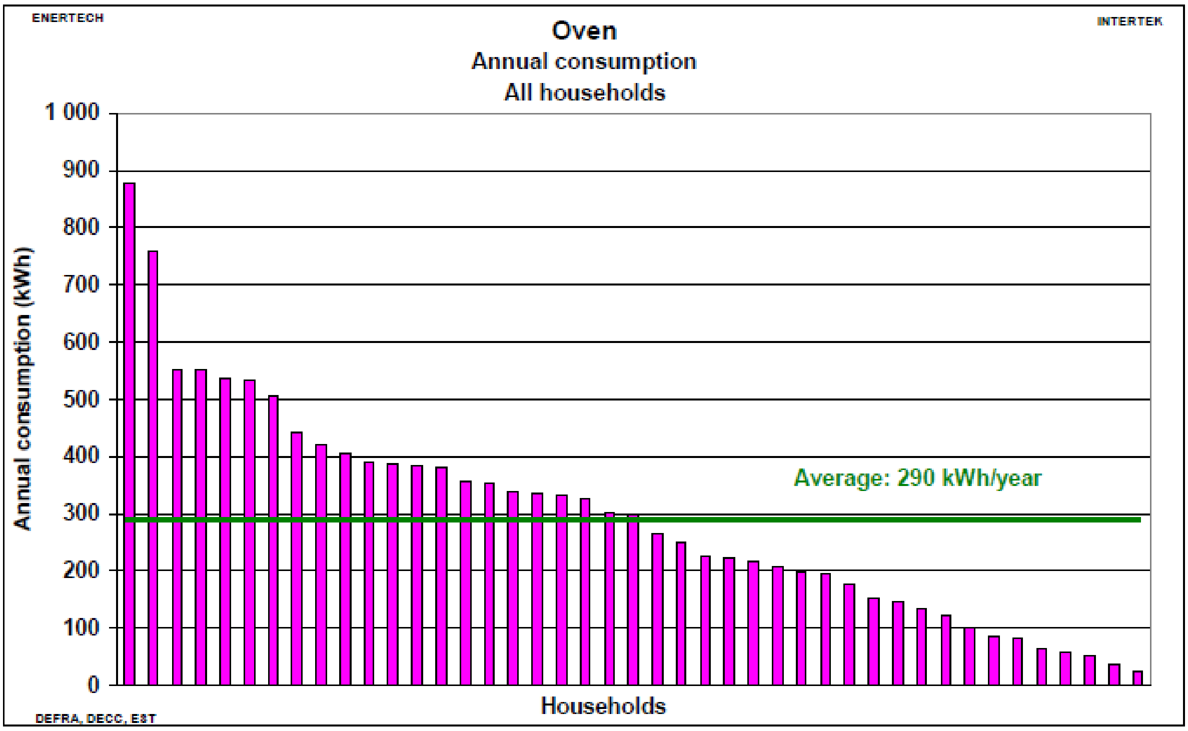


Figure 1.4 Annual consumption for ovens without an electric hob for households in the HES[3]

The study also noted that the average annual consumption for other cooking appliances. It was 226 kWh for hobs, 56 kWh for microwaves and 167 kWh for kettles. The annual consumption noted for less common items were 23.6 kWh for bread makers, 31.8 kWh for coffee machines, 52.7 kWh for food steamers, 12.8 kWh for grills and 21.9 kWh for toasters.

Subsequent reports further analysed data and surveys from the Household Electricity Survey. These included Powering the Nation 2[4] and Electrical appliances at home: tuning in to energy saving[5].

Powering the Nation 2 noted the average size of fridges and freezers had been increasing between 1985 and 2011. This has also continued over the last decade and the increase in size as noted has been undermining efficiency gains through improved design and materials. For the majority of households in the HES, their cold appliances used 300 to 840 kWh per year. However, for 19 of the households, the cold appliances could use more than double the average consumption. This was likely to be due to malfunctioning appliances which had

[3] Household Electricity Survey – A study of domestic electrical product usage, Intertek Report R66141, https://www.gov.uk/government/publications/household-electricity-survey--2 (Accessed 23 May 24)

[4]Palmer and Terry (2014), Powering the Nation 2: Electricity use in homes, and how to reduce it, https://www.gov.uk/government/publications/powering-the-nation-2 (Accessed 23 May 23)

[5] Palmer et al (2013), Electrical appliances at home: tuning in to energy saving, https://assets.publishing.service.gov.uk/media/5a7c2e05ed915d7d70d1d17a/electricity_survey_2_tuning_in_to_energy_saving.pdf (Accessed 23 May 24)

atypical consumption profiles. Normally the compressor pump for the cold appliances runs intermittently in cycles. For some of the malfunctioning devices there was continuous consumption rather than cycles of consumption. This was more common in older cold appliances it was suggested the issues might have been caused by poor door seals or faulty thermostats.

1.3 Energy labels for appliances

Energy labels are a simple method that consumers can use to judge between the energy efficiency of different appliances. They were introduced in the late 1990s across the European Union with a letter rating between A and G and further information to indicate the level of consumption[6]. As appliances became more energy efficient additional A+, A++ and A+++ ratings were added and, in some cases, the lower ratings E-G were no longer needed.

More recently, the energy labels have been revised to be easier to understand, returning to the A to G-rating and dropping the use of multiple '+' signs in most appliance categories.[7] The new labels were introduced from March 2021 (October 2021 for lighting). The new labels were available for cold appliances, washing machines and washer-dryers, dishwashers, TVs and light sources. The new labels were designed to allow improvements in energy efficiency of products. Appliances classified with the previous version of the energy label would generally now have a lower rating.

In addition to the energy efficiency scale (A-G), the energy label for refrigerators and freezers provides information on the likely annual energy consumption per year in kWh. The consumption for appliances such as washing machines, washer dryers and dishwashers is shown as kWh per 100 cycles. An annual consumption value would depend on level of actual use in the home.

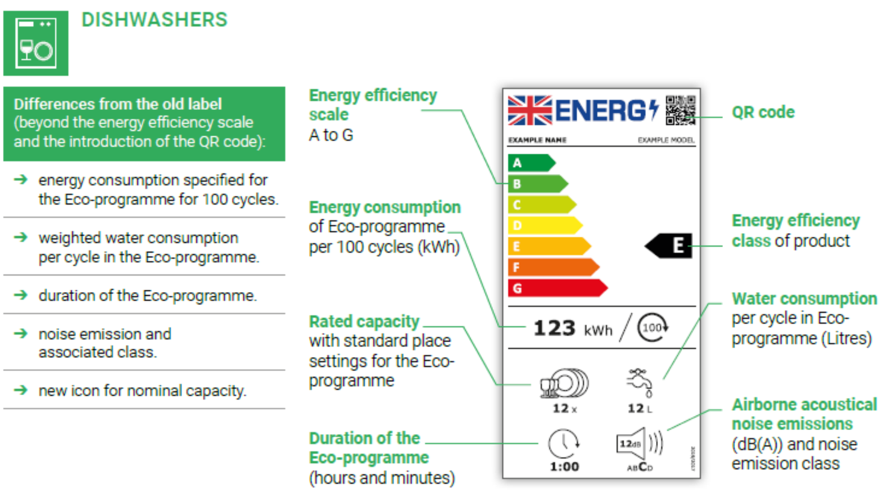


Figure 1.5 Example information on the Energy Label for Dishwashers [6 7]

[6] In focus: A new generation of EU energy labels, https://commission.europa.eu/news/focus-new-generation-eu-energy-labels-2020-08-13_en (Accessed 24 May 24)
[7] The New Energy Label – Guidelines for Public and Private Buyers, EST, https://www.energylabel.org.uk/fileadmin/uk/EST_LABEL2020_Green_Procurement_guidelines_WEB.pdf (Accessed 24 May 24)

Energy Class	Refrigerator	Dishwasher	Washing Machine	Washer Dryer
	(kWh/year)	(kWh/cycle)	(kWh/cycle)	(kWh/cycle)
A	91	0.50	0.5	2.33
B	116	0.60	0.59	2.86
C	144	0.71	0.68	3.44
D	180	0.81	0.78	4.16
E	225	0.91	0.9	5.02
F	281	1.02	1.01	6.05
G	344	1.12	1.13	7.16

Table 1.6 Examples of energy consumption for appliances in different energy classes [7]

Table 1.6 shows examples of the energy consumption for appliances in different energy classes. [7] The boundaries for the energy class are dependent on details of the appliance. So, for example the boundary between A and B would be different for an 8kg capacity washing machine than for one with a 12kg capacity.
In table 1.6, the figures were based on a 230-litre fridge and 100 litre freezer, while those for the dishwasher were for a model with 15 place settings. The values for the washing machine were for one with a 12kg capacity and the washer dryer was for one with a capacity of 12kg for washing and 8kg for drying [7].

While the energy labels for refrigerators, dishwashers and washing machines were updated from March 2021, those for tumble dryers were left unchanged while a review took place. From 1 July 2025, the energy labels for tumble dryers will be rescaled from A+++ to D to have ratings between A and G. Initially there will be no A-rated appliances to allow improvements in energy efficiency. Within the European Union, it will only be possible to sell the most efficient tumble dryers which use heat pump technology from 1 July 2025 [8]. It is likely that vented, and condenser tumble dryers will be phased out from sale in the UK as well.

[8] Tumble dryers: Energy labelling and ecodesign requirements apply to this product, Energy Efficient Production, European Commission, (2024), https://energy-efficient-products.ec.europa.eu/ecodesign-and-energy-label/product-list/tumble-dryers_en (Accessed 15 Jul 2024)

1.4 Rating label

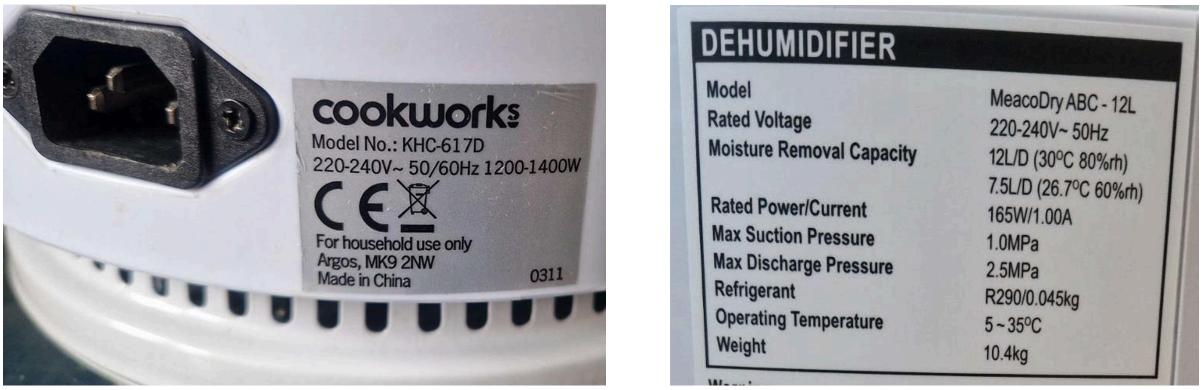


Figure 1.7 Manufacturer's labels showing the rated power of appliances

Appliances normally have a label providing details of the appliance model number and also provides the rated power of the appliance.

The rated power is often used to estimate the electricity consumption of the appliance. So, for example an appliance which uses 165W for 1 hour could be estimated to use 0.165kWh.

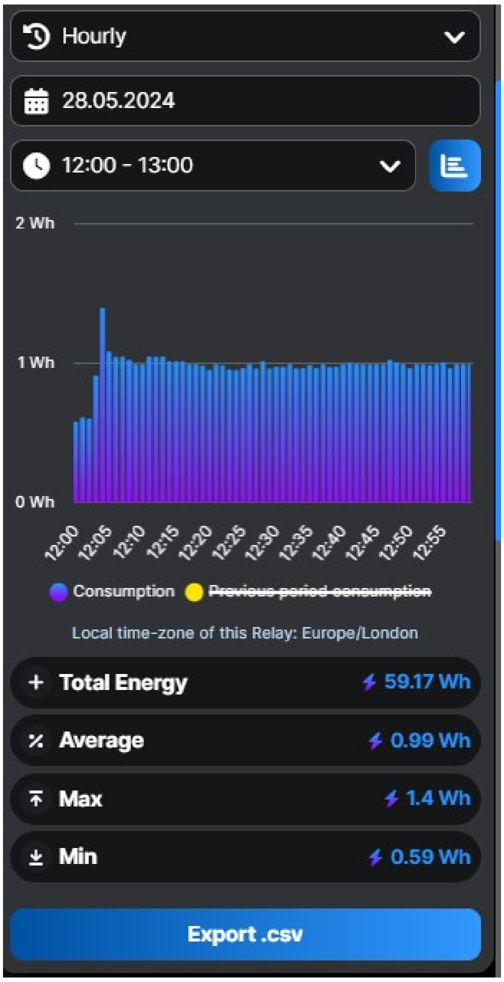
While this might be a reasonable estimate for an appliance with constant electricity consumption this would provide a poor estimate for an appliance which has varying consumption. An example is a washing machine which may have a rated power of 2000W but will only consume this amount during the period of the washing cycle while heating water. The rated power is therefore the maximum power for the device.

1.5 Methods of monitoring

For appliances where the electricity consumption varies over time, the power rating on the manufacturer's label would over estimate the running costs for the device. Energy labels provide consumption often under specified conditions. Older appliances may or may not perform as well as modern appliances. This project aimed to measure the real life consumption of a range of different home appliances.

The electricity consumption of of home appliances was measured using a variety of methods. The main device used was a Shelly Plus smart Wi-Fi and Bluetooth plug. These were used by NEA staff along with other volunteers.

Figure 1.8 Shelly Plus smart plug



The Shelly smart plugs could be monitored and controlled using the Shelly Smart Control app. It was also possible to monitor the smart plugs using the Shelly Cloud monitoring portal[9].

At the time of writing, there was a free Shelly account which provided consumption data with a minimum resolution of 1 hour. For this project, we used a Shelly Premium account[10] which had the advantage of a finer minimum resolution of 1 minute. This was particularly useful to record the consumption patterns for appliances with variable rates of electricity consumption.

The web portal and app will show the instantaneous power consumption in watts for a plug at any time. It is also possible to plot historic graphs such as in figure 1.9 which shows an hourly plot from 12.00-13.00 on 28 May 24. It also shows that the total consumption was 59.17 Wh over the hour or an average of 0.99 Wh per minute. The maximum consumption was 1.4 Wh in a minute and the minumum was 0.59 Wh in a minute. Consumption data with 1 minute intervals could be exported in the form of a CSV file.

Figure 1.9 Hourly plot from the Shelly Cloud portal

The electricity consumption of some appliances varied or modulated at a much greater rate than 1 minute. For these devices it aided understanding of the consumption to be able to monitor at 1 second resolution.

In order to do this, a special monitoring cable was assembled. The live and neutral cables of a 13A lead were separated within a sealed plastic box and a 200A Chauvin Arnoux current clamp was safely fitted around the live cable.

The current clamp was connected to a Tinytag View 2 datalogger. The monitoring interval was set to a 1 second logging interval using the Tinytag Explorer software. The Tinytag View 2 had a recording capacity of 8 hours 37 minutes for this recording interval.

Figure 1.10 Monitoring lead for Tiny Tag View 2 data logger

[9] Shelly Cloud monitoring portal https://control.shelly.cloud/#/login (Accessed 28 May 24)
[10] Shelly Premium account https://www.shelly.com/en-gb/app/shelly-app-premium (Accessed 28 May 24)

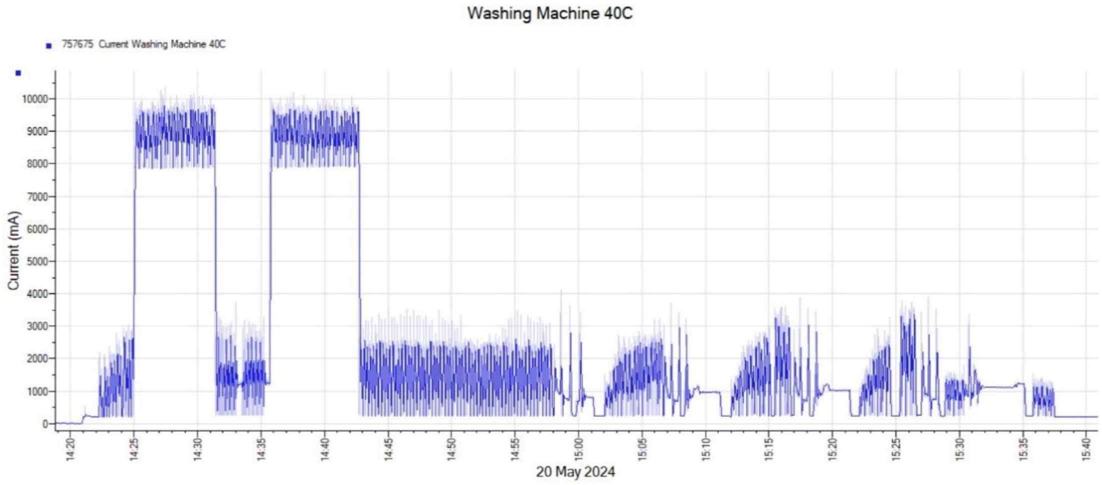


Figure 1.11 Electricity consumption of a Hotpoint WMTL80 washing machine with a 40°C wash cycle

Figure 1.11 shows a plot of electricity consumption against time from the Tinytag Explorer software for a washing machine on a 40°C washing cycle.

For some appliances it was not possible to monitor the consumption with a smart plug. Examples include built-in kitchen appliances. In this case, smart meter electricity readings were taken at the start and end of the appliance cycle. During the test as many other appliances as possible were turned off, although this was not possible with built-in fridges and freezers. The in-home display recorded to 3 decimal places but for some models this reading was updated each minute.

Figure 1.12 Example smart meter in-home display

2. Appliance consumption and testing

2.1 Washing machines

The main factor which affects the electricity consumption of washing machines is the washing temperature. Modern washing machines are cold water fed and this water needs to be heated by the washing machine to the desired temperature for the wash. It takes 420 kJ[11] or 0.117kWh to raise the temperature of 10 litres of water by 10°C.

The cold-water feed temperature is usually at around 15°C but this varies by season and

[11] Energy consumption Q = mass x specific heat capacity x temperature change; the specific heat capacity for water is about 4.2 kJ kg^{-1} K^{-1} and 1 litre of water has a mass of about 1kg

across the country[12]. It can fall below 10°C in winter and approach 20°C in summer. Little heating is required for a wash temperate of 20°C, but the water temperature needs to rise about 45°C for a wash temperature of 60°C.

A report from GINETEX noted that reducing the washing temperature from 40°C to 30°C could save about 30% in electricity consumption while increasing the wash temperature to 60°C could increase the consumption by 50%.[13].

Domestic washing machines currently on the market usually have a washing load capacity of between 7kg and 12kg. Those with a larger capacity will use more water and often more electricity in a washing cycle. For households washing significant quantities of laundry who would rarely have partial loads, a large capacity washing machine is beneficial. However, for those frequently washing smaller loads, a smaller capacity washing machine is likely to save on both electricity and water costs.

Modern washing machines usually have spin speeds up to 1400 rpm. Using a spin speed of 1400 rpm with fabrics such as cotton lowers the residual moisture in the washing and is therefore beneficial, reducing the time (and potentially energy) for drying the clothes. However, higher spin speeds use more electricity. For synthetic clothing, lower wash temperatures are typically used as well as lower spin speeds such as 600 or 800 rpm. Both lowering wash temperature and spin speed will reduce electricity consumption of the washing machine.

All modern washing machines have a default programme called Eco 40-60. This became a standard requirement for washing machines sold after 1 March 2021 under the Ecodesign requirements for washing machines. Eco 40-60 is an energy efficient programme designed to clean cotton laundry washable at 40°C or 60°C[14] and has a laundry temperature under 40°C. The Eco 40-60 cycle is designed for lower electricity and water consumption and achieves good cleaning performance by washing for longer periods (up to 4 hours) at lower temperatures. Washing machines must now also have a 20°C washing cycle.

[12] Measurement of Domestic Hot Water Consumption in Dwellings, Energy Saving Trust (2008), https://assets.publishing.service.gov.uk/media/5a75a29ced915d6faf2b4829/3147-measure-domestic-hot-water-consump.pdf (Accessed 30 May 24)
[13] Laundry: How washing machine programs affect electricity consumption, GINETEX (2022), https://www.wko.at/oe/gewerbe-handwerk/mode-bekleidung/textilreiniger/washing-electricity-consumption-study.pdf (Accessed 30 May 24)
[14] The Ecodesign for Energy-Related Products and Energy Information Energy Information Regulations 2021 https://www.legislation.gov.uk/ukdsi/2021/9780348222920/schedule/9 (Accessed 28 May 24)

Washing Machine	Beko B5W5841AW	Beko B3W5941IW	Beko WTK94121W	Bosch WGG254F0GB
	8kg wash	9kg wash	9kg wash	10kg wash
Energy rating	A	A	C	A
Cycle				
Energy label (kWh)	0.423	0.49	0.57	0.511
Eco40-60 full load wash (kWh)	0.695	0.77	0.867	0.99
Eco40-60 half load wash (kWh)	0.356	0.51	0.58	0.46
Eco40-60 quarter load wash (kWh)	0.181	0.24	0.3	0.22
Cotton 60°C full load wash (kWh)	1.8	2	1.9	1.9
Cotton 40°C full load wash (kWh)	0.97	1.1	1.1	1.3
Cotton 20°C full load wash (kWh)	0.6	0.75	0.55	0.41
Synthetics 60°C (kWh)	1.35	1.6	1.4	
Synthetics 40°C (kWh)	0.85	1.1	0.95	0.9

Table 2.1 Examples of electricity consumption for different models of washing machines based on data from the manufacturer's manual[15] [16] [17] [18]

Table 2.1 shows energy consumption per cycle for 4 modern washing machines with between 8kg and 10kg load capacities. Consumption data was derived from their manuals. The values for the Eco 40-60 programme were measured using the methodology required by the EU Ecodesign Directive, starting with cold water at 15°C. The consumption shown on the energy label is based on a weighted energy consumption over 100 cycles of full and partial loads for the Eco 40-60 programme. Consumption from other common cycles is also shown which the manufacturers note is indicative.

It is apparent from table 2.1 that a Cotton wash at 60°C can use 2 to 4 times more electricity than a Cotton wash at 20°C for the washing machines shown. Appliances with a better energy rating have lower consumption and those with a lower load capacity often have a lower electricity consumption per cycle. 2 half load washes normally use more electricity than a single full load wash on the Eco 40-60 cycle.

The Eco 40-60 cycle with a full load uses between 21 and 30% less electricity than for a Cotton 40°C cycle for the washing machines in table 2.1. For the Beko B3W5941IW, the laundry temperature for Eco 40-60 under full load is 33°C with a cycle time of 3 hours 48 minutes. Under quarter load, the laundry temperature is 22°C with the cycle time reduced to 2 hours 53 minutes[16]. For the Bosch WGG254F0GB, the maximum temperature over 5 minutes for Eco 40-60 at full load was 35°C with a cycle time of 3 hours 50 minutes. Again, the temperature and time were lower for an Eco 40-60 with a quarter load with a maximum temperature of 23°C and a programme duration of 2 hours 30 minutes[18].

[15] Beko B5W5841AW washing machine manual, https://bekoplc.blob.core.windows.net/bekoupload/manuals/B5W5841A.pdf (Accessed 28 May 24)

[16] Beko B3W5941IW washing machine manual, https://bekoplc.blob.core.windows.net/bekoupload/manuals/B3W5941IW.pdf (Accessed 28 May 24)

[17] Beko WTK94121 washing machine manual, https://bekoplc.blob.core.windows.net/bekoupload/manuals/WTK94121.pdf (Accessed 28 May 24)

[18] Bosch WGG254F0GB washing machine manual, https://media3.bosch-home.com/Documents/9001842409_A.pdf (Accessed 28 May 24)

We further investigated the electricity consumption of washing machines by measuring the electricity consumption of models of different ages using smart plugs. The models tested in more depth were as follows:

- Hotpoint WMTL80 washing machine
  - Top-loading, 5kg load capacity, nominal power 2100W
  - Spin speed up to 1000 rpm
  - Manufacture date ca 2000
  - Potential for hot feed, but not used during testing
- LG F1496TDA washing machine
  - Front loading, 8kg load capacity, nominal power 2100W
  - Spin speed up to 1400 rpm
  - A+++ energy efficiency class (with old Energy Label)
  - Annual energy consumption: 175 kWh/year, water consumption: 11,000L/year
  - Manufacture date ca 2016
- Bosch W04409GB
  - Front loading, 9kg load capacity, nominal power 2300W
  - Spin speed up to 1400 rpm
  - A-rated energy efficiency class (with new Energy Label)
  - Energy consumption: 0.46kWh/cycle, water consumption: 48L/cycle
  - Manufacture date ca 2024

All the washing machines heated water at the start of the washing cycle using more than 2kW. This was followed by cycles of turning the drum while washing and spinning to remove the water. For households with solar PV who want to use the washing machine and minimise their electricity costs, it is best to wash clothes on a sunny day when there is more solar generation. This also allows the washing to be dried outside on a line. The ideal time to wash the clothes is later in the morning when there is greater solar PV generation which might exceed consumption when the washing machine is heating water. A smart meter in-home display can often be used to show the amount of solar generation that is being exported to the grid. If this exceeds 2kW, then it is a good time to wash clothes[19].

[19] Solar PV advice (NEA, 2022), https://www.nea.org.uk/who-we-are/innovation-technical-evaluation/solarpv/ (Accessed 30 May 24)

Hotpoint WMTL80 top loading washing machine


Figure 2.2 Hotpoint WMTL80 top loading washing machine

A Hotpoint top-loading washing machine was tested with washing cycles with temperatures between no heat and 60°C. The appliance was more than 20 years old. It was narrower than a standard washing machine and had a maximum load of 5kg, which was less than low load appliances currently on the market. A Shelly Plus smart plug was used to measure electricity consumption and collected average consumption data (Wh) at 1-minute intervals produced. The consumption was also monitored using a Tinytag View 2 data logger with 1 second intervals to show changes in consumption on a smaller time scale.

Table 2.3 shows the average electricity consumption for the Hotpoint WMTL80 washing machine with different washing temperatures. Several tests were carried at 30°C and 40°C and the values shown are the average of these. The consumption on the cycle with no water heating was only 0.11kWh. Here the consumption was due to rotating the drum during the washing cycle and spinning at up to 1000 rpm to lower the level of residual moisture.

Cycle	Temperature	Cycle time	Average consumption
No heating	About 15°C	1h 5m	0.110 kWh
Cotton	30°C	1h 5m – 1h 15m	0.492 kWh
Cotton	40°C	1h 5m – 1h 25m	0.684 kWh
Cotton	60°C	1h 35m	1.023 kWh

Table 2.3 Average electricity consumption of Hotpoint WMTL80 with different washing temperatures

As noted by the GINETEX report, the electricity consumption was about 50% higher when washing at 60°C compared to 40°C. There was also a 28% reduction in consumption at 30°C compared to 40°C. The GINETEX report suggested about a 30% reduction.

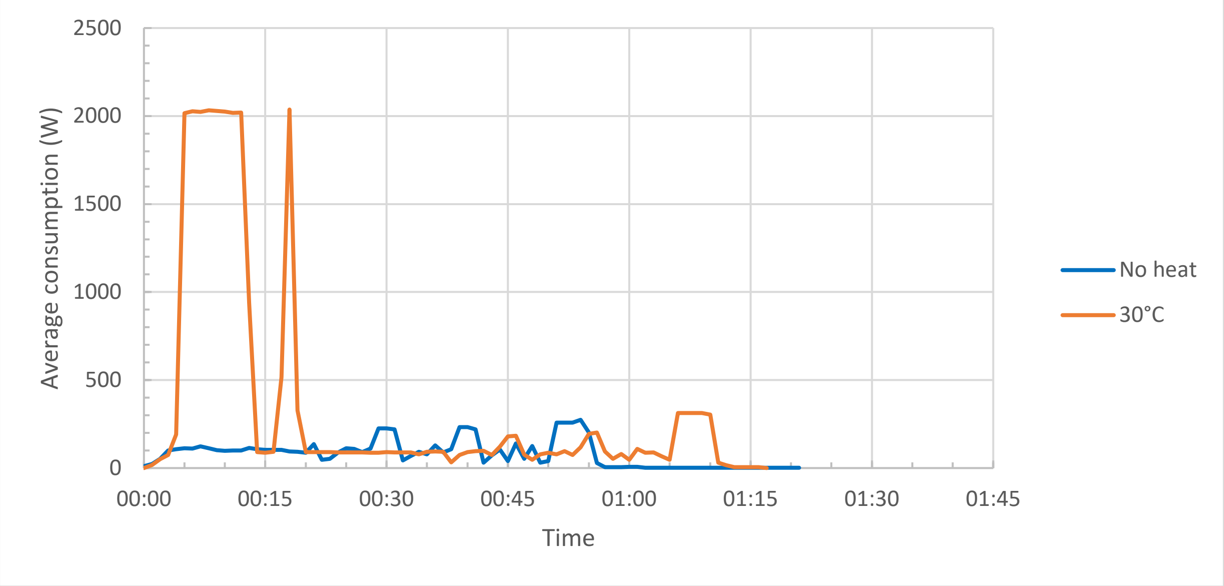


Figure 2.4 Plot of average consumption per minute for Hotpoint WMTL80 with no heat and at 30°C

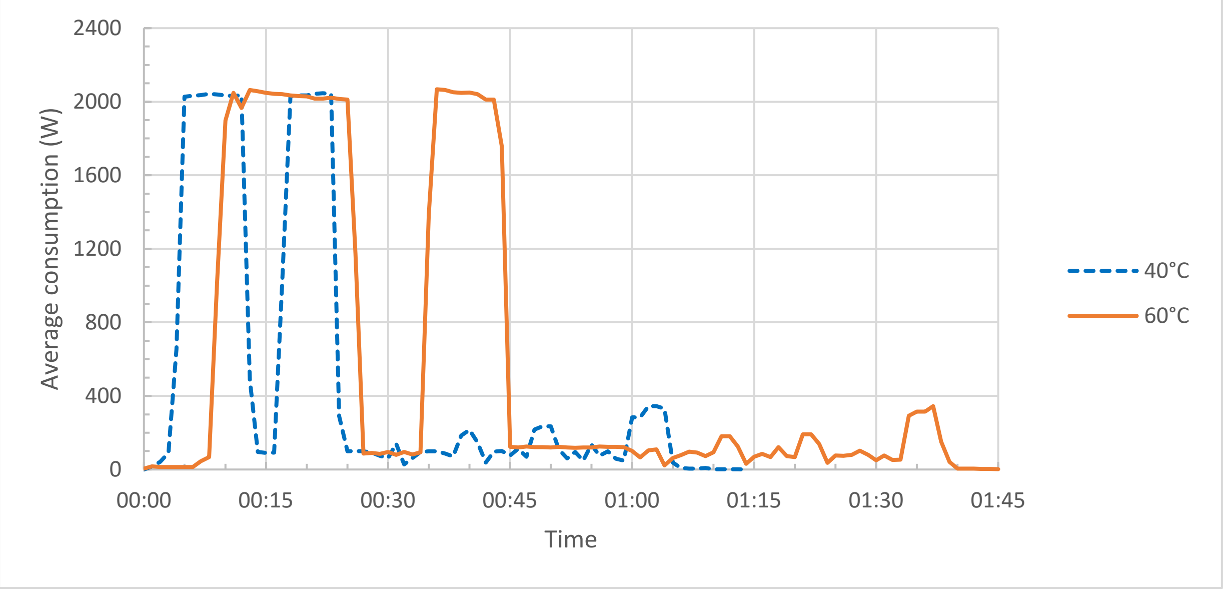


Figure 2.5 Plot of average consumption per minute for Hotpoint WMTL80 with cycles at 40°C & 60°C

Figures 2.4 and 2.5 are graphs showing the average electricity consumption per minute for the Hotpoint WMTL80 washing machine measured using a Shelly Plus smart plug. There was no water heating consumption peak of over 2000W for the washing cycle with no heating as the washing machine heating element did not need to operate. There were however 3 smaller consumption peaks due to the spin cycle of the washing machine, with average consumption reaching 274W on the final spin cycle.

For the 30°C wash, there was an initial heating cycle for 8.5 minutes at about 2030W, followed a few minutes later by a further heating cycle for 1.5 minutes. At the end of the washing cycle there was again an extended spin cycle at 1000 rpm where the average consumption recorded reached 313W.

The first heating cycle for the 40°C wash was again 8.5 minutes but this time the second heating cycle to enable the water temperature to reach 40°C was 6.5 minutes instead of 1.5 at 30°C. Again, there were 3 smaller peaks later in the cycle due to the spin cycle with the last having the highest average consumption.

The 60°C cotton wash cycle was longer than the others at 1 hour 35 minutes. Again, there were 2 heating cycles, but both were longer than at 40°C. The first heating cycle lasted just over 17 minutes while the second was about 9.5 minutes.

The water heating consumption at 60°C can be estimated. Assuming a consumption of 2040W for 26.5 minutes gives a value of 0.90 kWh. Adding the consumption of the washing cycle with no heating of 0.11 kWh gives 1.01 kWh. This is slightly under the 1.023 kWh measured by the Shelly smart plug.

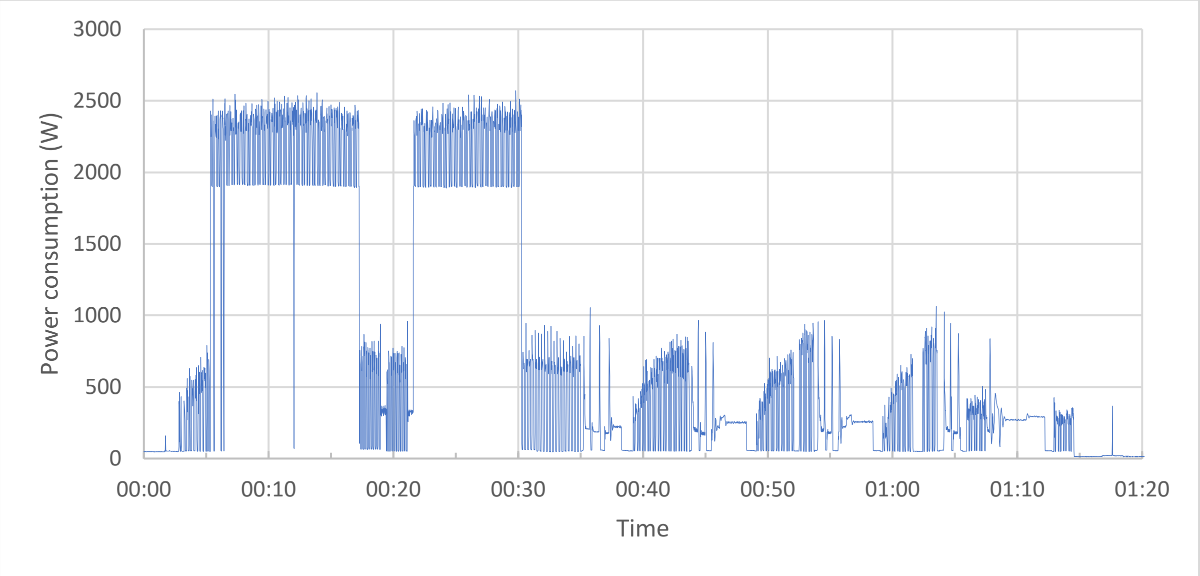


Figure 2.6 Plot of consumption for a Hotpoint WMTL80 washing machine recorded using a Tinytag View 2 data logger at 1 second intervals for a 40°C washing cycle

A plot of the electricity consumption at 1-second intervals for the washing cycle at 40°C is shown in figure 2.6.

The 1-second interval data is less smooth than for the 1-minute interval data with the smart plug. This is because the drum turns every few seconds to redistribute the laundry. Only during the spinning cycle is the consumption fairly consistent for a few minutes.

A full set of 1-second interval plots for the Hotpoint washing machine at different cycle temperatures is included in Appendix 1. These are Tinytag Explorer graphs which are a plot of current (mA) against time.

LG F1496TDA washing machine

The LG F1496TDA washing machine tested was a front-loading machine with a load capacity of 8kg. When released, it was A+++ rated under the previous energy label with an estimated annual consumption of 175kWh/year. It was about 8 years old.

Table 2.7 shows values of consumption and cycle time recorded using a Shelly smart plug for a range of different washing cycles and temperatures. The Eco 40-60 cycle was not available on this washing machine as it was manufactured before the cycle became mandatory. Instead, there was a standard Cotton cycle lasting over 4 hours or Cotton Eco with a shorter cycle time.

Cycle	Temperature	Spin speed	Cycle time	Average consumption
Delicate	Cold: about 15°C	800 rpm	1h	0.067 kWh
Sports Wear	20°C	800 rpm	45m	0.062 kWh
Quick 30	20°C	1400 rpm	40m	0.103 kWh
Cotton Eco	20°C	1400 rpm	2h 10m	0.203 kWh
Cotton Eco	40°C	1400 rpm	2h 20m	0.648 kWh
Cotton Eco	60°C	1400 rpm	2h 35m	1.268 kWh
Cotton	40°C	1400 rpm	4h 15m	1.177 kWh
Cotton	60°C	1400 rpm	4h 10m	1.631 kWh
Mixed	40°C	1400 rpm	1h 25m - 1h 35m	0.656 kWh

Table 2.7 Average electricity consumption of LG F1496TDA with different washing temperatures

Figure 2.8 shows a plot of average electricity consumption measured using the Shelly Plus smart plug for 3 washing cycles for the LG1496TDA washing machine with no heat or at 20°C.

The Delicate wash used just the cold-water feed and there was no water heating consumption peak between 5 and 10 minutes. There were small peaks of consumption of between 205 and 225W at 25 minutes, 42 minutes and 54 minutes which were likely to be due to spinning at 800 rpm.

The consumption recorded for the Delicate cold wash was 0.067 kWh, which was very similar to the 0.062 kWh consumption for the Sports Wear wash at 20°C. The Sports Wear wash cycle was shorter that for the Delicate wash and there was about 1 minute of water heating to bring the water temperature up to 20°C. Later in the wash cycle there were smaller peaks in consumption due to spin cycles at 800 rpm.

The Quick 30 cycle in fact appeared to last about 40 minutes. There was again water heating for about 1-minute, bringing the temperature up to 20°C. In this case the Shelly plug recorded an average of 2,098W over the minute rather than 1,132W for the Sports Wear wash. This may be due to heating for the Sports Wear wash lasting less than a minute. The Quick 30 wash at 20°C had a consumption of 0.103 kWh. A major cause of the higher consumption than the Sports Wear wash was the 1400 rpm final spin cycle which lasted longer and had a greater peak rate of consumption of 386W.

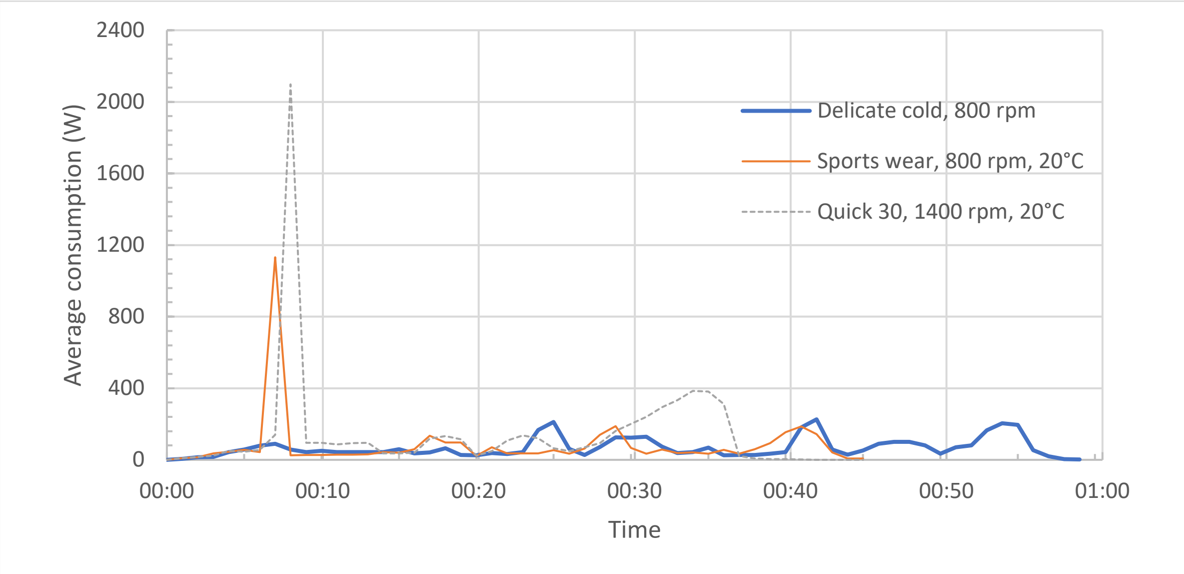


Figure 2.8 Plot of average consumption per minute measured with the Shelly Plus smart plug for the LG1496TDA washing machine on wash cycles with no heat and at 20°C

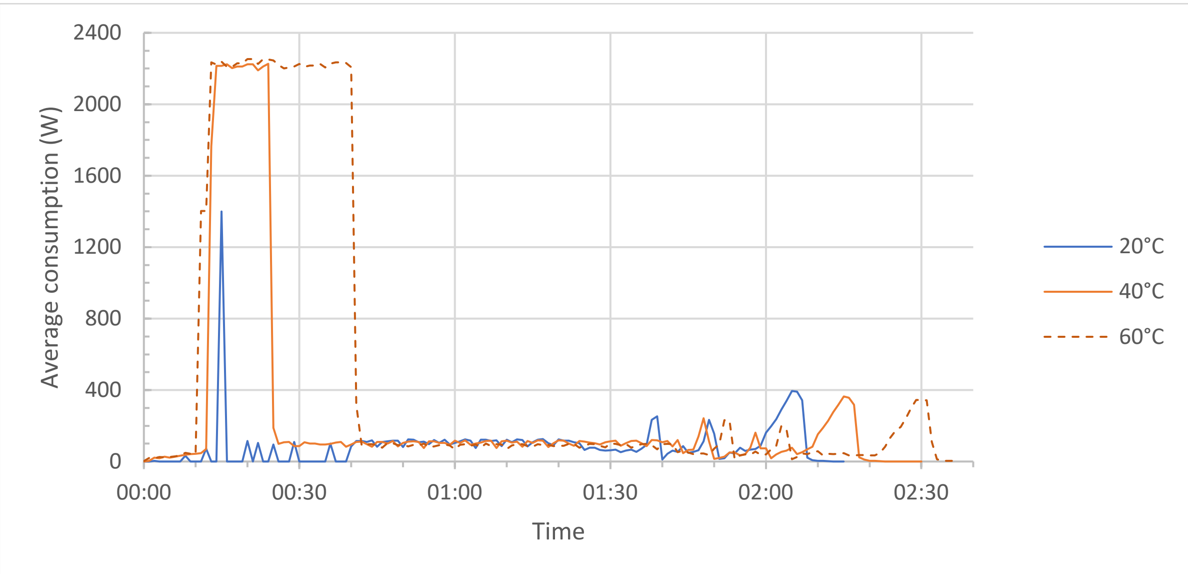


Figure 2.9 Plot of average consumption per minute measured with the Shelly Plus smart plug for the LG1496TDA washing machine with the Cotton Eco cycle at different temperatures

Figure 2.9 shows the electricity consumption of the LG1496TDA washing machine on the Cotton Eco cycle at 20, 40 and 60°C. For the 20°C Cotton Eco cycle, there was again 1 minute or less of water heating. The wash cycle length was 2 hours 10 minutes, and the consumption was 0.203 kWh. This was about double the consumption for the Quick 30 wash at 20°C which only lasted 40 minutes.

As the temperature increased for the Cotton Eco cycle, the cycle length also increased, with it lasting 2 hours 20 minutes for the 40°C wash and 2 hours 35 minutes for the 60°C. There was also a shift in the peak for the final 1400 rpm spin to later times for washes at higher temperature. The water was heated for 12 minutes to reach 40°C and 30 minutes to reach 60°C. The increased water heating also increased electricity consumption with consumption for the Cotton Eco cycle 0.648 kWh at 40°C and 1.268 kWh at 60°C.

A plot of the electricity consumption for the LG1496TDA washing machine on the Cotton washing cycle at 40°C and 60°C is shown in figure 2.10. The wash cycle length was longer for the Cotton cycle at 4 hours 15 minutes at 40°C and 4 hours 10 minutes at 60°C. The initial water heating cycle was longer than for the Cotton Eco wash cycle with water heating occurring for about 19 minutes at 40°C and 32 minutes at 60°C. There were further consumption peaks of about 800W recorded by the Shelly plug at between 2 hours 25 minutes and 35 minutes and between 3 hours 5 minutes and 12 minutes. These may have been due to short pulses of further water heating. Near the end of the wash cycle, the 1400 rpm spin cycle lasted about 12 minutes and had a peak of consumption of 400 – 450W.

The Cotton wash cycle used more electricity than the Cotton Eco cycle with the wash at 40°C using 1.177kWh compared to 0.648kWh for the Eco cycle. The Cotton cycle at 60°C used 1.631kWh compared to 1.268kWh for the Cotton Eco cycle. Reasons for this higher consumption include longer periods of water heating for the Cotton cycle and an extended cycle length with consistent low consumption.

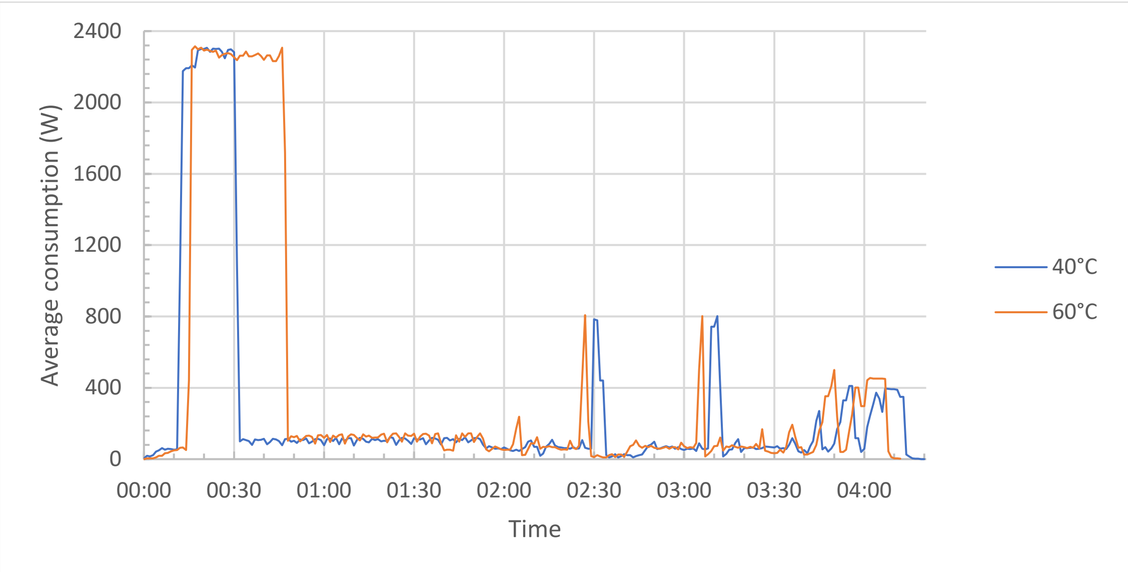


Figure 2.10 Plot of average consumption per minute measured with the Shelly Plus smart plug for the LG1496TDA washing machine with the Cotton cycle at 40°C and 60°C

Bosch WGG04409GB washing machine

The Bosch WGG04409GB washing machine tested had a 9kg load capacity and was purchased in 2024. It was A-rated under the most recent Energy Label and the consumption indicated on the Energy Label was 0.46kWh/wash cycle.

Programme	Load (kg)	Programme duration (h:min)[1]	Energy consumption (kWh/ cycle)[1]	Water consumption (l/ cycle)[1]	Maximum temperature (°C) 5 mins[1]	Spin speed (rpm)[1]	Residual moisture (%)[1]
Eco 40-60[2]	9.0	3:48	0.870	75.0	38	1351	50.00
Eco 40-60[2]	4.5	2:54	0.370	40.0	27	1351	49.00
Eco 40-60[2]	2.5	2:22	0.180	30.0	23	1351	52.00
Cottons 20 °C	9.0	3:44	0.400	98.0	23	1400	50.00
Cottons 40 °C	9.0	3:44	1.290	98.0	44	1400	50.00
Cottons 60 °C	9.0	3:44	1.750	98.0	60	1400	50.00
Prewash 40 °C	9.0	4:14	1.330	110.0	44	1400	50.00
Easy Care 40 °C	4.0	2:37	0.800	61.0	44	1200	30.00
Mixed Load 40 °C	4.0	1:05	0.640	44.0	42	1400	53.00
Wool 30 °C	2.0	0:41	0.300	48.0	29	800	26.00

[1] Due to the influence of water pressure, hardness and inlet temperature, ambient temperature, type, amount and soiling of laundry, detergent used, fluctuations in the power supply and the selected additional functions, the actual values may deviate from the stated values.
[2] Test programme in accordance with the EU Ecodesign Directive and the EU Energy Labelling Regulation with cold water (15 °C).

Table 2.11 Consumption values from the Bosch WGG04409GB washing machine manual[20]

Data on the electricity and water consumption of the washing machine for different washing programmes is shown in table 2.11. This data is from a table in the Bosch WGG04409GB manual. It is again apparent that there is a significant increase in electricity consumption when the temperature of the Cotton programme increases from 20°C to 60°C. The manual suggests the consumption rises from 0.40kWh at 20°C to 1.75kWh at 60°C.

The consumption of the Eco 40-60 cycle depends on whether it is a full, half or quarter wash load. The volume of water consumed is lower for the Eco 40-40 cycle than for the Cotton cycle and is also lower for smaller washing loads. The manual suggests the maximum temperature is 38°C for a full washing load but only reaches 23°C for a quarter load. The lower washing temperature and volume of water heated lead to lower electricity consumption with smaller loads. For a full load on Eco 40-60, the electricity consumption was measured to be 0.87kWh according to the test programme in accordance with the Ecodesign Directive. For a quarter load, the consumption was measured to be 0.18kWh. The spin speed for Eco 40-60 at 1351-rpm is lower than the 1400-rpm for the Cotton cycle which will lower electricity consumption to some extent.

[20] Bosch WGG24409GB washing machine manual https://media3.bosch-home.com/Documents/9001639343_A.pdf (Accessed 31 May 24)

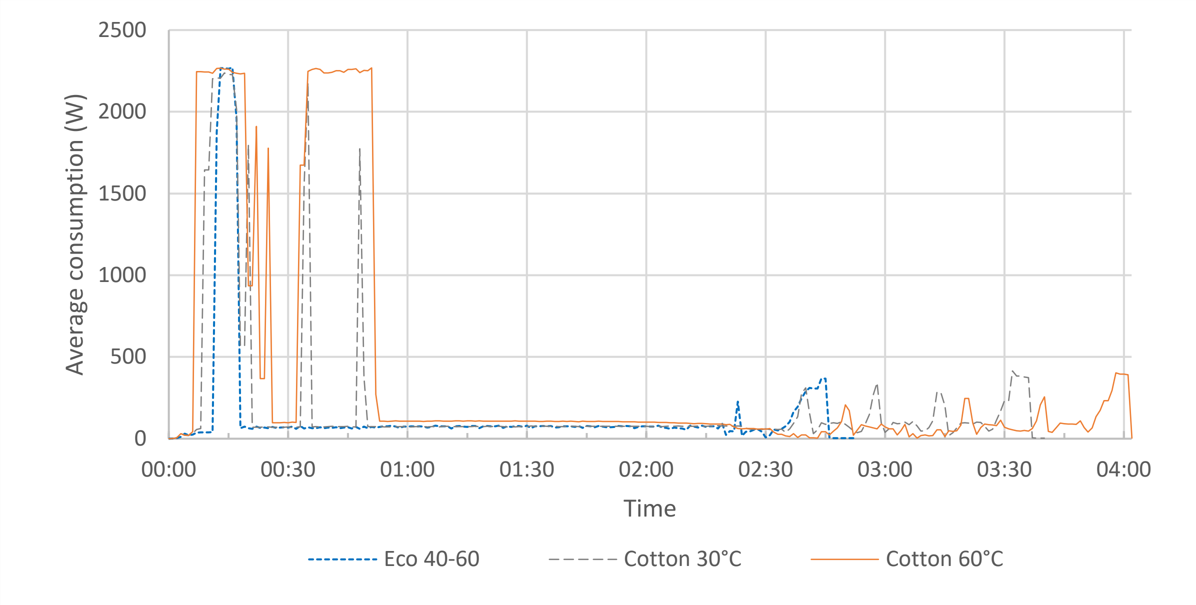


Figure 2.12 Plot of average consumption per minute measured with the Shelly Plus smart plug for the Bosch WGG04409GB on Eco 40-60 and Cotton cycles

The electricity consumption of the Bosch WGG04409GB washing machine was also measured using Shelly smart plugs for comparison with data from the manual. The consumption measured with the Eco 40-60 cycle was 0.425kWh and the cycle time was 2 hours 51 minutes. This was somewhat higher than the 0.37kWh for a half-load cycle in the manual. There was just 6-minutes of water heating followed by a low average consumption of 60-80W until a 10-minute spin at the end of the washing cycle.

In addition to the Eco 40-60 cycle, figure 2.12 shows the Cotton cycle at 30°C and 60°C which lasted 3 hour 40 minutes and 4 hours respectively. The Cotton 30°C wash had an initial water heating cycle of about 10-minutes followed later by a couple bursts of 1 – 2 minutes of water heating. The overall consumption was 0.758kWh, 78% higher than the Eco 40-60 cycle test. The Cotton 60°C wash had 2 extended periods of water heating as seen with the Hotpoint WMTL80. The first lasted for about 15 minutes and the second for about 18 minutes. The total consumption for the Cotton 60°C cycle was 1.60kWh, nearly 4-times the consumption measured with an Eco 40-60 wash. The suggested consumption for a 60°C cotton wash in the Bosch manual was 1.75kWh. At the end of the Cotton wash cycles, there were 3 or 4 spin cycles. The final spin cycle consumed the most power with a maximum of 400W measured on the last 1400 rpm spin for the Cotton 60°C wash.

The full list of washing cycles tested using the Shelly Plus smart plug is shown in table 2.13, with the cycle time and average consumption. It is apparent that low temperature, short cycles with low spin speeds had the lowest consumption. The Sports Wear 20°C cycle with an 800-rpm spin used 0.067 kWh with the Bosch WGG04409GB washing machine while the same cycle on the LG F1496TDA used a comparable amount at 0.062 kWh.

Cycle	Temperature	Spin speed	Cycle time	Average consumption
Sports Wear	20°C	800 rpm	47m	0.067 kWh
Sports Wear	30°C	800 rpm	47m	0.201 kWh
Delicates	30°C	600 rpm	34m	0.195 kWh
Mixed Load	30°C	1400 rpm	1h 21m	0.428 kWh
Mixed Load	40°C	1400 rpm	1h 15m	0.889 kWh
Mixed Load	60°C	1400 rpm	1h 48m	1.380 kWh
Cotton	30°C	1400 rpm	3h 40m	0.758 kWh
Cotton	60°C	1400 rpm	4h 0m	1.60 kWh
Eco 40-60	Dependent on washing load	1351 rpm	2h 51m	0.425 kWh

Table 2.13 Average electricity consumption of Bosch WGG04409GB with different wash cycles

For the Sports Wear cycle at 20°C, there was only about 1-minute of water heating. For the same cycle at 30°C, figure 2.14 shows there was about 5-minutes of water heating. The water heating peak was typically between 2,250 and 2,300W. The nominal power recorded in the manual for the washing machine is 2,300W. The maximum power consumption recorded during the 800-rpm spin cycle was 150 – 160W for the Sports Wear washes at 20°C and 30°C.

Figure 2.14 also shows the consumption profile for a Delicates wash at 30°C, which again had about 5-minutes of water heating. In this case, the spin cycle was lower at 600-rpm. Here the maximum consumption during the spin cycle was 109W. Both the Sports Wear and Delicates washes at 30°C had a short cycle time and lower spin speed. As a result, the consumption for each was about 0.2 kWh.

Figure 2.15 plots the average electricity consumption for the Mixed Load washing cycle at different temperatures. The measured consumption is shown in table 2.13 and was 0.428 kWh at 30°C, 0.889 kWh at 40°C and 1.38 kWh at 60°C. The consumption of the Mixed Load wash at 30°C was more than double that of the Sports Wear and Delicates washes at the same temperature. While the Sports Wear and Delicates washes heated the water for about 5-minutes, the Mixed Load cycle heated the water in a series of pulses for about 8 to 9-minutes.

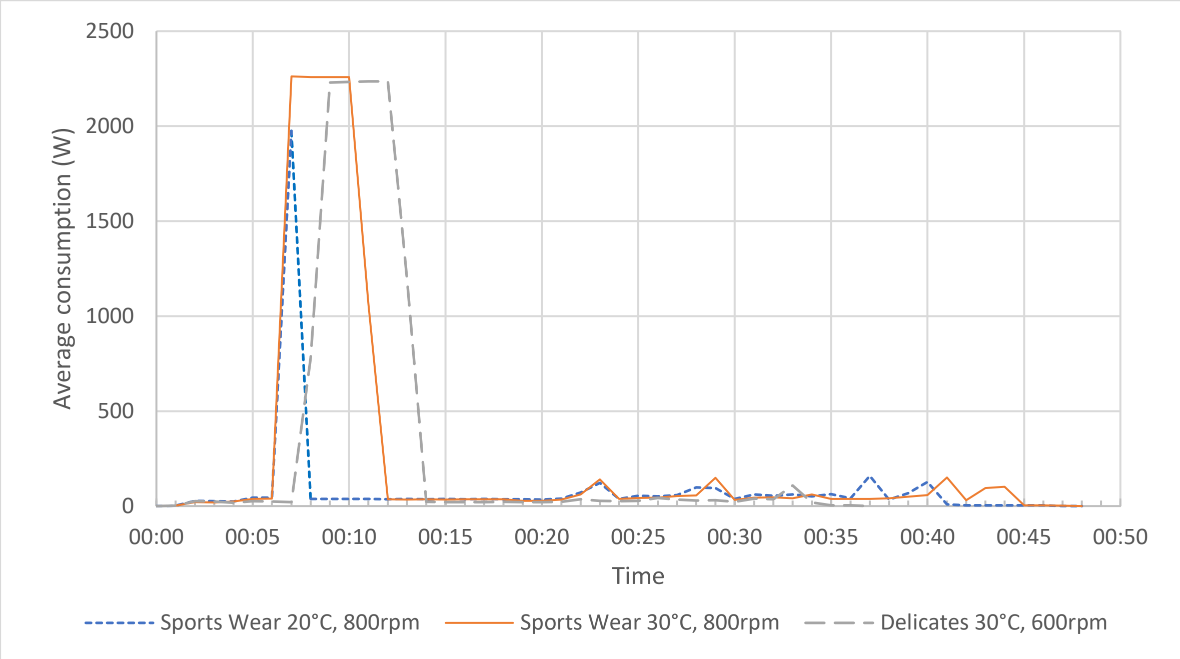


Figure 2.14 Plot of average consumption per minute measured with the Shelly Plus smart plug for the Bosch WGG04409GB washing machine on low temperature, low spin cycles

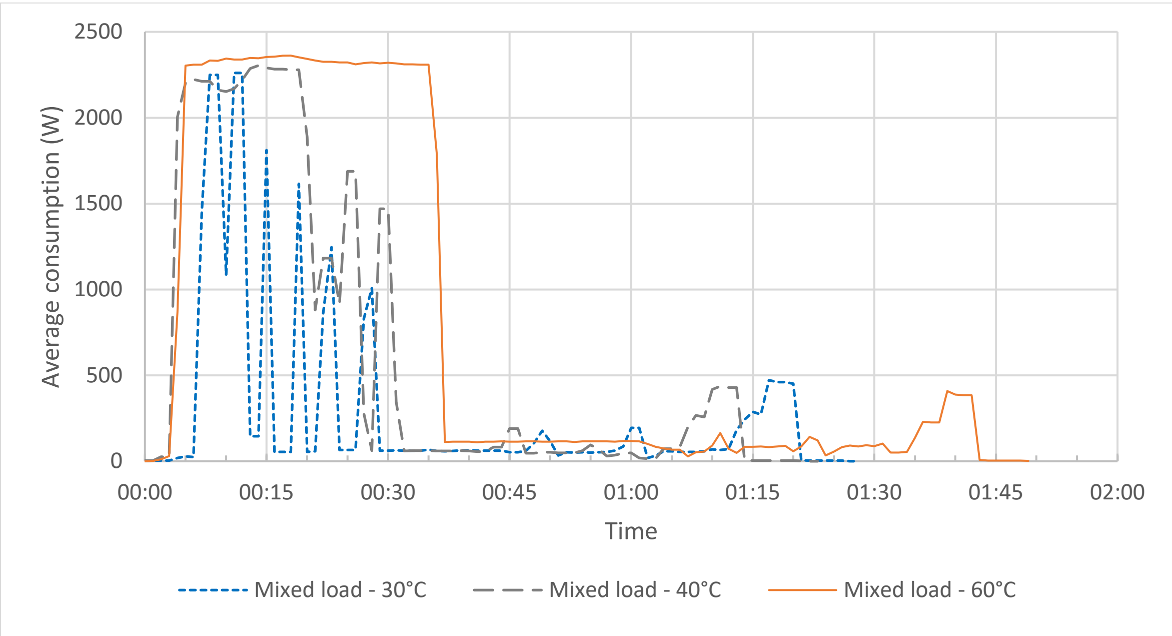


Figure 2.15 Plot of average consumption per minute measured with the Shelly Plus smart plug for the Bosch WGG04409GB on Mixed load washing cycle at different temperatures

The Mixed Load wash at 40°C initially heated the water for about 16-minutes but there continued to be periodic water heating in pulses for around a further 11-minutes. The high levels of water heating led to a high electricity consumption for the washing cycle of 0.89 kWh. It should be noted that the Bosch manual suggested the consumption on the Mixed Load cycle at 40°C was lower at 0.64 kWh. For the Mixed Load cycle at 60°C, the water was consistently heated with an electricity consumption of 2,300 – 2,360W for about 32 minutes.

The total consumption recorded for the 60°C cycle was 1.38 kWh. The spin cycle peak was higher for the Mixed Load cycle than for the Sports Wear and Delicate cycles. The Mixed Load cycle had a 1,400-rpm spin and this had a peak of 408 – 460W. This compares 150-160W for the 800-rpm spin on the Sports Wear cycle and 109W for the 600-rpm spin on the Delicate cycle.

Summary

- Modern washing machines have a cold feed and heat water in the washing machine
- Heating water is the main cause of electricity consumption in a washing machine
- The washing machine consumes between 2 and 2.5kW during water heating and only 150 to 500W during the spin cycles
- A cotton cycle wash at 40°C can consume 2 to 3 times more electricity than a cotton wash cycle at 20°C
- More than 30 minutes of water heating is usually required for a wash cycle at 60°C and the electricity consumption is usually between 1 and 1.75kWh
- The Eco 40-60 wash cycle is the default wash cycle on modern washing machines and is designed to economically wash clothes intended for 40 or 60°C wash cycles
- An Eco 40-60 cycle will use less water and the wash temperature is typically between 20 and 40°C and dependent on the washing load; good performance is achieved with a longer washing time
- Synthetic materials are best washed at lower temperatures and dry more easily, with low spin speeds sufficient
- The lowest consumption is achieved by short low temperature washing cycles at 20 or 30°C with low spin speeds with the electricity consumption only 0.1 to 0.2kWh
- Washing cycles with high spin cycles such as 1400 rpm use more electricity, however these can be useful to reduce the level of moisture in cotton clothing and reduce the drying time and potentially the energy consumed while drying the clothes
- When purchasing a new washing machine, check the energy label, with the electricity and water consumption per cycle
- Smaller households may not need washing machines which accommodate larger loads and can have higher consumption

2.2 Dishwashers

Use of a dishwasher can lead to significant reductions in water and energy consumption. A study was published in 2010 where UK consumers were asked to wash the same number of dishes manually and with a dishwasher. On average, participants used 49 litres of water to manually wash the dishes and consumed 1.7kWh of energy. When using the dishwasher, they used an average of 13 litres of water and consumed 1.3kWh of electricity[21]. Since this study, dishwashers have become more efficient, with A-rated appliances using less than 10 litres of water and under 0.6 kWh of electricity on an Eco cycle.

Schencking and Stamminger have published a brief and more detailed review on the science of dishwashing and daily routines of households[22] [23]. The benefits of a dishwasher and how to get optimum performance out of the appliance have also been discussed in the BBC Radio programme, Sliced Bread[24].

It was not possible to test any dishwashers with smart plugs as the households able to test appliances had integrated dishwashers with no access to the power socket. This section is therefore based on data published by manufacturers and the above reports.

Table 2.16 shows the specifications of a range of dishwashers with different energy efficiency ratings. Further examples are available in the guidelines for the new energy label[25]. These show values of energy consumption for dishwashers in each energy class for a 15-place dishwasher using the Eco programme.

The appliances listed in table 2.16 in bands A-C had a water consumption on the Eco cycle of between 9 and 10 litres. This increased to between 10.5 and 12 litres for the dishwashers with energy efficiency ratings in band D and below.

Key factors in the energy consumption of dishwashers are the volume of water heated and the temperature it is heated to. The energy consumption on the Eco programme was under 0.6kWh/cycle for the A-rated appliances. Dishwashers with lower number of place settings can use less energy per cycle, however this was not the case for the Bosch Series 2 and Samsung Series 5 dishwashers in table 2.16. Here the water consumption was quite high at above 10 litres/cycle and this was a factor in the high energy consumption of 0.92 and 1.04kWh/cycle respectively.

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[21] Berkholz et al (2010), Manual dishwashing habits: an empirical analysis of UK consumers, International Journal of Consumer Studies, Volume 34, Issue 2, pp. 235-242, https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1470-6431.2009.00840.x (Accessed 16 Jul 2024)
[22] Schencking and Stamminger (2023), The science of dishwashing – changing habits for a greener world, https://researchoutreach.org/wp-content/uploads/2023/10/Rainer-Stamminger-Lotta-Schencking.pdf (Accessed 16 Jul 2024)
[23] Schencking and Stamminger (2022), What science knows about our daily dishwashing routine, Tenside Surfactants Detergents, Volume 59, Issue 3, pp. 205-220, https://www.degruyter.com/document/doi/10.1515/tsd-2022-2423/html (Accessed 16 Jul 24)
[24] Sliced Bread – Dishwashers, 21 Mar 2024, https://www.bbc.co.uk/sounds/play/m001xdbx (Accessed 16 Jul 2024)
[25] The New Energy Label – Guidelines for Public and Private Buyers, Energy Saving Trust, https://www.energylabel.org.uk/fileadmin/uk/EST_LABEL2020_Green_Procurement_guidelines_WEB.pdf (Accessed 16 Jul 2024)

Manufacturer and model	Description	Place settings	Energy efficiency rating	Energy consumption (kWh/cycle)	Water consumption on Eco programme (L/cycle)
Beko Pro BDIN38560CF	Integrated	15	A	0.55	9.9
Bosch Series 6 SMD6TCW01G	Free-standing	14	A	0.54	9.5
Kenwood KID16X23	Integrated	16	A	0.56	9.0
Hoover H-Dish 500 HF6B4S1PW	Free-standing	16	B	0.66	9.5
Beko Pro Fast45 BDEN38640FG	Free-standing	16	C	0.77	9.5
Kenwood KID60S23	Integrated	14	D	0.85	11
Bosch Series 2 SMV2ITX18G	Integrated	12	E	0.92	10.5
Samsung Series 5 DW60M5050BB	Integrated	13	F	1.04	12

Table 2.16 Energy and water consumption of different models of dishwasher[26]

Table 2.17 shows the energy and water consumption data for an AEG 7000 series model FFB74707PM. This is a freestanding dishwasher with 14 place settings which has an Energy efficiency rating of C. The table shows some of the different dishwasher programmes as well as the dishwashing water temperature and final rinse temperature.

Dishwashers have spinning arms which spray water from below the bottom and top trays. After spraying onto the dishes, the water is collected and filtered, recycled and fed back to the spray arms during the dishwashing cycle. The device may use only a few litres of water at a time, but this water is sprayed over the dishes many times a minute[27]. Longer cycles have a prewash and after about 10 minutes, fresh water is added with the detergent for the dishwashing cycle which can last for 1-2 hours. At the end of the cycle there is a final rinse and the heat in the dishes is used to dry the plates through evaporation.

[26] Specifications were taken from Currys (2024), https://www.currys.co.uk/ (Accessed 16 Jul 2024)
[27] Sliced Bread – Dishwashers, 21 Mar 2024, https://www.bbc.co.uk/sounds/play/m001xdbx (Accessed 16 Jul 2024)

Programme	Duration (mins)	Energy consumption (kWh/cycle)	Water consumption (L/cycle)	Dishwashing temperature (°C)	Final rinse temperature (°C)
ECO	240	0.746	11	50	55
160 min	160	1.21	11.9	60	60
90 min	90	1.11	11.9	60	55
60 min	60	0.97	11.8	60	50
30 min	30	0.62	11	50	45
Auto	170	1.22	12.1	50-60	60

Table 2.17 Energy and water consumption during different dishwashing cycles for an AEG 7000 series FFB74707PM dishwasher with 14 place settings and an energy rating of C[28]

The 160-minute wash consumes the most electricity and water and is typically used for dishes where there is heavy soiling which has dried on. The consumption is higher due to the high dishwashing and final rinse temperatures at 60°C.

The Auto setting is for all levels of soiling while the 90- and 60-minute cycles are for normal or lightly dried on levels of soiling. These all have higher levels of electricity consumption due to dishwashing temperatures at 60°C.

The 30-minute wash is only for freshly soiled dishes with a 50°C dishwashing temperature and a 45°C final rinse temperature. These low temperatures and the short time mean this has the lowest energy consumption, but it may not fully clean the dishes if there is too heavy soiling or it has dried on.

The best compromise for achieving energy efficiency and a high standard of cleaning where there is a normal level of soiling which is lightly dried on is with the Eco cycle.
Here the dirt is slowly broken down over the longer dishwashing cycle by enzymes in the detergent which can operate at lower temperatures such as 50°C. Without the long washing time, the dishwasher temperature needs to be higher so that other chemicals in the detergent can break down the dirt. However, the higher temperatures lead to greater electricity consumption[27].

[28] AEG FFB74707PM Dishwasher manual https://api.electrolux-medialibrary.com/asset/82064b5b-7e5d-4f5f-9ba5-9d899e585829/E4RM3Q/04a1e849-95cb-41c8-b344-b4b44309057c/ORIGINAL/04a1e849-95cb-41c8-b344-b4b44309057c.pdf (Accessed 18 Jul 24)

It is best to select an appropriately sized dishwasher for your household so that you are able to run it with close to full loads. Underfilling the dishwasher is less efficient while overfilling it can mean items may not be cleaned properly and will need to be cleaned again.

Tabletop and slimline dishwashers are not energy efficient options and often have F and G energy efficiency ratings. An example of a slimline dishwasher had 10 place settings and consumed 0.84kWh/cycle and 11.5 litres/cycle[29]. This is worse that the A-C rated dishwashers in table 2.16 which had 14-16 place settings. Tabletop dishwashers are best avoided unless there is no space available for a larger undercounter model. These can have between 2 and 6 place settings. They use more electricity and water per place setting and can use more electricity per cycle than a larger more efficient model.

Whirlpool has produced a guide on how to load a dishwasher properly to ensure better cleaning with each cycle[30]. Have larger plates and pans on the lower rack with the dirty side facing downwards so it will be washed by the spray arm. Avoid overcrowding and leave sufficient space between plates so that the water jet can clean the items.

The upper rack is for items like glasses and mugs, small plates and bowls and light items. The upper spray arm is not as powerful as the lower.

Summary

- Handwashing of dishes can use more than 3 times the water and also more energy than a dishwasher
- When purchasing a dishwasher, check the energy label for the energy efficiency rating, the energy and water consumption
- Avoid purchasing slimline or tabletop dishwashers if possible as they are less efficient
- The Eco cycle is the most energy efficient programme despite the long wash time; this consumes less energy due to the lower dishwashing temperature and relies on enzymes in the detergent to break down the dirt over the longer washing time
- The most efficient dishwashers can use less than 0.6kWh/cycle and 10 litres/cycle on the Eco setting
- Avoid overfilling or underfilling the dishwasher and be careful where items are placed in the racks to ensure they are properly washed

[29] Indesit DSFE 1B10 S UK N slimline dishwasher, https://www.indesit.co.uk/indesit-dsfe-1b10-s-uk-n-dishwasher-silver-f161620/p (Accessed 18 Jul 24)
[30] How to load a dishwasher properly, Whirlpool, https://www.whirlpool.com/blog/kitchen/proper-way-to-load-a-dishwasher.html (Accessed 18 Jul 2024)

2.3 Drying laundry

Laundry after washing can weigh over 2kg more due to retained moisture[31]. This is particularly true with cotton fabrics even with high spin speeds. Factors which assist in drying clothes through evaporation are higher temperatures, movement of air and having a low humidity[32].

It is generally best to wash laundry on a sunny day and to dry it outside for free on a clothes-line. The laundry will dry quicker on a windy day when the humidity is low. Drying laundry outside is not always possible due to the weather, the amount of laundry or access to a clothes line.

When laundry needs to be frequently dried indoors, a suitable option might be a tumble dryer. The electricity consumption of different models of tumble dryer varies considerably, with more modern heat pump tumble driers using significantly less electricity than vented or condenser tumble driers.

Some households are known to dry clothes on radiators or storage heaters. It is recommended to never to dry clothes on storage heaters due to the fire risk[33]. When drying clothes on a radiator, it blocks heat getting to the room and the boiler has to work harder using more gas. It is better to dry the laundry on a clothes horse at least 30 cm from the radiator or heater.

Drying laundry inside increases the humidity in the room and the moist air is likely to condense on colder surfaces which can lead to damp and mould. Good ventilation is important or use of a dehumidifier. Some households use an electric heated clothes dryer, but these can be slow to dry the clothes. Use of a dehumidifier and a fan with an unheated clothes rack is a more energy efficient way of drying. The following sections discuss methods of drying clothes and the associated electricity consumption.

[31] David MacKay (2009), Sustainable Energy without hot air, https://www.withouthotair.com/c7/page_54.shtml (Accessed 12 Jul 24)
[32] Chris Woodford (2023), Clothes Dryers, Explain that Stuff, https://www.explainthatstuff.com/how-clothes-tumble-dryers-work.html (Accessed 12 Jul 23)
[33] Dimplex Quantum Series Heater, Installation and Operating Manual, https://www.dimplex.co.uk/sites/g/files/emiian551/files/media_import/medias/docus/13/Quantum%20G12%20Installation%20User%20Instructions%20-%20Issue%202.pdf (Accessed 15 Jul 24)

2.3.1 Tumble Dryers

Figure 2.18 Photo of a tumble dryer (Pexels, Sarah Chai)

There are three main types of tumble dryer[34]:

- Vented
  - Air is electrically heated and passed into the drum, warming clothes and evaporating water as the clothes are tumbled in the dryer
  - The hot damp air is piped out from the dryer through an external vent which might be through an external wall
- Condenser
  - A condenser tumble dryer heats air up to 70-75°C to dry the clothes
  - The hot damp air is passed into a condensing chamber where the moisture is condensed into water which is stored in a tank
  - There is greater flexibility in siting a condenser tumble dryer, but it has higher running costs than for a vented tumble dryer due to condensing the water
- Heat Pump
  - While Vented and Condenser dryers expel heat from the dryer, a heat pump tumble dryer recycles the heat already used for drying, making it more efficient
  - Moisture from the warm damp air is removed and stored in a water tank avoiding the need for an exhaust air pipe
  - Laundry is dried at a lower temperature of about 50°C, requiring lower power
  - The lower drying temperature means longer drying times but is less damaging to fabrics

[34] Beko (2024), What are the differences between heat pump, vented and condenser tumble dryers, https://www.beko.co.uk/support/faqs/tumble-dryers/differences-between-heat-pump-and-condenser-dryer (Accessed 12 Jul 24)

Manufacturer and model	Type of dryer	Energy efficiency rating	Consumption per cycle on full load (kWh)	Energy consumption (kWh/year)	Electrical connection rating (W)
AEG 9000 TR959M6BC	Heat pump	A+++	1.68	194.1	700
Bosch Series 6 WQG233D8GB	Heat pump	A+++	1.4	176	600
Hotpoint H8 D93WB UK	Heat pump	A++	2.12	259	850
Beko DTLCE90051W	Condenser	B	5.21	616	2700
Bosch Series 4 WTN83203GB	Condenser	B	4.71	560	2800
Hotpoint H2 D81W UK	Condenser	B	4.75	561	2500
Hotpoint H2 D80W UK	Vented	C	5.02	585	2500
Hoover HLE V9DG-80	Vented	C	5.34	636	-

Table 2.19 Energy performance of different models of tumble dryer

Examples of the energy efficiency rating and consumption of different models of tumble dryer are shown in table 2.19. This data is from manufacturers manuals and websites like Currys.

Energy efficiency ratings for tumble dryers in the UK were between A+++ and D at the time of writing. A review of the energy efficiency of tumble dryers has been carried out in the European Union as part of the Ecodesign regulations. From 1 July 2025 energy efficiency ratings for tumble dryers in the EU will be rescaled to be in the range A to G. Initially no models will be A-rated in order to allow improvements in performance. Only heat pump tumble dryers will be available for sale in the EU after 1 Jul 2025[35]. It is likely that vented and condenser tumble dryers will also be withdrawn from the UK market after a significant decrease in the numbers of these models being sold.

[35] Tumble dryers: Energy labelling and ecodesign requirements apply to this product, Energy Efficient Products, European Commission, (2024), https://energy-efficient-products.ec.europa.eu/ecodesign-and-energy-label/product-list/tumble-dryers_en (Accessed 15 Jul 2024)

The electricity consumption of heat pump tumble dryers may only be 30 to 45% per cycle of the amount for a vented of condenser tumble dryer. The most efficient heat pump tumble dryers can use less than 1.7kWh to dry a full 8 or 9kg load of laundry. For comparison the Bosch and Hotpoint 8kg condenser tumble dryers in the table can use 4.71kWh and 4.75kWh respectively while the 9kg Beko condenser tumble dryer can use 5.21kWh. The Hotpoint H2 D80W UK vented tumble dryer had a load of 8kg and can use 5.02kWh for a full load and the Hoover vented tumble dryer with a maximum load of 9kg can use 5.34kWh for a full load.

The energy consumption per year assumes 160 drying cycles using the standard cotton programme at full and partial load[36]. These values ranged from under 200kWh for the A+++ heat pump tumble dryers to 560 – 640kWh for the condenser and vented tumble dryers.

The maximum power consumption of heat pump tumble dryers in the table is between 600 and 850W. This compares to 2500 to 2800W for the vented and condensing tumble dryers. The heat pump tumble dryer requires less power due to running at a lower temperature and recycling of heat.

The drying time with a heat pump tumble dryer is normally longer than for a condenser or vented tumble dryer. The time to dry a full load in a heat pump tumble dryer is typically between 180 and 250 minutes. This compares with around 120 to 180 minutes with a condenser or vented tumble dryer.

Tips for improving performance from a tumble dryer[37] and lowering costs include:

- Spin clothes in the washing machine sufficiently to reduce residual moisture
- Untangle and separate laundry before putting it in the dryer
- Regularly clean the lint and evaporation filters to avoid increased energy consumption
- Empty the water tank each time you use a condenser or heat pump tumble dryer
- Dry similar fabrics together as they will take a similar time to dry
- Avoid overloading the dryer and hindering drying performance
- Avoid underloading the dryer and using excess energy to dry a few items
- Select a sensor drying programme which stops once clothes are sufficiently dry rather than a timed programme which may continue to operate after the clothes are dry
- Adding wet laundry mid-cycle decreases efficiency with dry clothes becoming damp from the wet clothes
- Remove laundry from the dryer once it has completed the drying cycle to avoid the drum continuing to periodically rotate in order to prevent creases
- If there are several loads of laundry, dry one after another to benefit from heat already in the drum of the tumble dryer

[36] Beko DTLCE90051W dryer user manual, p.20, https://bekoplc.blob.core.windows.net/bekoupload/manuals/DTLCE90051.pdf (Accessed 15 July 2024)
[37] Beko, 9 tips for energy efficient drying, https://www.beko.com/nz-en/support/tumble-dryer--using--article/9-tips-for-energy-efficient-drying (Accessed 15 July 2024)

Hotpoint TVFS83 vented tumble dryer

The only tumble dryer that it was possible to test with a Shelly smart plug was a Hotpoint TVFS83 vented tumble dryer. This was able to have a maximum load of 8kg. Table 2.20 from the manufacturer's manual indicates the energy consumption for a full load was about 4.99kWh while for a partial load (half load) it was 2.64kWh.

Product Data - Regulation 392/2012.	
Brand HOTPOINT	
Model TVFS 83C GG.9 UK TVFS 83C GP.9 UK	
Rated capacity of cotton laundry for the "standard cotton programme" at full load - kg	8.0
This household tumble drier is a	Vented
Energy efficiency class on a scale from A+++ (low consumption) to D (high consumption)	C
The weighted Annual Energy Consumption (AEc)* kWh 1)	586.0
This household tumble drier is a	Automatic
Energy consumption full load; Edry - kWh 2)	4.99
Energy consumption partial load; Edry½ - kWh 2)	2.64
Power consumption: off-mode (Po) - Watts	0.14
Power consumption: left-on mode (Pl) - Watts	1.96
Duration of the 'left-on mode' for power management system - minutes	30
Prog. Time - weighted (Tt) full & partial load - minutes 3)	96
Full load (Tdry) - minutes	130
Partial load (Tdry½) - minutes	71
Condensation efficiency class on a scale from G (least efficient) to A (most efficient)	N/A
Average condensation efficiency - %	
weighted (Ct) full & partial load 3)	
full load (Cdry)	
partial load (Cdry½)	
Airborne acoustical noise emissions - dB(A) re 1 pW	69
1) "Standard cotton" at full and partial load is the standard programme to which the information in the label and the fiche relates. The standard cotton program is suitable to dry at cupboard level (0%) cotton laundry and is the most efficient programme in terms of energy consumption. Partial load is half the rated load.	
2) based on 160 drying cycles of the standard cotton programme at full and partial load, and the consumption of the low-power modes. Actual energy consumption will depend on how the appliance is used.	
3) Weighted average of 3 cycles at full load and 4 cycles at half load.	
Regulation 932/2012.	
Energy consumption in kWh, for program "Synthetics" full load	2.1
Programme time in minute, for program "Synthetics" full load	90
Partial load for program "Synthetics" N/A	

Table 2.20 Specification of Hotpoint TVS 83C vented tumble dryer[38]

38 Instruction booklet, Hotpoint TVFS 83, https://www.swiftuk.co.uk/All_Media/Product_Document/TVFS83_man.pdf (Accessed 16 Jul 2024)

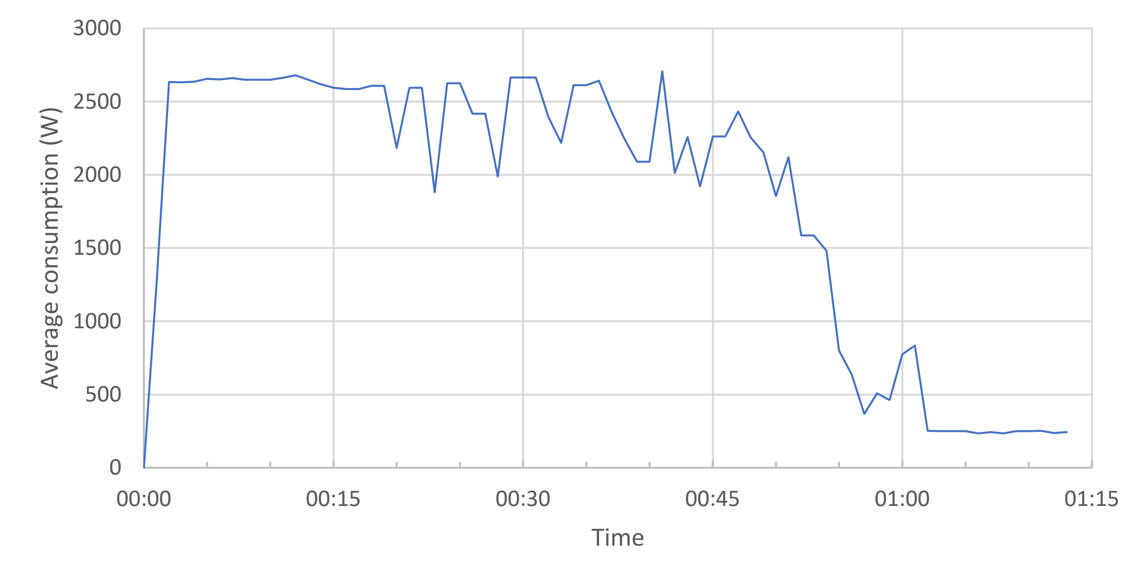

Figure 2.21 Plot of average consumption per minute measured with the Shelly Plus smart plug for a Hotpoint TVFS 83 vented tumble dryer with a partial load on the cotton cycle

Figure 2.21 shows the average electricity consumption per minute for a Hotpoint TVFS 83 vented tumble dryer with a partial load of laundry on the cotton cycle. Within a couple of minutes of starting, the average power consumption for the tumble dryer had reached about 2,650W. The average power consumption continued at this level for about 20 minutes. The average consumption subsequently was at a variable high level within the range 1,900 – 2,700W until about 50minutes into the cycle. The variable consumption is likely to have been due to the tumble dryer heater occasionally being turned off for short periods, lowering the average power consumption. There was a significant drop on average power consumption after around 50 minutes, with reduced heating as the laundry in the appliance approached being dry.

Just after an hour of operation, the tumble dryer average consumption fell to about 250W for approximately 10 minutes. This may have been due to the crease care function operating once the clothes have dried. This continues to occasionally rotate the drum and tumble the laundry to avoid the clothes getting creased.

The electricity consumption over the whole cycle was 2.26kWh. Without the crease control at the end of the cycle, it was estimated that the consumption by the tumble dryer was 2.21kWh.

The maximum average consumption was comparable to the connection rating for the vented and condenser tumble dryers in table 2.19. For a half load, the electricity consumption indicated by the Hotpoint TVFS 83 manual was 2.64kWh, with a cycle time of 71 minutes. The manual also suggests that a 3kg load of cotton clothing might take about 60 minutes to dry. The lower the load, the shorter the drying time and the associated drying costs.

For a heat pump tumble dryer, the maximum average power consumption may only be about 700W, but the cycle time will be longer.

Summary

- Vented and Condenser tumble dryers have a high maximum power consumption of 2,500 – 2,800W and a higher drying temperature
- Vented and Condenser tumble dryers have shorter drying times but have a high electricity consumption (typically 4.5 – 5.5kWh for a full load)
- Vented tumble dryers pipe the hot damp air outside though a vent in an exterior wall
- Vented and Condenser tumble dryers will no longer be on sale in the European Union after 1 July 2025, with only more efficient heat pump tumble dryers available
- A heat pump tumble dryer has a lower drying temperature and recycles the heat, allowing it to be more efficient
- The maximum power consumption for a heat pump tumble dryer is 600 – 850W which is typically less than one third of the maximum power consumption of a vented or condenser tumble dryer
- Despite it taking longer to dry laundry with a heat pump tumble dryer, the energy consumed drying a full load of washing is considerably lower at 1.4 – 2.2kWh

2.3.2 Heated clothes airer

Figure 2.22 Example of an electrically heated clothes airer with wings

Heated clothes airers can broadly be divided into 2 categories: airers with heated rails and those with a fan heater and drying pod above it. 13 heated clothes airers have been tested and reviewed by The Independent[39]. The heated clothes airers can typically be folded up when not in use. Table 2.23 shows some examples of heated airers on the market with descriptions and power ratings with data from the Currys and Amazon websites.

[39] IndyBest, 13 best heated clothes airers and drying racks, tried and tested, https://www.independent.co.uk/extras/indybest/house-garden/household-appliances/best-heated-clothes-airer-indoors-b1892835.html (Accessed 22 Jul 2024)

Manufacturer and model	Description	Drying capacity in weight or space	Power rating (W)
Abode AECRD2001	18 heated rails – 1 tier with wings	10kg	230
Abode AECRD2003	30 heated rails in 3 tiers	30kg	330
Beldray EH3752	36 heated rails in 3 tiers	30kg or 20m	300
Dunelm 30752153	18 heated rails – 1 tier with wings	10kg or 12m	220
Dunelm	24 heated rails in 2 tiers	10kg or 13m	220
Dunelm	36 heated rails in 3 tiers	15kg or 20m	330
Easylife XL	30 heated rails in 3 tiers	15kg or 21m	300
JML DriBUDDi	Fan heater and drying pod	10kg	1,200
Lakeland Dry:Soon	Fan heater and drying pod	10kg	1,000
Minky Wing EV-230	19 heated rails – 1 tier with wings	16kg or 12m	230
Uemusi	Fan heater with 2 tier drying pod	20kg	1,000

Table 2.23 Specification of different models and designs of heated airers

The heated rail clothes airers have aluminium rails with heating elements inside. The single tier design usually has fold out wings, a total rail length of about 12m and a rated power consumption of 220 to 230W. There are also larger drying racks with 3 tiers which can have 30-40 rails and a total rail length of about 20m. These have a rated power of 300 to 330W. Some of the more expensive models have both temperature and time control while cheaper models just have an on/off button. Since it is just the rails that are heated, some of the 3 tier models have a cover going over the top of the airer to keep in the heat.

The other common design involves a fan heater and drying pod. This relies on hot air in a similar way to a tumble drier. The fan heater is at the base of the unit and has a rated power of 1,000 – 1,200W. Above this is a drying rack for clothes on hangers. Once the damp clothes have been hung up, a cover is fitted over to create a drying pod. This may be cylinder shaped (similar size to a hot water cylinder) or rectangular (more like a small wardrobe). Some models have different heat settings.

We have been able to test a couple lower cost models of heated airer. These had a single tier of 8 long rails along with 2 foldable wings with 5 short rails each. The Dunelm single tier unit was rated at 220W and figure 2.24 shows a graph of average electricity consumption. Over the first 4 hours of the test, the average consumption of the Dunelm heated airer was 232.6W. This was during a test where the Shelly plug indicated the household supply was at 244.8V. Had the supply voltage been at 230V, the consumption of the airer was likely to have been closer to 219W[40]. In advertising, Dunelm claimed that the running cost for this heated airer was 6p/hour. This would be correct for a household with an electricity unit rate of 27.3p/kWh and a voltage of 230V. If the voltage was as high as 244.8V as on the below test, the running cost would be 6.35p/hour.

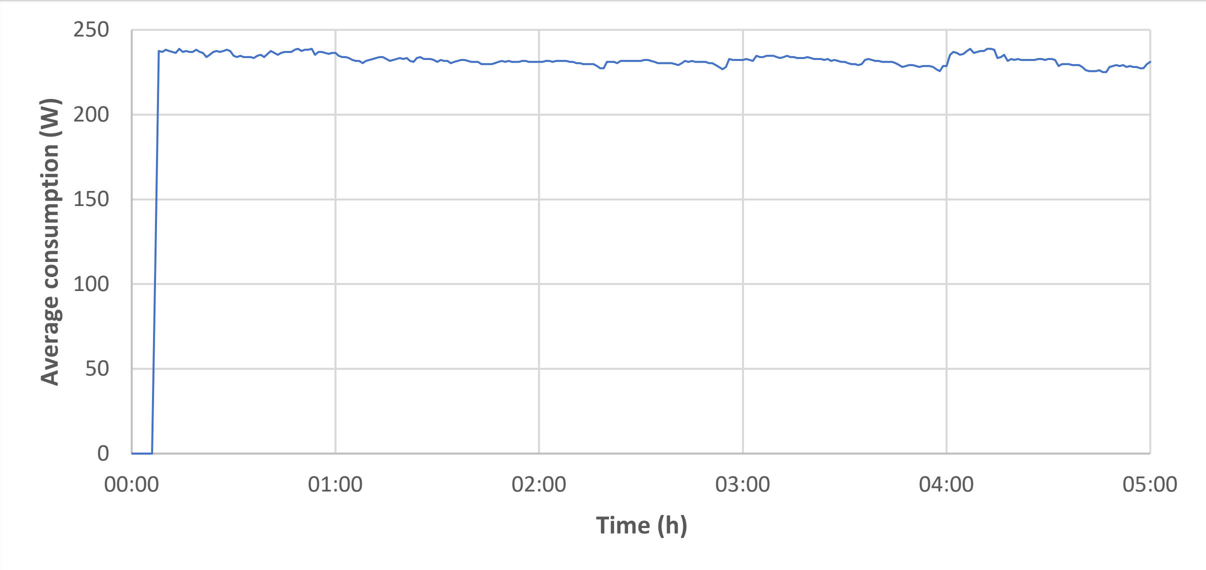

Figure 2.24 Average electricity consumption for a Dunelm 220W heated airer with wings

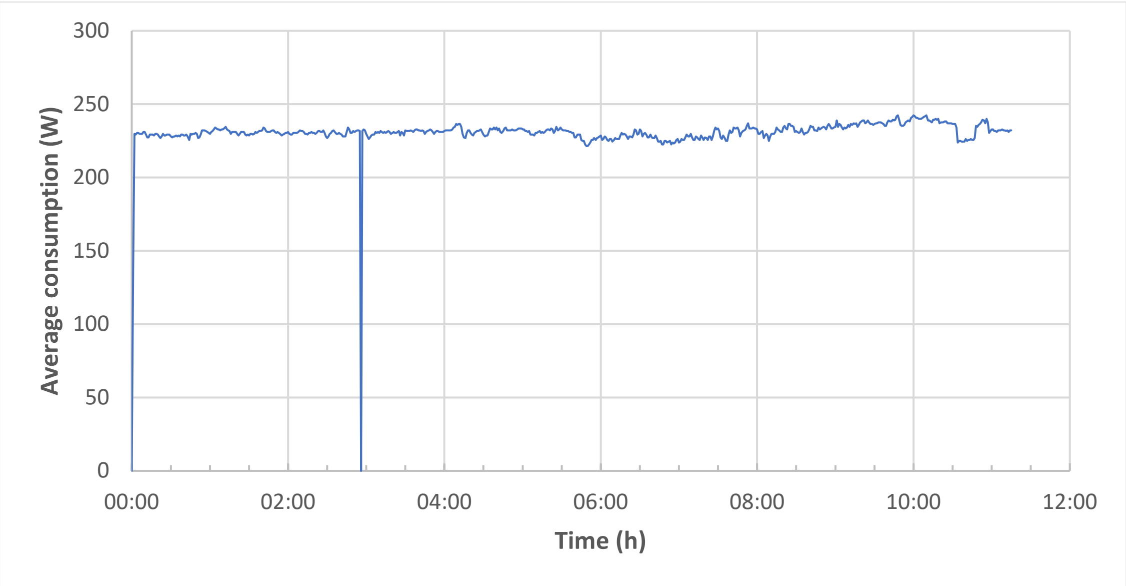

Figure 2.25 Average electricity consumption for an Argos 220W heated airer with wings

[40] Power (Watts) = Voltage (Volts) x current (Amps)

The other test (figure 2.25) was carried out with an Argos 220W heated airer with wings. Here the airer was run for over 10 hours although the power briefly cut out after nearly 3 hours. The electricity consumed over the full 11.25 hours of operation was 2.6kWh. Over the 6 hours between t=4 and t=10 hours, the consumption was 1.387kWh with an average of 231.2W. The supply voltage at the property was about 240V at the time of the test. As before, if the supply had been 230V, it is likely the power consumption would have been around 221.6W.

With the same electricity unit rate as used by Dunelm, the cost per hour would have been 6.3p/hour with a supply voltage of 240V and 6.04p/hour if it was at 230V.

There was no modulation (turning on and off) of the power consumption for either the Dunelm or Argos heated airers. Other more expensive heated airers with temperature control may turn the heating on and off.

The larger 3 tier Dunelm heated airer (table 2.23) had a rated power of 330W which is at the upper end of power rating for the 3 tier heated clothes airers. Dunelm advertised a running cost of 10p/hour. With a unit rate of 27.3p/kWh (as for the single tier airer with wings), the cost at a constant 330W would be 9p/hour which is lower than advertised.

There has been considerable volatility in electricity prices since the recent energy crisis. From 1 Oct 2024, the energy price cap for single rate electricity will be 24.5p/kWh[41] and for the previous quarter it was 22.36p/kWh. These unit rates were lower than those used by Dunelm in the calculation for the heated airer running costs.

The clothes airers with heated rails are quite slow acting on clothes like cotton and may need to dry them for several hours. The area dried is often just around the heated rail and so clothes may need to be repositioned multiple times. A cover with larger 3-tier airers might keep in the heat and speed up drying.

The other type of heated clothes airer uses a fan heater rated at 1,000-1,200W to blow hot air into a pod with clothes on hangers. Many of these heated air dryers have a timer which can be set for up to 3 hours. The Uemusi heated airer has the fan heater at the base of a frame the size of a small wardrobe which can have clothes on hangers on one or two tiers. A fabric cover is fitted over the frame to keep the heat in. Promotional literature suggests it might take 60 minutes to dry a shirt, 90 minutes for a towel and 120 minutes for a slower drying fabric like denim[42].

Running the Uemusi clothes dryer rated at 1,000W for 1 hour would use 1kWh or 1 unit of electricity. Most items hanging in the dryer may dry after 2 hours using 2kWh of electricity. Using the same unit rate as for the Dunelm heated rail dryer, the total cost would be 27.3p for 1 hour of operation or 54.6p for 2 hours. These dryers may have similar running costs or

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[41] Energy Price Cap Calculator – How much less will you pay from October?, Money Saving Expert (27 Aug 2024), https://www.moneysavingexpert.com/utilities/what-are-the-price-cap-unit-rates-/ (Accessed 23 Sep 2024)
[42] Uemusi electric clothes dryer, https://www.amazon.co.uk/Electric-Clothes-Portable-Stainless-UEMUSI/dp/B0CYC12J64/ (Accessed 22 Jul 24)

perhaps lower than for a vented or condensing tumble dryer. They would however have higher running costs than a heat pump tumble dryer.

A major issue with heated clothes airers is that the moisture in the damp clothes evaporates and raises the humidity of the air in the house. When the damp air hits a cold surface, it will condense back to water. These damp surfaces could lead to the growth of mould.

Summary

- Heated clothes airers can be divided into those with heated rails and those using a fan heater to blow warm air
- The heated rail dryers can have between 18 and 40 heated rails and may be in a single tier with wings or 2 or 3 tiers
- The single tier with wings heated rail dryers have about 12m of drying space and consume a consistent 220-230W
- The 3 tier heated rail dryers have 20-24m of drying space and consume 300-330W
- Electricity costs of the heated rail dryers can be 5-10p/hour but it can take over 5 hours to dry the clothes
- The heated air dryers have a 1,000-1,200W fan heater at the base which blows hot air over clothes on hangers which have a covering over the frame where the clothes hang
- The heated air dryers can take 1-3 hours to dry the clothes and are likely to use 1kWh or more of electricity per hour
- Using the same unit rate as for the heated rail dryers, the running cost is 27.3p/hour
- Heated air dryers may have a similar running cost to a vented or condensing tumble dryer but would be more expensive to run than a heat pump tumble dryer
- Both heated rail and heated air clothes dryers will raise the humidity in the room while drying and could lead to damp and mould unless there is ventilation or use of a dehumidifier

2.3.3 Dehumidifiers

When laundry is dried inside it is important to either ventilate or use a dehumidifier to avoid development of damp and mould. Dehumidifiers use either a compressor/refrigerant (like a fridge) or a desiccant to collect the moisture in the air[43]. Compressor dehumidifiers cost less and have lower running costs than dehumidifiers which use a desiccant that regenerates. It is possible to buy small containers which contain desiccant at low cost, but these tend to be left in cupboards and wardrobes to collect small amounts of moisture and are subsequently disposed of. Some models of dehumidifiers include an air purifier to remove dust and particles with a HEPA filter which would need replacing periodically.

Details of 10 dehumidifiers including their power ratings are also shown in table 2.26. Generally, more powerful dehumidifiers such as those capable of collected 20 or 25 litres of moisture per day have a higher power rating. Models using a desiccant also use more electricity as regenerating the desiccant with heating uses more electricity than a compressor.

Manufacturer and model	Description	Size	Power rating (W)	Tank capacity (litres)
Black+Decker BXEH60001GB	Portable Dehumidifier		22.5	0.9
Cosihome	Dehumidifier (compressor)	12L/day	190	2.5
Devola DV12L	Dehumidifier (compressor)	12L/day	185	2
Dimplex EverDri10E	Dehumidifier (compressor)	10L/day	290	2
EcoAir DD1	Dehumidifier (desiccant)	7.5L/day	300-580	2
Honeywell TPFIT	Dehumidifier (compressor)	12L/day	210	2.5
MeacoDry Arete One	Dehumidifier and air purifier (compressor)	12L/day	151	2.5
MeacoDry Arete One	Dehumidifier and air purifier (compressor)	20L/day	216	4.8
MeacoDry ABC	Dehumidifier (compressor)	12L/day	165	2.6
Russell Hobbs RHDH1001B	Dehumidifier (compressor)	10L/day	340	2

Table 2.26 Specifications for dehumidifiers based on data from manufacturers and retailers' websites

[43] How does a dehumidifier work?, Which?, (2 Jul 2024), https://www.which.co.uk/reviews/dehumidifiers/article/how-does-a-dehumidifier-work-aynpr9t2A2ku (Accessed 22 July 2024)

A range of different dehumidifiers have been tested and reviewed by the Independent[44]. This considers factors such as ease of use, size of water tank and whether it includes an air purifier.

The electricity consumption of a dehumidifier depends on the temperature and level of relative humidity (%RH) in the room. Power rating values published by manufacturers and retailers normally use the electricity consumption at 20°C and 60% relative humidity which are typical conditions. There is a significant increase in electricity consumption as the room temperature increases from 10°C to 30°C with a smaller increase in consumption as the %RH increases. This is illustrated in data published by Meaco for the MeacoDry Arete One 12L dehumidifier and air purifier which is shown in table 2.27.

It should be noted that although this and other devices are rated as 12 litre appliances, they will only achieve this under conditions such as 30°C room temperature and 80% RH which will be rare in the UK. Under more typical conditions of 20°C and 60%RH the device is rated to remove up to 5.23 litres per day. There may be circumstances where it is used in a particularly damp room where the relative humidity might reach 80% or more. Here the maximum water withdrawal could reach 8.33 litres per day at 20°C. However, as the dehumidifier operates, it is likely that the %RH will fall. As a result of the lower volumes of water collected in practice, it makes sense for 12L rated devices to have 2 – 2.5L water tanks. This could be enough for 8 to 10 hours of operation at 20°C and 60% RH.

Room conditions	Maximum water withdrawal	Power consumption (W)
10°C and 60% RH	1.95 litres per day	130
20°C and 60% RH	5.23 litres per day	151
30°C and 60% RH	8.21 litres per day	186
10°C and 80% RH	3.77 litres per day	131
20°C and 80% RH	8.33 litres per day	157
30°C and 80% RH	12.18 litres per day	198

Table 2.27 Extraction rate and power consumption at different temperatures and levels of relative humidity for a MeacoDry Arete One 12L dehumidifier and air purifier[45]

[44] IndyBest, 13 best dehumidifiers to help tackle damp and mould at home, The Independent, https://www.independent.co.uk/extras/indybest/house-garden/household-appliances/best-dehumidifier-uk-b1987947.html (Accessed 23 Jul 2024)
[45] Extraction rate data, MeacoDry Arete One 12L Dehumidifier/Air Purifier, https://www.meaco.com/products/meacodryarete1-12l (Accessed 23 Jul 2024)

Drying laundry with a dehumidifier and a fan

If you are drying laundry in the house use of a dehumidifier will help reduce the humidity in the air and speed up the drying process. Many dehumidifiers have a dedicated laundry mode to assist in drying washing. Here the device may operate at full fan speed and aim to reduce the %RH to a low target level of 35% or turn off after 6 hours.

Figure 2.28 Tefal 14-inch fan rated at 45W

There is potential to combine using a dehumidifier with a heated rail clothes airer. However, there could be a consumption of 150 – 200W from the dehumidifier and 230 – 330W from the heated rail clothes airer. Over 5 hours this could add up to 5kWh, a similar consumption to a vented or condenser tumble drier.

An alternative is to use an unheated clothes horse and place the dehumidifier at one end and a fan blowing air across the clothes at the other end[46]. Laundry dries quicker if there is a good air flow past it. Pedestal or table-top fans which are 14 or 16-inch diameter (36 or 41cm) can provide a high air flow while using relatively low power.

We tested a Tefal 14-inch diameter table-top fan which like many of a similar size is rated at 45W. The fan had 3 speed settings and on the lowest used 23W. On medium fan speed it used 32W while on the highest setting it consumed 42W.

The fan provided a high rate of air flow on the high-speed setting and significantly reduced the drying time for the laundry. We found it was possible to dry a mixed load of laundry in about 6 hours with a dehumidifier and fan running at full speed. Meaco also suggested drying the laundry in a smaller room which is likely to make it easier for the dehumidifier to reduce the level of relative humidity in the room[46].

The following section shows results from testing several different models of dehumidifier with a Shelly Plus smart plug. These tests were typically carried out while drying laundry, often with a fan blowing air over the laundry towards the dehumidifier.

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46 How to save nearly £300 a year when drying your laundry with a MeacoDry Arete One Dehumidifier, https://www.youtube.com/watch?v=mx1OL4GE4tg (Accessed 23 Jul 24)

Testing different models of dehumidifiers

Devola DV12L

The Devola DV12L is a dehumidifier capable of extracting 12 litres of water per day from the air at 30°C and 80% relative humidity. The rated power consumption published is 185W which is likely to be recorded at 20°C and 60%RH. There is a 2-litre water tank[47].

Several tests were carried out with the Devola DV12L using Shelly Plus smart plugs recording data at 1-minute intervals and also with the Tinytag View 2 lead recording 1-second interval consumption. The Tinytag View 2 data showed that there was a short spike in consumption when the dehumidifier compressor started up as for the compressor with heat pumps.

Figure 2.29 shows a plot of the average consumption of the Devola DV12L over a period of 9 hours. The dehumidifier was using laundry or continuous mode which meant it was set to continuously operate with a high fan speed. It was not possible to set the unit to stop working at a particular level of relative humidity in this mode.

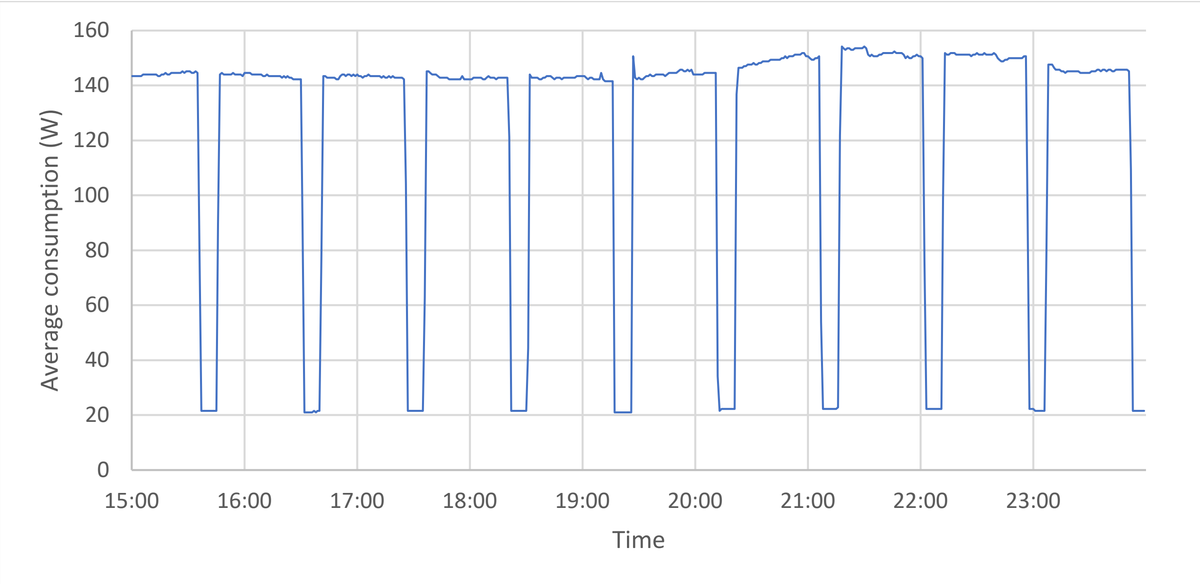

Figure 2.29 Plot of average consumption per minute measured with the Shelly Plus smart plug for the Devola DV12L dehumidifier using laundry mode

The graph shows that the Devola DV12L went through cycles of running at full power for 45 minutes. After this, the power would drop to about 20W for 10 minutes before running again on full power for a further 45 minutes. This behaviour was due to the compressor being turned off every 45 minutes followed by just the fan running for 10 minutes in a regular cycle.

It is apparent that the electricity consumption was higher between 20:30 and 23:00. The heating came on in the room from 20:30 to 23:20 raising the temperature from about 15°C to 19°C. As noted earlier (see table 2.27), the electricity consumption of a dehumidifier is higher

[47] Devola 12L compressor dehumidifier, with dust-proof filter – DV12L, https://www.devola.co.uk/products/devola-12l-compressor-dehumidifier-with-dust-proof-filter-dv12l (Accessed 23 Jul 2024)

at higher temperatures. It should be noted that the laundry should also dry quicker at higher temperatures.

At the start of the test, the Devola DV12L was using 142-144W during the peaks while the compressor was running. However, by 21:30 the consumption had risen to 154W due to the warmer room temperature.

Over 9 hours of the test from 15:00 to 00:00, the Devola DV12L consumed 1.11kWh or an average of 123.5W. Over the full 9.5-hour test, the device collected about 1.55 litres of water. 5 further tests were conducted for durations between 4 and 8 hours and the average consumption during these tests was between 124.8W and 128.6W.

A further test was carried out using low fan speed mode. The graph had the same characteristics as figure 2.29 running in laundry mode, with 45 minutes running at full power followed by 10 minutes with the compressor turned off. The electricity consumed after the first 8 hours was 0.989kWh or an average of 123.65W over the 8-hour period. Peak electricity consumption was between 140W and 150W. During the full 8-hour 18-minute test, the dehumidifier collected about 0.9 litres of water. This was lower that for some tests of similar length with the high fan spend. Using the lower fan speed seemed to significantly reduce the moisture collected while the electricity consumption decreased only a small amount.

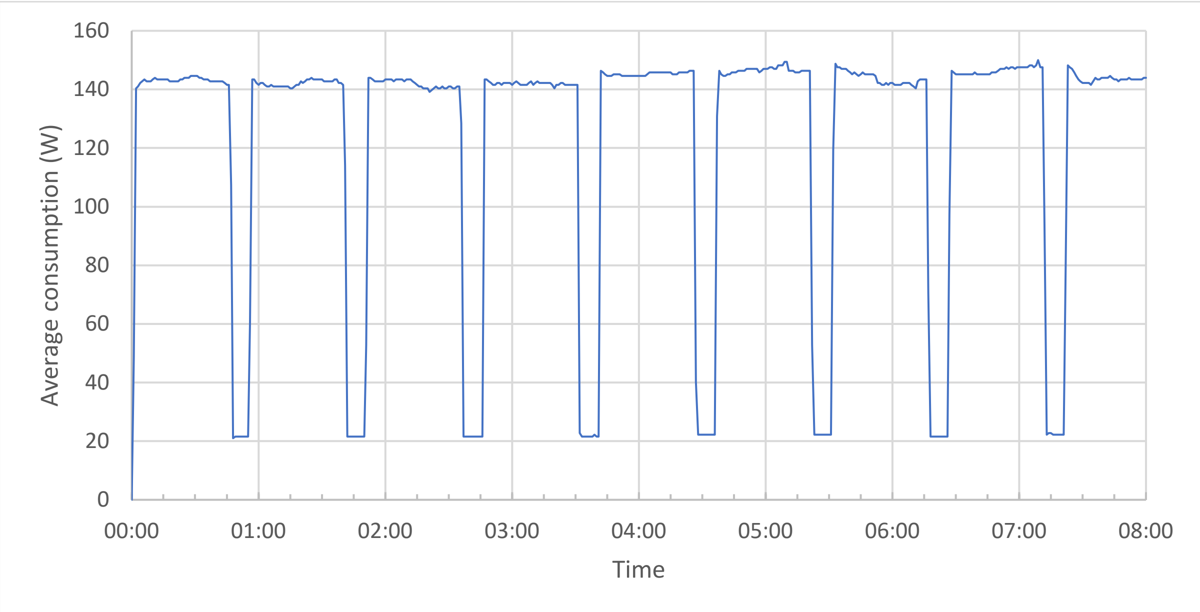

Figure 2.30 Plot of average consumption per minute measured with the Shelly Plus smart plug for the Devola DV12L dehumidifier using low fan speed mode

The technical specification for the Devola DV12L suggests a power consumption of 185W. However, during tests the maximum consumption was in the range 140 to 158W. Over longer-term testing, the average consumption of the dehumidifier was 124 – 128W due to the compressor turning off for 10 minutes every 45 minutes. The device was effective at decreasing moisture while having a low running cost.

MeacoDry ABC 12L

The MeacoDry ABC 12L has a rated power consumption of 165W at 27°C and 60% relative humidity. The water tank has a capacity of 2.6 litres. Further details of the extraction rate and power consumption are shown in table 2.31 using data from the Meaco website.

It is apparent that the fan speed has little impact on the power consumption. However, the water collected by the dehumidifier is significantly lower when using the low fan speed rather than the high fan speed. The only benefit of the low fan speed is likely to be a reduction in the level of noise from the unit.

As noted before, the power consumption increases significantly as the temperature increases from 10°C to 30°C. As the relative humidity increases, there is a small increase in power consumption. The maximum amount of water that can be extracted from the air at a given level of relative humidity increases with temperature.

Room conditions	Maximum water withdrawal	Power consumption (W)
10°C and 60% RH	1.88 litres per day (high fan) 1.04 litres per day (low fan)	125W (high fan) 124W (low fan)
20°C and 60% RH	5.18 litres per day (high fan) 4.61 litres per day (low fan)	149W (high fan) 148W (low fan)
30°C and 60% RH	8.24 litres per day (high fan) 7.32 litres per day (low fan)	185W (high fan) 185W (low fan)
10°C and 80% RH	3.73 litres per day (high fan) 2.62 litres per day (low fan)	128W (high fan) 127W (low fan)
20°C and 80% RH	8.31 litres per day (high fan) 7.21 litres per day (low fan)	157W (high fan) 157W (low fan)
30°C and 80% RH	12.1 litres per day (high fan) 10.5 litres per day (low fan)	204W (high fan) 202W (low fan)

Table 2.31 Extraction rate and power consumption at different temperatures and levels of relative humidity for a MeacoDry ABC 12L dehumidifier[48]

The consumption of a MeacoDry ABC 12L dehumidifier was also measured while drying washing. Figure 2.32 shows a plot of average power consumption over a test which lasted 6 hours. Unlike the Devola DV12L, the MeacoDry ABC 12L ran continuously over the period of the test. On startup it initially reached an average power consumption of 140W. Over the course of the test the consumption varied, with increases likely to be due to heating in the room. The maximum consumption was 160W which occurred 1 hour after the heating was turned on. Over the 6-hour test, the consumption was 0.93kWh or an average of 155W.

[48] Extraction rate data, MeacoDry ABC 12L Dehumidifier, https://www.meaco.com/products/meacodry-abc-range-12l-dehumidifier (Accessed 23 Jul 2024)

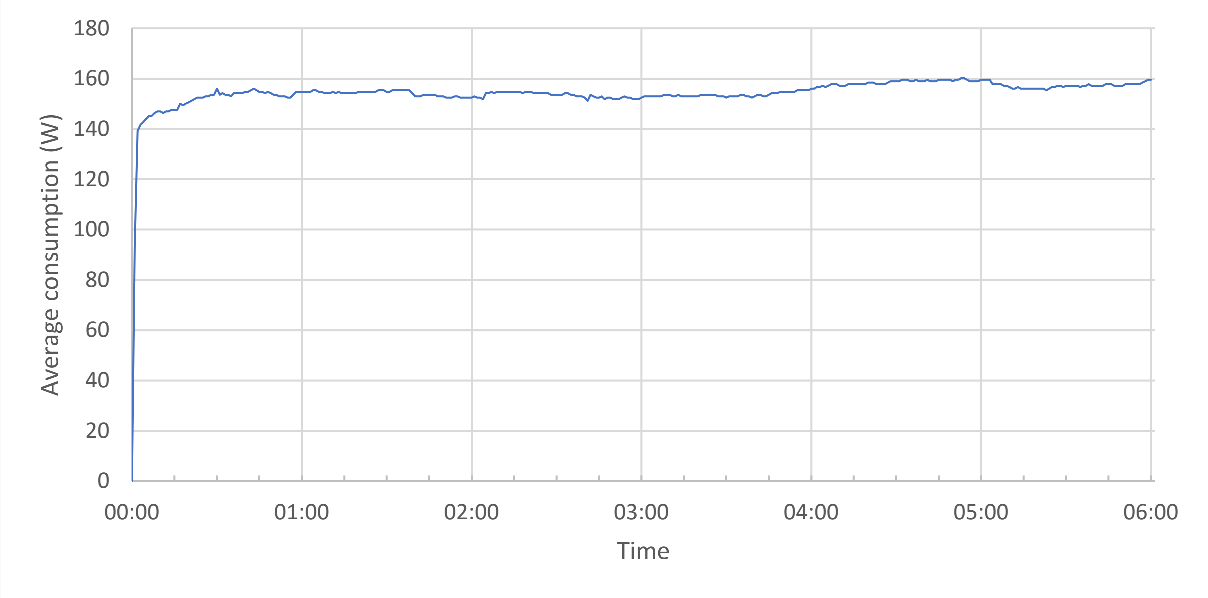

Figure 2.32 Plot of average consumption per minute measured with the Shelly Plus smart plug for the MeacoDry ABC dehumidifier in laundry mode

Figure 2.33 MeacoDry ABC dehumidifier

The water tank collected 1.45 litres over the 6 hours of the test. This suggests 5.8 litres could have been collected over a full day which is between the 5.18 and 8.31 litres/day which table 2.31 suggests is the maximum extraction rate in a room at 20°C and between 60 and 80% relative humidity. During the test however, the room temperature was lower than 20°C at between 17 to 19°C, reducing the amount of water that could be extracted.

The average power consumption measured of 155W is lower than the rate of 165W which is normally published for the device. This is because the value published in most technical specifications is for a room temperature at 27°C and 60%RH which was a higher temperature than during our test and in most homes.

Comparing the average measured with the more in-depth data from Meaco in table 2.31, these values are comparable to or slightly lower than the average value of electricity consumption that we measured.

MeacoDry Arete One 20L

We were able to also test a MeacoDry Arete One 20L dehumidifier and air purifier. In this case we provided a Shelly Plus smart plug to a household living in a stone cottage who started to regularly use the dehumidifier in a damp room. The north facing exterior wall in the room needed to be cleaned once a week due to mould despite heating and ventilating the room.

The dehumidifier was used each day or every other day during the colder weather, typically for up to 4 hours. Since using the dehumidifier, the resident noted that the mould had not returned and the room temperature had increased by several degrees Celsius. The temperature rise was likely to be due to it being easier to heat drier air than damp air. The water tank which has a capacity of 4.8 litres was often over half full by the time the dehumidifier was turned off. The device was used on 19 days in April 2024 and consumed a total of 10.9kWh during the month.

A plot of average electricity consumption over a 4-hour run time is shown in figure 2.34 for the MeacoDry Arete One 20L dehumidifier and air purifier. Over the 4-hour period, the device consumed 0.94kWh with an average of 235.1W. The device took about 10 minutes to warm up and for the consumption to reach 231W. Over the course of the test, the maximum consumption was 242W.

The MeacoDry Arete One 20L dehumidifier and air purifier is a more powerful device than the 12L dehumidifiers previously tested and so the electricity consumption is expected to be higher. Data from the Meaco website on extraction rate data suggests the power consumption was likely to be 225W in a room at 20°C and 80% relative humidity. During this test the average power consumption was higher at 235W. It was unlikely that the room temperature was higher than 20°C during the test.

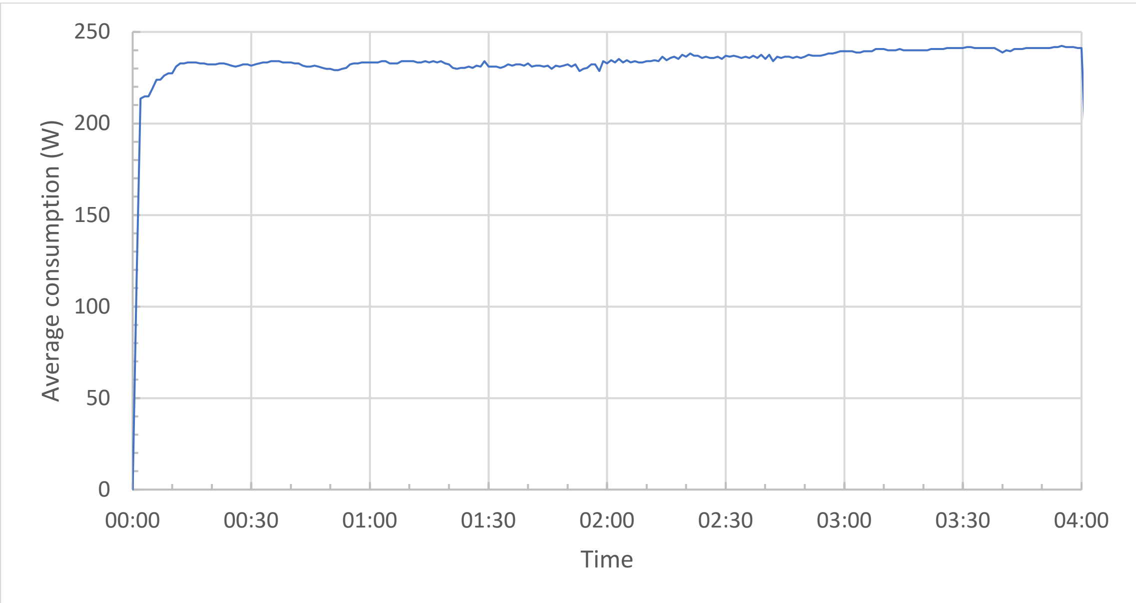

Figure 2.34 Plot of average consumption per minute measured with the Shelly Plus smart plug for the MeacoDry Arete One 20L dehumidifier and air purifier operating in a damp room

Argos MDT-10DMD3

The Argos MDT-10DMD3 is an older dehumidifier which has a maximum extraction rate of 10 litres/day at 30°C and 80% relative humidity. The rated input power is 220W. The device did not have a display showing the relative humidity or a range of control settings as other devices that were tested.

The electricity consumption of this dehumidifier was monitored by one of our team members while drying laundry. The device was running for a total of 17.5 hours. For most of the first 10 hours, the power consumption was periodically reducing as for the Devola DV12L. This was largely in a cycle of 15 minutes with the compressor running and about 9 minutes with just the fan running. For the last 8 hours, the compressor was running continuously.

Over the full 17.5-hour test period, the electricity consumption was 2.62kWh. During the last 7.5 hours, the consumption was 1.37kWh with an average consumption of 182.2W. This was lower than the rated power input of 220W. This might be due to the rated power being measured at a higher temperature such as 27 or 30°C.

Over the full period of the test, the average consumption was 149.5W

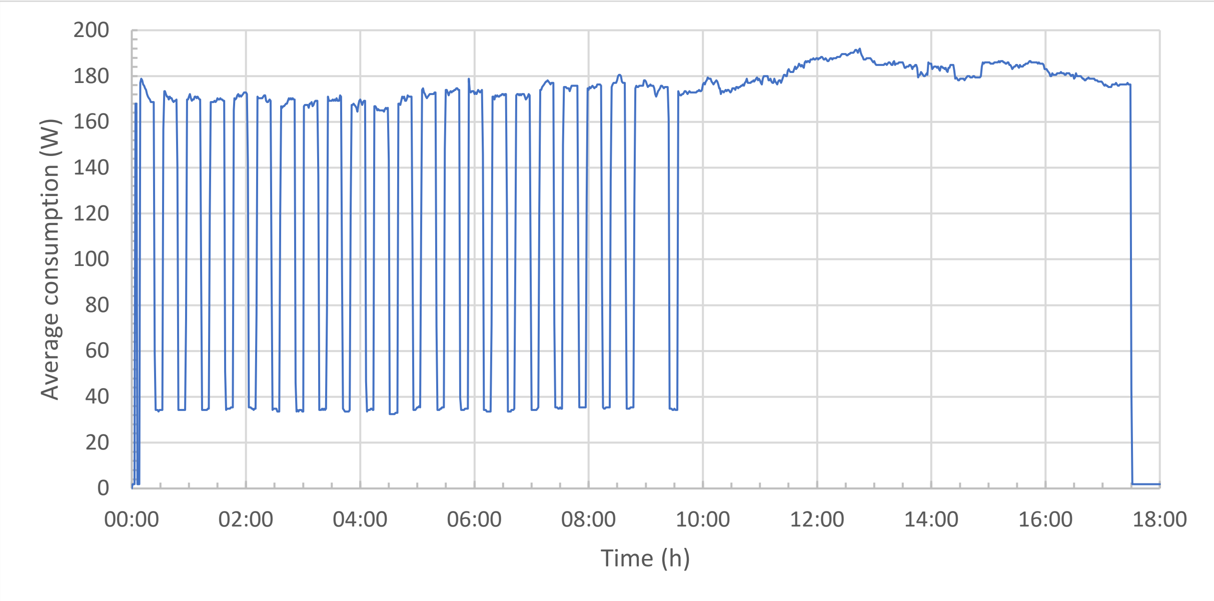

Figure 2.35 Plot of average consumption per minute measured with the Shelly Plus smart plug for the Argos MDT-10DMD3 10L dehumidifier

Cosihome CH-D01

The Cosihome CH-D01 is another dehumidifier with a maximum extraction rate of 12 litres per day. The rated power is 190W[49]. Like most other models, it has a humidistat. A target level of relative humidity can be set or it can run in continuous dehumidification mode.

Figure 2.37 shows a plot of average consumption over a test of 6 hours with laundry and a fan. There was limited variation in the average consumption over the test after the first 15 minutes. This was likely to in part be due to there being no change in heating in the room during the test. This contrasts with the test in figure 2.29 with the Devola DV12L where the room was heated during part of the test.

Figure 2.36 Cosihome CH-D01 dehumidifier

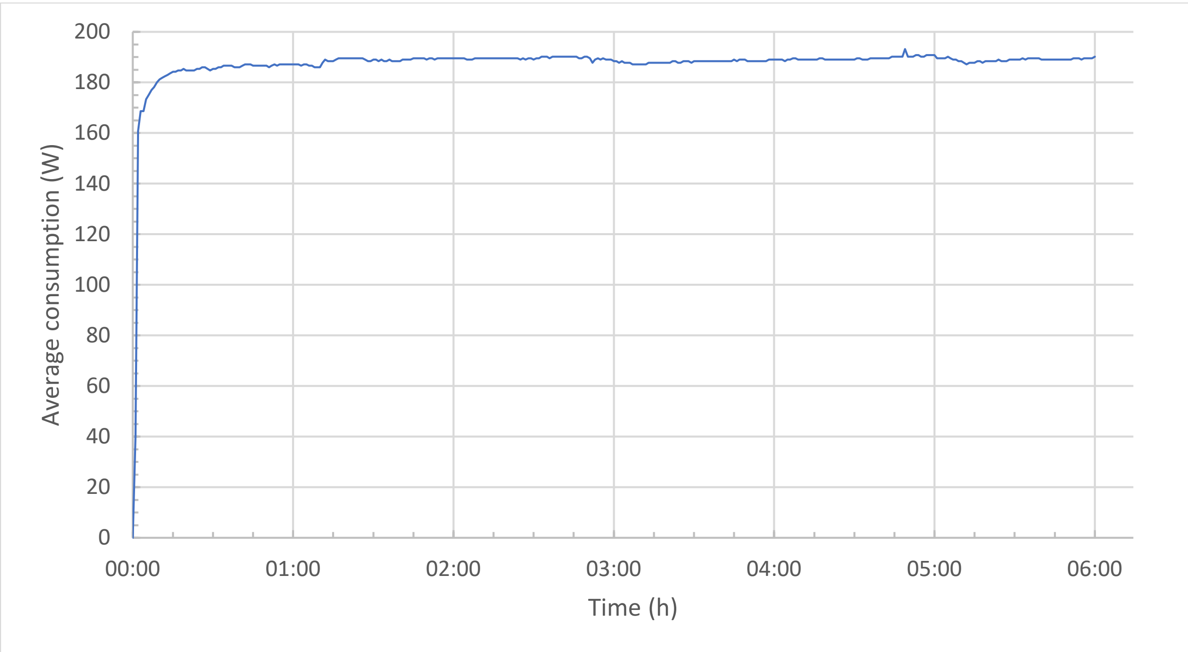

Figure 2.37 Plot of average consumption per minute measured with the Shelly Plus smart plug for the Cosihome CH-D01 12L dehumidifier

[49] Cosihome CH-D01 instruction manual, One Retail Group (2023), https://cdn.shopify.com/s/files/1/0754/9249/1578/files/CH-D01_Instruction_Manual__UK_EU__FEB_23_FINAL_v3.pdf?v=1682588427 (Accessed 24 Jul 2024)

Over the 6-hour test, the electricity consumption was 1.13kWh with an average of 187.8W. There were 1.4 litres of water collected over the period. A test under similar conditions was carried out several weeks earlier and here the consumption was 1.16kWh over 6 hours with an average of 193.4W. The volume of water collected was lower at 1.125 litres. The average consumption was about 190.6W which was close to the 190W rated power provided by the manufacturer.

A further shorter 4-hour test was carried out where the fan on the dehumidifier was running at low speed. Over the test, the electricity consumption was 0.749kWh with an average power consumption of 187.3W. The impact of the fan speed on the electricity consumption of the dehumidifier was low. However, over the 4-hour test, the device only collected 0.575 litres of water or about 3.45 litres per 24 hours compared to 4.5 and 5.6 litres per 24 hours on the other 2 tests at full fan speed. A low fan speed is therefore likely to reduce the amount of water collected by the dehumidifier.

Summary

- When drying laundry indoors, it is recommended that you ventilate a room or use a dehumidifier
- The laundry will dry faster if a fan blows air from one side of the clothes horse towards the dehumidifier on the other side
- There are dehumidifiers that operate with a compressor/refrigerant and others which use a desiccant which is regenerated after being heated – dehumidifiers using a compressor are less expensive to buy and to run
- The electricity consumption of a dehumidifier increases as the room temperature increases
- The amount of water collected by the dehumidifier also increases as the room temperature increases
- Common domestic dehumidifiers may be described at 12-litre or 20-litre models – these volumes of water would only be extracted at 30°C and 80% relative humidity; at lower temperatures the amount of water collected will be lower
- Some dehumidifiers may regularly turn off the compressor for short periods (such as 10-minutes) – this will lower the average electricity consumption but also affect the amount of water collected
- Many 12-litre rated dehumidifiers have an electricity consumption of 140 to 200W; higher rated dehumidifiers can use more electricity such as 200 – 300W
- Altering the dehumidifier fan speed from high to low has a marginal impact on electricity consumption but leads to a more significant reduction in moisture collected

2.4 Refrigerators and freezers

There are a variety of cold appliances on the market and in people's homes. There are stand-alone refrigerators which may or may not have a small 'ice box'. There are fridge-freezers combined in one appliance with separate doors. There are also upright freezers with a small lid on the top as well as chest freezers with a larger lid. Small separate fridges and freezers can be undercounter. In recent years, they are more commonly integrated into a fitted kitchen.

Cold appliances accounted for about 16.2% of the electricity consumption of households without electric heating in the Household Energy Survey carried out in 2010/2011[50].

The average consumption of refrigerators among all households in the survey was measured to be 162kWh. For fridge-freezers it was 427kWh, while it was 327kWh for upright freezers and 362kWh for chest freezers.

Figure 2.38 Integrated fridge-freezer, (Pexels, Polina Tankilevitch)

Data derived by the Department for Energy Security and Net Zero (DESNZ) through modelling estimated that there were 37.8 million cold appliances owned by households in the UK in 2022. Out of these cold appliances, 54.5% were estimated to be fridge-freezers. The estimated electricity consumption of the cold appliances was 9.8GWh[51].

Figure 2.39 shows a plot of average consumption per appliance for cold appliances between 1995 and 2022. This was produced using a similar methodology to Brooks and Roy from published estimates of numbers of cold appliances and their energy consumption[51] [52]. This suggests there have been significant reductions in the electricity consumption of fridges and freezers over the last 25 years. Factors which have contributed to this are improved insulation, more energy efficient compressors and motors as well as the switch to LED lighting. However, in recent years, more households have been purchasing American-style larger fridge-freezers which typically have a higher electricity consumption than smaller models.

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[50] Household Energy Survey – A study of domestic electrical product usage, Intertek Report R66141, (2012) (https://www.gov.uk/government/publications/household-electricity-survey--2 (Accessed 24 July 2024)

[51] Energy Consumption in the UK (ECUK): Final Energy Consumption Tables, Electrical Products data tables, (2023) https://www.data.gov.uk/dataset/26afb14b-be9a-4722-916e-10655d0edc38/energy-consumption-in-the-uk (Accessed 24 Jul 2024)
[52] Brooks and Roy (2021), Fridge 2050 – The future of large domestic appliances, City University of London, https://www.city.ac.uk/__data/assets/pdf_file/0006/674709/Fridge-2050-The-Future-of-Large-Domestic-Appliances.pdf (Accessed 24 Jul 2024)

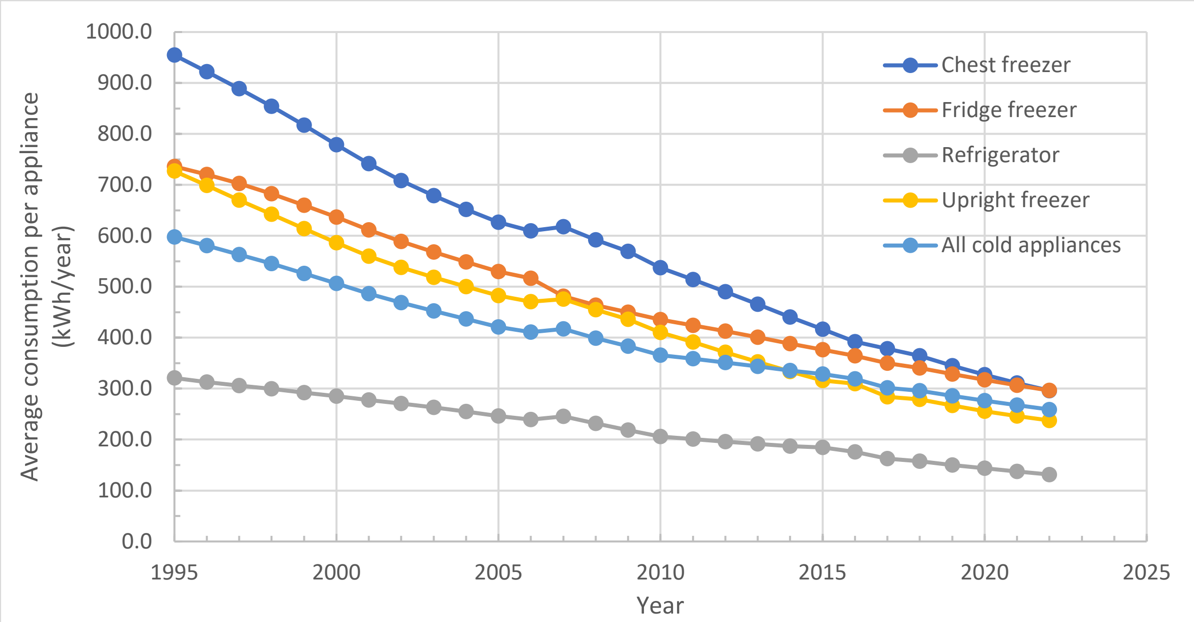

Figure 2.39 Plot of average consumption per appliance between 1995 and 2022 using estimates of numbers of appliances and electricity consumption from the appliance type[51 52]

Table 2.40 shows details of a range of different fridge-freezers on the market at the time of writing. This data was obtained from manufacturer's and retailer's websites. The table shows fridge-freezers with models across the range of energy efficiencies from A-rated to F-rated.

However, while more energy efficient models are available, they are smaller in number and higher priced. Checking the Currys website showed there were 10 A-rated fridge-freezers being sold at the time of writing along with 3 B-rated models. There were however 73 D-rated and 350 E-rated fridge-freezers. Prices for the A-rated models were in the range £700-£1700. In contrast small E-rated fridge-freezers were available starting from £150-£200[53].

The Bosch KGN39AIAT fridge-freezer with an energy efficiency rating of A has an energy consumption of only 104kWh/year. The F-rated Beko CF1685 fridge-freezer has an annual consumption of 314 kWh which is three times more despite having a smaller fridge. A difference in annual consumption of 210kWh would cost £42/year for an electricity unit rate of 20p/kWh, £52.50 for a 25p/kWh unit rate and £63 if the unit rate was 30p/kWh.

The highest energy consumption in table 2.40 of 430kWh/year was for the LG GSLV71MCTF which had an F energy efficiency rating. This was an American-style fridge-freezer with a 416-litre fridge and 219-litre freezer. At the time of writing, Currys were selling 143 fridge-freezers which they classed as American-style, with 114 of these E-rated.

There are more energy efficient larger and American-style fridge-freezers available. The Hissense RS818N4TIC is C-rated and has a similar sized fridge and freezer to the LG GSLV71MCTF. The annual energy consumption is 221kWh/year, almost half that of the F-rated LG model.

[53] Currys, https://www.currys.co.uk/appliances/refrigeration/fridge-freezers (Accessed 25 Jul 2024)

Manufacturer and model	Type of appliance	Energy efficiency rating	Energy consumption (kWh/year)	Fridge storage volume (L)	Freezer storage volume (L)
Bosch Series 6 KGN39AIAT	Fridge Freezer	A	104	260	103
Haier HDPW5620ANPD	Fridge Freezer	A	114	289	120
LG GBP52YNBN	Fridge Freezer	B	137	277	107
Hisense RB470N4SFCUK	Fridge Freezer	C	169	255	106
Hisense RS818N4TIC	American	C	221	417	215
Haier HDW5618DWPK(UK)	Fridge Freezer	D	214	232	117
Haier HSR5918DNMP	American	D	256	337	191
Samsung RB33B610ESA/EU	Fridge Freezer	E	254	230	114
Samsung RS68CG853ES9/EU	American	E	351	409	225
Beko CF1685	Fridge Freezer	F	314	233	101
LG GSLV71MCTF	American	F	430	416	219

Table 2.40 Energy performance of different models of fridge freezers

Older fridge-freezers purchased before March 2021 will have energy efficiency ratings based on the old labelling scheme with the most energy efficient being A+++ rated.

We analysed the electricity consumption of several cold appliances using Shelly Plus smart plugs. There are risks doing this as it is possible for the smart plug to turn a device off, either by accident or a technical issue. This is more serious if a freezer is turned off by the device.

Testing of different models of cold appliances

Beko K54299H/B725U fridge-freezer

The Beko fridge-freezer tested was about 10 years old and was A+ rated under the old energy rating label. It had a 142-litre fridge and 87-litre freezer which was frost free. The rated power for the device was 80W. Since this model was purchased, the fridge size of most fridge-freezers on the market has increased significantly. The fridges in table 2.38 are 60 to 200% larger than for the Beko model. Freezer sizes have not expanded as much with many about 20% larger while the freezer in an American-style fridge-freezer can be 150% larger.

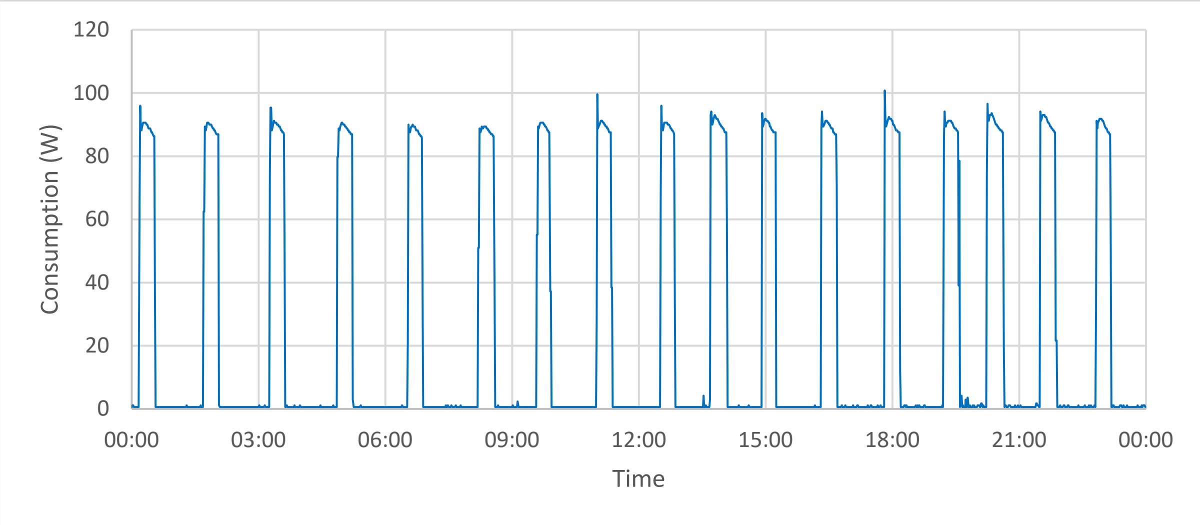

Figure 2.41 Plot of average consumption per minute measured with a Shelly Plus smart plug for the Beko K54299H/B725U fridge-freezer on 8 Feb 2024

Figure 2.41 shows a plot of average electricity consumption of the Beko fridge-freezer over a single day. The compressor for the fridge-freezer ran in a series of 17 cycles over the day. After an initial higher peak due to the compressor starting up, the fridge-freezer typically used 87-90W while the compressor was running. This was higher than the rated power of 80W for the device. The baseload consumption was 1W or less, but the consumption increased to 16W when the fridge door was opened due to the fridge light. More modern fridges have more energy efficient LED lighting. The electricity consumption over the day was 0.56kWh.

The compressor cycles were normally about 22 minutes long. The period between cycles was affected by how often the door of the fridge or freezer was opened. Overnight, the period between cycles was up to 1 hour 18 minutes. However, it fell to about 50 minutes after lunch and 38 minutes after cooking an evening meal.

For days of normal use of the fridge-freezer, the consumption was in the range 0.53-0.59kWh. However, during a weekend away, the daily consumption fell to 0.43kWh and while on holiday for a couple weeks, the daily consumption was between 0.35 and 0.51kWh with an average of 0.41kWh. There were 11 compressor cycles on the lowest consuming day of the holiday.

Assuming an average of 0.55kWh per day, the estimated annual consumption is 201kWh.

Siemens KGNEWEAG/03 fridge-freezer

The Siemens KGNEWEAG fridge-freezer was a recent model with a 279-litre fridge and 89-litre frost-free freezer. It had an energy efficiency rating of E and the published annual energy consumption was 238kWh[54]. The connection rating was 100W/300W. The appliance had a super freezing function to quickly freeze food. The compressor will run constantly when in this mode. This leads to lower freezer compartment temperatures than in normal operation.

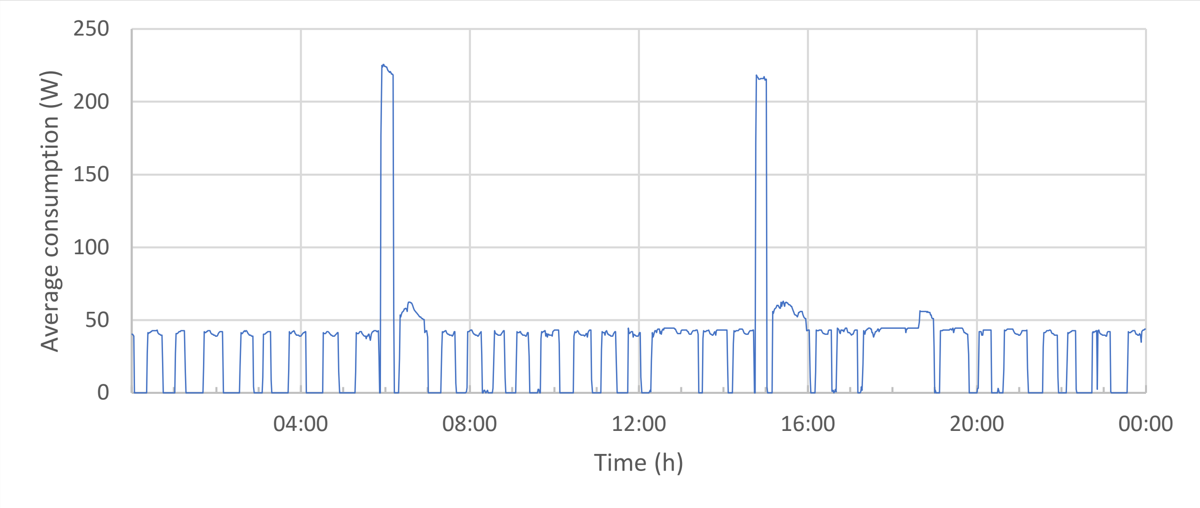

Figure 2.42 Plot of average consumption per minute measured with a Shelly Plus smart plug for the Siemens KGNEWEAG fridge-freezer on 30 May 2024

Figure 2.42 shows a plot of average electricity consumption over a day for the Siemens fridge-freezer. There were 33 consumption peaks over the 24-hour period compared to 17 for the Beko fridge-freezer in figure 2.39.

Most of the peaks had a consumption of 39-43W, about half the peak consumption for the Beko fridge-freezer. As well as there being more compressor cycles in the day, they were of variable length unlike for the older Beko appliance. While the compressor cycle for the Beko appliance was consistently about 22 minutes long, those for the Siemens could last from about 12 minutes overnight to 100 minutes in the early evening around the time of an evening meal. The Siemens appliance may have a more modern inverter driven compressor, which may account for the difference in behaviour.

There were also two peaks where the average electricity consumption was much higher. At 05:55 to 06:11, the consumption was 218-226W while from 14:46 to 15:01 it was 215-218W. These 15-minute cycles of higher consumption might have been associated with the doors of the appliance being opened and perhaps the super freezing function running for a period.

Over the full day, the consumption recorded was 0.776kWh. This was higher than for the Beko fridge-freeze which was a smaller appliance. Assuming 30 May 24 was a typical day, this

[54] Siemens KG39NEWEAG data sheet, https://media3.bsh-group.com/Documents/specsheet/en-GB/KG39NEWEAG.pdf (Accessed 25 Jul 2024)

suggests an annual electricity consumption for the appliance of 283kWh which is higher than the published value for the appliance.

Electrolux Premier ECO undercounter refrigerator

We also tested some separate fridges and freezers. One of these was an Electrolux Premier ECO undercounter refrigerator which was A-rated at the time of purchase over 10 years ago. Undercounter fridges often have a capacity of about 135 litres.

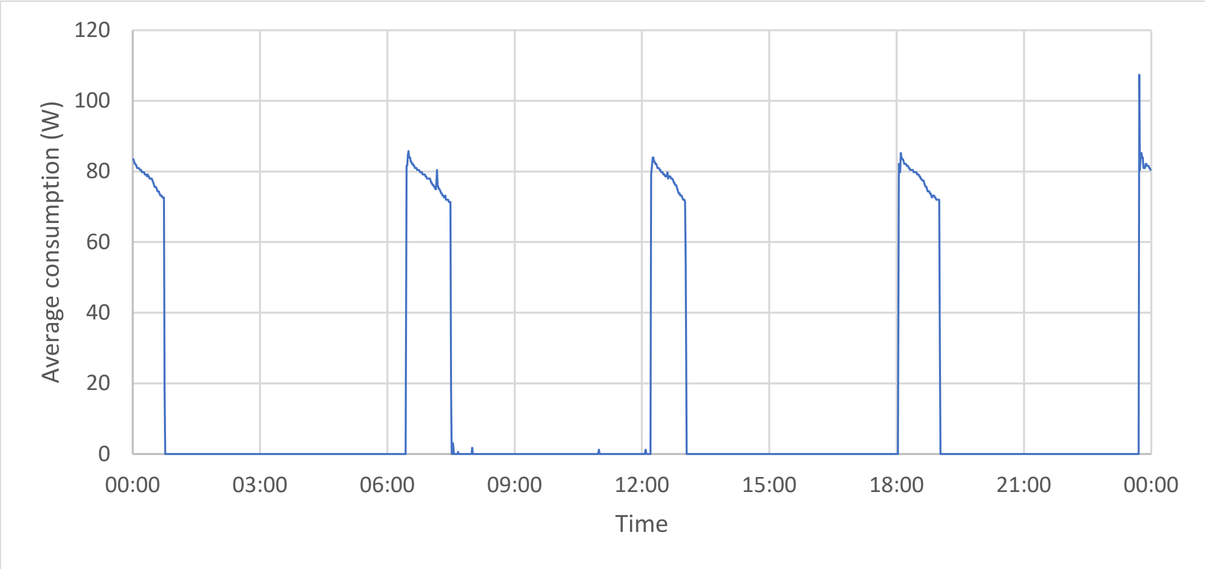

Figure 2.43 Plot of average consumption per minute measured with a Shelly Plus smart plug for the Electrolux Premier ECO undercounter refrigerator on 8 Feb 2024

A plot of the electricity consumption of the Electrolux Premier ECO undercounter fridge is shown in figure 2.43. There were only 4 peaks in electricity consumption during the day due to the fridge compressor running. These lasted between 49 minutes and 1 hour 3 minutes, with the gap between cycles ranging from 4 hours 42 minutes to 5 hours 41 minutes overnight.

At the start of the compressor cycle, the average electricity consumption was 82-86W but by the end of the cycle it decreased to 70-72W. The maximum value for consumption peaks for the Beko fridge-freezer that was tested was quite similar at 87-90W. However, with the Beko, the length of the cycles was shorter and they were more frequent.

Over the day, the Electrolux undercounter fridge used 0.305kWh. This compared to 0.326kWh on a day with similar occupancy and 0.27kWh on a day with no one at home from 08:00 to 20:00. Assuming that 8 Feb 2024 was a typical day, the estimated annual consumption could be about 111kWh. This is about the level of annual consumption for the most energy efficient A-rated appliances in table 2.40, where the fridge is likely to be about double the size and there is an additional freezer.

Electrolux Premier ECO undercounter freezer

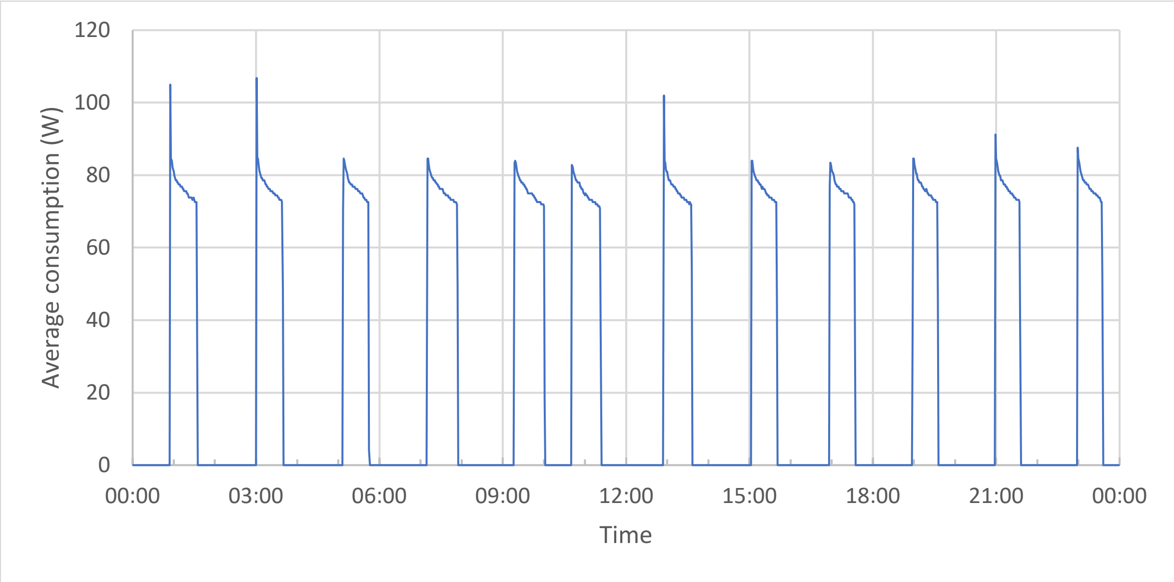

Figure 2.44 Plot of average consumption per minute measured with a Shelly Plus smart plug for the Electrolux Premier ECO undercounter freezer on 14 Feb 2024

The Electrolux undercounter freezer was purchased at the same time as the Electrolux undercounter fridge and was also A-rated. Typically, undercounter freezers have a capacity in the range 80-90 litres.

A plot of the average electricity consumption per minute is shown in figure 2.44 for the Electrolux undercounter freezer. There was a total of 12 compressor cycles on the day shown. Normally there is a short spike in electricity consumption when a compressor starts running and this can be seen at the start of several of the compressor cycles despite the data being averaged over a minute. For the first minute of the first two compressor cycles, the consumption was 105 and 107W. After that it fell initially to 85W and then to 73W by the end of the compressor cycle.

The compressor cycles were shorter than for the undercounter refrigerator at between 37 and 45 minutes. Normally the period between the compressor running was 83 to 90 minutes, however it was much shorter mid-morning with a time between cycles being only 40 minutes. This shorter time between cycles might have occurred after the freezer door had been opened.

For the day discussed, the electricity consumed by the undercounter freezer was 0.606kWh. Data from 3 earlier days showed the electricity consumption of the appliance ranging from 0.577 to 0.672kWh. The average over the 4 days was 0.624kWh/day. Assuming this average is typical of the consumption across the year, this suggested an estimated annual consumption of 228kWh. This value is slightly higher than the 10-year-old Beko fridge-freezer that was tested and about double the consumption of the A-rated fridge-freezers in table 2.40.

Currys Essentials Chest freezer

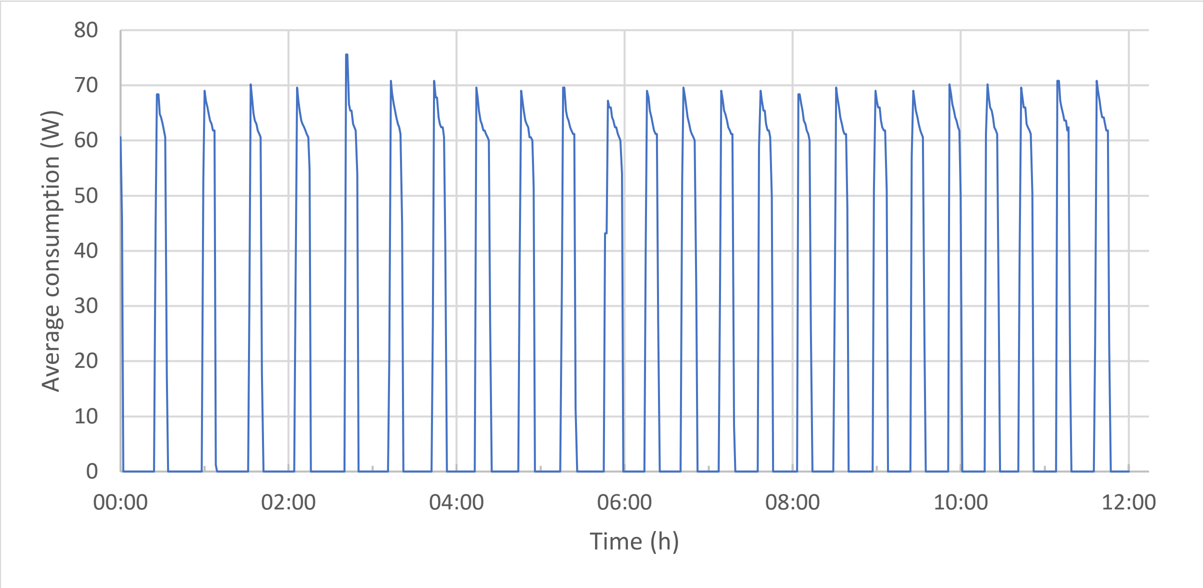

Figure 2.45 Plot of average consumption per minute measured with a Shelly Plus smart plug for a Currys Essentials 60 litre chest freezer for 12 hours on 30/31 May 2024

Figure 2.45 shows a plot of average electricity consumption over a 12-hour period for a Currys Essentials 60 litre chest freezer. For this appliance, the compressor ran in more frequent short cycles compared to the other devices tested. There were 25 compressor cycles in a 12-hour period compared to 12 cycles in a 24-hour period for the Electrolux undercounter freezer.

For this appliance, the duration of the compressor cycles was consistent through the day at about 10 minutes. The gap between cycles was normally about 17 minutes during the day, but it was 20-25 minutes for the first cycles of the test early in the morning.

The consumption over the full 24-hour period monitored was 0.513kWh, however this was over 25% higher than the rated energy consumption of 0.4kWh/day on the energy label. The consumption was however lower than for the Electrolux Premier Eco undercounter freezer also tested which used an average of 0.624kWh/day. Assuming the Currys Essentials chest freezer used an average of 0.513kWh/day across the year, this would be an annual consumption of 187kWh.

Over-consuming household cold appliances

There has been concern about some cold appliances having much higher electricity consumption than the specification for the appliance. The UK Government funded a project which included a literature review, a field trial studying about 1,000 cold appliances (with consumption data from 665) and a study of 22 cold appliances scheduled for recycling.[55]

The field trial was carried out by the Building Research Establishment (BRE) between March and November 2015[56]. Consumption data was collected from 665 cold appliances, temperature data from 938 appliances and 766 households were interviewed. The study defined 'over-consuming' appliances as having the compressor running more than 90% of the time. A 'high-consuming appliance had the compressor running 50 to 90% of the time while a 'normal' appliance was defined to have the compressor running less than 50% of the time.

The study found that 8% of the appliances were 'over-consuming' and these had an average electricity consumption of 730kWh/year. This was more than double the average of 322kWh/year for the cold appliances that were defined as 'normal' or 'high-consuming'.

Appliances were more likely to be 'over-consuming' if they were freezers (chest or upright) and if they were an older appliance (particularly if over 10 years old). The main cause of over-consumption (53% of cases) was due to how the resident used the appliance. This could be due to having the fast-freeze function running permanently or the appliances on the coldest setting. It is recommended that a fridge is kept at 4°C and a freezer at -18°C[57]. However, in the BRE trial, a freezer left on the fast freeze setting was at -33°C and used 925kWh/year.

Among the 'over-consuming' appliances in the trial, 47% had at least one technical fault. Issues included: a faulty thermostat (affecting temperature control), damage to the door seal or hinge (allowing greater infiltration), insulation breakdown (increasing transmission of heat) and damage to the refrigeration system (issues with the compressor or loss of refrigerant).

In addition to mechanical faults with the appliance, problems were also noted due to the location of the appliance. This could be due to being too close to the wall, causing insufficient air flow around the condenser at the back of the appliance. There can also be problems due to being close to a source of heat or in a small unventilated room.

The study noted that low-income households were more likely to have an over-consuming appliance and less able to get a replacement. Education on the correct use of cold appliances was important.

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[55] Department for Energy Security and Net Zero (2017), Study of over-consuming household cold appliances, https://www.gov.uk/government/publications/study-of-over-consuming-household-cold-appliances (Accessed 26 Jul 2024)

[56] Study of Over-Consuming Household Cold Appliances, Field Trial Report (BRE, 2017), https://assets.publishing.service.gov.uk/media/5a806a5340f0b623026935f9/Cold_appliances_field_trial_report_FINAL_230117__2_.pdf (Accessed 26 Jul 2024)

[57] What is the optimal temperature in the refrigerator/freezer? (AEG, 2023), https://www.aeg.co.uk/support/support-articles/cooling/fridge-freezers/what-is-the-optimal-temperature-in-the-refrigerator-freezer/ (26 Jul 2024)

Summary

- Households have a variety of different cold appliances with fridge-freezers the most common, but there are also separate appliances which may be integrated or undercounter
- There has been an improvement in the energy efficiency of cold appliances over the last 25 years, but a trend in larger appliances has limited the reduction in electricity savings
- Energy efficiency ratings for cold appliances from March 2021 are between A and G
- The most energy efficient A-rated appliances can have energy consumptions of just over 100kWh/year, but there are fewer models available on the market and they have a higher price
- Larger American-style fridge-freezers are becoming more common and can have a consumption of over 400kWh/year but more energy efficient versions are available
- A number of different models of cold appliances were tested with smart plugs and these showed the compressor for the appliance to run periodically throughout the day
- The peak in consumption for the appliances was typically 80-90W but the number of compressor cycles and their duration varied between appliances
- An Electrolux undercounter fridge had only 4 consumption peaks in the day which lasted 50-60 minutes while a separate chest freezer had about 50 compressor cycles in a day each lasting 10 minutes
- The consumption varied significantly with household behaviour; a Beko fridge-freezer had a consumption of 0.53-0.59kWh/day on days of normal activity but fell to an average of 0.41kWh/day during a period with the resident away on holiday
- A modern Siemens fridge freezer with a larger fridge used 0.78kWh/day compared to the 10-year old Beko model which used about 0.55kWh/day
- An Electrolux undercounter fridge used 0.31kWh/day while an Electrolux undercounter freezer used 0.62kWh/day
- The Electrolux undercounter freezer used more electricity than the Beko fridge-freezer and also a chest freezer which used 0.51kWh/day
- There is an issue with over-consuming cold appliances which are defined as those where the compressor runs for more than 90% of the time
- A study by BRE found 8% of cold appliances in a field trial were over-consuming
- Just over half of the problems with these appliances were due to use of the appliance by the resident such as leaving fast freeze on or running the appliance on the coldest setting
- Just under half of the over-consuming appliances had at least one fault; these included a faulty thermostat, damaged door seal or hinge, insulation breakdown or faulty refrigeration system
- The location of the appliance can affect performance and issues like having the appliance too close to the wall or near a source of heat can lead to higher consumption
- An appliance was more likely to be over-consuming if it was a freezer (chest or upright) or over 10 years old
- Lower income households are more likely to have an over-consuming cold appliance and are less able to replace it

2.5 Cooking

In the Household Electricity Survey carried out among 251 households in England from May 2010 to July 2011, cooking made up 13.8% of the electricity consumption of the households without electric heating[58].

There has been great interest in energy efficient cooking since the energy crisis began in 2021/22. Air fryer sales soared with these considered a more energy efficient alternative to ovens. In September 2023, The Independent noted that annual sales of air fryers from Lakeland were up 1,175% on the previous year.[59] There have been many articles on energy efficient cooking appliances and ways of cooking in the last couple of years[60] [61].

In addition to air fryers, other appliances advertised as being energy efficient include microwaves, grills and steamers. Many of the articles assume that the appliance runs at its power rating for the full time it operates. This is the case for some appliances but not all. There are further complications where an appliance like a microwave is described as being 800W but that is the power for heating the food and not the electricity consumed by the appliance.

This section will discuss the electricity consumption of cooking appliances with results from testing different appliances with Shelly Plus smart plugs and Tinytag View 2 loggers.

[58] Household Electricity Survey – A study of domestic electrical product usage, Intertek Report R66141, https://www.gov.uk/government/publications/household-electricity-survey--2 (Accessed 29 Jul 24)
[59] Air fryer sales continue to soar as households look to save energy – Lakeland, 14 Sep 2024, The Independent, https://www.independent.co.uk/news/uk/britons-sales-b2411104.html (Accessed 29 Jul 2024)
[60] How much could you save by not using your oven?, BBC Food, March 2022, https://www.bbc.co.uk/food/articles/energy_saving_tips (Accessed 29 Jul 2024)
[61] 8 energy-efficient appliances out reviews experts love, 18 Nov 2022, BBC Good Food, https://www.bbcgoodfood.com/review/energy-efficient-appliances (Accessed 29 Jul 2022)

2.5.1 Ovens

There have been concerns about how expensive it is to run an oven. It makes sense to consider using another appliance if cooking a small meal for one. However, when cooking a larger meal for several people or when batch cooking, an oven may still be the best option. Beko have published a series of ways to make cooking with your oven more energy efficient[62]. These tips include:

- Cooking more than one dish at the same time
- Putting the dish straight into the oven and not waiting for it to heat up
- Turning off the oven early and allowing the residual heat to finish cooking the food
- Avoiding opening the oven door during cooking
- Defrosting the food before cooking
- Using ceramic or glass dishes rather than metal
- Keeping the oven clean and not putting aluminium foil at the bottom of the oven

Manufacturer and model	Energy efficiency rating	Capacity (Litres)	Rated power (W)	Energy consumption Conventional Mode (kWh/cycle)	Energy consumption Fan Mode (kWh/cycle)
AEG BPK74830B	A++	71	3500	1.09	0.52
Grundig GEBM1240BC	A+	72	3300	0.88	0.69
Hisense BSA65222PBUK	A+	77	3500	0.97	0.71
Beko BBXIE22300S	A	66	2400	0.88	0.79
Bosch Series 4 HBS573BS0B	A	71	2990	0.99	0.81

Table 2.46 Examples of specifications of ovens taken from manufacturer's websites

At the time of writing, the energy ratings for ovens in the EU were still based on labels adopted in 2015, with ratings between A+++ and D[63]. There was a public consultation on Ecodesign and energy labelling requirements for cooking appliances in the summer of 2023 and it is likely

[62] 9 ways to make your oven more energy efficient, Beko, https://www.beko.com/au-en/support/oven--using--article/9-ways-to-make-your-oven-more-energy-efficient (Accessed 29 Jul 2024)
[63] Domestic Ovens, Ecodesign and Energy Label, https://energy-efficient-products.ec.europa.eu/ecodesign-and-energy-label/product-list/domestic-ovens_en (Accessed 29 Jul 2024)

a new design of energy label will have ratings between A and G[64]. The current label includes information on the consumption per cycle for conventional and fan-forced convection mode.

Table 2.46 shows examples of the specification for 5 different models of oven. Power ratings for ovens can be in the range 1,800 – 3,500W. It is clear that significant savings are possible when using an oven in fan mode rather than conventional mode.

A fan oven will ensure that the heat is evenly distributed throughout the oven. As there is continuous recirculation of the air, it speeds up cooking times and allows lower cooking temperatures[65] to be used (typically 20°C lower). This means that an oven in fan mode will use less electricity than a conventional oven. Typically, between 10 and 25% savings can be made when using a fan oven.

Measuring the electricity consumption of an oven is not straightforward as the device has its own electrical circuit and there is no 13A socket where a smart plug could be used.

We were able to measure the electricity consumption for a couple different models of oven by monitoring the cooker electrical circuit with a current clamp.

[64] Cooking appliances: Public consultation on ecodesign and energy labelling requirements, https://energy.ec.europa.eu/news/cooking-appliances-public-consultation-ecodesign-and-energy-labelling-requirements-2023-06-08_en (Accessed 29 Jul 2024)
[65] What is the best setting to use on an oven, Oven Guides and Advice, https://www.myappliances.co.uk/ovens/oven-guides-and-advice/what-is-the-best-setting-to-use-on-an-oven (Accessed 29 Jul 2024)

Rangemaster Professional+ 110 Range Cooker

We measured the electricity consumption of the oven for a Rangemaster Professional+ 110 Range Cooker which had LPG fuelled hobs and 2 full sized electric ovens. These had a net capacity of 80 litres and 73 litres. The maximum power for the oven with forced air convection was 2.5kW at 230V. The electricity consumption (in mA) was measured using a current clamp on the cooker electrical circuit. Readings were recorded every second. The apparent power consumption was calculated by multiplying the current recorded by 240V, which was typical at the site. Tests were carried out for 1-hour at 180°C and 200°C.

It is apparent that the oven initially ran continuously on full power before reaching the desired temperature. After this the oven was powered in short cycles to maintain the cooking temperature. The time to reach 180°C was 8.5 minutes while it was 20 minutes for 200°C.

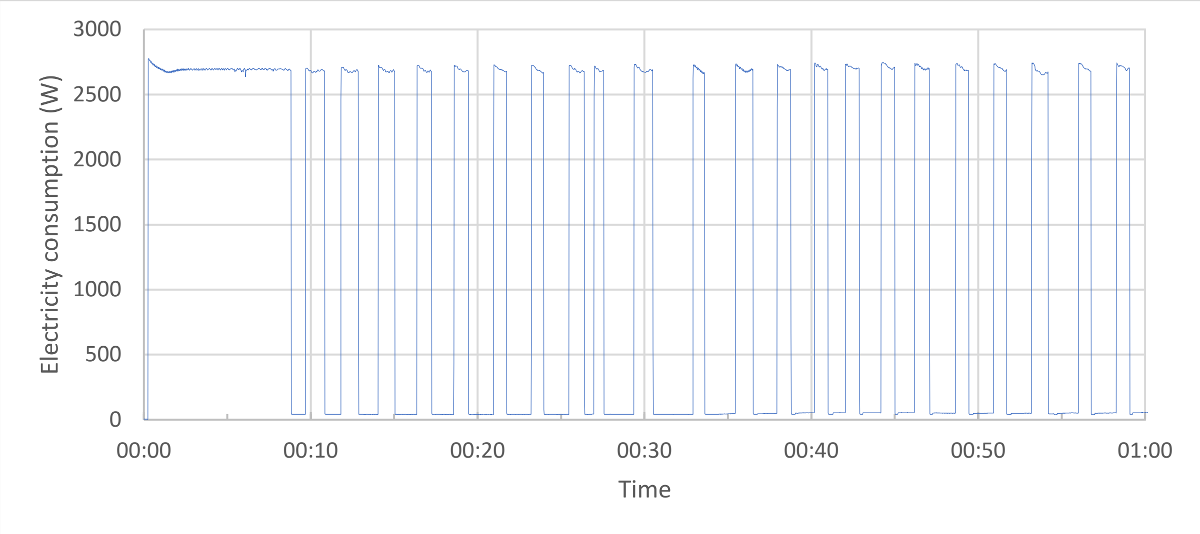

Figure 2.47 Plot of apparent power consumption measured every second with a Tinytag View 2 for the fan oven for a Rangemaster Professional Plus Range Cooker at 180°C

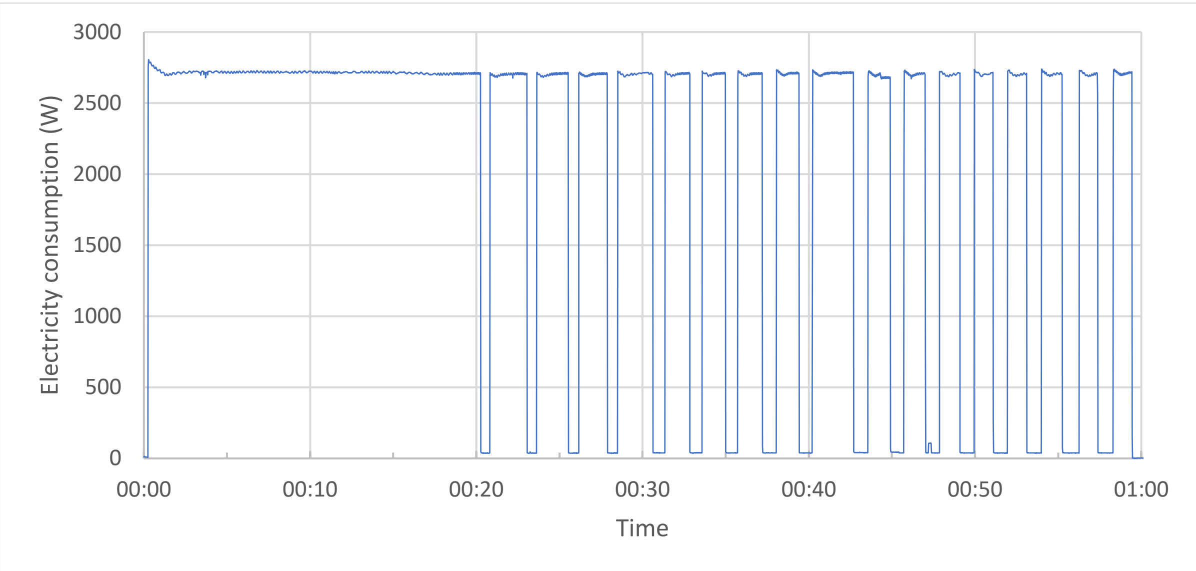

Figure 2.48 Plot of apparent power consumption measured every second with a Tinytag View 2 for the fan oven for a Rangemaster Professional Plus Range Cooker at 200°C

The maximum power consumption of about 2.7kW recorded during the test was higher than the 2.5kW in the specification for the cooker.

Figure 2.49 shows the cumulative electricity consumption for the appliance at the two test temperatures. The electricity consumption was the same at both cooking temperatures until 8.5 minutes into the test where the gradient for the 180°C graph became lower due to the power on the oven modulating. The gradient for the 200°C graph reduced after 20 minutes when the oven had reached temperature. After running for an hour, the Rangemaster oven had used 1.27kWh at 180°C and 2.08kWh at 200°C

The oven for the Rangemaster cooker was A-rated and the specification for the consumption per cycle in conventional mode was 1.03kWh/cycle and 0.88kWh/cycle in forced convection mode[66].

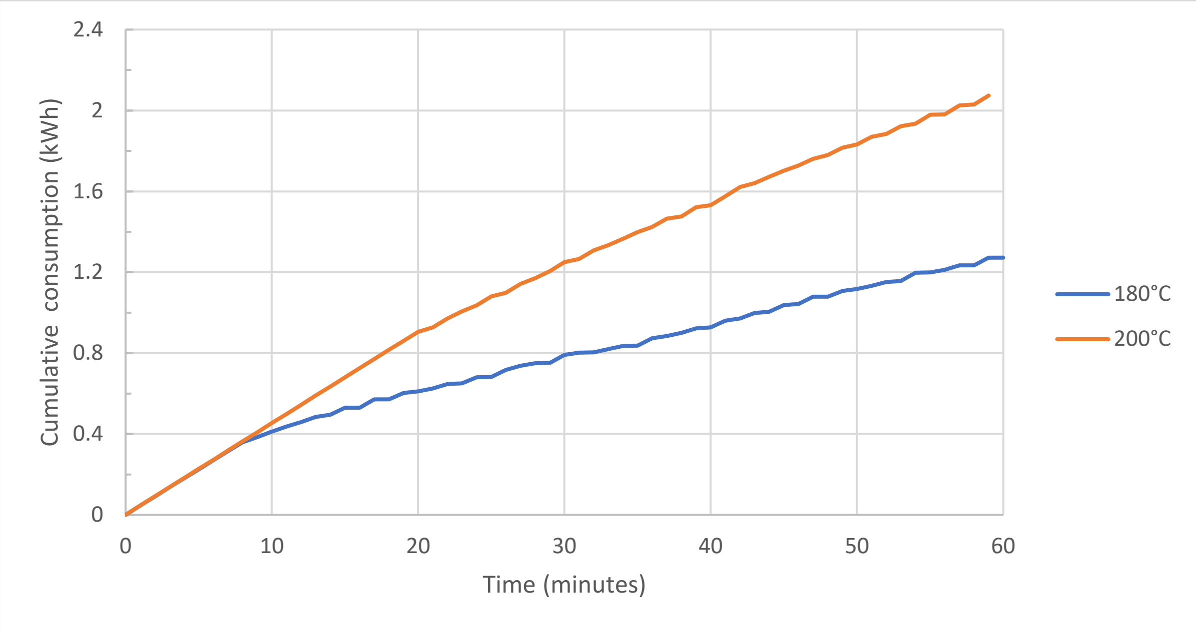

Figure 2.49 Plot of cumulative electricity consumption measured with a Tinytag View 2 logger for the fan oven for a Rangemaster Professional Plus Range Cooker at 180 and 200°C

[66] Marks Electrical, Rangemaster Professional Plus PROP110DFFGB/C, https://markselectrical.co.uk/91680_rangemaster-110cm-dual-fuel-range-cooker (Accessed 29 Jul 2024)

AEG DEB331010M main built in fan oven

Figure 2.50 AEG built-in double oven

The electricity consumption of an AEG main built-in fan oven was measured using the Tinytag View 2 current clamp monitoring the cooker circuit on the consumer unit.

According to the manual, both the top oven and main oven were efficiency class A. The energy consumption for the top oven with a standard load in conventional mode was 0.78kWh per cycle while it was 0.79kWh per cycle for the main oven in fan-forced mode[67]. The main oven, which was deeper and taller had a capacity of 66 litres while it was 42 litres in the top oven.

Figure 2.51 shows a graph of electricity consumption against time for the AEG main oven running in fan-assisted mode at 180°C. This is a typical temperature for oven cooking and is the equivalent to 200°C in a conventional oven. The oven had a steady consumption just under 1,800W (average of 1,787W) for the first 9.5 minutes while heating up. There were then pulses of consumption while the thermostat maintained the oven at temperature.

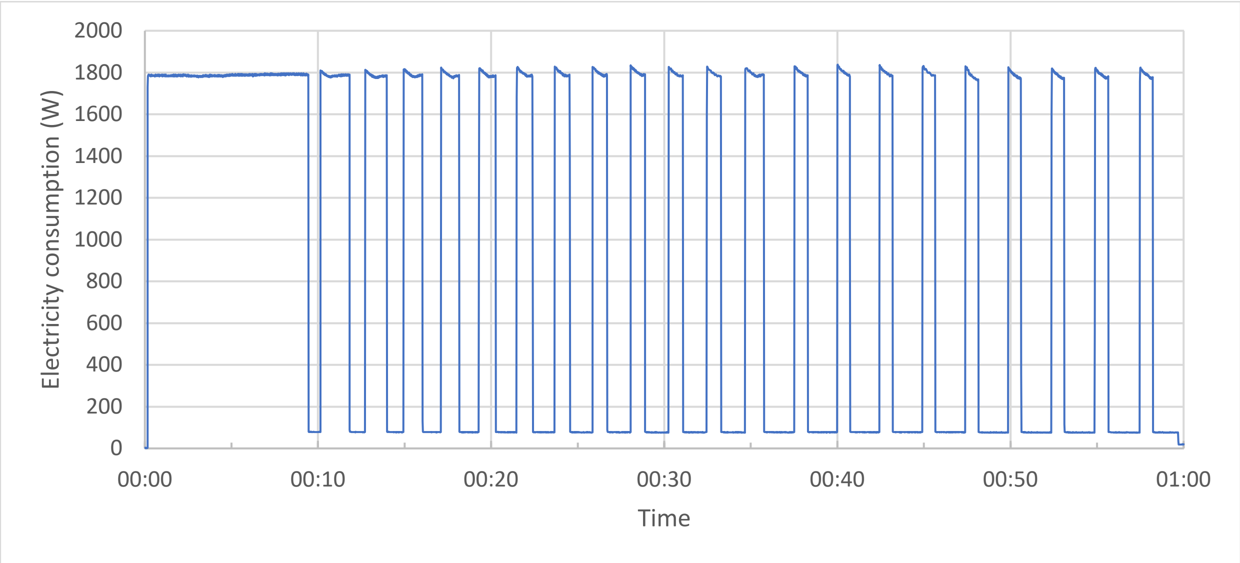

Figure 2.51 Plot of apparent power consumption measured every second with a Tinytag View 2 for the fan oven for an AEG DEB331010M main fan oven at 180°C

[67] AEG DEB331010M built-in double oven user manual, https://api.electrolux-medialibrary.com/asset/b97ebbe2-d7d3-4089-ad8d-ef91f79cfd3b/E4RM3Q/1a08426b-6207-4a5c-9d4d-30577df283f2/ORIGINAL/1a08426b-6207-4a5c-9d4d-30577df283f2.pdf (Accessed 20 Aug 2024)

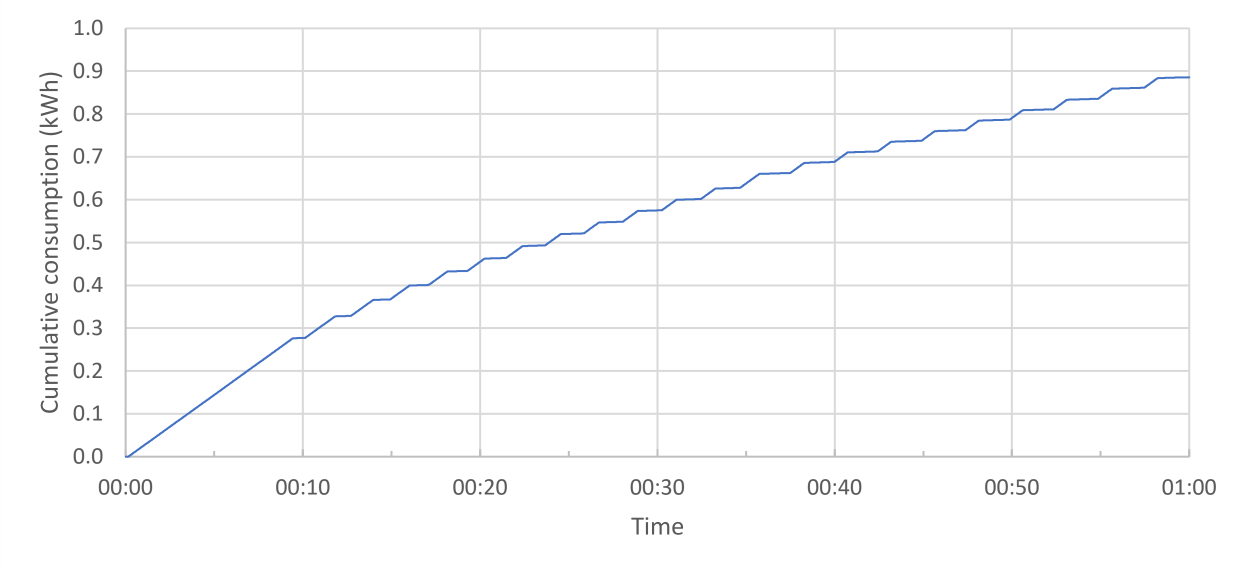

Figure 2.52 Plot of cumulative electricity consumption measured with a Tinytag View 2 logger for the fan oven for an AEG DEB331010M main fan oven at 180°C

The second consumption pulse lasted 1 minute 40 seconds with a gap of 55 seconds until the next pulse. These pulses of consumption shortened in length and the gaps increased over the cooking time in the oven until later on the pulses lasted about 45 seconds with a gap in between of about 1 minute 45 seconds.

The graph in figure 2.52 plots the cumulative electricity consumption in kWh against time for the test with the AEG oven at 180°C in fan-assisted mode. For the first 9.5 minutes there was a straight-line graph while the oven reached temperature. Subsequently the gradient of the graph decreased due to the electricity consumption for the oven modulating and these consumption pulses becoming shorter in length and the gaps in between larger.

Cooking test	Time for oven to reach temperature (mins)	Consumption after 20 mins (kWh)	Consumption after 30 mins (kWh)	Consumption after 60 mins (kWh)
AEG oven at 180°C in fan assisted mode	9.5	0.46	0.575	0.89
Rangemaster oven at 180°C in fan assisted mode	8.5	0.61	0.79	1.27
Rangemaster oven at 200°C in fan assisted mode	20	0.905	1.25	2.08

Table 2.53 Comparison of the consumption of AEG and Rangemaster ovens with different temperatures and cooking times

Table 2.53 compares the 3 tests carried out with the AEG and Rangemaster ovens. This includes the time for the oven to reach temperature as well as the consumption after different cooking times. It took about 9 minutes for the AEG and Rangemaster ovens to reach a cooking temperature of 180°C with the Rangemaster slightly quicker. Although the Rangemaster oven was larger than the AEG, the higher power consumption probably enabled it to heat quicker. For the test at 200°C, the Rangemaster took about 20 minutes to reach the cooking temperature which was more than double the time when cooking at 180°C.

For the tests at 180°C, after 20 minutes, the AEG oven had used 0.46kWh while the Rangemaster had used nearly one third more at 0.61kWh. For an electricity unit rate of 25p/kWh, the cost after 20 minutes would be 11.5p with the AEG oven and 15.25p with the Rangemaster oven. After 20 minutes at 200°C, the Rangemaster had used 0.905kWh, nearly double the consumption of the AEG oven at 180°C. The cost for this would be 22.6p. It might take about 20-25 minutes at 180°C in a fan assisted oven to cook fish, a burger or potato wedges.

After 30 minutes cooking time, the AEG oven at 180°C had used 0.575kWh while the Rangemaster oven consumed 0.79kWh at a cost of 14.4p and 19.75p for a unit rate of 25p/kWh. When the Rangemaster oven was at 200°C, the consumption after 30 minutes was 1.25kWh or about 31.25p. Bread is often baked at 180-200°C in a fan oven for about 30 minutes.

The AEG oven used 0.89kWh after 60 minutes of cooking at 180°C in the fan assisted oven at a cost of 22.25p for a unit rate of 25p. This compared to 1.27kWh or 31.75p for the Rangemaster oven at 180°C and 2.08kWh or 52p for the Rangemaster at 200°C. Longer cooking times like this might be needed for cooking a jacket potato or roast potatoes.

Summary

- Main ovens are typically 65-80 litres in size and they heat the air in the oven which heats the food in the appliance
- Given the size of the oven, to use it efficiently, it makes sense to cook more than one dish at the same time or batch cook
- Where possible, put the food in the oven when it is turned on and turn off the oven before the food is cooked to allow the residual heat to finish off the cooking
- A fan oven uses a fan to recirculate the air in the oven, ensuring the heat is evenly distributed and speeding up cooking times
- It is possible to lower the temperature by 20°C with a fan oven compared to using it in conventional mode; savings of 10 to 25% are possible when using a fan oven
- Main ovens can have a power rating of between 1,800 and 3,500W
- When using an oven, it initially heats up on full power and once it reaches the cooking temperature, the oven maintains the cooking temperature by turning the power to the heating element on and off
- The time to reach temperature is longer for higher cooking temperatures – in our tests it took 8.5 minutes to reach 180°C and 20 minutes to reach 200°C with a Rangemaster range cooker oven
- The Rangemaster oven used 0.79kWh after 30 minutes at 180°C at a cost of 19.75p for a unit rate of 25p/kWh; this increased to 1.27kWh or 31.75p after 60 minutes
- When the Rangemaster oven was used at a higher temperature of 200°C, there was a significant increase in consumption, using 1.25kWh (31.25p) after 30 minutes and 2.08kWh after 60 minutes (52p)
- A smaller AEG oven with a 66-litre capacity consumed a maximum power of about 1,800W compared to about 2,700W for the Rangemaster oven
- The AEG oven consumed less energy than the larger Rangemaster oven at 180°C, using 0.575kWh (14.4p) after 30 minutes and 0.89kWh (22.25p) after 60 minutes

2.5.2 Microwave ovens

Figure 2.54 Panasonic NN-CT559W combination microwave

Conventional ovens and fan ovens cook by heating food from the outside with hot air. In contrast, microwave ovens use electromagnetic waves (microwaves) to cook food by causing molecules of water, sugar and fat in the food to vibrate and heat[68]. The microwaves cook to a depth of 40-50mm and heat penetrates further by conduction. The microwave is more energy efficient as it is heating the food directly rather than heating the surrounding air.

Microwaves are ideal for reheating food and some foods like jacket potatoes and Christmas puddings are well suited to being cooked in a microwave. It can take an hour or more in an oven at 200°C to cook a jacket potato and only 10 minutes on high in the microwave. Large energy savings can also be made cooking a Christmas pudding in a microwave which only takes 3-5 minutes compared to about 1-2 hours when steaming.

Microwaves do not provide the same crisp exterior and moist interior achieved by ovens. A combination microwave which includes a grill and oven can provide the benefits of both technologies. A typical microwave oven will have a power of between 700 and 1,200W. Those with higher power cook quicker[69]. It should be noted that the power rating quoted is the power going into the food. The electricity consumption of the appliance is higher than this.

We tested microwave ovens from Panasonic, Kenwood and Russell Hobbs using Shelly Plus smart plugs and with Tinytag View 2 loggers recording at 1 second intervals.

[68] How do microwaves work to cook your food?, Kitchen Articles, Whirlpool, https://www.whirlpool.com/blog/kitchen/how-do-microwaves-work.html (Accessed 30 Jul 2024)
[69] Microwave: Buying Guide, Appliance City, https://www.appliancecity.co.uk/cooking/microwaves/microwave-buying-guide/ (Accessed 30 Jul 2024)

Panasonic NN-CT559W combination microwave

Microwave setting	Power level (W)	Consumption after 10mins (kWh)
High	1,000	0.21
Defrost	270	0.04
Medium	600	-
Low	440	0.13
Simmer	250	0.08
Warm	100	-

Table 2.55 Power level and consumption for Panasonic NN-CT559W combination microwave

The Panasonic NN-CT559W combination microwave tested was about 15 years old. The power level for the appliance on different microwave settings is shown in table 2.55 using data from the appliance manual[70]. The input power for the microwave was 1,135W while the output power (heating the food) was 1,000W. The input power for the grill and convection oven were 1,305W and 1,320W respectively, with the output of these both 1,300W.

Tests were carried out over 10 minutes using 4 different settings on the microwave and results are shown in column 3 of table 2.55. It was possible to cook 1 or 2 jacket potatoes in 10 minutes on the high setting for the microwave. This used on average about 0.21kWh. For comparison, cooking a jacket potato can take about 1 hour at 180°C in a fan oven, which could take 0.9kWh or more. Figure 2.56 shows a plot of average consumption per minute for the Panasonic microwave on 'high'. There was an initial peak in consumption of about 1,600W.

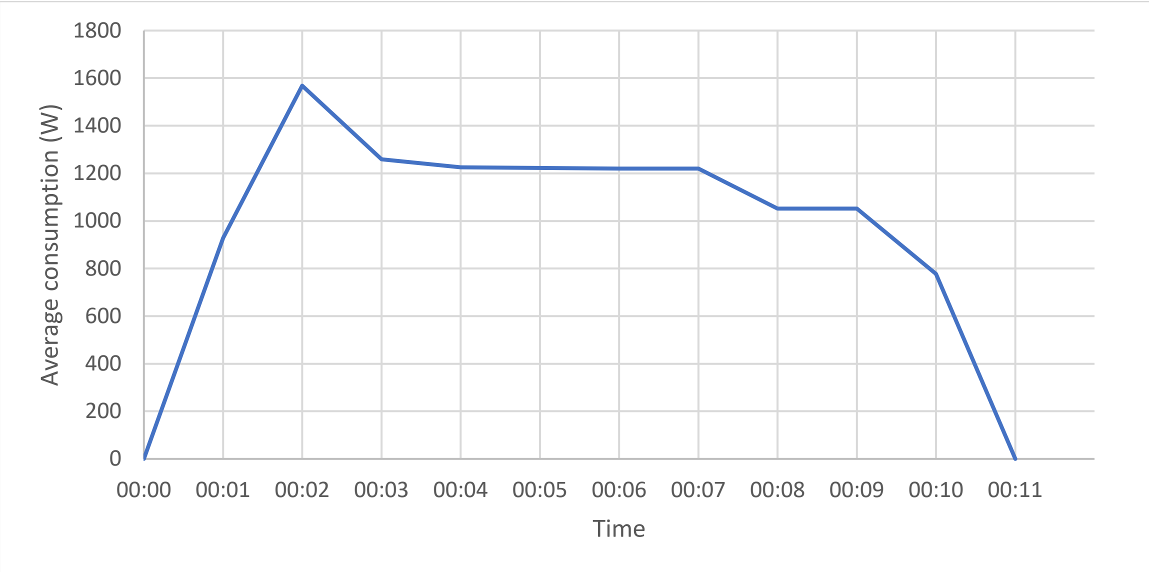

Figure 2.56 Plot of average consumption per minute measured with a Shelly Plus smart plug for a Panasonic NN-CT559W microwave on the 'high' setting

[70] Panasonic Operating Instructions & Cookery Book, Microwave Oven, Model No: NN-CT559W, https://www.canterbury.ac.uk/asset-library/students/current-students/Accommodation/Panasonic-NN-CT559W-MICROWAVE.pdf (Accessed 30 Jul 2024)

This was followed by more steady consumption at about 1,200W before reductions in consumption after 7 minutes. On average, the appliance was using about 1,250W over the cooking period.

Figures 2.57 and 2.58 show plots of electricity consumption for the Panasonic microwave on the low, simmer and defrost settings over 10 minutes. These were derived from data from a Tinytag View 2 data logger and current clamp, with readings taken every second and multiplying by the typical voltage in the property of 240V to get the apparent power. There was an issue that several appliances when monitored with the Tinytag View 2 showed a baseload consumption of about 60-70W even with the appliance on standby. The same issue was not apparent with the Shelly Plus smart plug and might have been due to wiring issues in the kitchen affecting the current clamp.

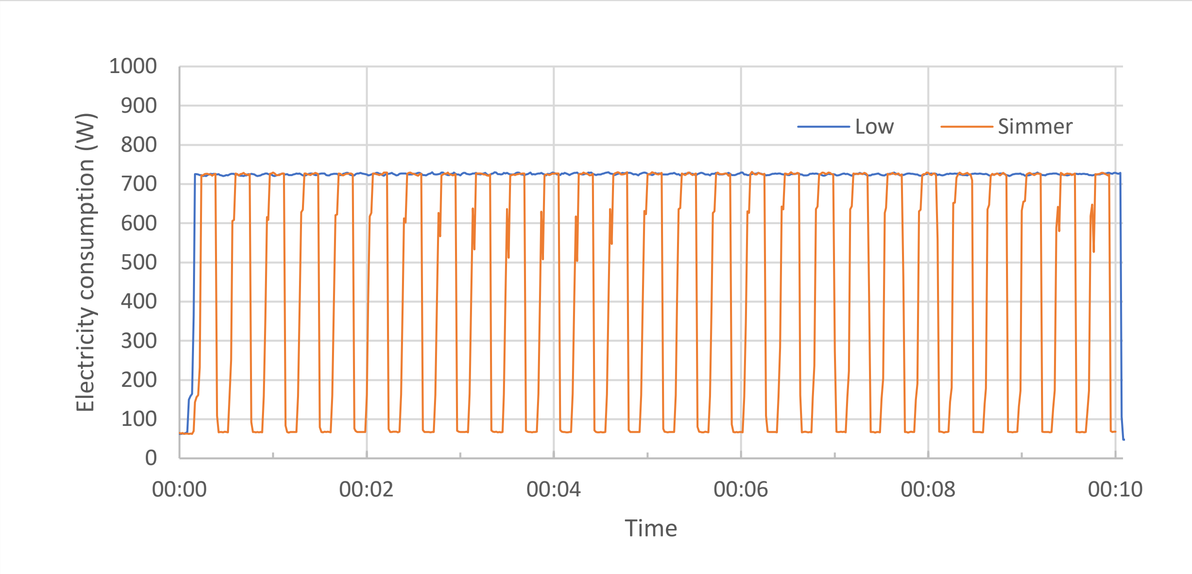

Figure 2.57 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Panasonic NN-CT559W Microwave on the low and simmer settings

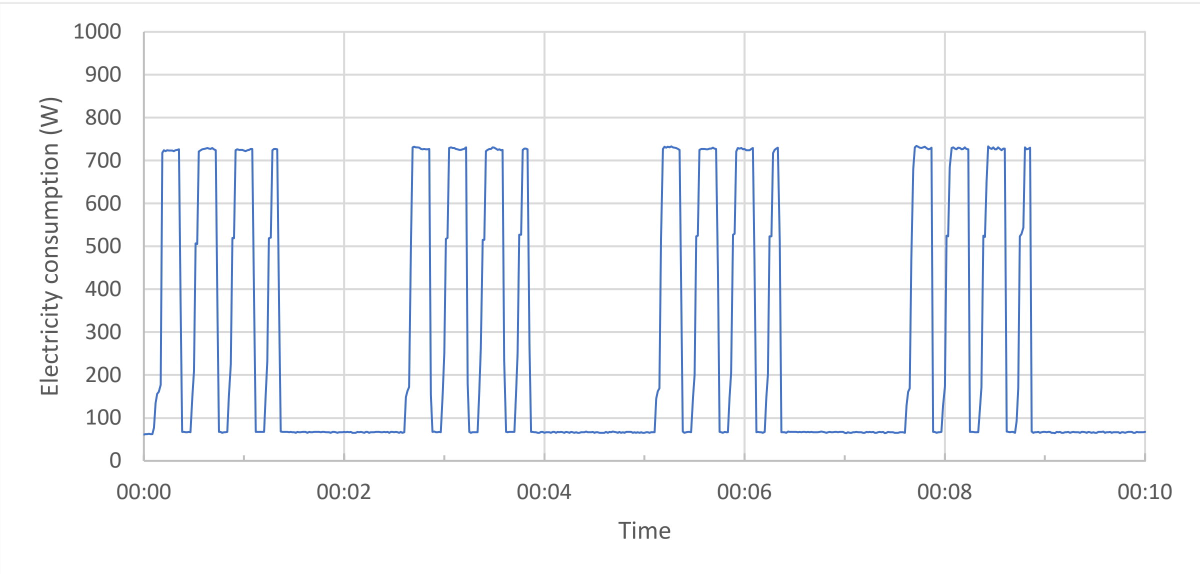

Figure 2.58 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Panasonic NN-CT559W Microwave on the defrost setting

Some microwaves use inverters which allow the device to vary the power output of the microwave rather than just modulating the device (turning it on and off). This is supposed to provide better temperature control and allows more even heating[71].

The Panasonic microwave manual indicates it includes inverter technology. However, this feature may be more advanced in more recent models. There is some variation of the power consumption while running on the 'high' setting, dropping from an initial peak of 1,600W to about 1,200W for an extended period before a further drop. On the 'low' setting the microwave consistently consumed about 725W. For the 'simmer' setting, the maximum power consumption was also about 725W but there were regular pulses of electricity consumption with a gap of about 10 seconds in between. With the 'defrost' function there were 4 pulses of consumption with a peak of 725W followed by gap of about 75 seconds before there were another 4 pulses of consumption.

The Panasonic microwave was able to vary the input power on different settings by a combination of reducing the input power and turning the input power on and off. In the case of the defrost setting, the input power was reduced further by having a larger gap between pulses of power consumption.

[71] What is an inverter microwave? https://www.choice.com.au/home-and-living/kitchen/microwaves/articles/what-is-an-inverter-microwave (Accessed 30 July 2024)

Kenwood K25MMS14 and Russell Hobbs RHM1721BC microwaves

	Kenwood K25MMS14	Russell Hobbs RHM1721BC
Microwave Output (W)	850 - 900	700
Microwave Input (W)	1,400 – 1,450	1200
Oven capacity (litres)	25	17
Consumption at high power after 10 minutes (kWh)	0.236	0.187
Consumption on defrost after 10 minutes (kWh)	0.063	0.087

Table 2.59 Specification of Kenwood and Russell Hobbs microwaves[72] [73] and consumption after 10 minutes on the high power and defrost settings

Two other microwaves were also tested using Shelly Plus smart plugs and Tinytag View 2 loggers with a current clamp. The Kenwood K25MMS14 had an oven capacity of 25-litres and an output power of 850-900W. The Russell Hobbs RHM1721BC was more compact with an oven capacity of 17-litres and output power of 700W. Both appliances were run on the 'high' power setting for 10 minutes, which was sufficient to cook a jacket potato. The higher power Kenwood microwave used 0.236kWh over 10-minutes compared to 0.187kWh for the 700W Russell Hobbs. On the defrost setting over 10-minutes, the Russell Hobbs microwave consumed more at 0.087kWh compared to 0.063kWh for the Kenwood. The nominally 1,000W Panasonic microwave consumed 0.21kWh on high power over 10-minutes and about 0.04kWh on the defrost setting.

Figure 2.60 plots the electricity consumption for the Kenwood K25MMS14 microwave assuming a supply voltage of 240V which was typical at the site. On the high setting, the consumption initially reached 1,500W but then gradually fell to about 1,275W after 10-minutes. The average was 1,375W over the full cooking cycle, which was slightly lower than the value in the specification in table 2.59. On the defrost setting, the Kenwood microwave had regular pulses of consumption which consistently reached a peak of about 1,560W.

[72] Kenwood K25MMS14 instruction manual, https://www.4kenwood.co.uk/images/mediator/90/Kenwood%20K25MMS14%20IB.pdf (Accessed 30 Jul 2024)
[73] Russell Hobbs Compact Manual Microwave User Guide, RHM1731, https://www.appliancesdirect.co.uk/PDFs/RHM1731_UserManual1.PDF?v=1 (Accessed 30 Jul 2024)

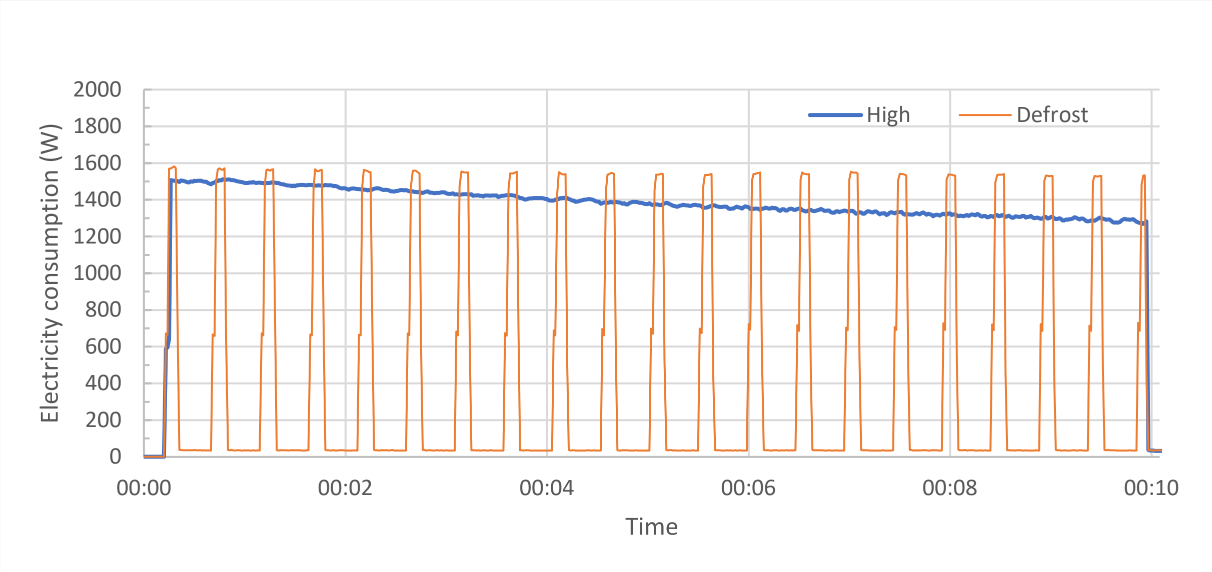

Figure 2.60 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Kenwood K25MMS14 microwave on the high and defrost settings

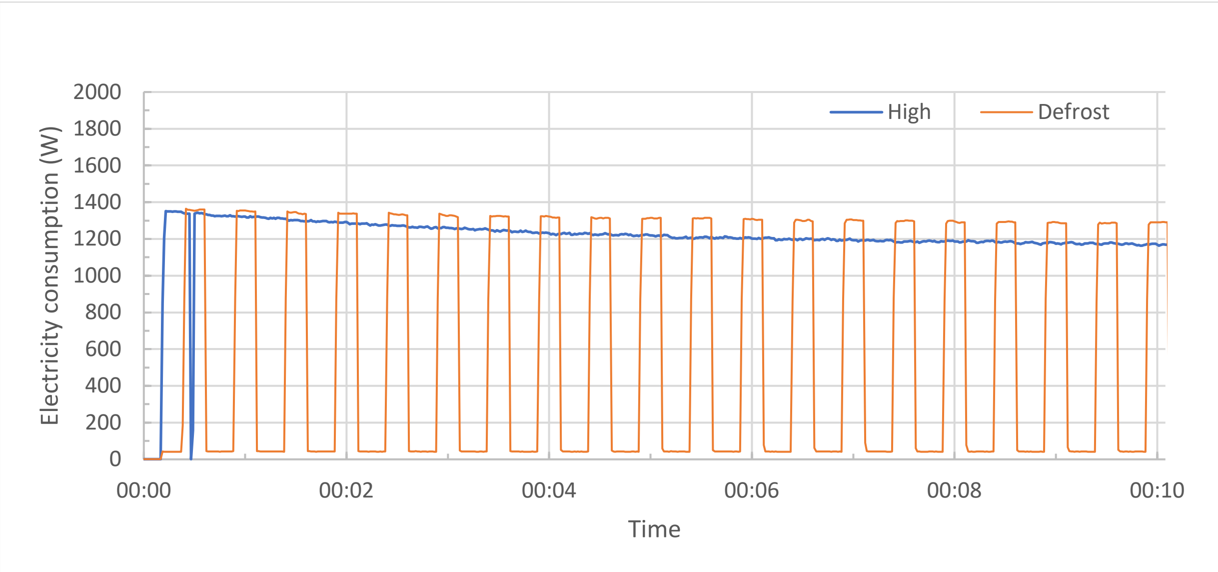

Figure 2.61 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Russell Hobbs RHM1721BC microwave on the high and defrost settings

The Russell Hobbs microwave had a similar pattern of consumption to the Kenwood on the high and defrost settings. On the high setting, the Russell Hobbs initially consumed 1,350W and this fell to about 1,175W after 10 minutes. The average over the full cooking period was 1,226W, which was close to the value in the specification for the input power of 1,200W. Most people, however, would consider this to be a 700W microwave due to the output power. Those making simple estimates of the consumption based on this value underestimate the consumption of the device. The pulses on the defrost setting had a peak in consumption of 1,300-1,350W and each lasted about 12 seconds. For the Kenwood microwave, the maximum power of the consumption peaks was about 1,560W. Overall, the peaks lasted about 9 seconds but with 3 of these seconds at about 660W. The Russell Hobbs microwave had higher electricity consumption than the Kenwood microwave on the defrost setting due to the pulses in consumption lasting for longer and having a higher average value.

Summary

- Microwave ovens cook food using electromagnetic waves which cause molecules of water, sugar and fat in the food to vibrate and heat
- Since the microwave oven heats the food directly, it is more energy efficient than a conventional or fan oven which heats the air in the oven which then heats the food
- A typical microwave is described as having a power of between 700 and 1,200W – this is in fact the power to heat the food and not the power consumption of the appliance which is higher
- A Russell Hobbs microwave with a 700W output used about 1200W of electricity while a Kenwood microwave with an 850-900W output used an average of nearly 1,400W of electricity on the high setting
- Cooking a jacket potato for 10 minutes on high used 0.19 to 0.24kWh in the 3 microwaves tested; for comparison, cooking a jacket potato in a fan oven at 180°C for 1 hour can use 0.9kWh or more
- Assuming an electricity unit rate of 25p/kWh, the cost of cooking a jacket potato in the 3 microwaves tested was 4.75p to 6p compared to 22.5p or more in a fan assisted oven
- When cooking on high power, the microwave runs constantly and can start at a higher power of 1,350-1,600W with the power consumed gradually decreasing to 1,000-1,200W by the end of the cooking time
- Microwaves have other lower power settings, and these use less electricity due to the power consumption regularly turning on and off and/or use of an inverter to turn down the power
- The 3 microwaves tested on the defrost setting for 10 minutes used 0.04-0.09kWh, this would be a cost of 1p to 2.25p for a unit rate of 25p/kWh

2.5.3 Halogen ovens

Figure 2.62 Cookworks KHC-617D halogen oven

A halogen oven is an energy efficient way to grill or bake food. A halogen lamp in the top of the oven becomes hot and emits infrared heat which cooks the food in the oven. There are fewer heat losses with infrared cooking compared to use of a standard oven which relies of convection and conduction where the heat transfer to the food is less efficient.[74] The infrared heat causes molecules in the surface of the food to vibrate and heat.

The size of the halogen oven is small compared to a conventional oven at only 10 – 17 litres and there is a fan in the top to ensure good heat distribution. The halogen oven has a clear glass bowl so you can see the food cooking.

The lamp heats up and starts providing infrared energy as soon as the device is turned on, which saves cooking time. The strength of the heat means that food can be grilled or baked with a crispy surface and moist interior as with an oven.

The power rating of the device is typically between 1,200 and 1,400W. The lower power rating and quicker cooking times lead to a lower cost way of cooking meals. This is better suited to 1 or 2 person households. It is usually possible to grill/bake fish or a burger within 15 minutes, turning the food once part way through to ensure a browned surface on both sides.

[74] How a Halogen Oven Works to Cook Tasty Meals, Halogen Ovens, https://www.halogenoven.org.uk/how-halogen-ovens-work.html (Accessed 31 Jul 2024)

Cookworks KHC-617D halogen oven

The Cookworks KHC-617D halogen oven has a power rating of 1,200-1,400W for an AC voltage of 220-240V. The capacity is normally 10-litres, but this can be expanded to 15-litres by using an extender ring.

During testing with the Shelly Plus plug, it was found that the device modulated between consuming about 1.4kW with the halogen bulb running and 18W with just the fan still running. The consumption was 1W on standby with the digital display running but not the fan.

Figure 2.63 shows a plot of electricity consumption while cooking a large fish cake at 200°C for a total of 15 minutes, turning after 10 minutes. The halogen oven does not run at full power during the whole of the cooking time. Initially, the halogen lamp ran constantly for 5 minutes 20 seconds while the halogen oven reached temperature. Subsequently the lamp ran for periods of about a minute at a time before switching off. There was a longer gap between consumption peaks after 10 minutes due to turning the food over and the following peak was longer due to warming the oven again. The typical consumption recorded on this test run while the lamp was running was 1,335W. There was a spike in consumption for the first second after the lamp was turned on and here the consumption could be 1,600W to 2,100W. Over the 15 minutes of cooking at 200°C, the halogen oven used 0.295kWh.

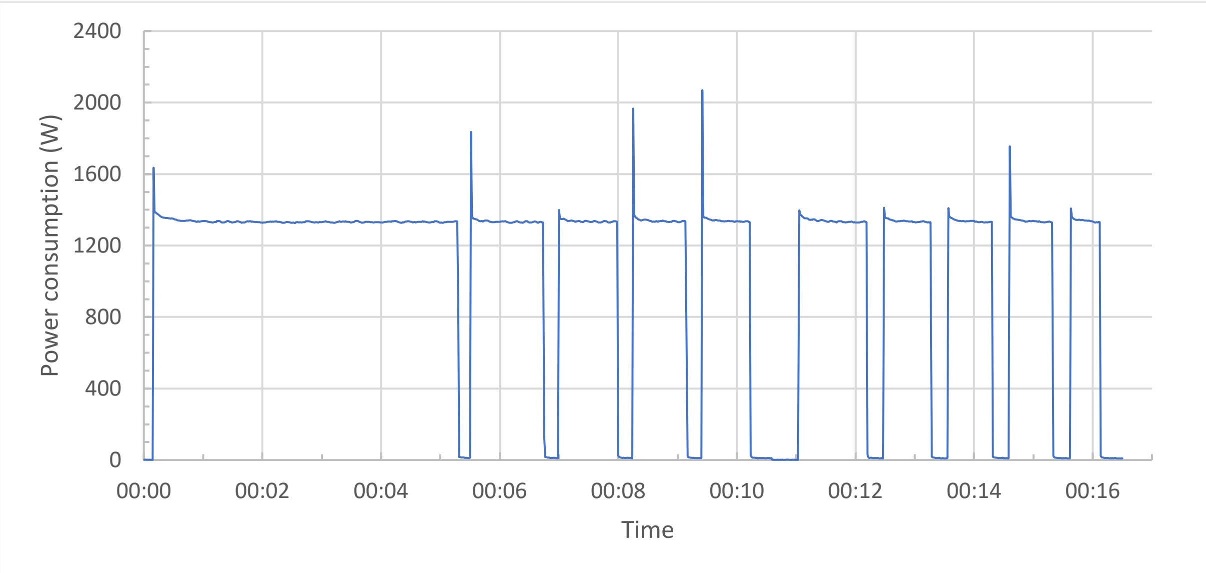

Figure 2.63 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Cookworks KHC-617D halogen oven for 10 minutes + 5 minutes at 200°C

Table 2.64 shows the electricity consumption of the halogen oven for different temperatures and times as measured by the Shelly Plus smart plug. Any difference in consumption between cooking at 190°C and 200°C was within the measuring error for the test. Normally cooking at 160°C might be used for warming food while cooking at 190°C/200°C would be used for cooking fish, meat and pizzas. It could take about 10 minutes to cook a pizza while fish and meat would normally take about 15 minutes unless particularly thick.

Temperature	Consumption (kWh) after 10 minutes	Consumption (kWh) after 15 minutes	Consumption (kWh) after 20 minutes
160°C	0.134	0.18	0.253
190°C/200°C	0.19	0.295	0.36

Table 2.64 Electricity consumption of Cookworks KHC-617D halogen oven measured by the Shelly Plus smart plug for different temperatures and times

The electricity consumption of the halogen oven was 0.134kWh after 10 minutes at 160°C. If the cooking time was 20 minutes the consumption increased to 0.253kWh, which was slightly under double the amount for 10 minutes, most likely due to there being more modulation of the power consumption after the first few minutes.

The electricity consumption of the halogen oven was 0.19kWh after cooking for 10 minutes at 190°C/200°C and 0.295kWh after 15 minutes. Cooking foods like fish or burgers for 15 minutes at 190°C in the halogen oven is similar to cooking in a fan oven for about 25 minutes. For comparison, an AEG fan oven at 180°C used 0.52kWh over 25 minutes which is more than 75% higher than the consumption of the halogen oven over 15 minutes.

A microwave oven on high used 0.19 to 0.236kWh over 10 minutes. This is similar to or slightly higher than the consumption of the halogen oven at 190°C/200°C for 10 minutes. While it is possible to heat a jacket potato all the way through with a microwave after 10 minutes, this would take might take 40 minutes to cook with a halogen oven and so it is a case of selecting the appliance best suited to the food. If a household has multiple appliances, it is possible to do most of the cooking in a microwave and crispen the surface in a halogen oven.

Summary

- A halogen oven uses infrared heat from a halogen lamp to cook the food
- The appliance is more energy efficient due to infrared heating providing better heat transfer to the food, a fan improving heat distribution and the oven having a lower volume to be heated
- Foods can normally be cooked quicker in a halogen oven compared to a fan oven
- A halogen oven can produce the same crispy, browned surface and moist interior to a normal oven
- Halogen ovens are normally rated at 1,200-1,400W but the electricity consumption varies during cooking due to the halogen lamp turning on and off
- The electricity consumption of a halogen oven is similar to that of a microwave running on high power but some foods are better suited to a halogen oven while others to a microwave
- It can take about 0.3kWh to cook fish or meat at 190°C/200°C in a halogen oven at a cost of 7.4p for a unit rate of 25p/kWh; this compares to 0.52kWh or more in a fan oven at a cost of 13p

2.5.4 Air fryers

Figure 2.65 Photo of an air fryer having cooked crispy chips and vegetables (Freepik)

An air fryer is a countertop appliance with some similarities to a halogen oven. The air fryer has either one or two baskets to cook the food and the total capacity can range from 4-litres to about 10-litres depending on the model[75].

The appliance has a heating element and a fan rapidly circulates hot air over the food. The cooking baskets are perforated to assist in distribution of the hot air. The air fryer is more energy efficient than a conventional oven due to the lower volume to be heated and the rapid flow of hot air over the food assisting the heat transfer[76]. For example, a larger air fryer can reach a cooking temperature of 200°C in about 3-4 minutes compared to it taking 15-20 minutes for an oven. Air fryers are known for being good for cooking chips and small amount of oil can be sprayed on the food to assist with the heat transfer and browning.

Air fryers with dual baskets can use only one or each can cook at different temperatures. The power rating for small air fryers is typically about 1,400W, but dual basket models can use up to 2,700W. More sophisticated air fryers can have multiple functions such as air fry, bake, dehydrate, steam, steam bake and can even act as a slow cooker.

The benefits of air fryers have been investigated by the BBC. They are good for cooking foods which are typically baked, grilled or fried. The energy consumption was compared for cooking a jacket potato and chicken legs between an oven and an air fryer. Savings in electricity consumption of about 60% were measured[77].

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[75] 16 best air fryers to buy in 2024, reviewed and rated by our testers, IndyBest, The Independent, 18 Jun 2024, https://www.independent.co.uk/extras/indybest/house-garden/kitchen-appliances/best-air-fryer-uk-reviews-b1979237.html (Accessed 1 Aug 2024)
[76] How does an air fryer work?, Salter, 5 Mar 2024, https://salter.com/blog/how-does-an-air-fryer-really-work/ (Accessed 1 Aug 2024)
[77] Air Fryers, BBC Sliced Bread, 21 Dec 2022, https://www.bbc.co.uk/programmes/m0018hjr (Accessed 6 Aug 2024)

Ninja Air Fryer MAX AF160

Figure 2.66 Ninja AF160 air fryer

The Ninja Air Fryer MAX AF160 is described as a family sized air fryer. It has a 5.2 litre basket which is capable of cooking 1.4kg of French fries or a 2kg chicken[78]. The manufacturer claims it will cook fish fingers and sausages 50% faster than a fan oven.

A cooking guide suggests it can take 8-10 minutes at 190°C to cook a burger, about 20 minutes at 190°C to cook a chicken breast, 10-13 minutes at 200°C to cook salmon fillets and 20 minutes at 180°C to cook frozen chips.

The power rating for the appliance is 1,750W. Tests were carried out with this air fryer using both a Shelly Plus smart plug with 1 minute resolution data and the lead with a Tinytag View 2 data logger measuring the current every second.

Figure 2.67 shows a plot of the electricity consumption while roasting vegetables with the Ninja air fryer for 10 minutes at 160°C. The heating element was powered initially for 1 minute 15 seconds while the air fryer heated up. Subsequently the heating element was powered for about 8 seconds at a time approximately every 22 seconds. Over a 10-minute cooking time, the device used 0.103kWh. For a unit rate of 25p/kWh, this would be a cost of 2.575p.

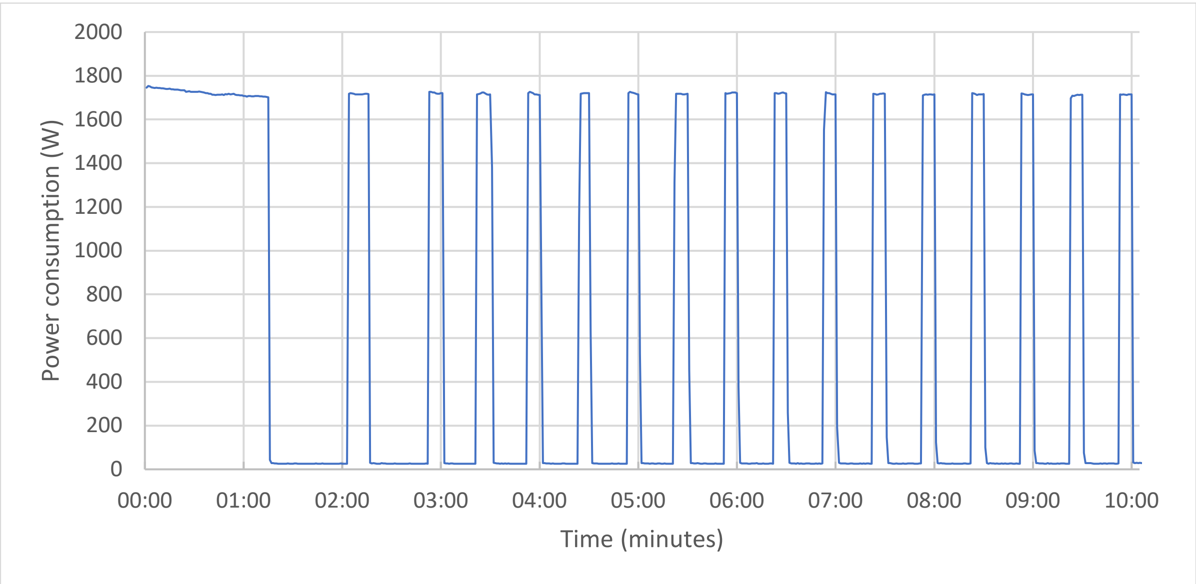


Figure 2.67 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Ninja AF160 air fryer over a cooking time of 10 minutes at 160°C

[78] Ninja Air Fryer MAX AF160UK, Ninja Kitchen, https://ninjakitchen.co.uk/product/ninja-air-fryer-max-af160uk-zidAF160UK (Accessed 1 Aug 2024)

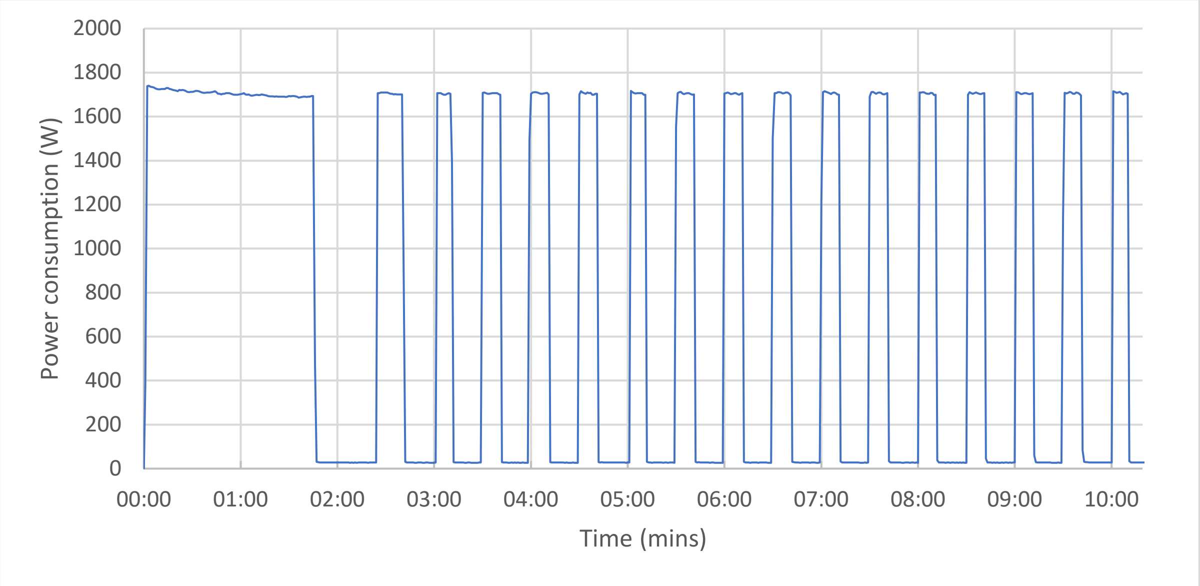


Figure 2.68 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Ninja AF160 air fryer over a cooking time of 10 minutes at 180°C

A similar plot of electricity consumption over 10-minutes is shown in figure 2.68 while cooking sausages at 180°C. Initially the Ninja air fryer was using about 1,725W and this gradually fell to 1,675W after 1 minute 45 seconds at the end of the first heating cycle. Subsequent heating cycles were about 10 seconds in length with a gap of about 19 seconds. Overall, the air fryer used 0.136kWh over 10-minutes at a cost of 3.4p for a unit rate of 25p/kWh

Another test was carried out at 200°C and the air fryer ran for about 3 minutes 40 seconds during the first heating cycle. Subsequent heating cycles varied more in the length, typically in the range 10 to 20 seconds. Over the 10-minute cooking time, the Ninja AF160 air fryer used 0.20kWh at 200°C, costing 5p with a unit rate of 25p/kWh.

The Ninja AF160 includes a dehydrate function which runs at 60°C and can be used to dehydrate fruit or vegetables to produce healthy snacks and extend the shelf life of the food. Figure 2.69 shows a plot of the power consumption over 1 hour. It took just 40 seconds to initially bring the air fryer to temperature. The next time the appliance was heated was about 4 minutes later, with just a 2 second burst of power at 1,750W. Further short bursts of power occurred approximately every 30 seconds.

Over the hour run time on the dehydration setting, the air fryer used 0.12kWh. This was less than the consumption at 180°C over 10 minutes. However, it can take 3 to 6 hours to dehydrate slices of fruit such as a banana or apple. We estimate the electricity consumption of the air fryer for such a dehydration cycle would be 0.33kWh to 0.65kWh. This would cost between 8.25p and 16.25p for a unit rate of 25p/kWh.

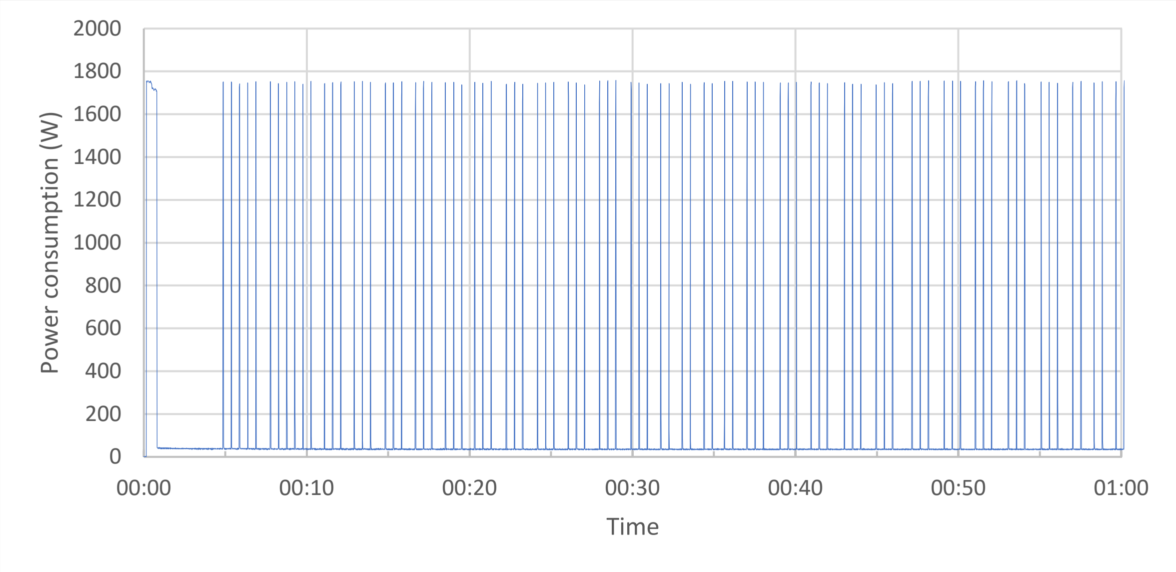


Figure 2.69 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Ninja AF160 on the dehydration cycle at 60°C over 1 hour

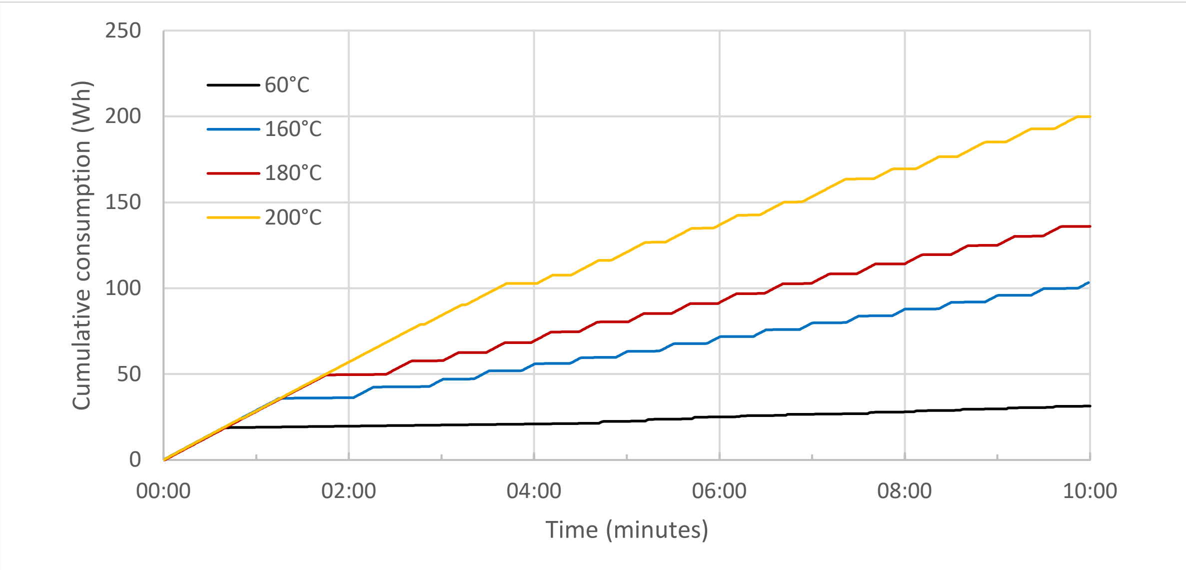


Figure 2.70 Plot of cumulative electricity consumption for the Ninja AF160 air fryer at cooking temperatures of 60°C, 160°C, 180°C and 200°C

Figure 2.70 shows a plot of cumulative electricity consumption for the Ninja AF160 air fryer over 10 minutes for the cooking temperatures of 60°C, 160°C, 180°C and 200°C. This is shown in Watt hours (Wh) where 1,000Wh = 1kWh.

The electricity consumption increased at a higher rate (with a higher gradient on the graph) while the air fryer was heating up. The time taken to heat up was longer for higher cooking temperatures. After the air fryer was at temperature, the gradient on the graph fell due to the heating element being powered periodically. The electricity consumption rate was lower at lower cooking temperatures.

Shanben HB-8031 air fryer

The Shanben HB-8031 air fryer is a single basket model with a capacity of 4.5 litres. The device has manual controls. This made it harder to set accurate cooking times. The device had a power rating of 1,500W.

Cooking times printed on the appliance note that French fries take 15-20 minutes to cook at 200°C, chicken takes 20-25 minutes at 180°C and fish takes 15-20 minutes at 200°C.

We measured the electricity consumption of the air fryer using a Tinytag View 2 logger and current clamp.

Figure 2.71 Shanben HB-8031 air fryer

Tests were carried out at cooking temperatures of 160°C, 180°C and 200°C, each for approximately 15 minutes. Figure 2.72 shows a plot of consumption against cooking time at 160°C. Here the air fryer initially heated for about a minute. Subsequent pulses of heating lasted about 40 seconds, with a gap of about 1 minute 15 seconds between the heating pulses. Over the 15-minute cooking time, the air fryer consumed 0.155kWh.

Comparing the consumption pattern for the Shanben air fryer at 160°C with that for the Ninja AF160 at the same temperature in figure 2.67, it is clear that the Ninja had more frequent shorter pulses of consumption (which lasted 8 seconds instead of 40 seconds). It is likely that the Ninja AF160 maintained a more consistent temperature while cooking due to the pattern of consumption. The Shanben air fryer used 0.105kWh after 10 minutes compared to 0.103kWh for the Ninja AF160.

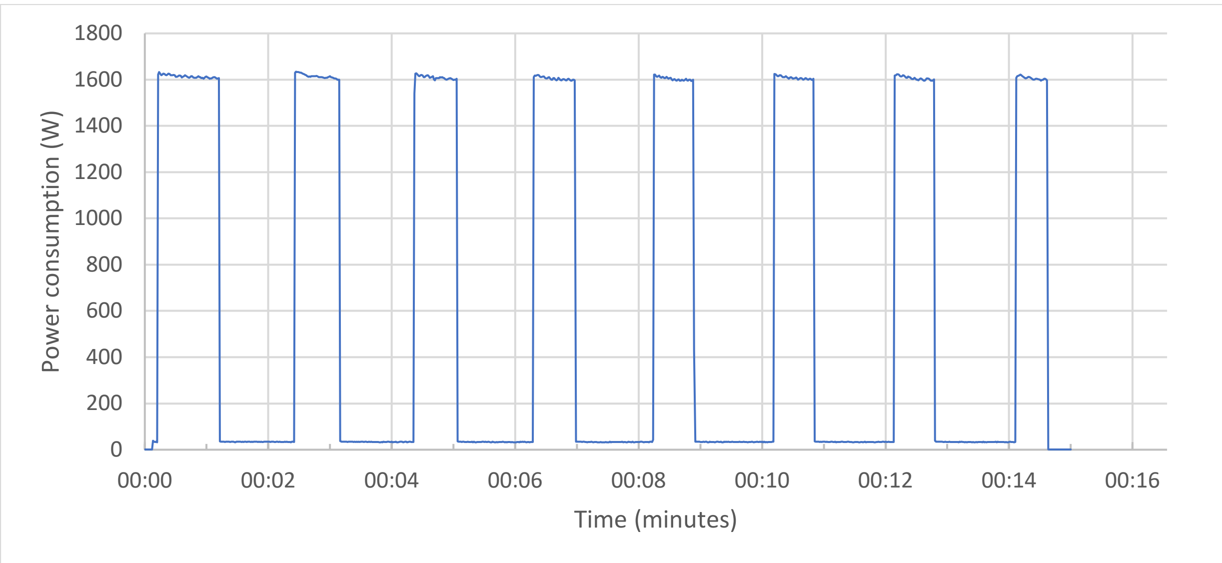


Figure 2.72 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Shanben HB-8031 air fryer over a cooking time of about 15 minutes at 160°C

A test of the Shanben air fryer at 180°C found that it took 1 minute 35 seconds for the air fryer to reach temperature, with subsequent pulses of heating lasting about 45 seconds with a gap of about 1 minute between pulses. The appliance consumed about 0.19kWh over 15 minutes at 180°C. This would be a cost of 4.75p with an electricity unit rate of 25p/kWh.

A plot of power consumption for the Shanben air fryer at 200°C is shown in figure 2.73. While heating the air fryer, the first peak in consumption initially consumed about 1,650W but fell to about 1,600W once the appliance had reached temperature after about 2 minutes 35 seconds. Subsequent peaks in consumption lasted about 1 minute and were 40-45 seconds apart. Over the approximately 15-minute cooking time at 200°C, the Shanben air fryer used about 0.25kWh. For a unit rate of 25p/kWh, this would have cost 6.25p.

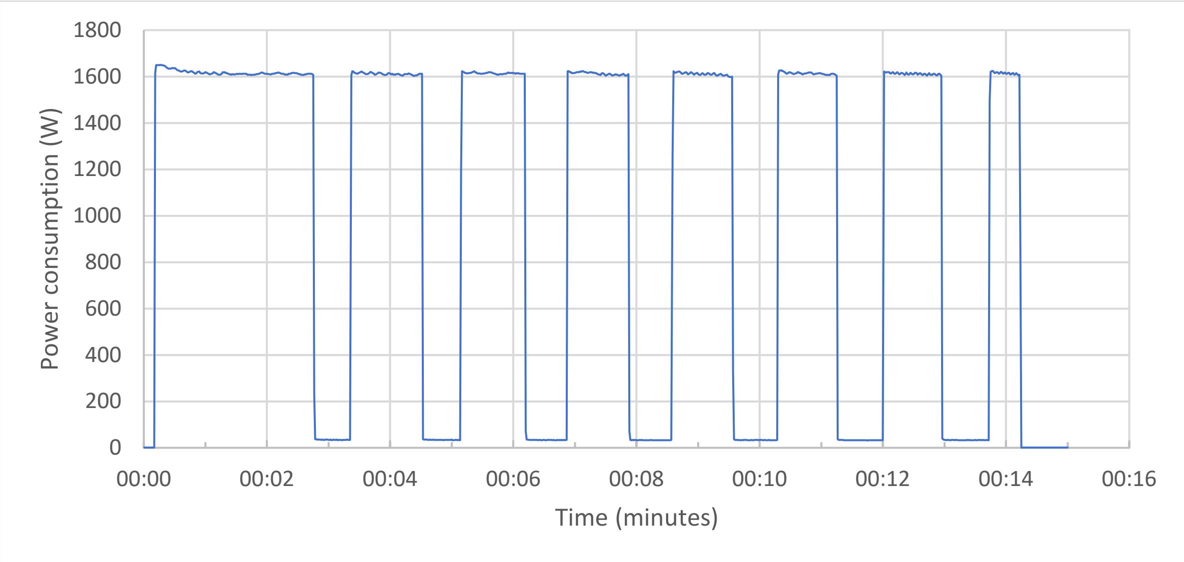


Figure 2.73 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Shanben HB-8031 air fryer over a cooking time of about 15 minutes at 200°C

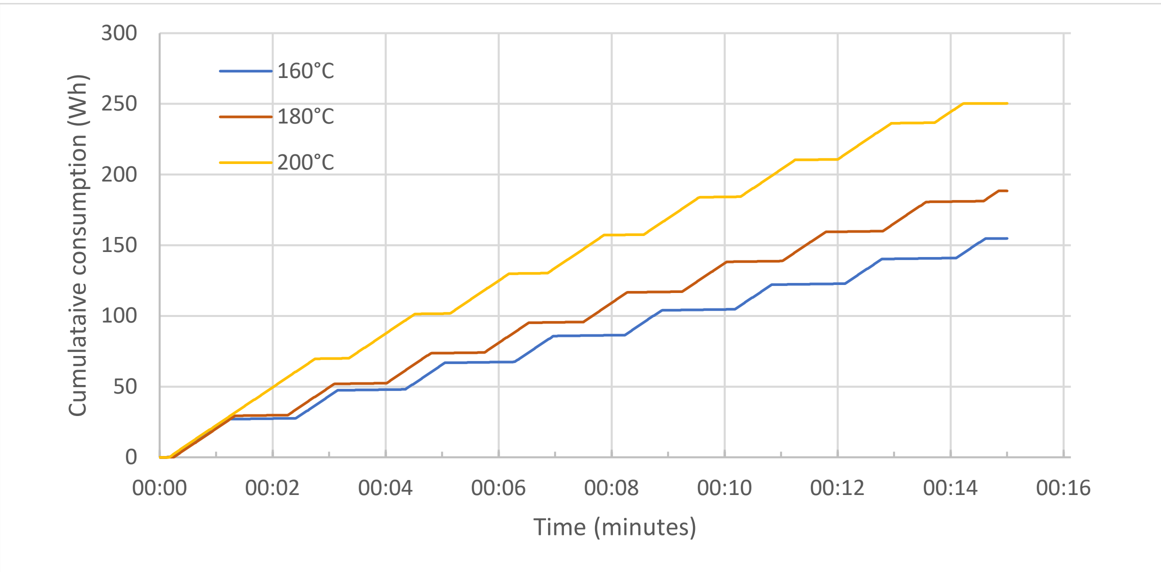


Figure 2.74 Plot of cumulative electricity consumption for the Shanben HB-8031 air fryer at cooking temperatures of 160°C, 180°C and 200°C

Figure 2.74 plots the cumulative electricity consumption of the Shanben HB-8031 air fryer at temperatures of 160°C, 180°C and 200°C. This can be compared to a similar graph in figure 2.68 for the Ninja AF160 over a shorter time period of 10 minutes.

As before, there was an initial period of higher consumption while the air fryer heated up. Subsequently there was a lower rate of consumption due to the heating element not being powered continuously. At lower cooking temperatures, the heating element could be powered for shorter periods and with longer gaps between these periods leading to a lower rate of increase in electricity consumption.

Table 2.75 compares the electricity consumption of the Ninja and Shanben air fryers at 3 temperatures. The Ninja AF160 had a slightly larger 5.2 litre basket compared to the Shanben HB-8031 which was 4.5 litre. The consumption at 160°C and 180°C over 10 minutes for the two air fryers were comparable. The Shanben air fryer used 8% less electricity at 200°C over 10 minutes. This may be due to a difference in methodology between the tests rather than a genuine saving.

Setting	Ninja AF160 Consumption (kWh)	Shanben HB-8031 Consumption (kWh)
160°C for 10 mins	0.103	0.105
160°C for 15 mins		0.155
180°C for 10 mins	0.136	0.138
180°C for 15 mins		0.188
200°C for 10 mins	0.20	0.184
200°C for 15 mins		0.25

Table 2.75 Comparing the electricity consumption of the Ninja and Shanben air fryers

Cooking times and electricity consumption with an oven were compared with those with an air fryer in the BBC radio programme Sliced Bread[79]. Table 2.76 illustrates the data recorded for cooking chicken legs and a jacket potato. Electricity consumption was measured using a smart meter. For both foods the cooking time was reduced with an air fryer and there was nearly a 60% reduction in the electricity consumption.

It should be noted that the electricity consumption measured for cooking the chicken legs over 20 minutes was more than double the consumption recorded over 10 minutes at 200°C in our testing of the Ninja and Shanben air fryers.

[79] Air Fryers, BBC Sliced Bread, 21 Dec 2022, https://www.bbc.co.uk/programmes/m0018hjr (Accessed 6 Aug 2024)

Food	Oven: cooking time and electricity consumption	Air fryer: cooking time and electricity consumption
Chicken legs	35 minutes and 1.05kWh	20 minutes and 0.43kWh
Jacket potato	1 hour and 1.31kWh	35 minutes and 0.55kWh

Table 2.76 Comparing the consumption of an oven and air fryer from BBC Sliced Bread[79]

The model or power consumption of the air fryer used for the BBC test was not specified. Our testing with an AEG fan-assisted oven at 180°C suggested that some ovens might use only 0.9kWh while cooking jacket potatoes for 1 hour.

Haden 9.5 litre dual basket air fryer

Figure 2.77 Haden 210500 dual basket air fryer

We also tested a Haden 210500 dual basket air fryer with a Shelly Plus smart plug. The total basket volume was 9.5 litres, and the rated power was 2,400W.

A single test was carried out using both baskets of the air fryer as follows:

- Small basket - Chicken programme 180°C for 21-minutes
- Large basket - Vegetable programme 160°C for 3 x 8-minute cycles

Figure 2.78 shows a plot of the average power consumption per minute recorded using the smart plug during the above cooking cycle. The minute level data from the smart plug does not show the regular pulses of electricity consumption that would be apparent with the 1-second data recorded by the Tinytag View 2 logger.

The maximum average consumption during the cooking period was 2,500W after 5 minutes. There were also periods with more steady average consumption of 2,200W and 1,500W. Over the full cooking period, the Haden air fryer used 0.61kWh with a cost of 15.25p assuming a unit rate of 25p/kWh. This was about double the consumption that might be expected from a single basket air fryer. So, in effect, the appliance was operating as 2 air fryers.

The dual basket air fryer is more appropriate for a family of 4 and savings in cooking time compared to an oven are achieved as for single basket air fryers. The overall savings in consumption are not as high as for a single basket model due to a higher volume being heated.

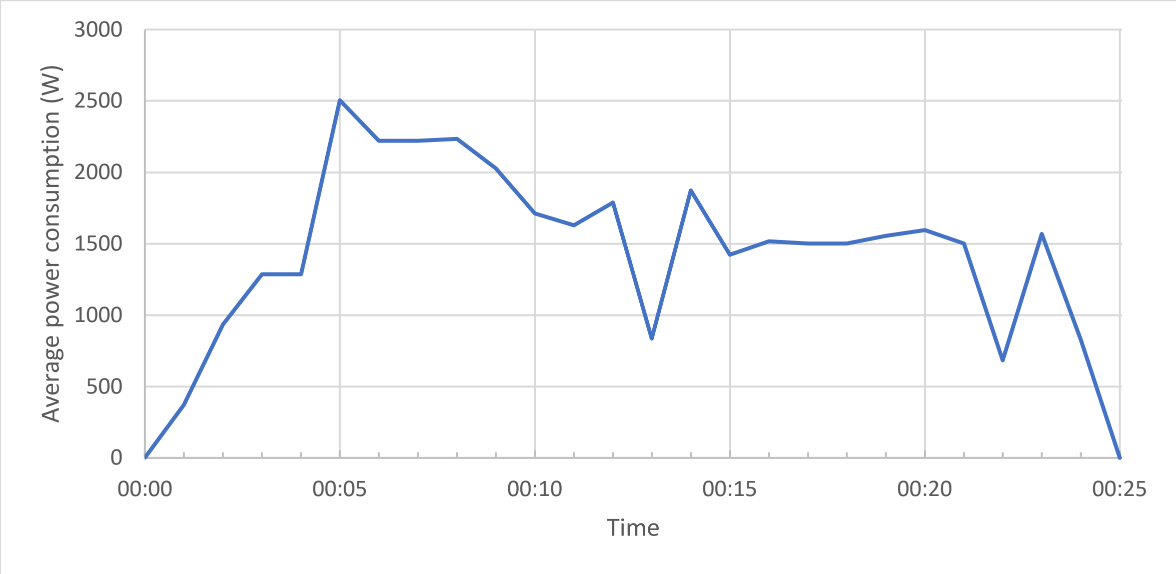


Figure 2.78 Plot of average consumption per minute measured with a Shelly Plus smart plug for the Haden dual basket air fryer at 180°C on small basket and 160°C on the large basket

Summary

- An air fryer has a heating element and a fan that rapidly circulates hot air over the food
- The device has 1 or 2 cooking baskets and these are perforated to assist in distribution of the hot air
- Air fryers are more energy efficient than ovens due to the lower volume heated and the rapid flow of hot air over the food
- Small air fryers can have a power rating of 1,400W while some dual basket models can be as high as 2,700W
- We tested 2 single basket air fryers with a basket capacity of about 5 litres and measured their consumption profiles at different temperatures
- The air fryer ran at full power while warming up and this took about 1 minute at 160°C but could take 3 minutes or more at 200°C; these heating times are much less than for an oven which can take about 20 minutes at 200°C
- After the air fryer heated up there were shorter regular pulses of consumption; these consumption pulses had a longer duration at higher temperatures
- The Ninja AF160 and Shanben HB-8031 air fryers recorded comparable electricity consumption of about 0.105kWh at 160°C and 0.137kWh at 180°C over 10 minutes
- The Ninja air fryer consumed 0.2kWh at 200°C and the Shanben used 0.184kWh over 10 minutes, with the difference more likely to be due to the testing than the performance of the appliances
- Testing by BBC Radio 4 Sliced Bread suggested an air fryer could make savings of nearly 60% when cooking a jacket potato or chicken legs compared to a fan oven
- Dual basket air fryers are more suited to larger families and have a reduced cooking time compared to an oven due to the high flows of hot air
- A dual basket 9.5 litre air fryer used 0.61kWh (costing 15.25p at 25p/kWh) on cycles while cooking chicken at 180°C in one basket and vegetables at 160°C in the other
- The higher consumption compared to the single basket air fryers is due to the larger volume being heated so effectively it was 2 air fryers running at once

2.5.5 Bread maker

Figure 2.79 Photos of Russell Hobbs 23620 bread maker

Households may want to bake their own bread due to the superior taste of fresh baked bread. There is also the ability to use healthier ingredients and avoid those which may produce allergies as well as the ability to try different recipes and flours. Apart from this, there is the attractive smell of fresh baked bread. Baking bread with a bread maker is easier, speeding up the preparation time and reduces the mess produced[80].

The cooking time for a loaf of bread in an oven is about 20 – 30 minutes at 200°C or 180°C in a fan oven[81] [82]. This could lead to a consumption of around 0.6 to 0.8kWh.

A bread maker has an electric heating element which goes around the bread tin. Only a small volume needs to be heated, and the consumption of the heating element is closely controlled to provide the temperature profile required by the programme for the bread maker. Tests were carried out using a Russell Hobbs 23620 bread maker which had a rated power of 660W[83].

Bread makers have a range of different programs for different types of breads or cakes. They can also vary the size of the loaf and the level of browning within the settings.

Electricity consumption was measured at 1-minute intervals using a Shelly Plus smart plug and consumption profiles were also recorded with a Tinytag View 2 logger and current clamp at 1 second intervals.

[80] Harpal Kaur, Benefits and Drawbacks of Bread Maker, (19 Feb 2024), https://appliancesinfo.com/benefits-and-drawbacks-of-bread-maker/ (Accessed 2 Aug 2024)
[81] Sara Bauenfeld, Homemade bread, Recipes, BBC Good Food, https://www.bbcgoodfood.com/recipes/easy-bake-bread (Accessed 2 Aug 2024)
[82] How to bake the ultimate loaf of bread, Tesco Real Food, https://realfood.tesco.com/step-by-step/how-to-bake-the-ultimate-loaf-of-bread.html (Accessed 2 Aug 2024)
[83] Russell Hobbs 23620 bread maker manual, https://uk.russellhobbs.com/amfile/file/download/file/623/product/98/ (Accessed 2 Aug 2024)

Basic program

This was used for plain white bread or multi-seeded bread. The program for a 500g loaf with medium crust lasted for 3 hours 10 minutes. Initially the bread maker mixed the ingredients with a paddle. While mixing, the appliance only used 30-50W (125-200mA). After about half an hour with mixing, the appliance provided a series of 5 second pulses of heat every 30 seconds for a few minutes at a time. This was to gently warm the dough and allow it to rise. While the heating element was powered, it used about 620W.

After about 2 hours 30 minutes, the bread maker started to bake the bread, with the heating element now powered for longer periods. The first cycle lasted 3-4 minutes with subsequent heating cycles lasting 1-2 minutes.

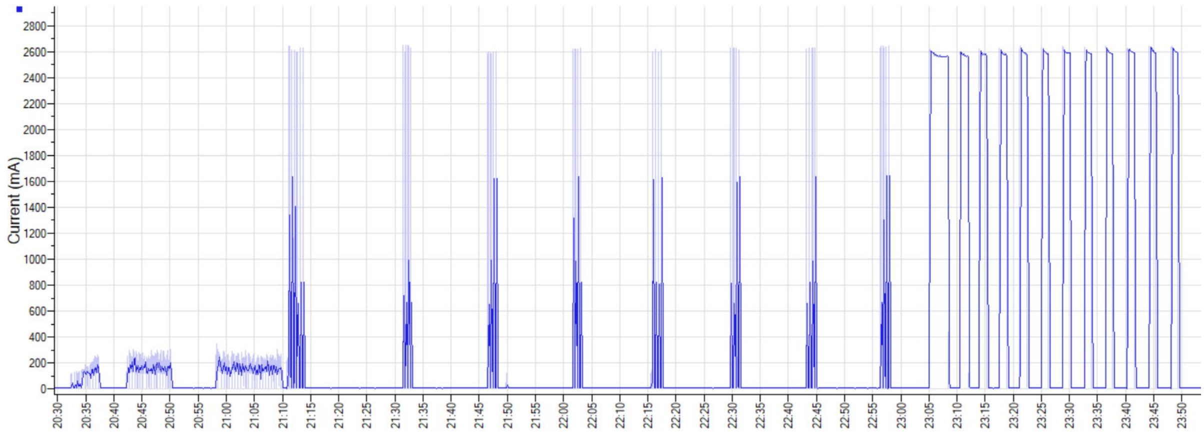


Figure 2.80 Electricity consumption (in mA) for a Russell Hobbs 23620 bread maker on the basic white loaf program recorded using a Tinytag View 2 data logger at 1 second intervals

Wholewheat program

Wholemeal flours need pre-heating before mixing and kneading to help the dough to rise. This means the Wholewheat program was longer and had a higher electricity consumption.

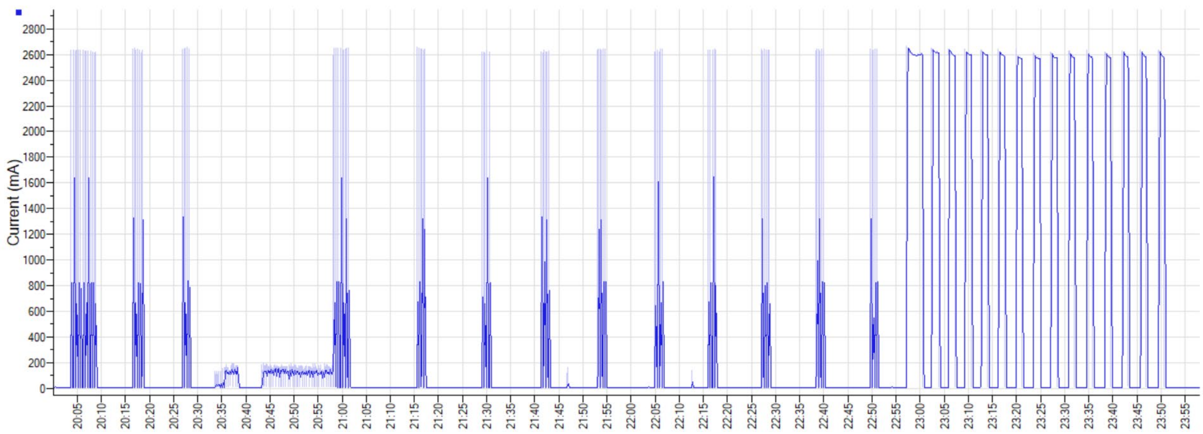


Figure 2.81 Electricity consumption (in mA) for a Russell Hobbs 23620 bread maker on the wholemeal program recorded using a Tinytag View 2 data logger at 1 second intervals

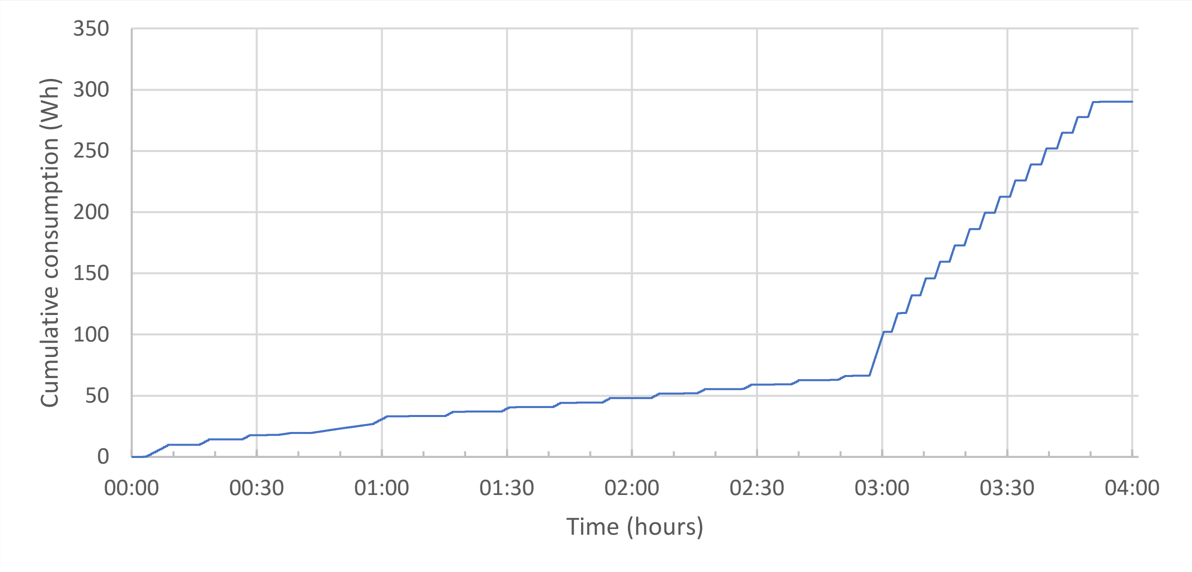


Figure 2.82 Cumulative electricity consumption (in Wh) for a Russell Hobbs 23620 bread maker on the wholemeal program recorded using a Tinytag View 2 data logger

A test was carried out using 500g of granary flour with a medium crust setting. A plot of the electricity consumption during the test is shown in figure 2.81. The mixture was preheated during the first 25 minutes of the program after which there was a further 25 minutes of mixing and kneading. The dough was periodically warmed for 2 hours to help it rise. The bread was baked during the final 45 minutes of the cycle.

Figure 2.82 plots the cumulative electricity consumption of the bread maker on the wholemeal program using data from figure 2.81. It is apparent that there was limited consumption during the first 3 hours of the program during the preheating, mixing/kneading and warming, with only 66Wh (0.066kWh) consumed after 2 hours 55 minutes. At the end of the wholewheat program an hour later after the baking, the cumulative electricity consumption had increased to 290Wh (0.29kWh).

Program	Setting	Cycle time	Average consumption (kWh)
Basic program	500g, medium crust	3h 10m	0.21
Wholemeal program	500g, medium crust	3h 45m	0.29
Cake program	500g, medium crust	1h 20m	0.20
Sweet program	500g, medium crust	3h 10m	0.27

Table 2.83 Cycle time and average electricity consumption for different bread maker programs

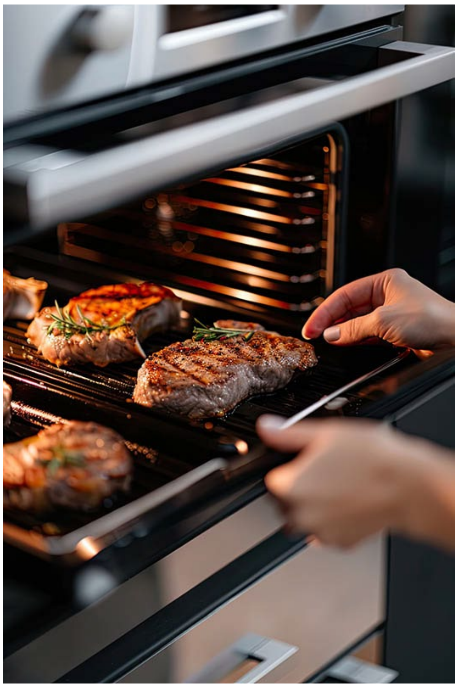
Table 2.83 shows the cycle time and average electricity consumption for different programs of the Russell Hobbs 23620 bread maker. This included the basic program for a 500g white loaf which used about 0.21kWh and a 500g wholemeal loaf which used 0.29kWh. Other programs tested using 500g of ingredients were the cake programme which used 0.2kWh and the sweet program (cooking a chocolate loaf) which used 0.27kWh.

Baking bread in an oven might use 0.6 to 0.8kWh. If only a single small loaf is cooked, the savings with a bread maker could be between 50% and 75%.

Summary

- Households may wish to bake their own bread due to the taste, using healthy ingredients or because of allergies
- It is much easier to bake bread using a bread maker than with an oven with the ingredients mixed by a paddle in the baking tin
- A heating element wraps around the baking tin and only a small volume is heated
- The low volume heated and precise control during the bread maker program leads to energy efficient baking
- A Russell Hobbs 23620 bread maker with a rated power of 660W was tested on several programs
- On the basic program for a white loaf which lasted 3 hours 10 minutes for a 500g loaf, the bread maker initially mixed the ingredients and then warmed the dough, allowing it to rise before baking over 40 minutes
- The wholemeal program for a 500g loaf was longer at 3 hours 45 minutes and preheated the ingredients before mixing, using more electricity
- The appliance used up to 620W and this tended to be in short pulses of consumption during preheating and longer pulses during the baking in the last 45 minutes
- The basic program for a 500g loaf used about 0.21kWh while the wholemeal program used 0.29kWh; this equates to costs of 5.25p and 7.25p for a unit rate of 25p/kWh
- Baking a small loaf in a bread maker can save 50% to 75% in consumption compared to an oven
- The savings with a bread maker will be lower if an oven is used efficiently, cooking several things at once or one after another

2.5.6 Grills



Many single ovens or top ovens will have a grill. In most cases, there is the ability to adjust the temperature while grilling and provide thermostatic control or to vary the size of the heating element which is powered.

While testing a Rangemaster Professional+ 110 range cooker, we measured the electricity consumption of the partial grill as 1,190W and the full-sized grill as 2,350W

Often it is not necessary to use the full-sized grill with an oven. A smaller amount of food can be cooked using a separate electric grill which uses less electricity. These devices claim faster cooking times and reduced running costs.

Figure 2.84 Using on oven grill (Freepik, arturstock)

George Foreman electric grill

We tested a George Foreman medium electric fit grill, which has a rated power of 1,630W. The manufacturer claims that the appliance used 82% less energy than a conventional oven grill during preheating and grilling beef burgers at 217°C[84].

The device had no temperature settings and the recommended cooking times[85] were:

- Sausages and burgers 6-10 minutes
- Chicken breast 8-10 minutes
- Bacon 3-5 minutes
- Salmon 3-5 minutes
- Cod 3-8 minutes
- Mushrooms 3-6 minutes

Figure 2.85 George Foreman medium electric fit grill

84 George Foreman Fit Grill Medium 25810, https://www.georgeforeman.co.uk/grills/fit-grill-black-medium (Accessed 5 Aug 2024)
85 George Foreman 25810 manual, https://cdn-img.georgeforemangrills.com/manager/georgeforemangrills_com/uk/ib/N25810_9708_03_SEP19.pdf (Accessed 5 Aug 2024)

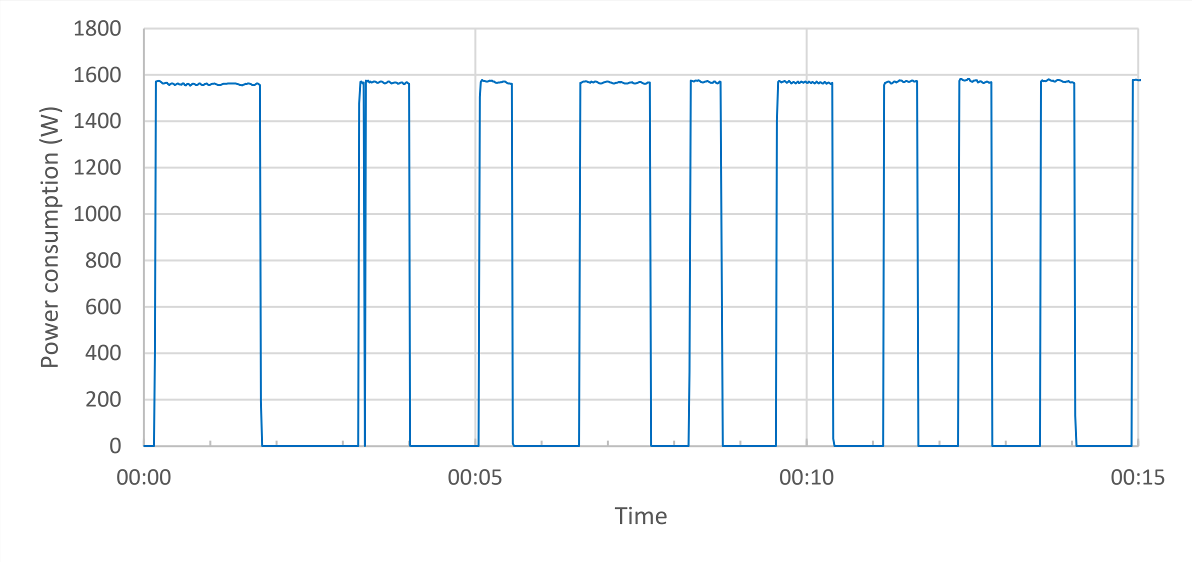


Figure 2.86 Plot of apparent power consumption measured every second with a Tinytag View 2 for the George Foreman medium electric fit grill over a cooking time of 15 minutes

Figure 2.86 shows the power consumption of the George Foreman medium grill while cooking for 15-minutes. Despite not having a temperature controller, the grill was thermostatically controlled to avoid overheating. This meant that there were pulses of electricity consumption rather than constant consumption.

After being turned on, the grill initially heated for 1 minute 34 seconds with an average consumption of 1,560W. The heating element then turned off for the next 1 minute 30 seconds. Subsequent pulses of heating were shorter, with the second pulse lasting 45 seconds. If the grill is opened during cooking, it is likely that the consumption will increase as the device warms up again.

Figure 2.87 plots the cumulative electricity consumption in Wh for the George Foreman grill using the data from figure 2.84.

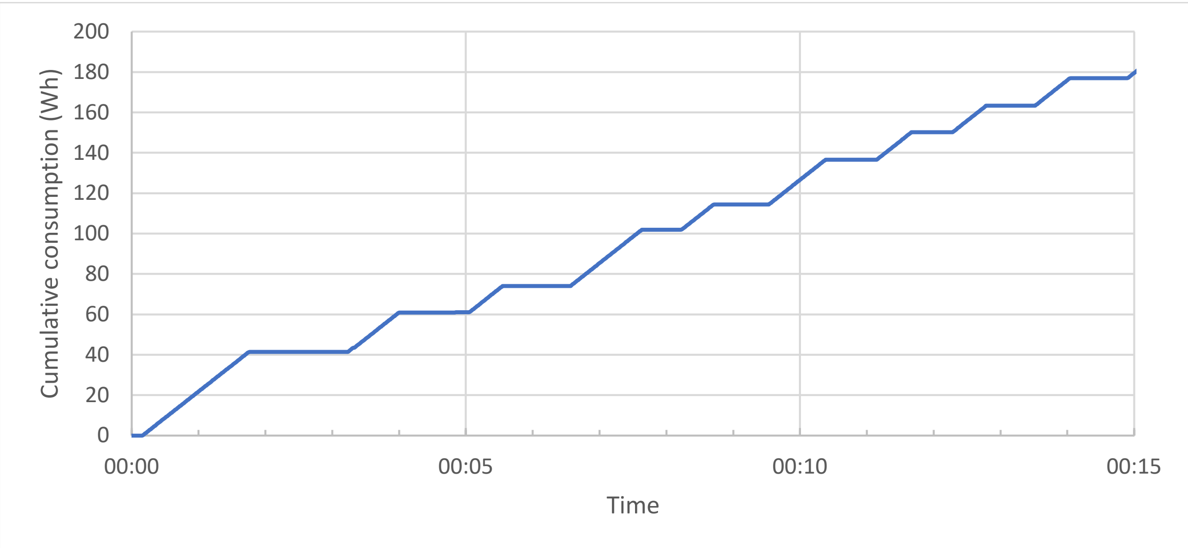


Figure 2.87 Cumulative electricity consumption (in Wh) for the George Foreman medium grill recorded using a Tinytag View 2 data logger

Cooking time (minutes)	Electricity consumption (kWh)	
	George Foreman Medium fit grill	Cookworks Halogen Oven at 190/200°C
5	0.061	0.114
10	0.127	0.19
15	0.18	0.295
20	0.225	0.36

Table 2.88 Comparing the electricity consumption of a George Foreman grill and Halogen Oven

Table 2.88 compares the electricity consumption of the George Foreman medium grill with that of a Cookworks halogen oven at 190/200°C. This assumes that neither appliance is opened part way through the cooking.

It normally takes about 15 minutes to cook burgers, sausages or fish in a halogen oven and this uses about 0.3kWh. With a similar cooking time, the George Foreman grill uses 0.18kWh, which is nearly 40% less. The manual for the grill claims these foods can be cooked in only about 10 minutes which would be 0.127kWh and more than a 55% saving compared to the halogen oven. In terms of electricity cost, cooking burgers, sausages or fish in the halogen oven might cost 7.5p for a unit rate of 25p/kWh compared to 3.18p for a cooking time of 10-minutes with the George Foreman grill.

Burgers or fish cooked in the oven might take about 25 minutes at 180°C for a fan-assisted oven. This could use at least 0.52kWh at a cost of 13p for a unit rate of 25p/kWh. Note that while cooking in the oven would use more electricity, other items could be cooked at the same time such as chips.

For a single person household who may only want to cook a single burger or chicken breast a smaller grill might be suitable. The George Foreman small electric fit grill has a smaller footprint than the medium grill (256mm x 193mm compared to 333mm x 275mm). As a result of the lower surface area to heat up, it can have the same cooking times while only having a rated power of 760W. Even greater savings are likely to be possible with this appliance if cooking in smaller quantities.

Silvercrest small raclette grill

Figure 2.89 Silvercrest 2-person raclette grill

A raclette is a traditional Swiss meal where melted cheese is eaten with potatoes, meat and vegetables. A grill heats the cheese in pans from above while warming a hot plate for cooking the meat and vegetables from below.

Figure 2.89 shows a 2-person raclette grill with a rated power consumption of 350W. Family sized raclette grills can have 8 pans and a power consumption of 1,200-1,500W. Figure 2.90 show a graph of power consumption over a 20-minute period with readings taken every second. It is apparent there was no thermostatic control of the grill, and the power consumption was consistent through the cooking period with an average consumption of 355W. It is likely that other raclette grills will run at full power throughout the cooking period.

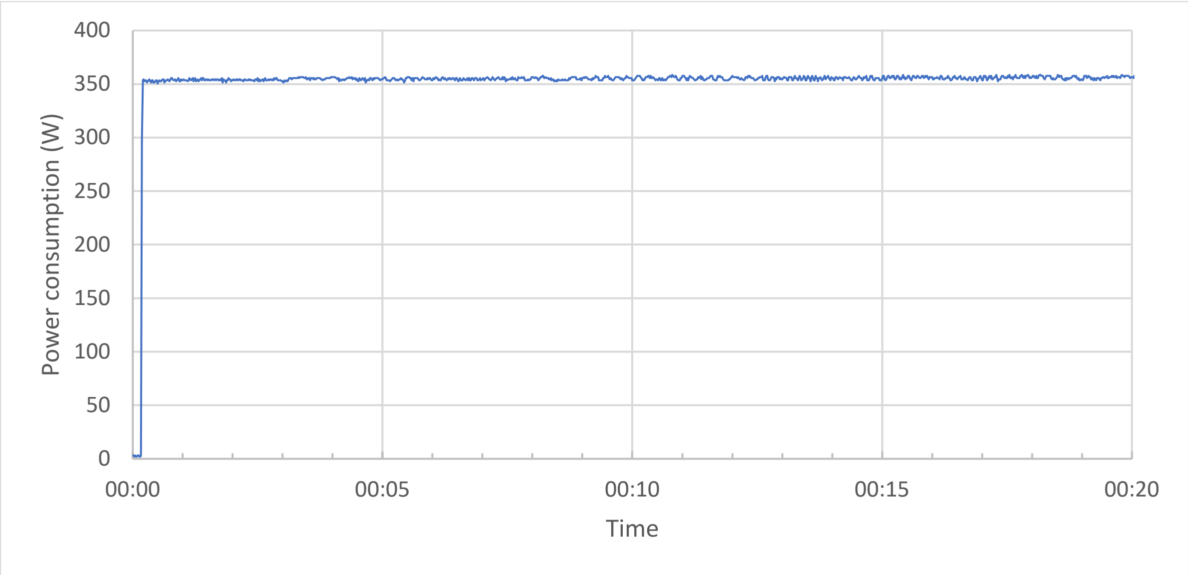


Figure 2.90 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Silvercrest 2-person raclette grill over a cooking time of 20 minutes

Cooking time (minutes)	Electricity consumption (kWh)
5	0.029
10	0.058
15	0.088
20	0.117

Table 2.91 Electricity consumption of a 2-person Silvercrest raclette grill for different cooking times

Table 2.91 shows the electricity consumption of the 2-person Silvercrest raclette grill based on the consumption data from figure 2.90. An 8-pan raclette grill will use about 1,400W, so over a 20-minute cooking period, it would use 0.47kWh at a cost of 11.75p for a unit rate of 25p/kWh.

Silvercrest SSMW 750B2 sandwich maker

Figure 2.92 Silvercrest sandwich maker

The Silvercrest sandwich maker has similarities to the George Foreman grill. There is a heating element in each side of the appliance. It has removable plates which can be used for toasting sandwiches, baking waffles or grilling food. There were no temperature controls on the appliance.

The device had a power rating of 750W and testing was carried out with a Tinytag View 2 logger recording the current consumed every second. This was converted to power assuming a supply voltage of 240V, which was close to the actual supply voltage at the sites used for testing.

During the test, the sandwich maker was used to toast 4 single sandwiches in a row.

A plot of the power consumption while the 4 sandwiches were toasted is shown in figure 2.92. The first sandwich took nearly 1 minute 40 seconds to toast. The average power consumption over this period was 794W with a total energy consumption of 21.8Wh. Subsequent sandwiches were quicker to toast, taking 30 seconds to 1 minute and using 6.8Wh to 13Wh of electricity. The shorter toasting time of the later sandwiches may have been due to the appliance being warmed during the first sandwich.

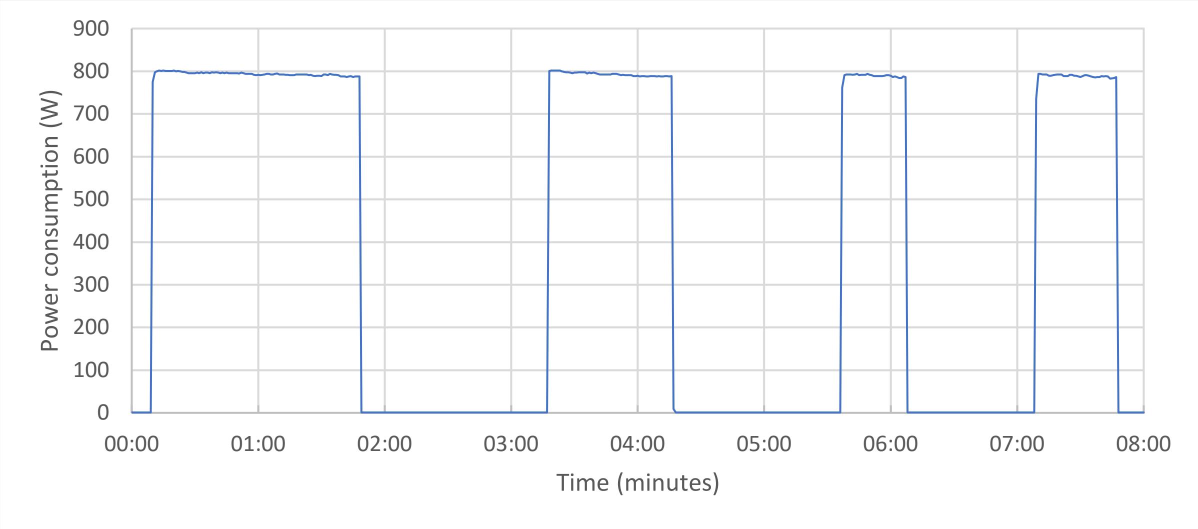


Figure 2.93 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Silvercrest SSMW 750 B2 sandwich maker

The manual for the Silvercrest SSMW 750 B2 sandwich maker[86] suggests sandwiches can take 5-6 minutes to cook depending on the type of filling and personal tastes. Cooking a waffle can take 5-7 minutes, depending on the type of batter and personal taste. This suggests our testing might have recorded lower electricity consumption than others might find in practice.

The modulation of the power consumption during the testing with the Silvercrest sandwich maker in figure 2.93 was due to multiple sandwiches being cooked rather than the device turning on and off due to a thermostat.

If the Silvercrest sandwich maker used a constant 790W over 5 minutes while toasting a sandwich, it is estimated the appliance would use 65.8Wh. This assumes there was no modulation during the toasting time due to a thermostat. This would cost 1.65p for a unit rate of 25p/kWh.

Summary

- Grills with an oven can use high levels of power with one using 1,200 – 2,400W
- An alternative is a separate electrically powered grill which can have low cooking times due to contact between the grill and the food
- The George Foreman medium electric fit grill tested was able to cook foods like sausages, burgers and fish within 10 minutes and only use about 0.13kWh at a cost of 3.25p for a unit rate of 25p/kWh
- This compares to cooking in a halogen oven which can take 15 minutes and use about 0.3kWh or in a fan oven, taking 25 minutes and using at least 0.52kWh
- The electricity consumption of the George Foreman grill varied during cooking as a thermostat caused the power to periodically cut out, ensuring the grill did not overheat; in contrast a raclette grill ran at full power (355W) during the full time it was operating

[86] Silvercrest SSMW 750 B2 sandwich maker manual, https://media.sit-connect.com/public/articlemanual/972490187/283004_CY_EN_EL.pdf (Accessed 8 Aug 2024)

2.5.7 Toasters

Figure 2.94 Russell Hobbs 24200 toaster

Electric toasters come in a variety of sizes, ranging from single slot toasters to 4 slot toasters. They can be used to toast thin or thick bread as well as other items such as muffins, crumpets and potato cakes. To achieve the required level of browning, the toasting time is varied with a control. Different products require different toasting times in different toasters.

Russell Hobbs 24200 toaster

A single slot Russell Hobbs 24200 toaster was tested that had a power rating of 690 – 820W. The toaster was tested with a Shelly Plus smart plug and the consumption recorded on each of the 6 browning settings. Toasting a thicker slice of bread used 16.6Wh or 0.017kWh with a cost of 0.4p for a unit rate of 25p/kWh.

Setting	Duration	Application	Consumption (Wh)
Level 1	50 seconds	Hot cross bun	11
Level 2	1 minute 5 second	Thinner bread	14.2
Level 3	1 minute 15 seconds	Thicker bread	16.6
Level 4	1 minute 26 seconds		19.4
Level 5	1 minute 36 seconds		21
Level 6	1 minute 47 seconds	Crumpet or potato cake	24

Table 2.95 Electricity consumption for a Russell Hobbs 24200 toaster on different settings

Smeg TSF03WHUK

Figure 2.96 Smeg TSF03WHUK toaster

We also tested a Smeg TSF03WHUK 4 slot toaster which had a rated power of 2,000W. This was tested in both 2 and 4 slot mode with a standard slice of bread. A Tinytag View 2 logger was used to monitor both the toasting time and the electricity consumption.

The toaster took 2 minutes 10 seconds to toast a standard slice of bread. Figure 2.95 plots the power consumption with 2 and 4 slices toasted. The electricity consumed when toasting with 2 slots was 35.3Wh with an average consumption of 969W. When using all 4 slots to toast a standard slice of bread, the consumption was 61.6Wh with an average power consumption of 1693W.

The Russell Hobbs single slice toaster used about 15Wh to toast a single slice of bread. This is just less than half the 35Wh the Smeg toaster used with 2 slots. If a single slice of bread is toasted with the Smeg the electricity consumed per slice is more than double. If 2 slices of bread are toasted in the Smeg, the electricity consumed per slice is slightly more than for the Russell Hobbs. If all 4 slots are used with 4 slices of bread, the consumption per slice is similar to the electricity used by the Russell Hobbs toasting a single slice.

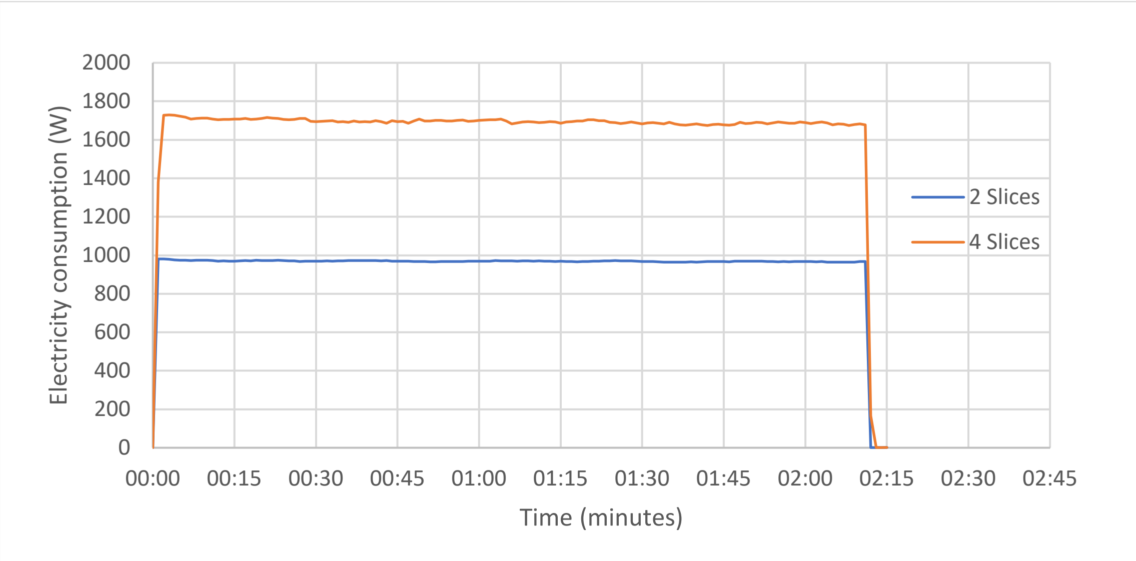


Figure 2.97 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Smeg TSF03WHUK toaster with 2 and 4 slices of toast

Summary

- Toasters can use between 800W and 2000W depending on the number of slots
- Single slot toasters are economic if only toasting single slices and can consume 15Wh

2.5.8 Cooker hobs

Cookers can have a variety of different types of hobs. There are gas hobs which provide a high degree of control but there are risks associated with using a gas appliance and not all households have access to gas. Older or cheaper electric cookers may have a solid electric plate hob where the heating element is covered by a solid metal plate[87]. These are slower to heat up and are less responsive. Instead of a solid electric plate, some cookers may have a ring heating element. The downside of this is that if the pan boils over, it is harder to clean the cooker. More modern cookers can have ceramic hobs where the heating element is under ceramic glass. These hobs are easy to clean but take time to heat up and cool down. Induction hobs use a magnetic field to create heat in the metal pan causing the food inside to heat up. They heat the pan directly rather than a heating element getting hot and transferring heat to the pan. This makes them more responsive and energy efficient[88].

While it was not possible to measure the consumption of an electric hob built into a cooker, we were able to test a couple of plug-in electric hobs. These were tested using Shelly Plus smart plugs with minute resolution monitoring and a Tinytag View 2 logger and current clamp with second resolution monitoring.

SQ Professional single electric hot plate hob

The SQ Professional single electric hot plate hob had a rated power of 1,000W. The controller had 5 temperature settings although it was an analogue control and so adjustments could be made between settings.

An initial test was carried out with a Shelly Plug to measure the electricity consumption and time required to boil 500ml of water from cold. This took 8 minutes and used 0.13kWh.

Figure 2.98 SQ Professional single electric hot plate hob

For comparison a kettle used 0.06kWh to boil the same amount of water. In another test, the electric hot plate hob was used to cook a paella on setting 5 (full power) for about 25 minutes. The consumption was recorded using the Tinytag View 2 logger and the current measured by the current clamp was multiplied by 240V to get the apparent power (figure 2.99). During the first 6 minutes, the electric hot plate hob consistently used over 1,000W. After that, a thermostat caused the power to modulate in order to keep the hot plate at the correct temperature.

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[87] CDA - Electric hob buying guide, https://www.cda.co.uk/hobs/electric-hob-buying-guide/ (Accessed 14 Aug 2024)

[88] What is an Induction Hob and How does one work?, Marks Electrical, https://markselectrical.co.uk/connect/what-is-an-induction-hob (Accessed 14 Aug 2024)

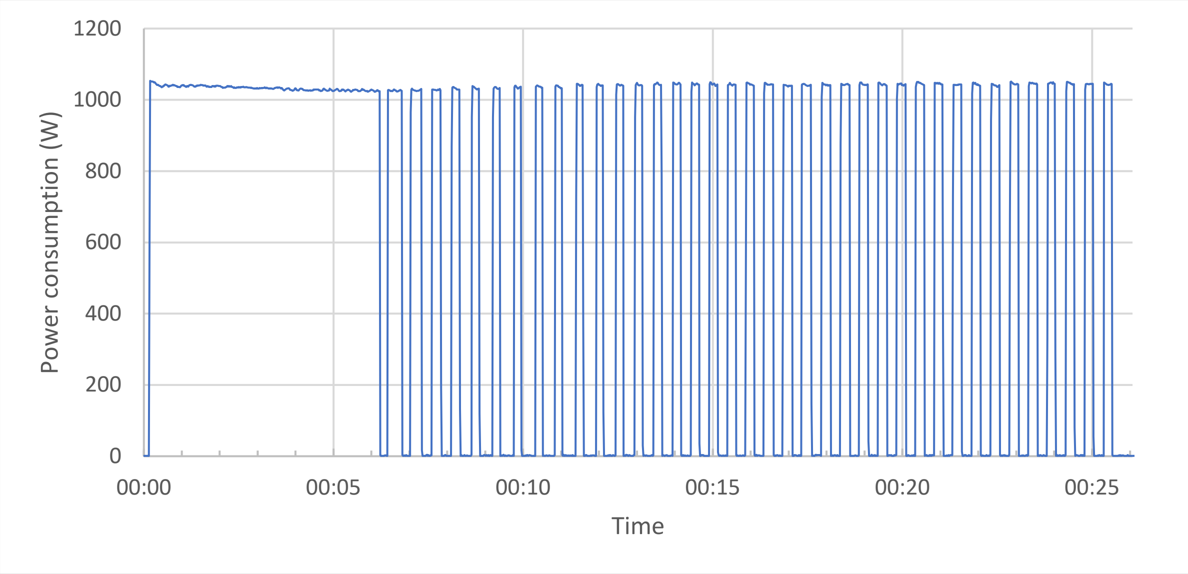

Figure 2.99 Plot of apparent power consumption measured every second with a Tinytag View 2 for the SQ Professional single electric hot plate hob on setting 5

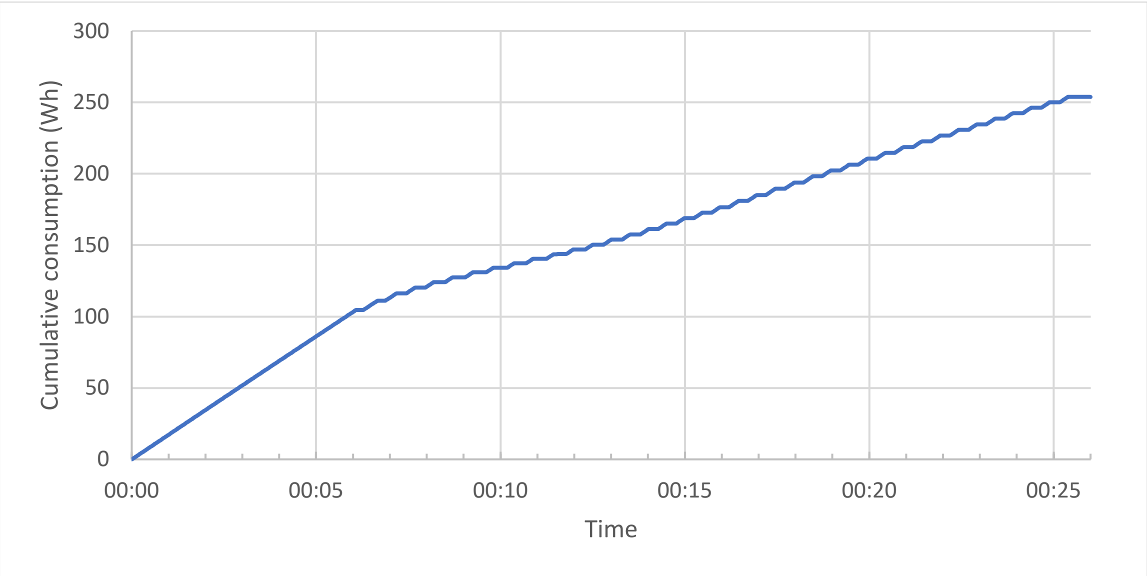

Figure 2.100 Plot of cumulative electricity consumption measured with a Tinytag View 2 logger for the SQ Professional single electric hot plate hob on setting 5

A plot of the cumulative electricity consumed by the electric hot plate hob on setting 5 is shown in figure 2.100. The appliance was using electricity at a higher rate while heating up and the rate decreased after 6 minutes when the thermostat caused the power to start modulating. The paella was cooked after 25 minutes with the electric hot plate hob having used 0.25kWh. The cooking time was longer than for an induction hob which heats faster.

The electricity consumption was also measured using a Shelly Plus plug while cooking pasta in a pan starting from cold water with vegetables above in a steamer (figure 2.101). The electric hot plate hob was left on full power (setting 5) until the water boiled, which again took about 8 minutes. After the water boiled, the control on the hob was turned down to 3. The power consumption dropped at this point and there was no consumption recorded over the following

2 minutes, most likely because the temperature of the hot plate stayed above the level where power was needed on setting 3. The average consumption per minute was subsequently 150W to 400W, most likely due to modulation of the power to the electric hot plate hob. The hot plate used 0.214kWh while cooking the pasta and steaming the vegetables. This would equate to a cost of 5.35p for an electricity unit rate of 25p/kWh.

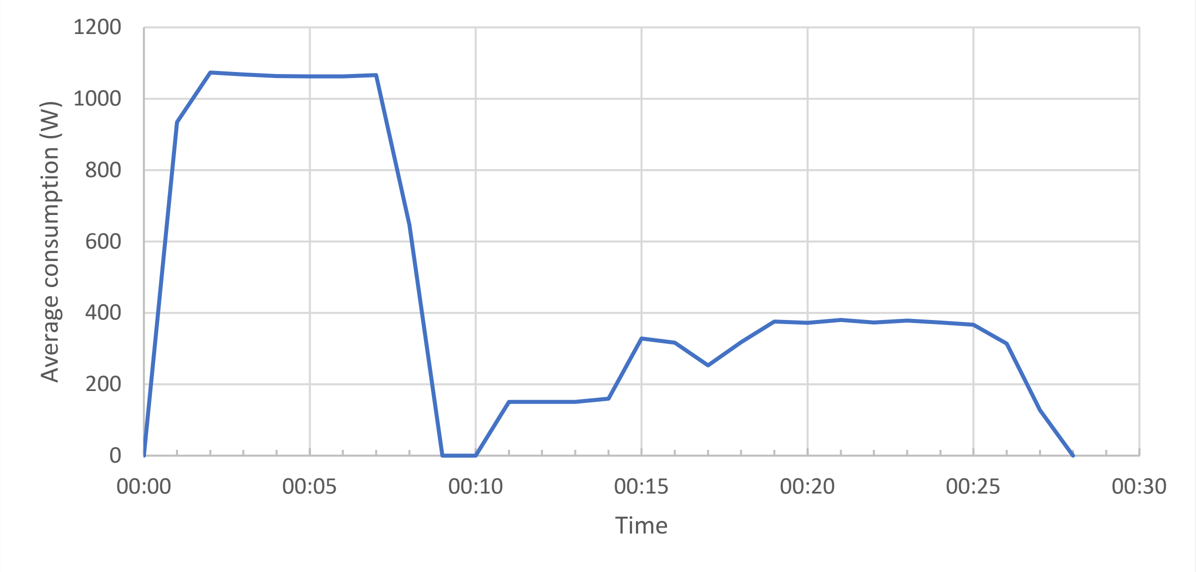

Figure 2.101 Plot of average consumption per minute measured with a Shelly Plus smart plug for the SQ Professional single electric hot plate hob starting on setting 5 and turned down to 3

Cooking details	Time	Consumption (Wh)
Boiling 500ml of water from cold on setting 5 *	8 mins	129
Cooking paella in wok on setting 5	10 mins	134
Cooking paella in wok on setting 5	15 mins	169
Cooking paella in wok on setting 5	20 mins	211
Cooking paella in wok on setting 5	25 mins	250
Cooking pasta and steaming vegetables initially setting 5 later on 3 *	27 mins	214

Table 2.102 Electricity consumption for the SQ Professional single electric hot plate hob for different cooking times and settings. * Data collected with Shelly Plus smart plug

Table 2.102 summarises the electricity consumption of the electric hot plate hob over the series of tests. As noted earlier, it took about 8 minutes to boil 500ml of water in a pan on the hot plate hob and this consumed 0.13kWh as measured by a Shelly Plus smart plug. This would be a cost of 3.25p for a unit rate of 25p/kWh.

Pasta was cooked starting with cold water and the hob setting on 5 until the water boiled. The hob setting was subsequently reduced to 3 until the pasta was cooked after a total of 28 minutes (8 minutes to boil and 20 minutes to cook). The Shelly Plug recorded the consumption as 0.21kWh.

The electricity was monitored using a Tinytag View 2 logger while cooking a paella. Here there was consumption data every second and this was used to calculate the cumulative electricity consumed (figure 2.98). Based on this data, the electric hot plate hob consumed 0.13kWh on setting 5 after 10 minutes, 0.17kWh after 15 minutes, 0.21kWh after 20 minutes and 0.25kWh after 25 minutes. A consumption of 0.25kWh would cost 6.25p for a unit rate of 25p/kWh.

Silvercrest single induction hob

Figure 2.103 Silvercrest single induction hob

The other cooking hob tested was a Silvercrest SIKP 2000 F1 plug-in single induction hob. The appliance had a rated power of 2,000W. The appliance had 10 power levels and the manual[89] suggested average power consumption and temperatures shown in table 2.104 for the different settings.

Also shown in table 2.104 is the electricity consumption measured with a Shelly Plus smart plug over a period of 10 minutes for the different power settings. These values were converted to a value of average power consumption in watts by multiplying by 6.

Setting 5 on the electric hot plate hob used 0.13kWh over 10 minutes. For comparison setting 4 for the induction hob used 0.11kWh and setting 5 used 0.18kWh.

The average power consumption measured by the Shelly Plus plug was close to the values published in the manual for settings 1 to 3. The difference between the measured average and the value in the manual was over 100W for levels 4 to 6. The measured average for setting 9 was over 200W lower than the published value. This may have been due to issues with the testing methodology with the water quickly boiling during the test and having to add cold water.

[89] Silvercrest Induction Hob SKIP 2000 F1 manual, https://media.sit-connect.com/public/articlemanual/44ce5b78-81ed-46de-be04-b2ae3ad3a35d.pdf (Accessed 14 Aug 2024)

Power setting	Power level (W)	Temperature level (°C)	Consumption measured by smart plug over 10 mins (Wh)	Average power consumption (W)
1	200	60	31.7	190.4
2	400	80	67.1	402.8
3	600	100	95.3	571.7
4	800	120	114.1	684.7
5	1000	140	184.3	1106
6	1200	160	224.89	1349
7	1400	180	238.6	1432
8	1600	200	264.7	1588
9	1800	220	260.7	1564
10	2000	240		

Table 2.104 Power level and temperature level for different setting on the Silvercrest induction hob from the manual.

The consumption pattern of the induction hob was also measured using a Tinytag View 2 logger and current clamp. There were issues with these results as data from the logger suggested there was an electricity consumption of about 200W with the appliance turned on with no heating despite the Shelly Plug indicating a consumption of just 1W. A high apparent base load consumption was also measured with some other appliances in this kitchen using the Tinytag View 2 but not to this extent. The cause was not identified but might be due to wiring issues in the house. This issue was not seen at other properties using the Tinytag View 2 logger and current clamp.

Figure 2.105 shows a plot of electricity consumption (current recorded x 240V) for the induction hob on levels 1 and 3. The graph shows the apparent baseload of over 200W, which was due to a monitoring issue.

It also shows there were 15 pulses of power consumption over the 2-minute 30 seconds monitoring period shown in the graph. Levels 1 to 4 on the heat setting all had pulses of power consumption with the pulses being wider as the heat setting increased. The pulses of power consumption lasted 2 seconds at a time on level 1 but this increased to 5 seconds at a time for level 3 and 6 seconds at a time for level 4.

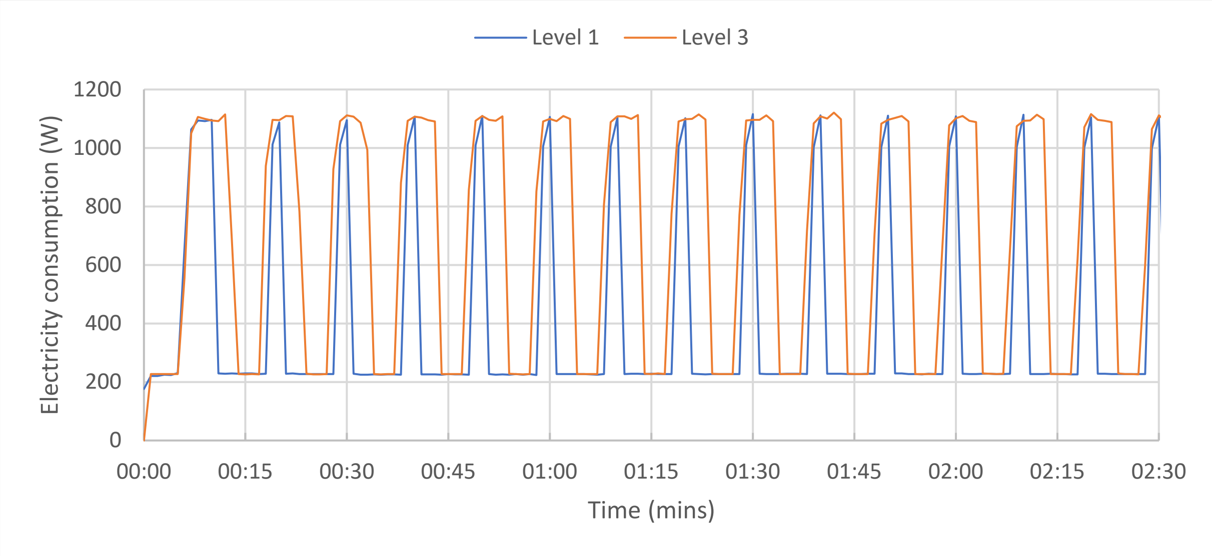

Figure 2.105 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Silvercrest Induction hob on levels 1 and 3

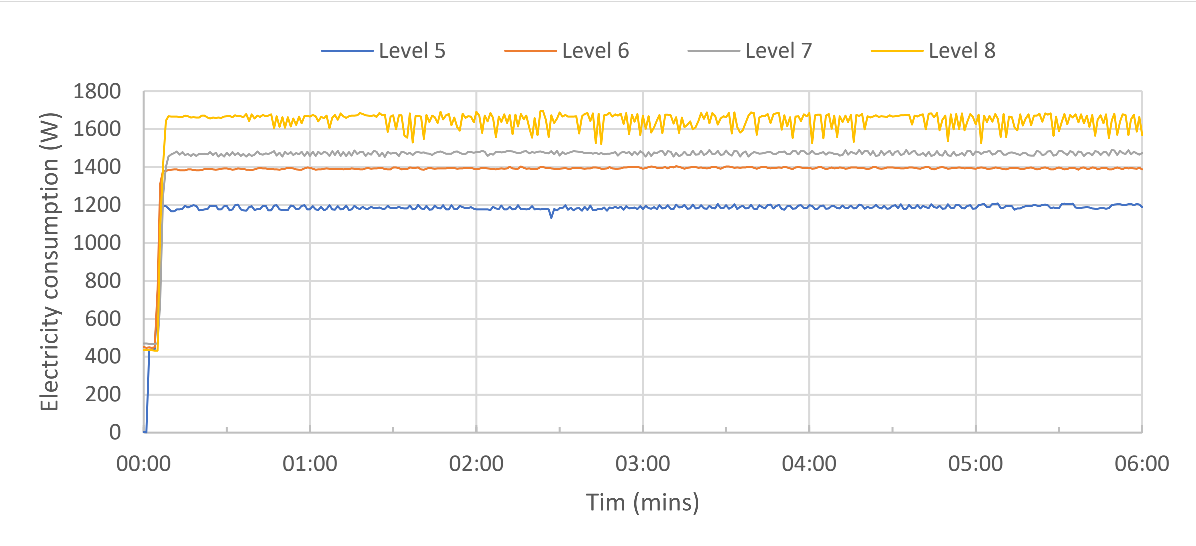

Figure 2.106 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Silvercrest Induction hob on levels 5 to 8

Figure 2.106 illustrates the electricity consumption measured for the induction hob on heat settings 5 to 8. Instead of there being short pulses of power consumption, it was generally at consistent level. The power consumption increased for the higher heating settings.

It took about 3 minutes 30 seconds to boil 500ml of water with the induction hob and this used 66Wh. For comparison it took the electric hot plate hob about 8 minutes to boil 500ml of water and this used 129Wh.

The induction hob was also tested cooking pasta and steaming vegetables. There was 500ml of cold water with pasta and this was heated on level 5 for about 5 minutes until the water was boiling. The power was turned down to level 2 for just over 15 further minutes. The electricity consumed was 205Wh which was little different to the 215Wh measured cooking the same dish with the electric hot plate hob.

Summary

- The main types of electric hobs are: electric hot plate hobs, electric ring hobs, ceramic hobs and induction hobs
- Induction hobs are more responsive as they use a magnetic field to heat the pan rather than the hot plate getting hot and heating the pan in contact with it
- It took about 8 minutes to boil 500ml of water in a pan on an electric hot plate hob using 0.13kWh; for comparison it took 3 minutes 30 seconds to boil the water on an induction hob using 0.07kWh while a kettle used 0.06kWh to boil the water
- The 1,000W rated SQ Professional electric hot plate hob when on the highest setting (5) consistently used over 1,000W for about 6 minutes while reaching temperature; subsequently the power to the heating element cut in and out due to temperature control from the thermostat
- The SQ Professional hot plate used 0.13kWh on setting 5 after 10 minutes and this increased to 0.25kWh after 25 minutes
- This would be a cost of 3.25p after 10 minutes and 6.25p after 25 minutes for a unit rate of 25p/kWh
- A Silvercrest 2,000W rated induction hob was also tested which had 10 power settings
- On power levels 1 to 4 there were regular pulses of power consumption with longer pulses of consumption on higher levels
- On power levels 5 and above, the consumption was consistent but had higher levels for higher settings; normally it was not necessary to use settings above power level 5
- Power level 5 would typically be used to bring a pan to boil while power level 2 would be used to keep it simmering
- Over a 10-minute period, the induction hob used 0.18kWh on power level 5 (costing 4.5p at 25p/kWh) and 0.067kWh on power level 2 at a cost of 1.68p
- Both the electric hot plate hob and the induction hob were tested cooking pasta with vegetables on a steamer above; this started with cold water and the hob on setting 5, with the power level turned down after the water boiled
- While it took the electric hot plate hob longer to warm up and boil the water than the induction hob, there was little difference in the power consumption cooking the food, with both using about 0.21kWh with a cost of 5.25p for a unit price of 25p/kWh

2.5.9 Steamers

Figure 2.107 Salter EK2726 steamer

Many people will steam vegetables in a steamer over a pan on a cooker hob. These can have one or more levels and make use of the steam from the boiling water in the pan. This means you can for example cook pasta in the pan and vegetables in the steamer at the same time, saving electricity.

As well as over pan steamers there are electric steamers available on the market. These can have multiple compartments and can steam vegetables, rice, fish and chicken.

Advantages of steaming include healthier meals which reduce the loss of vitamins and minerals during cooking. There is reduced use of oil, and the gentler cooking can avoid food shrinking or becoming tough[90]. In addition to the health benefits there are claims that steaming is an energy efficient way of cooking.

Salter EK2726 steamer

The Salter EK2726 has 3 steam baskets with a capacity of 7.5 litres which stack on top of each other. There is also a bowl for cooking rice. This model has a rated power consumption of 500W. When using the device, the first step is to fill the reservoir at the bottom with about 500 ml of boiling water. The food is placed in the baskets which are stacked on top of one another and the lid placed on the top. There is an analogue timer on the base which turns off the power after the set cooking time.

Recommended cooking times are shown in table 2.108. Cooking times are likely to be longer if 2 or 3 of the steam baskets are used or the food is in several layers in one of the baskets.

Food	Approximate cooking time
Broccoli or carrots	15 minutes
New potatoes	20-25 minutes
Fish fillets	10 minutes
Chicken breast	20-30 minutes
Rice	25-30 minutes (in rice bowl with water)

Table 2.108 Recommended cooking times with a Salter EK2726 steamer[91]

[90] 10 Benefits of Steam Cooking, Lars Appliance, 14 Jun 2023, https://larsappliance.com/what-10-benefits-steam-cooking/ (Accessed 8 Aug 2024)
[91] Salter EK2726 3-tier steamer manual, https://salter.com/content/EK2726.pdf (Accessed 8 Aug 2024)

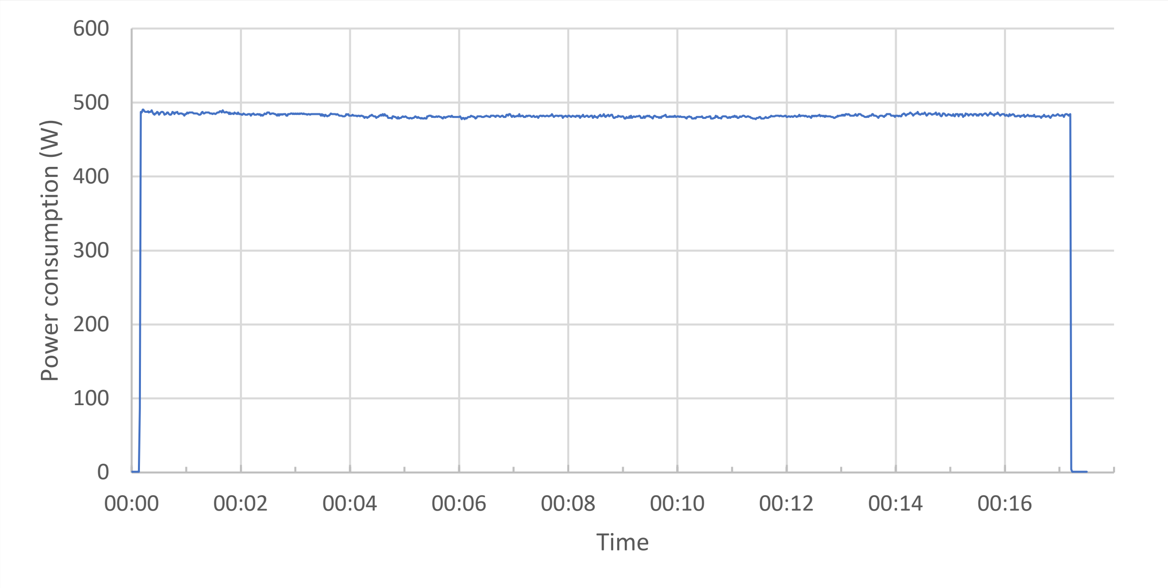

Figure 2.109 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Salter EK2726 steamer

Figure 2.109 plots a graph of the power consumption of the Salter EK2726 steamer over a cooking period of about 17 minutes. The heating element in the base ran consistently, heating the water to produce steam. There was no modulation of the power consumption and the average consumption over the test was 482W, which was slightly lower than the rated power of 500W.

In order to fill the reservoir for the steamer with boiling water, it is necessary to boil 500ml of water in a kettle. The efficiency of the kettle is about 70-80% and it takes about 60Wh of electricity to boil the required water[92]. We boiled 500ml of water in a kettle monitored with a Tinytag View 2 logger and measured the apparent power consumption to be 61Wh.

Using the consumption from boiling the water and data from the test in figure 2.109, it is possible to calculate the total electricity consumption for different cooking times with the Salter steamer.

Table 2.110 shows the electricity consumption for cooking times between 10 and 30 minutes. These values are quite low and using several baskets, it is possible to cook a whole meal for 0.2 to 0.3kWh. Salter claims that it is possible to save 69% on electricity consumption cooking 100g of broccoli with the steamer compared to using a 1.8kW electric hob[93].

We were able to cook pasta in a pan on an electric hob with vegetables steamed above using 0.21kWh. While it would be possible to cook broccoli in the steamer using only 0.18kWh, if wanting to cook rice (or perhaps pasta), the cooking time would probably be 25 minutes and use 0.26kWh. This suggests that the steamer is not necessarily a more energy efficient way of cooking.

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[92] Wirfs-Brock and Jacobson (2016), A Watched Pot: What is the Most Energy Efficient Way to Boil Water? https://insideenergy.org/2016/02/23/boiling-water-ieq/ (Accessed 8 Aug 2024)
[93] Salter 3-tier 7.5 litre food steamer, https://salter.com/3-tier-7-5l-food-steamer/ (Accessed 8 Aug 2024)

Cooking time	Total electricity consumption (kWh)	Electricity cost for a unit rate of 25p/kWh
10 minutes	0.14	3.5p
15 minutes	0.18	4.5p
20 minutes	0.22	5.5p
25 minutes	0.26	6.5p
30 minutes	0.30	7.5p

Table 2.110 Total electricity consumption for different cooking times with Salter EK2726 steamer Note that 0.06kWh of this consumption is due to boiling water for the reservoir

Morphy Richards Intellisteam Food Steamer

Figure 2.111 Morphy Richards Intellisteam 48781

There are more sophisticated electric steamers on the market and one example is the Morphy Richards Intellisteam 48781. The device had 3 steamer containers which were all at the same level making access easier than a tiered model. There were 2 smaller containers at the front and a longer one at the back and the total capacity was 8.2 litres, making it suitable to cook for a family of 4.

Each of the containers can have independent cooking times set by a digital controller. The food requiring the longest cooking time starts first and the appliance will have the different containers finishing cooking at the same time. There is a keep warm function that keeps the food hot until you are ready to serve it.

The rated power for the device was 1,350 - 1,600W.

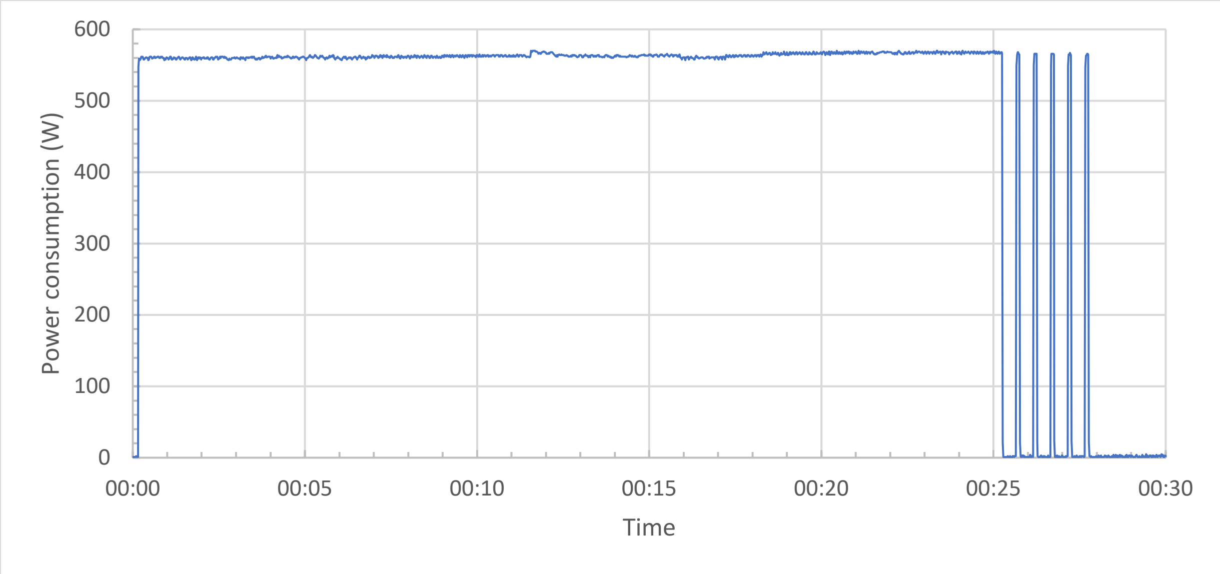

Figure 2.112 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Morphy Richards Intellisteam 48781 steamer using just the rear container

Two tests were carried out using the Tinytag View 2 logger measuring data every second and with the Shelly Plus smart plug measuring data each minute.

The first test involved cooking new potatoes for 25 minutes in the large rear container of the Morphy Richards steamer. Figure 2.112 shows a plot of the Tinytag View 2 data and the consumption consistent with an average of 563W over the cooking time. After that there was a period of about 2 minutes 30 seconds with short pulses of electricity consumption while the food was kept warm before serving.

The electricity consumption while cooking the potatoes was 236Wh while a further 5Wh was used while keeping the food warm. This would cost 6p for a unit price of 25p/kWh.

The second test used all 3 containers with different cooking times. These were:

- Large container at the rear – new potatoes – 30 minutes
- Front left container – salmon – 25 minutes
- Front right container – carrots and broccoli – 20 minutes

A plot of the electricity consumption during this cooking period is shown in figure 2.113. During the first 5 minutes of cooking with just the large container at the rear, the power consumption was consistent with an average of 556W. After the front left container started cooking, the power modulated between about 1,045W and 556W. Once all 3 containers were being heated the power consumption increased further and modulated between about 1,530W and 1,045W. After the cooking was completed, the power consumption dropped to zero. However, there were a couple of 6 second spikes of electricity consumption at 1,530W while the food was kept warm before being served.

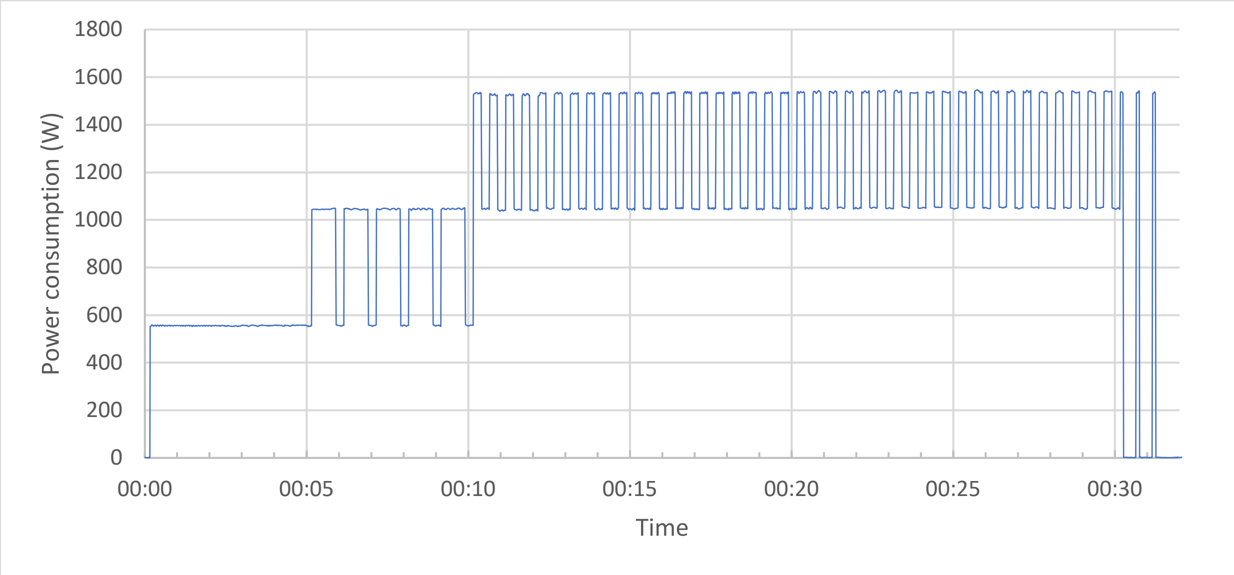

Figure 2.113 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Morphy Richards Intellisteam 48781 steamer using all 3 containers

The electricity consumption while cooking the full meal in the Morphy Richards Intellisteam was 0.556kWh. This would cost 13.9p with a unit rate of 25p/kWh. This compares to 0.3kWh and 7.5p for a cooking time of 30 minutes in the Salter steamer, although the cooking time would most likely need to be extended due to it being a large meal with 3 tiers of steamers. The Morphy Richards Intellisteam had greater electricity consumption but was easier to use than the Salter steamer and allowed different cooking times in the 3 compartments so that all finished cooking at the same time.

For comparison, cooking pasta on an electric hob and steaming vegetables used 0.21kWh while cooking fish in a halogen oven might use 0.3kWh making a total of 0.51kWh. The total cost for a unit rate of 25p/kWh would be 12.75p. Note that the Morphy Richards Intellisteam had a longer cooking time due to cooking potatoes.

The Morphy Richards Intellisteam is convenient to use and is a healthy way to cook but can have a similar consumption to using an electric hob and another appliance like a halogen oven or small air fryer.

Summary

- Food can be steamed over a pan on the hob but there are also dedicated electric stacking steamers and more sophisticated steamers with control of individual containers
- Steamers can be a healthier way of cooking, reducing loss of vitamins and minerals and using less oil
- There is also potential to cook a whole meal with the one appliance including rice or potatoes, vegetables and fish or chicken
- We tested a Salter 3-tier steamer with a power rating of 500W; during a test of over 16 minutes, the average consumption of the appliance was 482W
- Cooking times and electricity consumed can range from 15 minutes and 0.18kWh for vegetables to about 30 minutes and 0.3kWh for chicken or rice
- This would lead to costs of 4.5p after 15 minutes and 7.5p after 30 minutes for a unit rate of 25p/kWh
- Pasta with steamed vegetables can be cooked on an electric hob using 0.21kWh (at a cost of 5.25p), while it was likely to take at least 0.26kWh (costing 6.5p) to cook rice and vegetables using the Salter steamer
- We also tested the more sophisticated Morphy Richards Intellisteam which has a rated power of 1,350 – 1,600W
- The Morphy Richards Intellisteam has 3 separate containers which are individually controlled by a digital timer which means all components of a meal can finish cooking at the same time
- It was possible to cook potatoes in the large rear container over 25 minutes with an average consumption of 563W using 0.24kWh and costing 6p at 25p/kWh
- A meal was also cooked using all 3 of the individually controlled containers with potatoes, salmon and vegetables with cooking times varying from 20 to 30 minutes
- The electricity consumption while cooking this meal varied between about 556W and 1,530W over the cooking time with a total consumption of 0.56kWh for a cost of 13.9p using a unit rate of 25p/kWh
- Cooking a full meal in the Intellisteam used a similar amount of electricity to cooking with both a hob and a halogen oven or air fryer

2.5.10 Slow cookers, rice cookers and multicookers

Slow cookers are popular for several reasons. They can be convenient for households, allowing preparation in the morning or the night before and left to slowly cook over the day, so the meal is ready by the evening. With the extended cooking time, it means that cuts of meat that otherwise might be tough can be tender. They are also considered energy efficient with some slow cookers using around 160-200W on high power and only 100W on low power[94] [95]. Cooking times for casseroles can be around 4 hours on high power and 8 hours on low power[95].

We tested a Morphy Richards 460006 slow cooker which had a capacity of 3.5 litres and a power rating of 170W, with settings for high, low and warm.

Figure 2.114 Morphy Richards slow cooker

Morphy Richards 460006 slow cooker

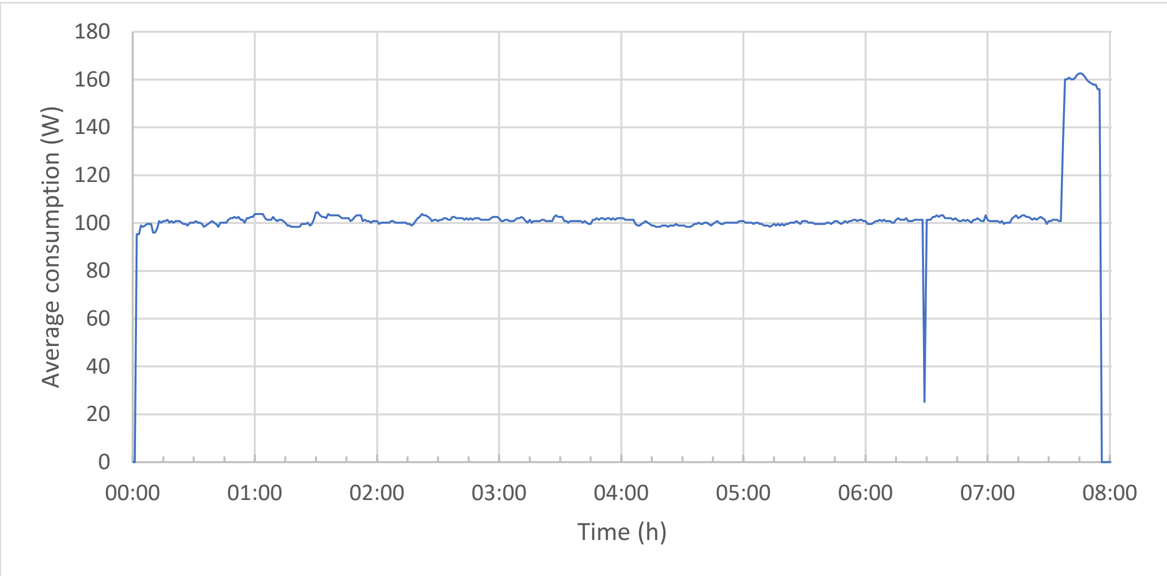

Figure 2.115 Plot of average consumption per minute measured with a Shelly Plus smart plug for the Morphy Richards 460006 3.5 litre slow cooker

Figure 2.115 shows the average power consumption per minute for the Morphy Richards slow cooker while cooking honey garlic chicken over a period of just under 8 hours. For the first 7

[94] Lydia Anderson (2024), 10 of the best slow cookers for delicious faff-free meals, BBC Good Food magazine, https://www.bbcgoodfood.com/howto/guide/slow-cookers-and-how-use-them (Accessed 13 Aug 2024)
[95] How to use a slow cooker, BBC Good Food magazine, https://www.bbcgoodfood.com/howto/guide/10-top-tips-using-slow-cooker (Accessed 13 Aug 2024)

hours 35 minutes the slow cooker was on low and using an average of about 100W. For the last 18 minutes of the setting on the slow cooker was altered to high and the consumption increased to 160W. Over the full cooking period, the slow cooker used a total of 0.81kWh.

It is possible to cook meat and vegetable recipes on low power over a period of about 8 hours, which can make meat more tender. Recipes can often also be cooked over about 4 hours on the high-power setting. The estimated consumption with a slow cooker where high power is 160W would be 0.64kWh. This could potentially use less electricity overall than on the lower power setting for a longer period.

We have limited data to compare consumption with a slow cooker with that for an oven cooking a casserole. A chicken casserole can take 75-90 minutes in an AEG conventional oven at 160-180°C[96]. Other meats like beef or lamb might cook for 150-180 minutes at 160-170°C. From our testing, an AEG fan assisted oven at 180°C can use 0.9kWh over 60 minutes. A longer cooking time will increase the consumption while a lower cooking temperature will lower the electricity consumed.

Drew and Cole Pressure King Pro 8-in-1 Multi Cooker

Figure 2.116 Drew & Cole Pressure King Pro

The Pressure King Pro has a capacity of 3 litres and a rated power of 700W. It can operate as a slow cooker or a pressure cooker and has 8 pre-set cooking functions for different foods. There is also a browning function for meat. The device has a digital control for accurate timings[97].

We cooked 3 different meals using the slow cooker function and 1 using the pressure cooker function. Figure 2.117 shows a plot of average power consumption per minute for the Pressure King Pro in slow cooking mode while cooking Honey Garlic Chicken. Rather than having a constant low power consumption of 100W or 160W as for the Morphy Richards slow cooker, the Pressure King Pro had periodic pulses of higher electricity consumption

There was higher consumption at the start of the cooking and then pulses of 200-750W lasting about a minute. Monitoring on a per second basis might have shown 700W pulses for 1 minute. Over the 5-hour 50-minute cooking period, the Pressure King Pro used 0.418kWh at a cost of 10.45p for a unit rate of 25p/kWh. This compares to 0.81kWh at a cost of 20.25p, cooking the same meal with the Morphy Richards slow cooker over 8 hours.

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96 AEG DEB331010M built-in double oven user manual, https://api.electrolux-medialibrary.com/asset/b97ebbe2-d7d3-4089-ad8d-ef91f79cfd3b/E4RM3Q/1a08426b-6207-4a5c-9d4d-30577df283f2/ORIGINAL/1a08426b-6207-4a5c-9d4d-30577df283f2.pdf (Accessed 20 Aug 2024)
97 Drew & Cole Pressure King Pro 3 litre 8-in-one pressure cooker, https://drewandcole.com/products/pressure-king-pro-3l/ (Accessed 13 Aug 2024)

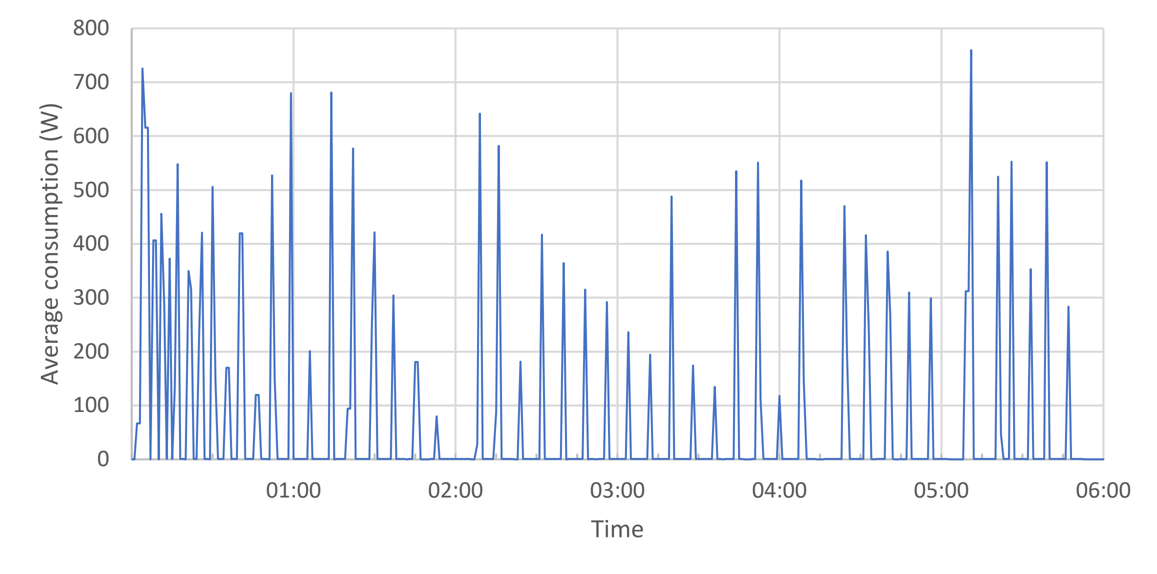

Figure 2.117 Plot of average consumption per minute measured with a Shelly Plus smart plug for the Drew & Cole Pressure King Pro 3 litre multi cooker in slow cooker mode

Meal	Cooking time	Electricity consumption (kWh)	Average power consumption (W)
Honey Garlic Chicken in slow cooker mode	5 hr 50 min	0.418	71.6
Sausage casserole in slow cooker mode	4 hr 10 min	0.394	94.5
Chilli in slow cooker mode with browning at beginning and end	9 hr 55 min	0.673	67.9
Chicken stew with browning and in pressure cooker mode	1 hr 20 min	0.454	345

Table 2.118 Cooking times and electricity consumption for Drew & Cole Pressure King Pro 3 litre

Table 2.118 shows 4 examples of meals cooked with the Drew & Cole multicooker, with 3 of them in slow cooker mode and one in pressure cooker mode. All the slow cooker mode meals used less than would be typical with a dedicated slow cooker running on low power (100W) for 8 hours. The Chilli in table 2.118 was cooked for nearly 10 hours, which was longer than was probably necessary and used 0.67kWh. Had the meal been cooked in the Morphy Richards slow cooker on low for the same period it could have used about 1kWh.

Figure 2.119 shows a plot of the average electricity consumption for the Pressure King Pro while cooking a chicken stew in pressure cooker mode. There was browning during the first

12 minutes and also the last 6 minutes at the end. There were extended periods during the browning and the subsequent pressure cooking where the average consumption per minute was around 770-790W. Despite this higher power consumption, the multicooker used only 0.45kWh due to the shorter cooking time. The consumption was only slightly higher than the approximately 0.39 and 0.42kWh of honey garlic chicken and sausage casserole cooked in the appliance in slow cooker mode.

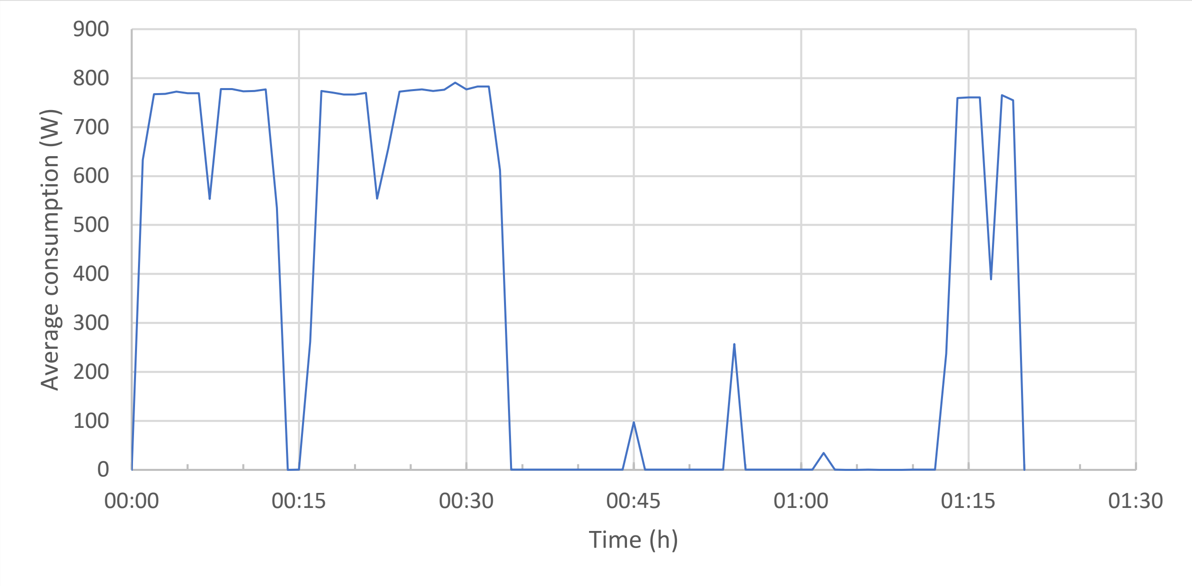

Figure 2.119 Plot of average consumption per minute measured with a Shelly Plus smart plug for the Drew & Cole Pressure King Pro 3 litre multi cooker in browning and pressure cooker mode

The Drew & Cole Pressure King Pro uses less energy than the Morphy Richards slow cooker despite having a higher power rating. This is due to the Pressure King Pro only having short bursts of electricity consumption at 700-800W compared to a constant consumption of 100W with the Morphy Richards slow cooker.

Households with solar PV will have varying levels of solar generation during a day and between different days due to the position of the sun and the level of cloud cover. A solar PV system is likely to be able to generate enough electricity to power a slow cooker for free for most if not all day. An appliance like the Pressure King Pro with short pulses of higher power consumption may have less of the consumption powered by the solar PV system.

Kenwood RC300 and VonShef rice cookers

Figure 2.120 (a) Kenwood RC300 rice cooker (b) VonShef 200W rice cooker

Rice cookers are standalone electrical appliances which can be used to cook portions of rice. Large rice cookers are suitable for larger families or dinner parties and these can cook up to 10 portions of rice and typically have a power rating of 700W. One example is the Kenwood RC300 rice cooker which could cook up to 10 portions of rice and had a power rating of 590W-700W for 220V-240V. Smaller models can cook up to 3 portions and can have a rated power of 200 to 350W. An example of this is the VonShef rice cooker with a rated power of 200W.

The Kenwood rice cooker was used to cook a couple portions of rice starting from cold water while the VonShef rice cooker was used to cook a single portion of rice. Figure 2.121 plots the average electricity consumption for both rice cookers. Each used close to the rated power over the cooking period with the Kenwood RC300 using up to 741W and the VonShef up to 221W. The cooking time was just over 20 minutes for the Kenwood and just under 20 minutes for the VonShef. Once cooking was completed, the appliances switched to ‘warming’ mode with the Kenwood RC300 then using an average of 50W. The instructions for the Kenwood RC300 recommended that the rice should be kept on the warming setting for at least 15 minutes at the end, perhaps to ensure the rice is dry and does not stick to the bowl. The VonShef having been manufactured more recently had a non-stick cooking bowl and the rice sticking was less of an issue.

The test with the Kenwood RC300 used 0.24kWh. Allowing the full warming period could increase this to about 0.25kWh. The VonShef rice cooker with a capacity of up to 3 portions (300ml) used only 67Wh or 0.067kWh. This was less than 30% of the consumption of the Kenwood rice cooker. If cooking rice for 3 people or fewer, significant energy savings can be made by using a small rice cooker rather than a large model. Cooking pasta and steaming vegetables on a hob used about 0.21kWh which is less than the consumption for the large rice cooker. When cooking a single portion of rice, the small rice cooker used only slightly more electricity than a kettle boiling 500ml of water (0.061kWh).

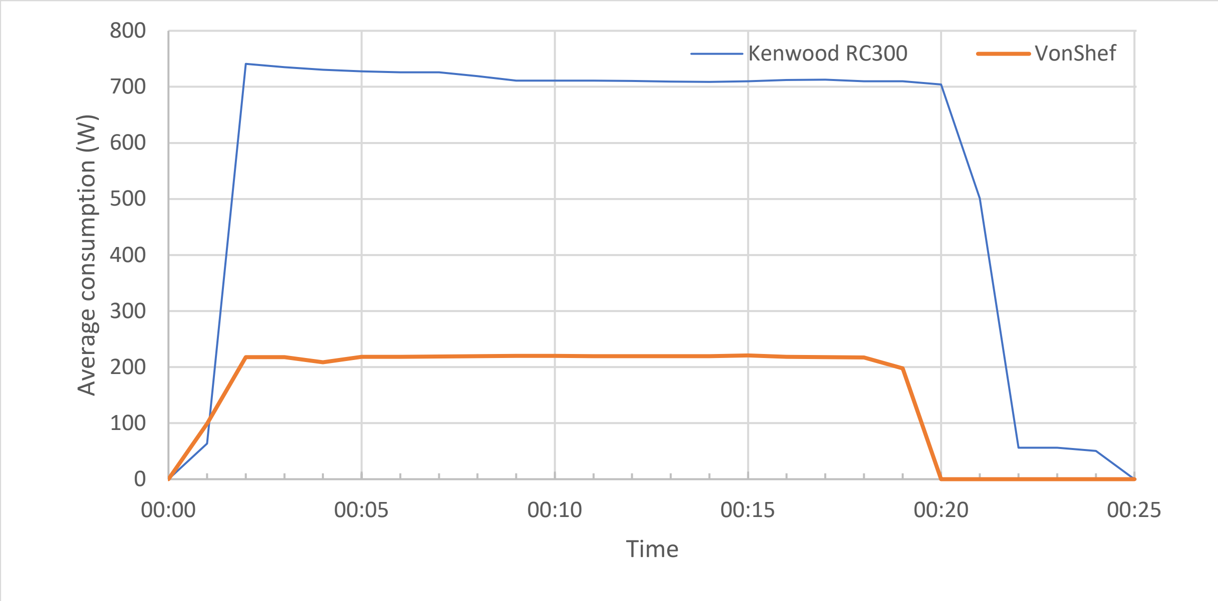

Figure 2.121 Plot of average consumption per minute measured with a Shelly Plus smart plug for the Kenwood rice cooker and the VonShef rice cooker

Summary

- Slow cookers are popular as they allow preparation of a meal in the morning and for it to be cooked by the evening; the longer cooking times can also mean more tender meat
- The devices can have a power rating of around 160W-200W for the high setting while consumption might be 100W on the low setting; cooking times can be about 4 hours on high and 8 hours on low
- A Morphy Richards 40006 slow cooker used 0.81kWh while cooking honey garlic chicken over a period of 8 hours with an electricity cost of 20.25p for a unit rate of 25p/kWh
- The electricity consumption of the Morphy Richards slow cooker while cooking this meal was consistent at around 100W until it was turned up to high for a short period at the end.
- Lower overall consumption could be possible with the slow cooker if cooking on high for about 4 hours
- A Drew and Cole Pressure King Pro multicooker with a rated power of 700W was also tested in slow cooker mode
- Here instead of there being a constant electricity consumption during the cooking period, there were short bursts of higher power to the heating element which led the food to be warmed
- The multicooker used 0.42kWh while cooking honey garlic chicken over a shorter period of 5 hours 50 minutes at a cost of 10.45p for a unit rate of 25p/kWh; this was about half the cost of cooking in the slow cooker
- Even when cooking a meal over nearly 10 hours using 0.67kWh, the multicooker still used less than the 0.81kWh used by the slow cooker over 8 hours
- The multicooker in pressure cooker mode had a more consistent higher power consumption but due to the shorter cooking time still used less electricity than the slow cooker, using 0.45kWh

- A slow cooker could be a better option for households with solar PV who could use it during the day and have most of the electricity consumption powered by the solar panels
- Rice cookers like slow cookers consume electricity consistently at close to the rated power while cooking
- A large rice cooker was tested and used just over 700W and a total of 0.25kWh with a cooking time of just over 20 minutes; this would be a cost of 6.25p for a unit rate of 25p/kWh
- This compared to 0.21kWh while cooking pasta and steaming vegetables with a pan on a hob
- If cooking rice for only 1 to 3 people, it is more energy efficient to use a smaller lower powered rice cooker
- A small rice cooker with a 200W rating used only 0.067kWh while cooking a single portion of rice with a cost of 1.68p for a unit rate of 25p/kWh
- The consumption by the small rice cooker with a single portion of rice was less than 30% of the consumption of the larger rice cooker when cooking two portions of rice

2.6 Personal heaters

During the height of the energy crisis, it became necessary for some to consider heating the person rather than the whole home as a way of reducing energy costs[98] [99]. This could range from extra warm clothing, hot water bottles to electric blankets.

While it is possible to reduce room temperatures to some extent and keep warm with a personal heater, care should be taken to avoid adverse impacts. Breathing air which is too cold can lead to respiratory illnesses, particularly among the vulnerable. If room temperatures become too cold, moisture in the air can condense on cold walls and lead to damp and mould. There can be severe health risks from damp and mould in the home[100].

In this section, the electricity consumption of 3 personal heaters was investigated.

Homeglow B-warm heated seat cover

Figure 2.122 Homeglow B-warm heated seat cover

The Homeglow B-warm heated seat cover has 4 adjustable heating settings with the manufacturer noting the power consumption was between 10W and 45W and claiming the device costs less than 1p per hour to run[101]. The device turns off automatically after 4 hours.

Tests were carried out with both a Shelly Plus smart plug at 1-minute intervals and with a Tinytag View 2 current clamp recording data every second. Each test lasted over an hour and the seat cover was allowed time to cool between tests.

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98 Heat the human not the home, Money Saving Expert, https://www.moneysavingexpert.com/utilities/heat-the-human-not-the-home-save-energy/ (Accessed 9 Aug 2024)
99 'Heat the human, not the home': Martin Lewis guide for 'desperate' households, 6 Apr 2022, https://www.theguardian.com/business/2022/apr/06/martin-lewiss-cost-of-living-guide-offers-advice-to-desperate-households (Accessed 9 Aug 2024)
100 Understanding and addressing the health risks of damp and mould in the home, 7 Sep 2023, https://www.gov.uk/government/publications/damp-and-mould-understanding-and-addressing-the-health-risks-for-rented-housing-providers (Accessed 9 Aug 2023)
101 Homeglow B-warm heated seat cover, https://www.homeglowproducts.co.uk/product-1-1 (Accessed 9 Aug 2024)

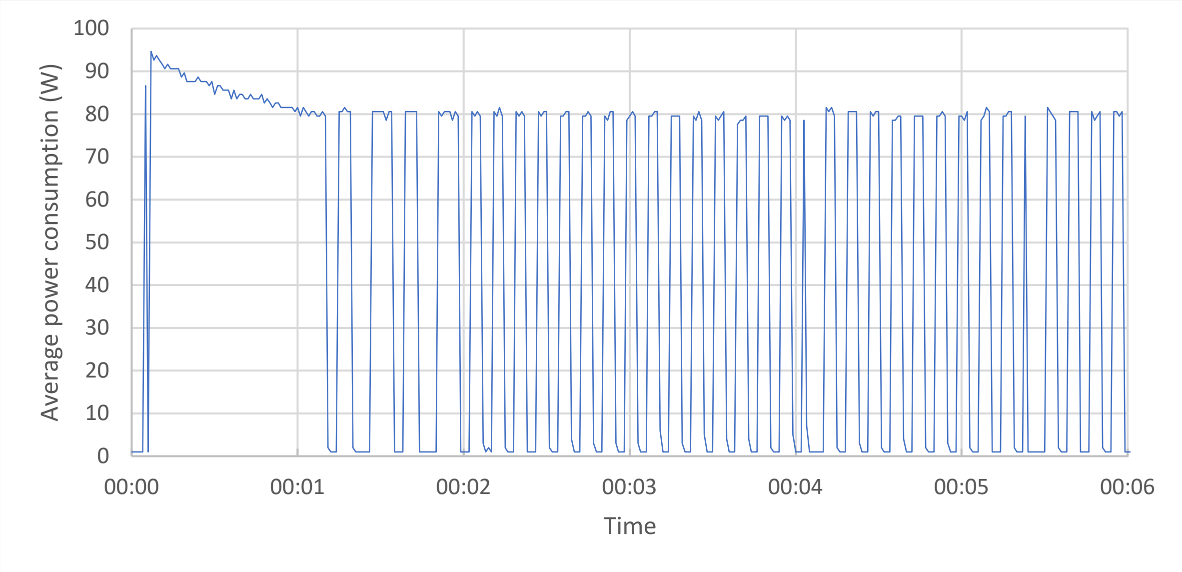

Figure 2.123 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Homeglow B-warm heated seat cover on setting 4

Figure 2.123 shows a plot of the electricity consumption recorded at 1-second intervals for the Homeglow B-warm heated seat cover using level 4, the highest heating setting. This graph was over a period of 6-minutes. After the device was turned on, it initially used just over 90W. This fell to 80W after about 1-minute once the seat cover had warmed. The power consumption of the seat cover subsequently varied with pulses of consumption lasting about 4 seconds followed by about 4 seconds with the power turned off. This modulation of the power lowered the average consumption.

A plot of the average electricity consumption of the heated seat cover is shown in figure 2.124 for each of the heating settings over a period of 1 hour.

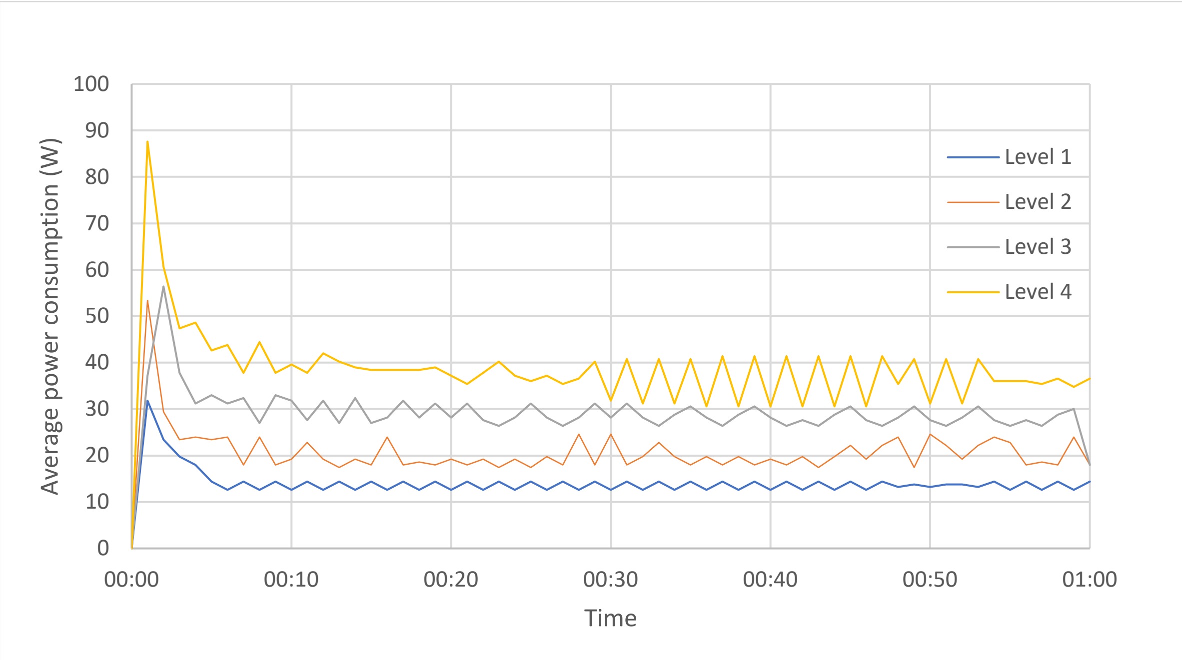

Figure 2.124 Plot of average consumption per minute measured with a Shelly Plus smart plug for the Homeglow B-warm heated seat cover on the 4 heating settings

After the initial peak in consumption of about 90W on level 4, the average power consumption fell to below 40W. The initial peaks in consumption for levels 1 to 3 were not as high in figure 2.122 due to the time for the seat cover to initially heat up being lower. For example, the first consumption peak lasted 38 seconds for level 3 instead of 1 minute 6 seconds for level 4.

The average electricity consumption after the initial peak was about 37W on level 4, 29W on level 3, 20W on level 2 and 13.5W on level 1. The appliance still consumed short pulses of 80W, but the lower average consumption was achieved by some these pulses lasting only for a second or being further apart.

Heating setting	Electricity consumption (Wh)	Cost per hour (unit rate 25p/kWh)
1	14.4	0.36p
2	20.9	0.52p
3	29.5	0.74p
4	38.9	0.97p

Table 2.125 Electricity consumption for B-warm heated seat cover after the first hour of use

Table 2.125 shows the electricity consumption used by the Homeglow B-warm heated seat cover. This was measured using a Shelly Plus smart plug. Over the first hour of use, the B-warm heated seat cover used an average of 14.4W on level 1 and 38.9W on level 4. This is close to the consumption values of 10W and 45W mentioned by the manufacturer[102]. The running cost per hour using these consumption values was between 0.36p and 0.97p for a unit rate of 25p/kWh, which fits in with the manufacturer's claim of costing less than 1p/hour to run.

While testing, the user noted there was little noticeable heat on levels 1 and 2 although this might have been more apparent after a longer period. On level 4, the seat cover was nice and warm initially but after an hour it had become uncomfortable, particularly on the bottom. The impact of the heat was felt less around the back and legs despite there still being direct contact. It might be best to use level 4 initially while warming up and subsequently turn down the heat to a lower setting.

[102] Homeglow B-warm heated seat cover, https://www.homeglowproducts.co.uk/product-1-1 (Accessed 9 Aug 2024)

Dunelm heated foot warmer

A Dunelm heated foot warmer was also tested which was 30cm x 30cm x 24cm. The device had 4 heating settings and was rated at 110W. The device automatically turns off after 90 minutes.

The outer grey fabric had wires from the heating element and there was a washable fleece inner lining.

Figure 2.127 shows a plot of the average power consumption of the heated foot warmer over a period of 1 hour 30 minutes on each of the heating settings. There were strong similarities with the graph for the B-warm heated seat cover in figure 2.124.

Figure 2.126 Dunelm heated foot warmer

There was a higher initial power consumption after the device was turned on. The average consumption on level 4 initially reached 79W but fell to about 30W within 15 minutes of operation. The typical average consumption on level 3 was 22.5W after 15 minutes, for level 2 it was 19W and for level 1 it was 13W.

Table 2.128 shows the electricity consumption of the Dunelm heated foot warmer over the first hour of operation. For levels 1 and 2, the consumption was the same as for the B-warm heated seat cover. On level 4 the consumption was 30.8Wh compared to 38.9Wh for the heated seat cover. The running cost was less than 1p/hour on all settings for a unit rate of 25p/hour.

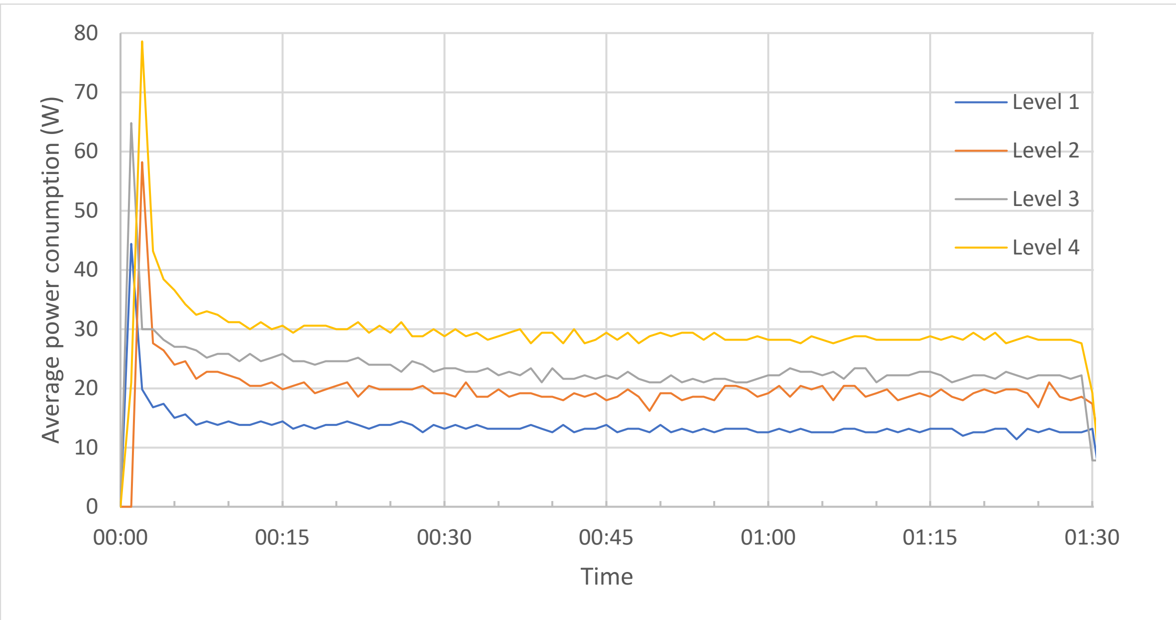

Figure 2.127 Plot of average consumption per minute measured with a Shelly Plus smart plug for the Dunelm heated foot warmer on the 4 heating settings

Heating setting	Electricity consumption (Wh)	Cost per hour (unit rate 25p/kWh)
1	14.2	0.36p
2	20.6	0.52p
3	24.3	0.61p
4	30.8	0.77p

Table 2.128 Electricity consumption for Dunelm heated foot warmer after the first hour of use

Monhouse heated throw

Figure 2.129 Monhouse heated throw

The last of the personal heaters tested was a Monhouse heated throw. The dimensions were 130cm x 160cm and the power rating was 120W.

There were 9 temperature settings: low, 1 to 7 and high. The device could be set to run for between 1 and 9 hours using the controller.

Figure 2.130 plots the power consumption of the electric throw on setting 6 over a period of 5 minutes. Initially there were consumption peaks of about 112W which lasted 6 seconds at a time. After just under 2 minutes the pattern of consumption changed with the consumption peaks only lasting 2 seconds at a time. This change in behaviour was likely to be due to higher consumption while the heated throw initially warmed up.

Figure 2.131 shows a plot of average electricity consumption recorded with a Shelly Plus smart plug at 1-minute intervals. There was a peak in average consumption over the first couple minutes for the heated throw on the higher settings (high, level 7, level 6) due to the difference in consumption pattern seen in figure 2.130 while the throw heated up. On the high setting, after a peak of 122W, the consumption stabilised after 5 minutes to an average of 63W.

The average consumption peak was 94W and 77W for levels 7 and 6 with averages after 5 minutes of 57W and 43W. For the lower heating settings, there was no initial peak in consumption apparent. Here the average consumption was 33W for level 2, 27W for level 1 and 20W for the low setting.

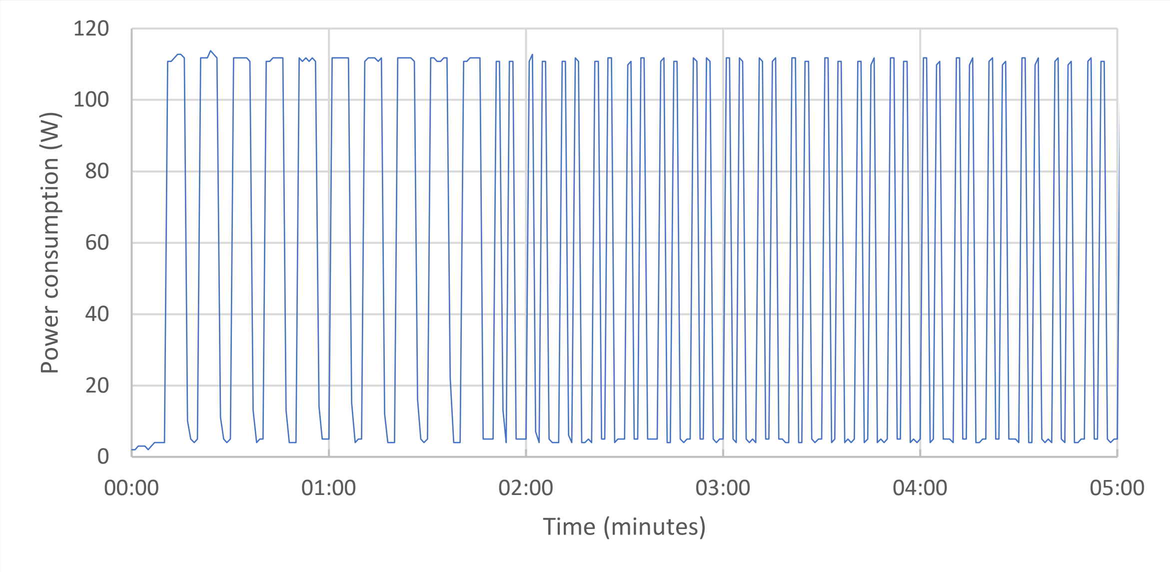

Figure 2.130 Plot of apparent power consumption measured every second with a Tinytag View 2 for the Monhouse heated throw on setting 6

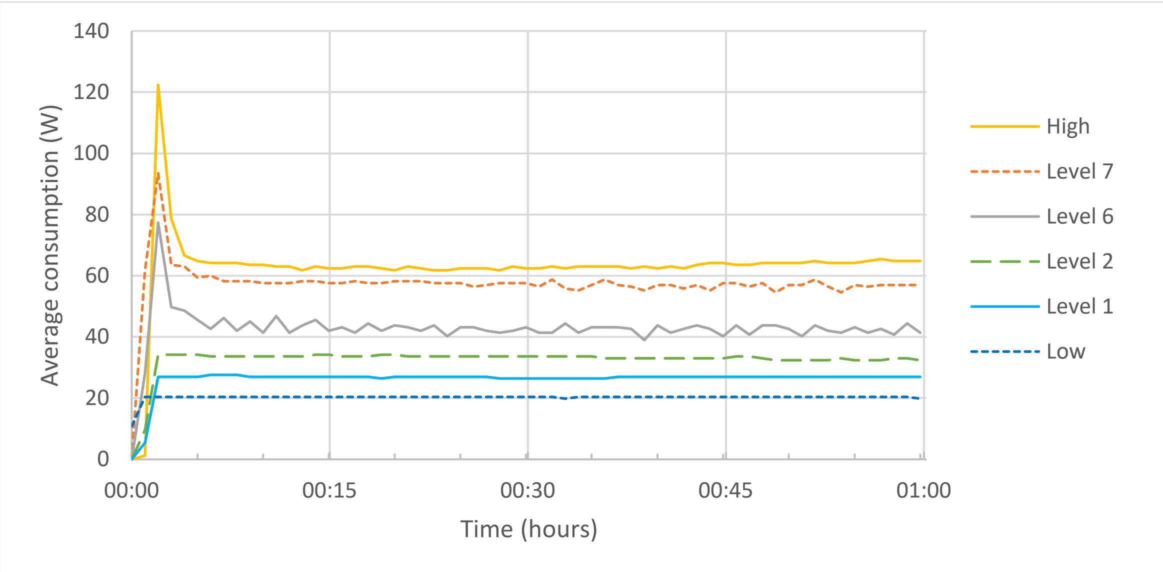

Figure 2.131 Plot of average consumption per minute measured with a Shelly Plus smart plug for the Monhouse heated throw on 6 of the heating settings

Table 2.132 shows the electricity consumption after the first hour for the Monhouse heated throw on the 3 lowest and 3 highest heating settings. It also shows the electricity costs assuming a unit rate of 25p/kWh.

The Monhouse heated throw used 20.2Wh over the first hour on the low setting at a cost of 0.51p assuming a unit rate of 25p/kWh. On the high setting, the consumption over the first hour was just over 3 times as much at 64.6Wh at a cost of 1.62p. Note that the Monhouse throw only runs on the high setting for one hour before switching to the low setting. A more typical setting for longer term use was setting 2 which used 33.1Wh at a cost for the first hour of 0.83p.

Heating setting	Electricity consumption (Wh)	Cost per hour (unit rate 25p/kWh)
Low	20.2	0.51p
1	26.7	0.67p
2	33.1	0.83p
6	43.3	1.08p
7	58.2	1.45p
High	64.6	1.62

Table 2.132 Electricity consumption for the Monhouse heated throw after the first hour of use

Summary

- Electrically heated throws, heated seat covers and heated foot warmers all provide a low cost way to keep warm in winter heating the person and not the house
- Care must be taken not to allow room temperatures to fall too low so that it might make residents vulnerable to respiratory infections and other medical conditions as well as increasing the likelihood of damp and mould in the house
- The electricity consumption of the device can depend on its size with the heated throw tested using more than the heated seat cover which had a higher consumption than the heated footwarmer
- There is often initially higher electricity consumption while the device heats up
- The initial peak in average consumption on the highest heating settings could be about 120W for the heated throw, 90W for the heated seat cover and 80W for the heated foot warmer
- The electricity consumption after the first hour on the highest setting was 65Wh for the heated throw, 39Wh for the heated seat cover and 31Wh for the heated footwarmer; assuming a unit price of 25p/kWh the costs were 1.6p, 1.0p and 0.8p respectively
- On the lowest setting, the electricity consumption after the first hour was 20Wh for the heated throw, 14Wh for the heated seat cover and 14Wh for the heated footwarmer with costs of 0.5p for the heated throw and 0.4p for the seat cover and footwarmer
- The consumption of 65Wh on the high setting for the Monhouse heated throw was similar to the consumption of 62Wh when using all 4 slots of a Smeg toaster
- The consumption of 14Wh on the lowest setting for the heated seat cover and foot warmer was similar to the consumption of 15Wh by a Russell Hobbs single slot toaster
- In most cases users found the lowest settings provided too little heat while the highest settings soon provided too much heat – the optimal use may be to either use a medium setting or initially a high setting and then turn it down
- Generally, it is possible to use these appliances at a running cost of less than 1p/hour as suggested on the Homeglow B-warm heated seat cover website

2.7 Phones, tablets and broadband routers

Figure 2.133 Connecting phone to charge (Julio Lopez, Pexels)

Many households have multiple phones and tablets. This section looks at electricity consumption while charging a device and the cost per charge. For modern smart phones, the typical nominal capacity for the battery can be in the range 2,500 to 4,000mAh while some larger phones could be as high as 5,000mAh. For tablets, the larger display consumes more energy, and the battery capacity tends to be in the range of 5,000 to 10,000mAh[103].

A common appliance many households have is the broadband router. Suppliers recommend that for best performance these are left on 24 hours a day. There would also be issues with smart devices which monitor and or control appliances if the router is turned on and off. Examples where issues could occur include with smart thermostats or battery storage.

We tested one smart phone and 2 tablets for their consumption while charging and 2 broadband routers for the longer-term consumption.

[103] Battery capacity, Everphone, https://everphone.com/en/wiki/battery-capacity-smartphone/ (Accessed 19 Aug 2024)

Samsung Galaxy S22 smart phone

The rated minimum capacity for the battery for the Samsung Galaxy S22 was 3,590mAh, with a typical battery capacity of 3,700mAh or 14.35Wh. The device was charged using the Samsung fast charger provided with the phone and this was rated at 15W.

Figure 2.134 shows a graph of average power consumption against time while charging the Samsung Galaxy S22 smart phone from 19% charge. For the first half hour of charging, the device was averaging 16.2W of consumption. There was a drop-off in consumption after about 45 minutes, but consumption increased again to a small peak of nearly 14W after 55 minutes. The smart phone was fully charged after just over 1 hour 20 minutes and used 16.2Wh while charging. This is similar to making a slice of toast in a single slot Russell Hobbs toaster. The cost is 0.4p with a unit rate of 25p/kWh. The consumption is nearly 13% higher than the published typical battery capacity in Wh.

The consumption during charging will depend on the charge level of the battery at the start of charging. For most smart phones and tablets, it is recommended that the device is not discharged below 20% battery charge.

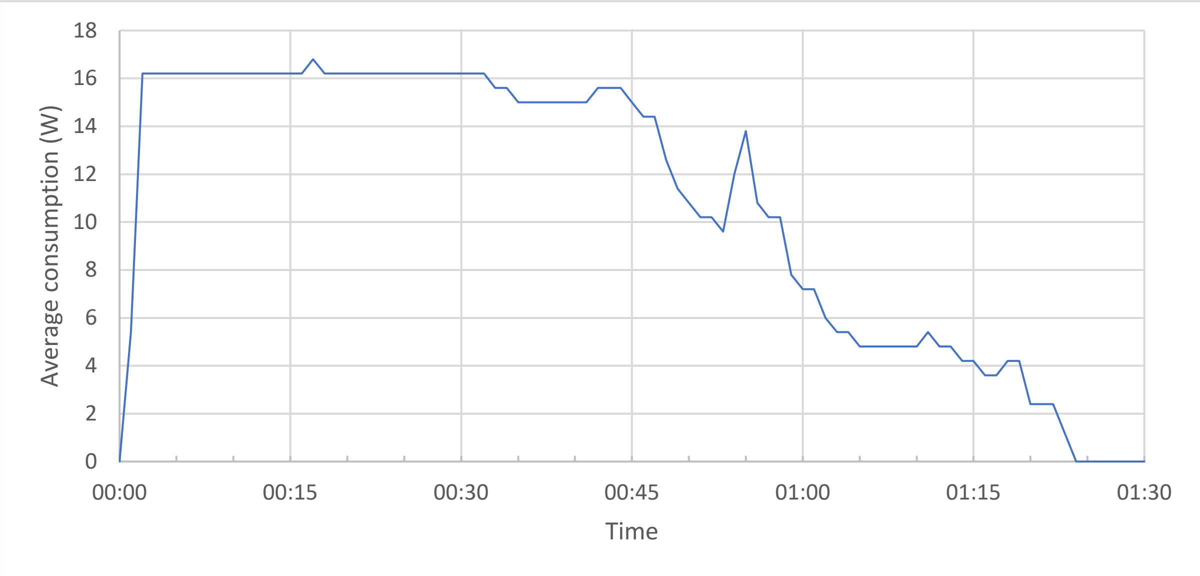

Figure 2.134 Plot of average consumption per minute measured with a Shelly Plus smart plug while charging a Samsung Galaxy S22 smart phone

Apple iPad model A2197 (7th generation) with Lightning connector

The charging performance was also tested for a 7th generation Apple iPad which was released in 2019 and had a 10.2" screen. The device had a built in 32.4Wh rechargeable lithium polymer battery and it had an Apple 12W USB Lightning charger[104].

After initially drawing 12 to 13W over the first 20 minutes, the consumption was a steady 12W until just under an hour when the consumption began to slow decrease over time until it had fallen to 9W after 3 hours 15 minutes. Subsequently there was a more rapid fall in consumption to 3W after 4 hours. The iPad consumption then suddenly dropped to 0.6W and 0W as the device became fully charged.

The iPad had been charged from 21% and used 39.4Wh. The consumption was 143% higher than for the Samsung Galaxy S22 smart phone.

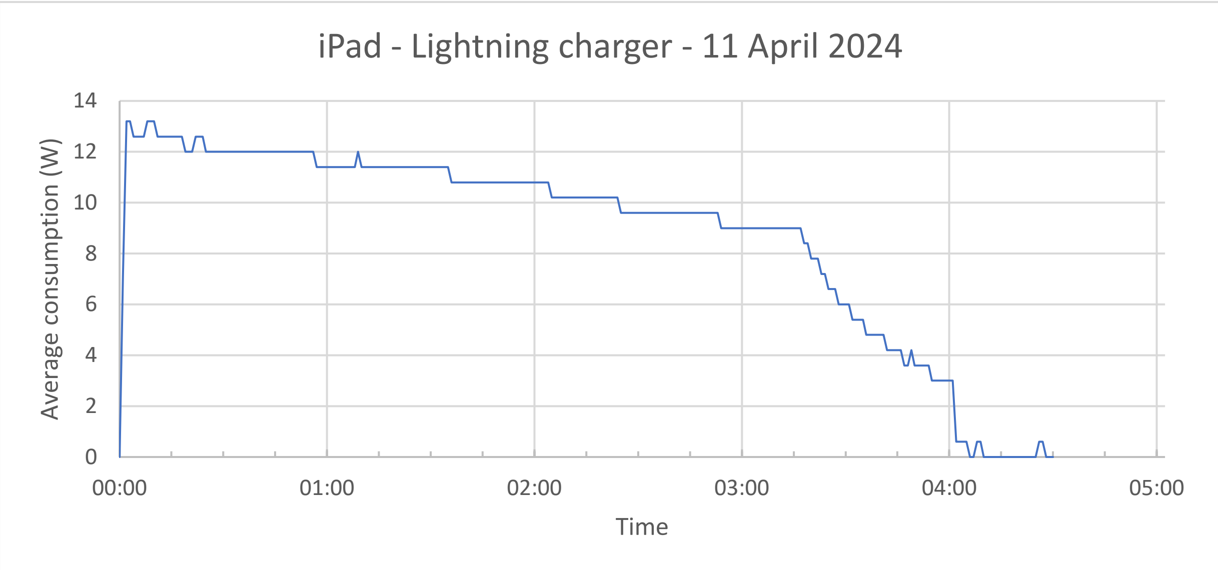

Figure 2.135 Plot of average consumption per minute measured with a Shelly Plus smart plug while charging a 7th generation Apple iPad

[104] Apple iPad (7th generation) – Technical Specifications, https://support.apple.com/en-gb/111911 (Accessed 19 Aug 2024)

Apple iPad Air model A2316 (4th generation) with USB-C connector

The 4th generation Apple iPad Air released in 2020 had a 10.9" screen and a rechargeable lithium-polymer battery with a capacity of 7,500mAh or 28.6Wh[105]. This was smaller than the 32.4Wh battery with the older 7th generation Apple iPad which had a smaller 10.2" screen. The device had a 20W USB-C power adapter.

A test was carried out charging the iPad Air from a battery charge level of 17%, just below the minimum advised discharge level of 20%. Figure 2.136 shows that the charge time with the 20W power adapter was about 2 hours 15 minutes rather than 4 hours for the 7th generation iPad with the 12W power adapter.

The consumption was steady over the first half hour of charging, using just over 21W. It then fell quickly to 18W and was steady then until a charge time of 55 minutes where the consumption fell to another plateau of about 14W. After 1 hour and 15 minutes there was a gradual decrease in consumption until about 2 hours 15 minutes when the battery was fully charged. Over the charging period, the smart plug measured a consumption of 28.5Wh which was very close to the 28.6Wh recorded in the technical specification. The cost of charging the iPad Air assuming a unit rate of 25p/kWh was 0.7p. The 39.4Wh consumption of the 7th generation iPad with the larger battery was 38% higher than the newer and more powerful iPad Air.

Other tests were carried out with the iPad Air starting with a battery charge of about 10%. Here the charge times were longer (about 2 hours 25 minutes) and the consumption was about 30.8Wh.

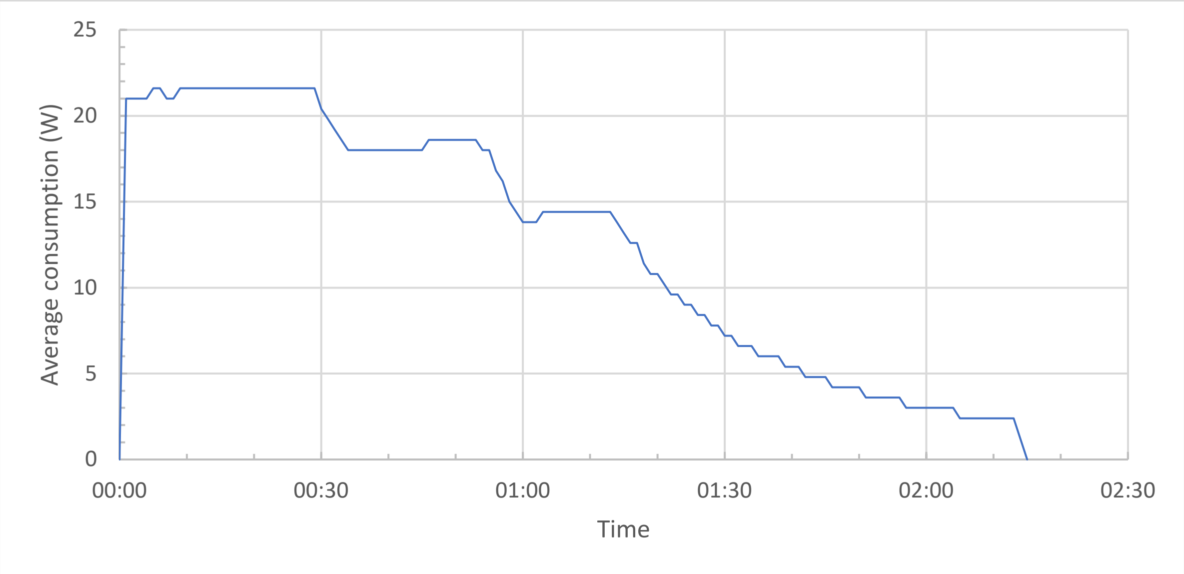

Figure 2.136 Plot of average consumption per minute measured with a Shelly Plus smart plug while charging a 4th generation Apple iPad Air

[105] iPad Air (4th generation) – Technical Specifications, https://support.apple.com/en-gb/111905 (Accessed 19 Aug 2024)

Miatone QBOX Bluetooth speaker

For comparison with the smart phone and tablets, a Bluetooth smart speaker was also tested. The Miatone QBOX had 2 x 8W loudspeakers. The lithium battery had a capacity of 2,500mAh[106]. This could provide up to 16 hours of sound but depending on use it could be less than 12 hours. The battery capacity of a Bluetooth speaker will depend on the size and model of the speaker and the desired operation time.

The device used a USB-C charging socket. It was tested once it had discharged using a Samsung fast charger rated at 15W. Figure 2.138 shows a plot of the average power consumption during the charging period. Although a fast charger was used, the battery on the speaker charged at less than 5W and had a total charge time of just over 3 hours.

Figure 2.137 Miatone QBOX Bluetooth speaker

While charging, the speaker initially drew up to 4.8W, but this fell to a steady 4.2W after 1 hour 15 minutes. This level of power consumption continued until just after 2 hours 30 minutes. The consumption then gradually decreased until the speaker was fully charged after just over 3 hours. During the charging, the speaker used 12.2Wh at a cost of 0.3p with a unit rate of 25p/kWh. The Miatone QBOX used less to charge than the Samsung Galaxy S22 which used 16.2Wh.

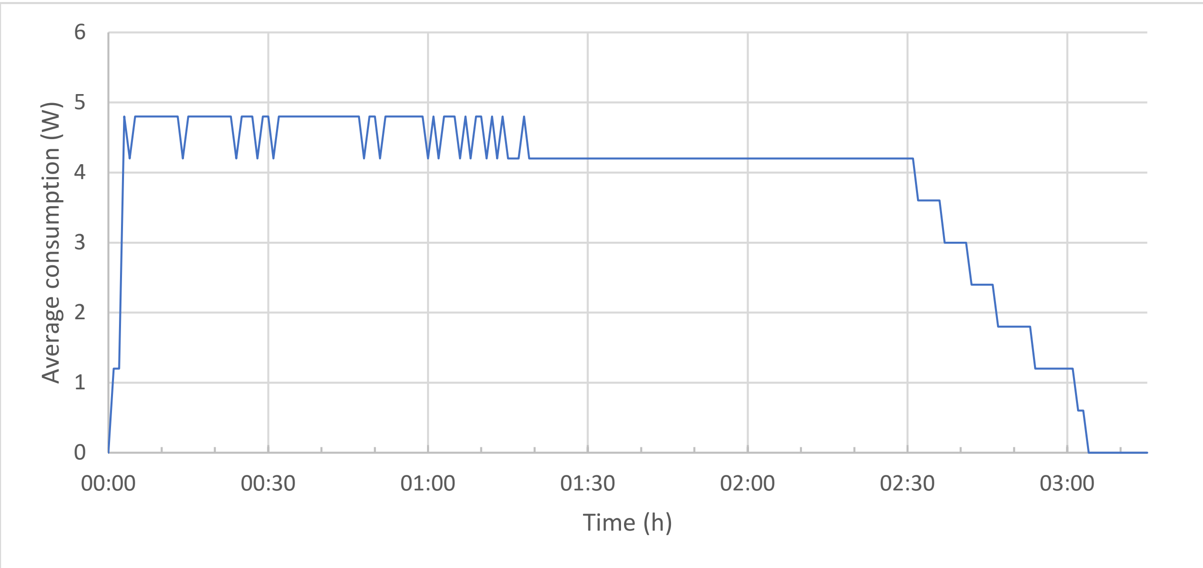

Figure 2.138 Plot of average consumption per minute measured with a Shelly Plus smart plug while charging a Miatone QBOX Bluetooth speaker

[106] Miatone Bluetooth speaker, https://www.amazon.co.uk/Bluetooth-MIATONE-Portable-360%C2%B0Surround-Waterproof/dp/B0B1WX8HTY/ (Accessed 19 Aug 2024)

Vodafone THG3000g broadband router

It is recommended that broadband routers are left on 24 hours a day. Reasons for this include ensuring network stability, being able to receive updates overnight and avoiding issues with smart home devices such as thermostats and batteries[107].

Zen (2024) noted that a typical broadband router can use between 5 and 20W.

Figure 2.139 Vodafone THG3000g broadband router

The Vodafone THG3000g has a power rating of 12V, 2.5A, which suggests a potential power consumption of 30W. The device was tested with a Shelly Plus smart plug over several days and the average daily consumption was 216Wh which is 5.4p/day with a unit rate of 25p/kWh. The average consumption over the 3 days was 9W.

There was a small amount of variation in the consumption of the router as shown in figure 2.140. The hourly bar chart of average consumption shows that overnight the consumption fell below 9W. However, there were times such as at 10:00-11:00 and 23:00 to 00:00 that the consumption was between 9.25 and 9.5W. These were times when there was a video conference call and streaming of online TV. These changes while noticeable were under about 5% of the total consumption.

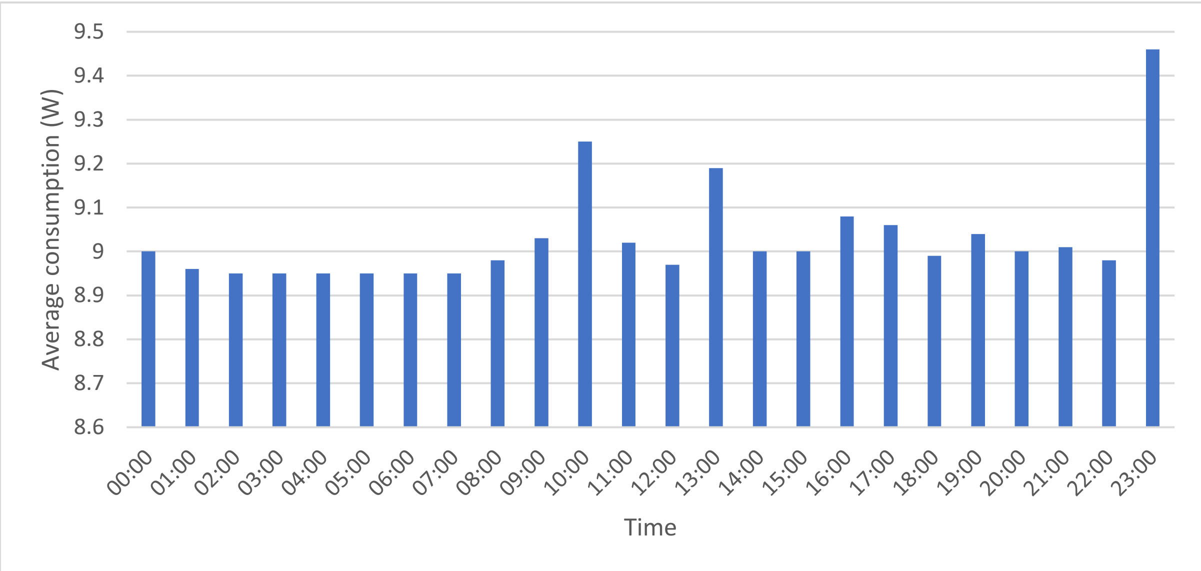

Figure 2.140 Plot of average consumption per hour measured with a Shelly Plus smart plug for a Vodafone THG3000g broadband router

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107 How much power does my WiFi router use, and when should I switch it off? Zen (2024), https://www.zen.co.uk/blog/posts/zen-blog/2024/02/26/how-much-power-does-my-wifi-router-use-and-when-should-i-switch-it-off/ (Accessed 19 Aug 2024)

Zyxel VMG8825-B50 broadband router

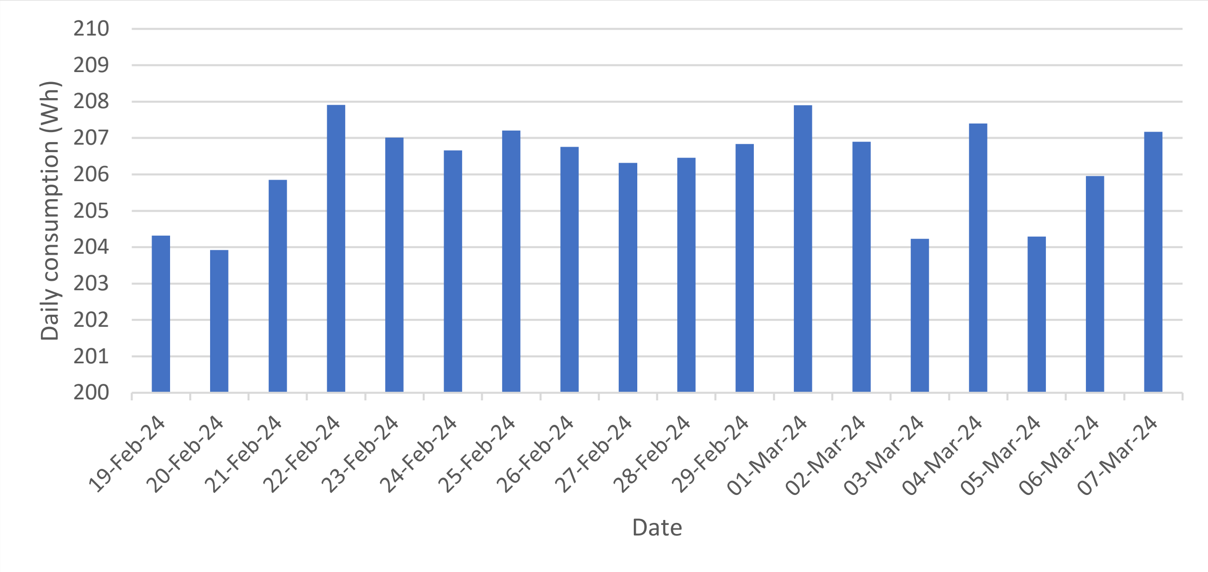

Figure 2.141 Plot of daily consumption measured with a Shelly Plus smart plug for a Zyxel VMG8825-B50 broadband router

The electricity consumption was also measured of a Zyxel broadband router with a nominal power input of 12V and 3A. This suggests a potential power consumption of 36W.

The broadband router was tested over a period of 18 days. Figure 2.139 shows a plot of daily electricity consumption with values between just under 204Wh and just under 208Wh. The average power consumption over the period was 8.6W. This corresponds to a cost of 5.2p/day with a unit rate of 25p/kWh. The actual power consumption of the router was significantly lower than the consumption suggested on the power rating label for the device.

More recent broadband routers which use the latest standard, WiFi 6E have higher power consumption. These may use about 12 to 15W.

Summary

- Many homes now have multiple smart phones and tablets and other IT related devices like broadband routers and battery powered Bluetooth speakers
- Modern smart phones have batteries with a nominal capacity of 2,500 to 4,000mAh although some larger phones might have battery with a capacity as high as 5,000mAh
- A Samsung Galaxy S22 was tested which had a typical battery capacity of 3,700mAh or 14.35Wh
- When charging from 19% over a period of 1 hour 20 minutes, the Samsung Galaxy S22 phone consumed 16.2Wh at a cost 0.4p assuming a unit rate of 25p/kWh
- The Samsung Galaxy phone had a fast charger which used just over 16W during the first half hour of charging
- Tablet computers can have battery capacities in the range 5,000 to 10,000mAh
- A 7th generation Apple iPad had a 32.4Wh battery and used a 12W USB Lightning charger
- The iPad took about 4 hours to fully charge from 21% and used 39.4Wh, higher than the rated battery capacity; the charging cost would be 1p for a unit rate of 25p/kWh
- A newer 4th generation Apple iPad Air had a 28.6Wh battery and used a 20W USB-C power adapter
- It took about 2 hours 15 minutes to fully charge from 17%, using 28.5Wh with a cost of 0.7p for a unit rate of 25p/kWh
- For comparison, a battery powered Miatone QBOX Bluetooth speaker was also tested which could provide around 12 hours of sound depending on the type of use
- The Bluetooth speaker had a battery capacity of 2,500mAh and used 12.2Wh while charging at a cost of 0.3p for a unit rate of 25p/kWh
- Broadband routers are recommended to be left on 24 hours a day to ensure network stability, to allow updates overnight and to avoid issues with smart devices like thermostats or batteries
- Broadband routers are powered by a DC supply from a transformer, and this can have a rated power of 30W or more
- A Vodafone broadband router used an average of 216Wh per day at a cost of 5.4p/day assuming a unit rate of 25p/kWh
- There was a small variation in average consumption from just under 9W to just under 9.5W with periods of higher consumption associated with periods with greater use of the internet
- A Zyxel broadband router used between 204Wh and 208Wh per day over a period of 18 days with an average consumption of 8.6W; this corresponds to 5.2p/day for a unit rate of 25p/kWh
- More modern WiFi 6E broadband routers can have higher consumption of about 12-15W

3. Appendix - Consumption profiles of a washing machine

Below are consumption profiles for a Hotpoint WMTL80 top loading washing machine at different washing temperatures. The washing machine was over 20 years old and had a 5kg load capacity. Graphs were plotted using the Tinytag Explorer software with data from a Tinytag View 2 data logger recording consumption at 1 second intervals.

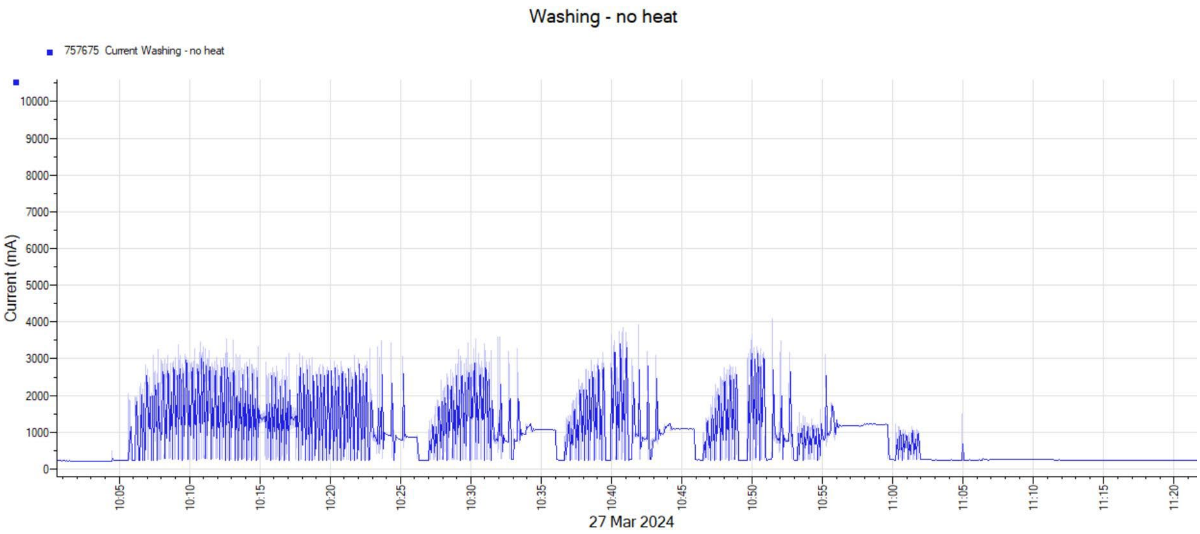

Figure 3.1 Plot of consumption of a Hotpoint WMTL80 washing machine recorded using a Tinytag View 2 data logger at 1 second intervals for a washing cycle using no heating

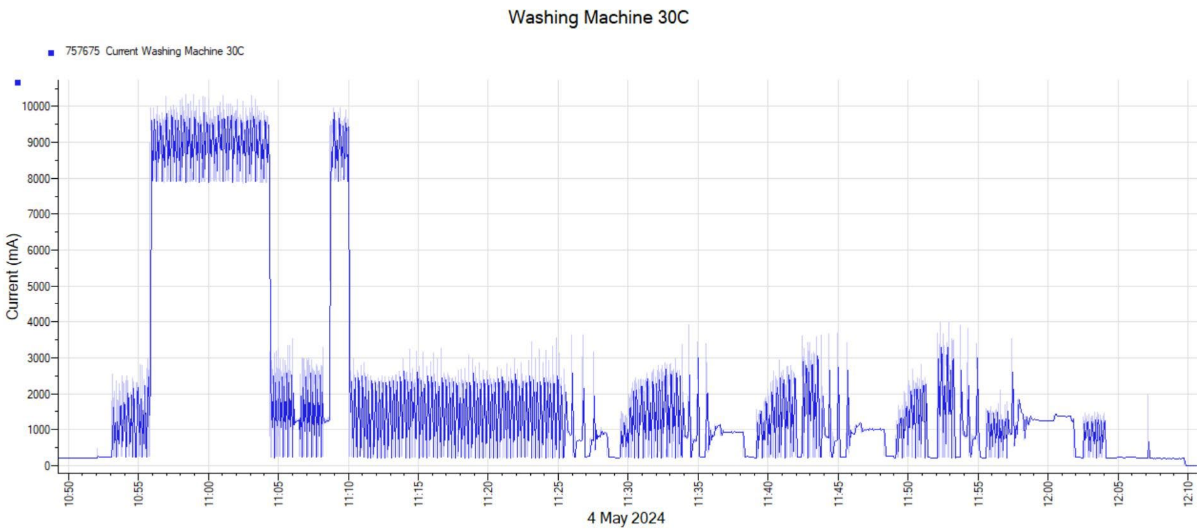

Figure 3.2 Plot of consumption for a Hotpoint WMTL80 washing machine recorded using a Tinytag View 2 data logger at 1 second intervals for a 30°C washing cycle

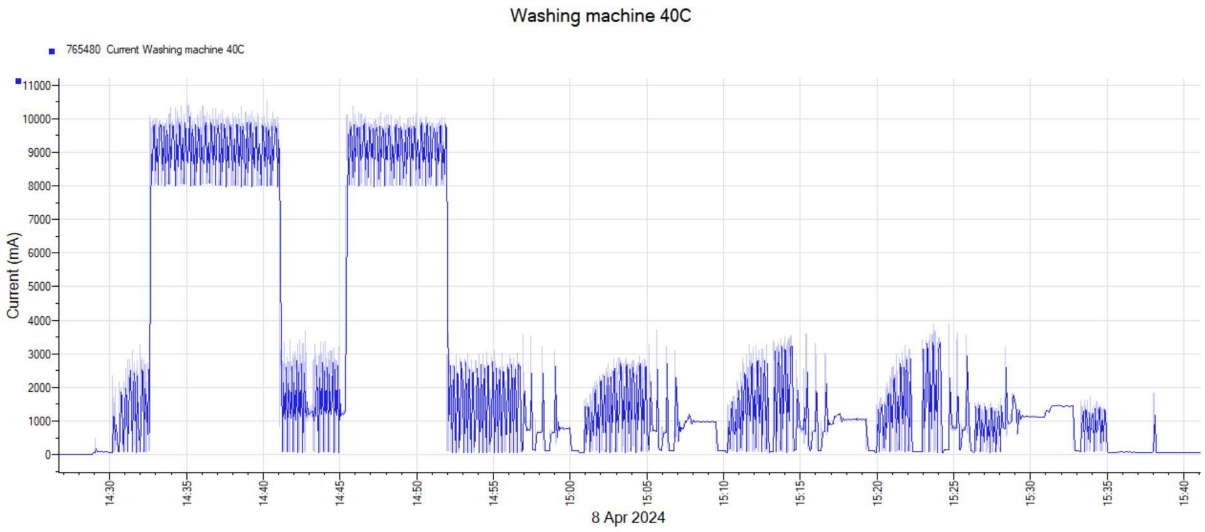

Figure 3.3 Plot of consumption for a Hotpoint WMTL80 washing machine recorded using a Tinytag View 2 data logger at 1 second intervals for a 40°C washing cycle

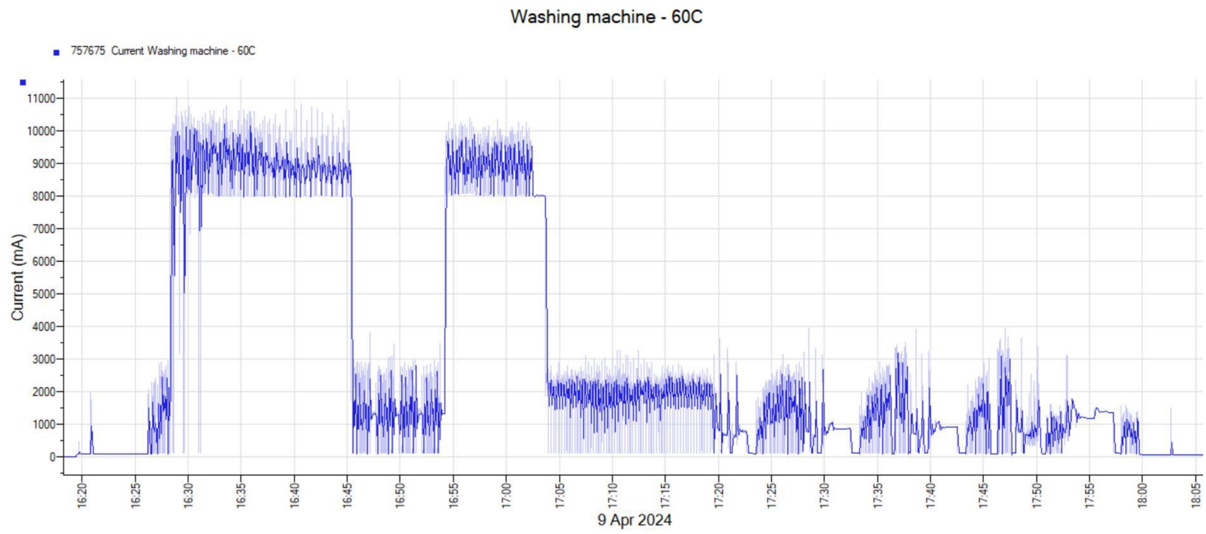

Figure 3.4 Plot of consumption for a Hotpoint WMTL80 washing machine recorded using a Tinytag View 2 data logger at 1 second intervals for a 60°C washing cycle

ENDS

National Energy Action (NEA) is the national fuel poverty and energy efficiency charity. We've worked across England, Wales, and Northern Ireland for over 40 years, to ensure that everyone in the UK can afford to live in a warm, safe and healthy home.

We work together with frontline practitioners, companies, regulators and the government for customers in vulnerable circumstances to make positive changes.