National Database of Household Appliances – Understanding Baseload and Standby Power Use

David Cogan[1], Michael Camilleri[2], Nigel Isaacs[2], Lisa French[2]

[1] Consulting Engineer, New Zealand
[2] BRANZ Ltd

Abstract

As part of the house audit undertaken by the New Zealand Household Energy End-use Project (HEEP) a detailed record is made of all appliances. This includes not only nameplate information, but also for major appliances details on the standby and in-use electricity requirements. The random sample covers 400 houses from throughout the nation – urban, suburban and rural locations, the full range of incomes, household demographics and house ages.

The computer database includes 11,891 appliance power measurements, label details from a further 5,656 appliances and detailed house light records. This provides a comprehensive overview of household electricity uses. All appliances in the house are recorded, with information on their location and power. A minimum of 7 and a maximum of 82 appliances were recorded in any house, with an average of 33.

The data have been used to prepare nationally representative estimates of standby and baseload power consumption.

The average energy use per house for standby is equivalent to 58 W continuous, while the average house baseload demand including standby is 112 W ± 4 W continuous. The top five appliance types in terms of their current impact on the electricity system account for more than half the total household standby energy consumption.

Analysis using the data obtained from the survey is being used to produce a bottom-up model of household energy use. The resultant modelling can be used to determine the extent to which energy efficiency may be increased, and energy consumption minimized.

The HEEP project

The New Zealand Household Energy End-use Project has been active for over ten years and is a comprehensive study of the way energy is used in New Zealand households. The data collected by the study include social interactions and mediating factors that may give rise to particular energy use patterns.

Standby and baseload power consumption has been reported in HEEP since the Year 3 report [1]. These early estimates of standby and baseload power consumption have been instrumental in raising awareness of this important energy use both locally in Australasia [2] and worldwide [3], [4]. In March 2000 New Zealand announced a policy of adopting a One Watt Target for the standby of all appliances. Such a target was achievable even at that time for most appliances. Unfortunately, institutional changes that took place later that year resulted in the target not being actively pursued. However, since then, standby power requirements have been included in some mandatory energy efficiency standards for appliances as part of the harmonized Australian and New Zealand minimum energy performance standards (MEPS) programmes. It is also notable that during power crises the reduction of standby power has been promoted as an energy conservation measure during power crises, although how much this contributed to the approximately 10% reductions in electricity consumption achieved during the most recent campaign is unknown.

HEEP Monitoring

Monitoring continued after the initial findings, and now, after a further six years, the HEEP database has data on a total of some 400 randomly selected houses, covering all New Zealand. The sample covers houses from throughout the nation – urban, suburban and rural locations, the full range of incomes, household demographics and house ages. The large majority (300) of these houses have been monitored in the past three years.

Now that the HEEP monitoring is complete, full, comprehensive and nationally representative estimates of standby and baseload power consumption can be prepared. This is a world first, as no other country in the world has undertaken a study comparable to HEEP that could provide such estimates. Most studies are non-random, with limited geographical or demographic coverage, or are desktop studies with some spot measurements taken of new appliances. For the full time ever, anywhere, a full account is presented of standby losses as they actually occur in use within houses.

The resulting computer database includes 11,891appliance power measurements, label details from a further 5,656 appliances and detailed house light records, thus providing a comprehensive overview of household electricity uses.

All appliances in the house are recorded, with information on their location and power. The most numerous electricity end-use is lights, ranging from a minimum of seven in a house up to a maximum of 143. A minimum of 7 and a maximum of 82 appliances were recorded in any house, with an average of 33. The largest numbers of a single appliance type were the 22 sewing machines in one house, but the most popular appliance is the television (averaging just under 2 per house). The largest number of televisions in one house was 9.

This rich database provides an internationally unique resource for New Zealand. The possibilities for its use are wide, limited only by the imagination of potential users. One example is the use of the data to prepare nationally representative estimates of standby and baseload power consumption.

Appliance energy use data collection

Unlike other studies, the HEEP data are based on three sources within the HEEP programme. This enables a comprehensive picture to be provided of baseload and standby. Other studies of standby tend to ignore how standby operates in practice. They also ignore the non-standby baseload, which represent comparable, or in some instances greater, energy waste.

Data on standby power come from three sources within HEEP:

- *Enduse data* — 10 minute monitored energy data from individual appliances
- Spot *power measurements* — Spot measurements of the standby power carried out with a power meter at the time of the house installation
- *Survey* — Occupant survey recording the number of each appliance type, and it's usage

By combining information from these three sources, a complete picture of household standby and baseload power consumption can be constructed.

The monitored enduse data are the most detailed and provides information not only on the standby power level but also on how long the appliance spends in standby mode, information which cannot be gathered in any other way. There were 1,026 unique appliances monitored in this way.

Due to resource limitations, the monitored enduse data were collected in only one quarter of the HEEP houses that were subject to detailed enduse monitoring. These resource limitations extended to limiting the number of appliances able to be monitored, so the coverage is not complete for all appliances and also some minor appliance types were not monitored at all.

Spot power measurements were carried out in all the HEEP houses by an auditor going through the house recording information on every appliance in the house. The information recorded included type, make, model, serial number, label information, measured power consumption, measured standby power, and the standby status. How much information was recorded depended on the type of appliance, with appliances such as whiteware and entertainment equipment having all information recorded, and minor appliances like blenders etc have only their presence recorded. If an appliance was found to be plugged in and switched on, a standby power reading was taking, and the state recorded – this allowed some information about what percentage of minor appliances (such as chargers) are left in standby mode, and is a valuable complement to the enduse data.

Survey data are recorded for the major appliance types. The occupant survey included questions on the number of each appliance in each house and the usage (e.g. constant, daily, weekly etc). Some additional information is collected for heating and cooking appliances. This information is primarily used for creating estimates of appliance stock levels, but for some appliances like heated towel rails it can be used to estimate energy consumption in the absence of energy monitoring

Analysis Methodology

The methodology for estimating standby losses and baseload was first described in the HEEP Year 5 report [5].

Standby power is drawn by an appliance when it is not in operation but is connected to the mains. Depending on the appliance type, this can range from nil (for example, a non-electronic dryer) to 20 W or more (for example, a television). These power consumptions may seem trivial (1 W continuous power is approximately 9 kWh per year and in New Zealand costs about $1.40 at 16c/kWh), but since most households have many such appliances, the actual energy consumption can become a significant fraction of the total energy consumption of a household.

Definitions of Standby Power and Baseload

The definition of standby power, prepared by a consensus panel for the IEA (International Energy Agency) [6] is:

> *'Standby power use depends on the product being analysed. At a minimum, standby power includes power used while the product is performing no function. For many products, standby power is the lowest power used while performing at least one function'.*
>
> *'This definition covers electrical products that are typically connected to the mains all of the time'.*
>
> *'Based on this definition, certain types of products generally do not have standby power consumption. This includes, for example, products that have only two distinct conditions: 'on' and 'off', where the product does not consume power when it is off'*.

The basic concept is that standby power is the power used when the appliance is not performing its primary function. This definition is applicable to a single appliance, but when considering what actually happens in a household, it is necessary to take into consideration how the appliances are operated and also how long they tend to last. Monitoring for standby also picks up certain loads that are not standby according to the above definition, but that appear to have similar characteristics. As a result, the HEEP study considers standby loads to be those loads that exist even when those dwelling in the house think nothing is happening. This has the effect of widening the scope for energy efficiency programmes, and indicating potentially effective programme areas that may otherwise be overlooked. Accordingly, as well as standby, HEEP investigated the baseload of houses.

For the purposes of the study, the baseload of a house is defined as the typical lowest power consumption when there is no occupant demand. It includes the standby power of appliances (e.g. microwave ovens, VCRs, multiple TVs, video games, dishwashers, etc), plus any appliances that operate continuously (e.g. heated towel rails, clocks, security systems etc). It is important for two major reasons:

- It defines the lowest continuous power demand that must be met by a network (or generation system), so having a large part to play in the network load factor.
- It includes a group of appliances that have potential for demand reductions.

When dealing with conditions in actual service, it is more realistic to define the standby power of an appliance as the power used when the appliance is not performing its primary function; it could include the following:

- ***Video**: power used when it is not playing or recording.*
- ***Range**: energy used by the clock (and other electronics) when no cooking is being done.*
- ***Washing machine**: power used by indicator light or electronics when not washing.*
- ***Refrigerator**: energy used when the refrigerator compressor is off, and it is not defrosting, which could be the butter conditioner, or transformer and electronics.*

Note that other studies do not necessarily include all of the power consumption during non-usage time for refrigerators and refrigerator freezers, videos and microwaves - since the power is consumed for specific tasks such as the butter conditioner, TV channel tracking, microwave clocks. This study used a more inclusive approach

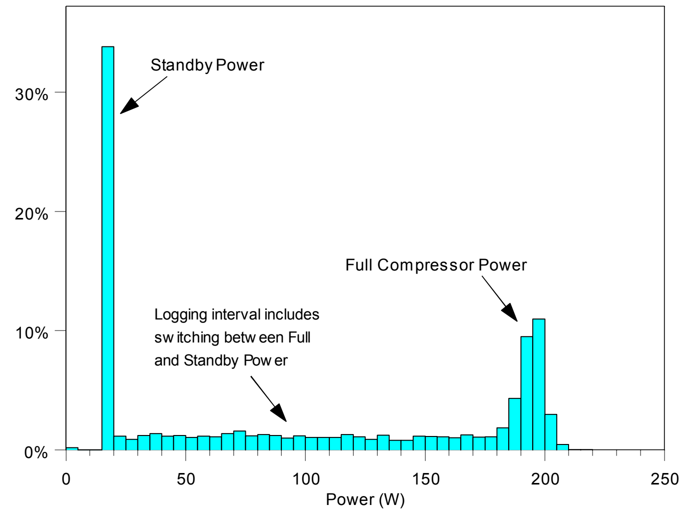


Figure 1 Histogram of refrigerator power
Source: BRANZ Study Report No, SR 141 (2005) Figure 39

Many modern appliances require a transformer or other power supply to supply DC power for electronic and computer controls, and this may consume power continuously, even when there is no power drawn by the appliance itself. For example, a washing machine may be used a few times each day, for about 60 minutes for each cycle. In between cycles, the electronic control system is waiting and hence the power demand does not drop to zero, but (in the case of at least one machine monitored) to about 9 W. This off-duty power consumption of 9 W is the standby power of this appliance. As it is used only a small fraction of the day, almost half of the total consumed energy is for the 9 W standby power, and not for washing clothes[*]. It is thus ‘wasted energy’ in the sense that it is not used to perform useful work.

The analysis method for calculating the standby power and losses is based on the frequency distribution of the appliance power consumption. For example, a refrigerator compressor is on for most of the time and, when the compressor switches off, the refrigerator has a standby power of about 17 W. The frequency distribution for such a refrigerator is given in Figure 1.

The histogram in Figure 1 has two strong peaks: one at about 190 W corresponding to full compressor power, and another at about 17 W corresponding to the standby power. Power uses in-

[*] The washing machine in question was operated with cold water wash cycles, as are the majority of washing machines in New Zealand.

between these peaks are the refrigerator switching on or off some time during the 15-minute sampling interval, so an intermediate power use is recorded.

The method for calculating the standby power is to find the standby power peak. Mathematically, the standby power is the **mode** of the distribution, which is defined as the value that occurs most often. As the data are measured in steps of 1 W (i.e. 1,2,3,4… W), finding the mode is easily done by identifying the most common value in the data.

For some appliances, the most common value is larger than the standby power, as they rarely switch to standby. In these cases the modal value of the data values less than the mean power is taken.

Once the standby power is known, the standby loss can be calculated. This is defined as the energy consumed when the appliance is in standby mode, rather than being 'on' or disconnected from the mains. This distinction is important as some appliances, such as televisions, are not always left in standby mode.

Presentation of results

For the purpose of reporting, household appliances have been divided into eight groups. The full range of standby data described in this section can also be generated for the individual appliance types:

- *Entertainment*: audio component, DVD player, games console, miscellaneous entertainment, radio, separate radio cassette, Sky/Saturn decoder, stereo, television, video
- *Kitchen*: bench top mini-oven, bread maker, coffee maker, Crockpot, dishwasher, electric oven, electric range (hobs + stove), extractor fan, food processor, frying pan, jug, juicer, microwave, mixer, Rangehood, separate electric grill, small kitchen appliance, toasted sandwich maker, toaster, waste disposal
- *Laundry*: dryer, iron, washing machine
- *Miscellaneous - Large*: pool pump, spa pool
- *Miscellaneous - Small*: alarm clock, cellphone charger, charger, electric blanket, electric fence, electric organ, electric power tool, garage door opener, hairdryer, lamp, miscellaneous gear, miscellaneous household appliance, miscellaneous personal, plug in air freshener, sewing machine, shaver, toothbrush, vacuum, waterbed
- *Refrigeration*: freezer, refrigerator, refrigerator-freezer
- *SOHO (Small Office, Home Office***)**: answer phone, computer, computer monitor, cordless phone, fax machine, intercom, miscellaneous computer peripherals, printer
- *Space Conditioning*: air conditioner, fan, dehumidifier, heater

Standby power and energy

Standby power

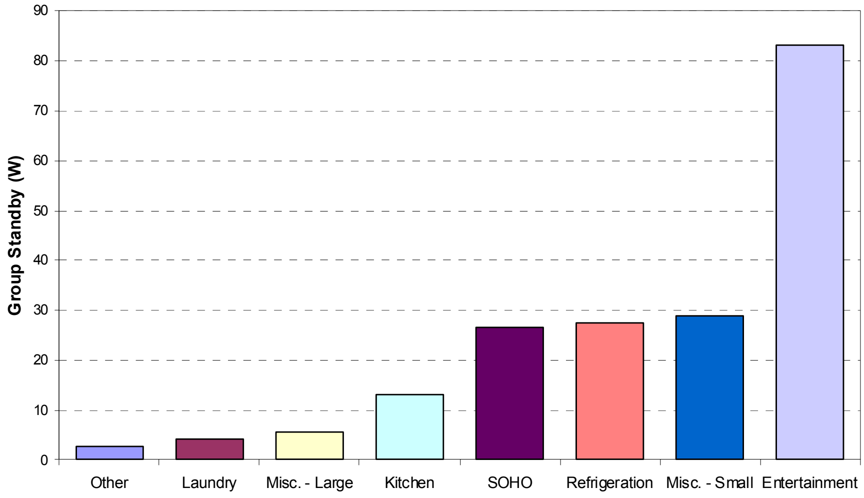
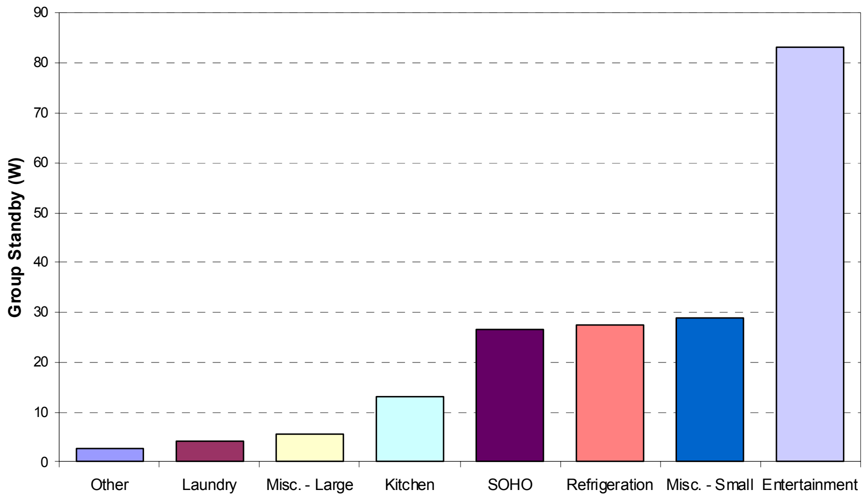


Figure 2 summarises the power demand for each of the different household appliance groups, while Figure 3 provides an overall analysis of the energy used by the different groups. The difference relates to the amount of time the appliance is turned on and in standby mode, and the relative proportions of the different appliances. For example, the ‘entertainment’ group is not only the largest



group in terms of standby (

Figure 2), but as they are plugged in for most of the time and they are found in many houses, their overall impact is 51% of the energy used for standby (Figure 3). Conversely, the ‘Miscellaneous – Large’ group (pool pump and spa pool) has a high standby but is found only in a relatively few houses, and therefore has very little impact on the overall standby energy use.

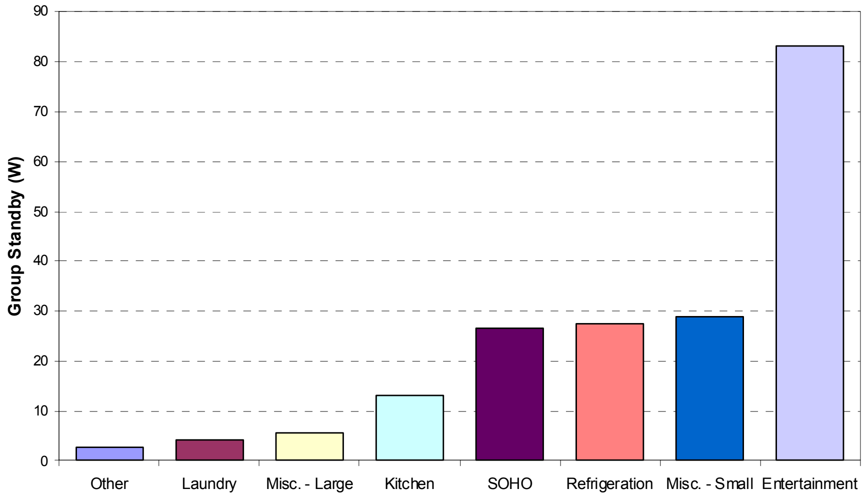


Figure 2 Standby power for household appliance groups
Source: BRANZ Study Report No, SR 141 (2005) Figure 40

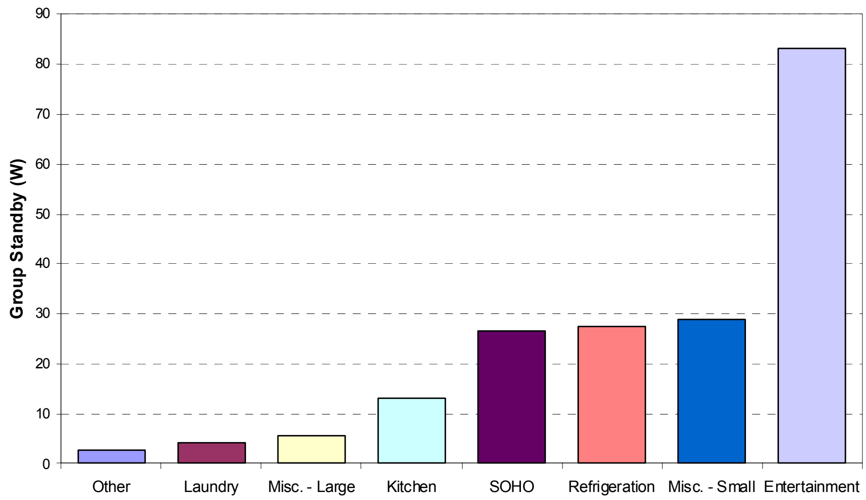
The five appliance types measured to have the highest standby electric power are (in order from largest to smallest):

- Combination Refrigerator Freezer
- Sky/Saturn decoder
- Refrigerator (single temperature)
- Video
- Instant Gas Water Heater

In almost all cases the level of standby power is a consequence of the design, and could if desired be significantly reduced.

Standby energy

The average energy use per house for standby is equivalent to 58 W continuous i.e. the average New Zealand house is spending around $80 a year (at 16 c/kWh) just keeping these appliances powered-on while they wait to be used.
The overall impact on the nations electricity demand, as mentioned above, is a combination of the individual appliance standby-by power, the proportion of time it is plugged in and ‘turned on’ at the wall (even though it may not be in use) and the size of the appliance population. Just because an appliance type has a high standby power



(

Figure 2) does not mean they are major loads of the electricity system.

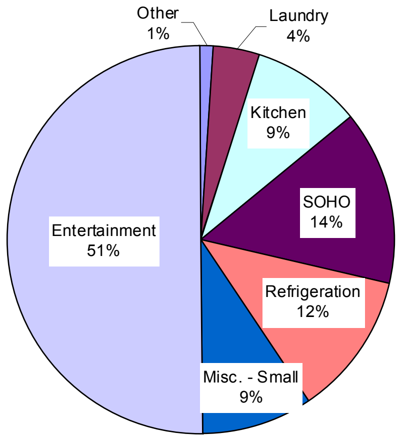


Figure 3 Standby energy
Source: BRANZ Study Report No, SR 141 (2005) Figure 41

The top five appliance types in terms of their standby energy per house are (in order from largest to smallest):

- Video
- Television
- Stereo
- Refrigerator Freezer
- Computer (includes CPU and monitor)

These five highest appliance types account for more than half the total household standby energy consumption. It is interesting to note that three out of the top five are in the 'home entertainment' grouping.

The average energy use per house for standby is equivalent to 58 W continuous.

It is important to note that as appliances increase their market penetration, the importance of their standby energy use increases, and vice versa. For example, video recorders are being replaced by DVD players/recorders. If each older, higher standby power, video recorder were replaced by a more efficient, lower standby power, DVD player then the national standby power demand of this appliance group will reduce. However, if DVD players/recorders achieve a greater market penetration, or if the new appliance has similar standby power, then the overall impact may be unchanged or possibly even result in an increase in standby power demand on the electricity system.

House baseload

The baseload of a house is the typical lowest power consumption when everything that is usually switched off is off. It is made up of the standby power of appliances, continuous loads like heated towel rails, other appliances that are always on, and faulty refrigeration appliances.

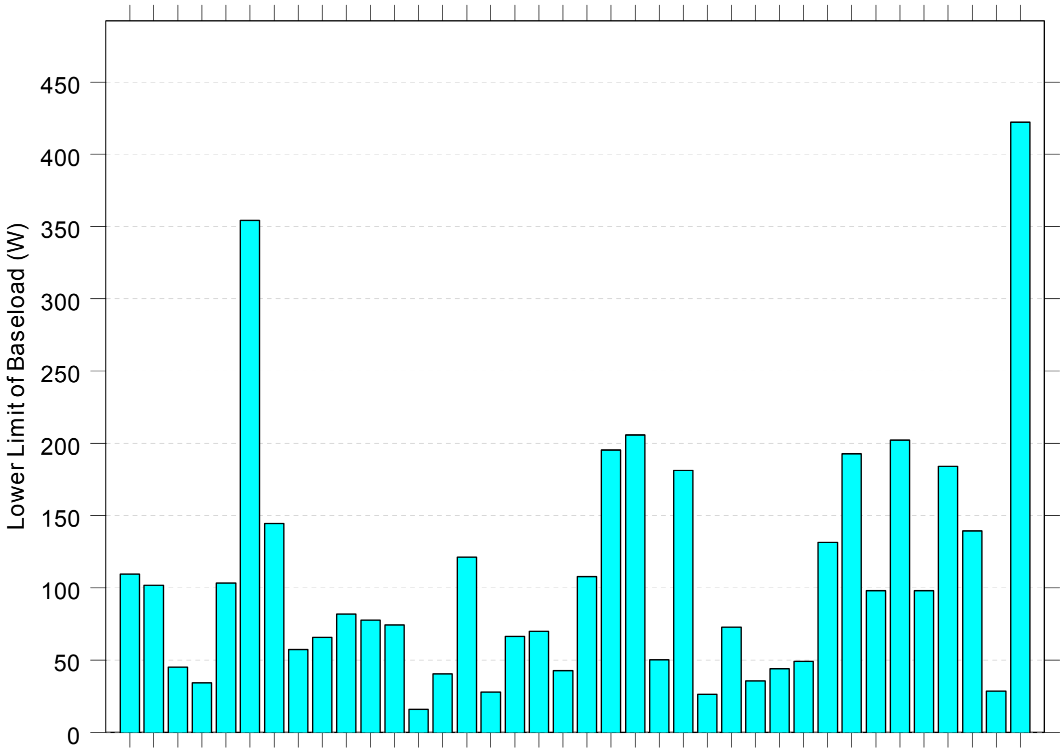


Figure 4 Measured baseloads for a small sample of houses
Source: HEEP Year 3 Report — Reference [7]

One of the indications from early monitoring is that the baseload of a household is often far more than that attributable to standby losses, which have received the greater attention. For some houses, non-standby baseload is particularly significant. Information as to the nature of the two particularly large loads in the sample shown in

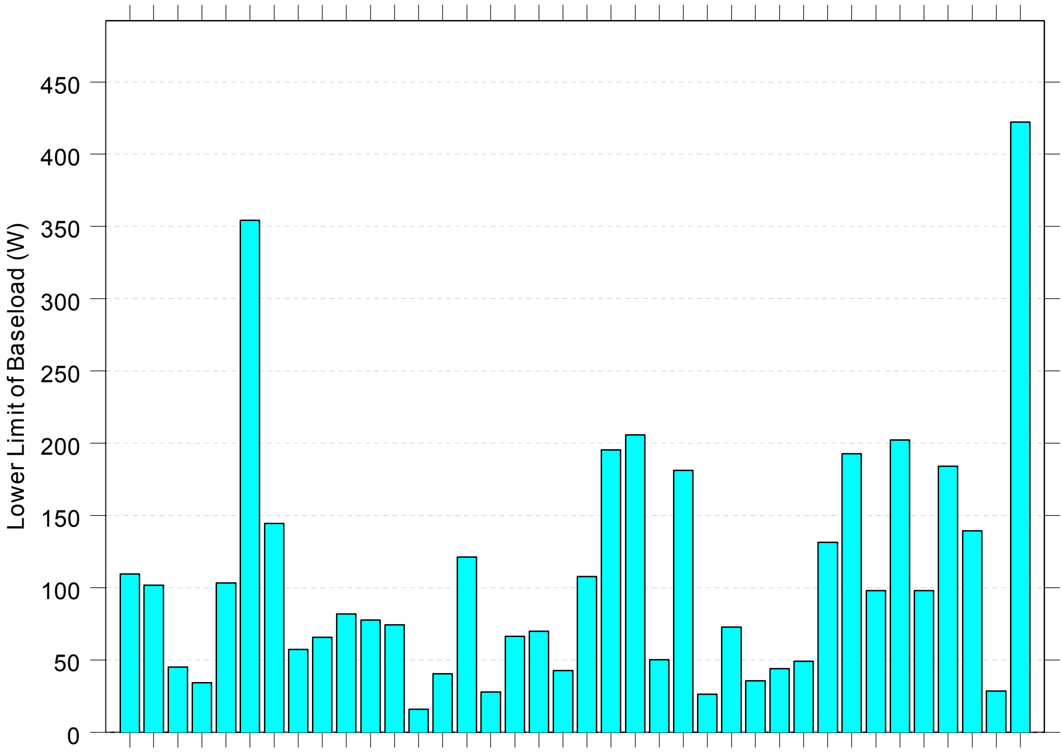


Figure 4 is anecdotal, but one at least is due to a faulty refrigerating appliance that is running continuously at full load.

Heated towel rails — an example of baseload

To demonstrate the concept of baseload, it may be helpful to consider the findings for one particular appliance type.

The HEEP survey questionnaire records how many heated towel rails there are in each house, and how often they are used, as self-reported by the occupant. The usage is recorded in categories as summarised in Table 1. More that half of the heated towel rails are on constantly, and dominate the energy consumption for this appliance type.

The hours of use per week for each category are needed to calculate the energy consumption. Some early HEEP surveys of 128 houses included occupant self-reported hours of use, and Column 3 of Table 1 is based on these estimates.

The average power rating of heated towels is also needed. This is not usually known by the occupants, and often no label is visible, and with fixed wiring it is not easy to conduct a power measurement. The early HEEP survey information (128 houses) also included power estimates, and those have been used. The average was 70 W ± 10 W.

Table 1 Heated towel rails by usage category and assumed hours used per week

Usage Category	**Assumed Hours per week**	**% of houses**
Constant	168	56%
Daily	35	11%
More than once per week	20	3.5%
Approximately once per week	10	1.5%
Approximately fortnightly	5	1.5%
Approximately once per month	2	5.5%
Less than once per month	0.5	10%
Never	0	10%

BRANZ Study Report No. SR 141 (2005) Table 31

Combining the number of heated towel rails with the usage information and the average power rating gives the average power consumption per house for heated towel rails as 21 W ± 2 W. The 95% confidence interval (CI) is 17 to 25 W. Nationwide for the 1,400,000 households this is an average of 30 MW ± 3 MW, of which almost all is continuous load.

Table 2 Heated towel rail average power use

Usage Category	**Average (W)**	**95% CI (W)**
Per house	21±2	17-25
Per house with heated towel rails	50±4	42-59
Per house that uses heated towel rails	62±5	53-72

BRANZ Study Report No. SR 141 (2005) Table 32

Since only about half the heated towel rails are used constantly, and there are only about 0.6 towel rails per house, most of the heated towel rail energy consumption is from a small fraction of houses.

A single heated towel rail used constantly costs more than $100 per year to operate, and can easily be 10% of more of the total electricity consumption in a house that uses them. Reductions of energy consumption, either by informing people of the real cost of operation, or by installing timer switches could cost-effectively give worthwhile energy savings, both at an individual household level and nationally.

Baseload Assessment

The methodology for assessing the baseload was described in the HEEP Year 5 report [5] and is provided below.

The assessment of baseload is analogous to the assessment of standby load, as the baseload can be thought of as the standby power load of the entire house. Baseload assessment is more complex, because there are a large number of appliances switching on and off during the course of a day, so that the total power may be only rarely at baseload level. It may perhaps occur in the middle of the night, when everyone is asleep and all appliances are switched to off or standby.

To find the baseload, the minimum monitored power for each day is taken, and a histogram created. The baseload is expected to be the most commonly occurring daily minima, which should be at the low end of the histogram. Calculating the mode generally gives a good estimate of the baseload. In households with many refrigeration appliances (or other fast switching, automated appliances) the histogram of daily minima may not be so easy to interpret, as it is rare for all of the fast switching appliances to be off concurrently. In such cases, a good estimate of the baseload cannot be made. For the HEEP sample households, this rarely occurred.

Results: Baseload

The average baseload demand is 112 W ± 4 W continuous, equivalent to an annual cost of approximately $150 per year. The 95% confidence interval is from 104 W to 121 W. With 1.4 million houses in New Zealand, this is equivalent to about 160 MW of continuous load – equivalent to the average output of a hydro-power station on the Waikato river. The baseloads ranged from a low of 7.5 W to a high of 583 W (which was for a house with a medical ventilator running 24 hrs).

With a standby power consumption of 58 W ± 4 W, and heated towel rail power consumption of 21 W ± 2 W, there is 33 W ± 6 W remaining to be accounted for in the calculated average New Zealand house baseload.

Other components of baseload

Continuous or overnight lighting

Some households leave some lights on continuously or overnight, often for security or convenience. The household lighting circuits are monitored in the end-use HEEP houses, and this component of the lighting use can be estimated from these data. The continuous or overnight lighting load is analogous to the household baseload and the same method is used to estimate it. Some houses have a heated towel rail that is on constantly, and this is frequently wired into the lighting circuit. Houses that reported in the survey that they had a heated towel rail used constantly and a lighting baseload greater than 60 W were set aside. Another complication is the resolution of the monitoring equipment. Some lighting circuits were monitored with current clamps with a resolution of 0.25 W, but others were monitored with pulsed output tariff meters, which a resolution of 6 W, which is too large to distinguish a small lighting load from no lighting load. Houses monitored with this equipment were removed. The average of the remaining houses was 7 W ± 3 W, and this represents a rough estimate of the average continuous lighting or overnight lighting load.

Faulty Refrigerators

Previous HEEP analysis (not yet published) found that 7% of refrigeration appliances were faulty (compressor running constantly) and 9% were marginal (compressor running continuously for days or weeks in hot weather). The excess energy consumption was on average 15±10 W of continuous load per house.

Other standby

Some other small standby loads that were not monitored could be from the stove (notably the clock), fixed wired sensor lights, security systems, and the electrical safety Residual Current Devices (RCD) now required on all new sub-circuits. These might account for 3-5 Watts.

Overall Baseload

The baseload 112 W ± 12 W baseload and is made up of:

- 58 W standby energy consumption
- 21 W for heated towel rails
- 15 W for faulty refrigeration appliances
- 7 W for continuous or overnight lighting
- Roughly 3-5 W for some standby appliances that were not estimated

This leaves 7 W ± 12 W that is not fully explained, but as this is not statistically significantly different from zero, we conclude that there are unlikely to be any large standby or baseload components unaccounted for.

This breakdown base on HEEP analysis gives very useful information as to where energy efficiency programmes ought to be directed, and also help with the analysis of such programmes.

Impact on energy efficiency policy

Results from the HEEP study can be used to indicate where particular effort should be made to make the greatest improvements in domestic energy efficiency. Decisions need to be based taking a number of factors into account. These include the standby or baseload power of the appliance; how it is used and the consequent annual energy consumption; the expected in-service life of the appliance, changes of performance over the life, changes in usage over the life and the consequent whole-of-life energy consumption; trends in the performance of new models; the type of energy efficiency programme that would be practical to apply; the stance of stakeholders and programme implementers (sometimes described as “willpower versus won’t-power”).

Reductions for 1-W plan

A rough estimate of the effect of the implementation of the 1-W plan was calculated by assuming that the average appliance standby power was reduced to 1 W for those appliances that are more than 1 W, with exceptions being set-top decoders reduced to 4 W (the interim target from AGO [8]) and refrigeration appliances to 5 W. The result is total standby energy per house would be reduced from 58 W to 21 W, with the largest contributions to the 37 W reduction coming from entertainment appliances (21 W) and home office equipment (6 W). This clearly shows the appliance types where reductions are most desirable and realisable.

Selections for standby energy efficiency programmes

External power supplies

On the face of it, external power supplies appear to be a suitable subject for a mandatory energy efficiency programme: there are several of them in most houses, and the technology for a low (1 Watt) standby power exists implying that it would be possible to save between ten and twenty watts per household. However, if reference is made to the values for “miscellaneous – small” category in

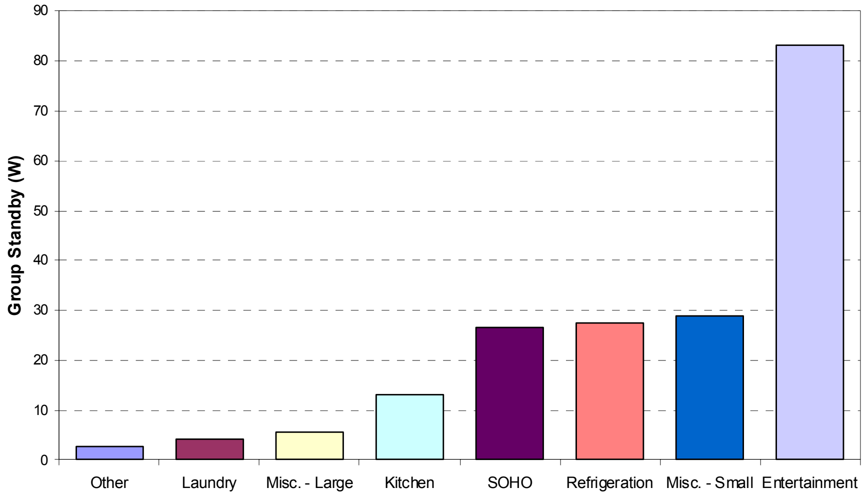


Figure 2 and Figure 3, it will be seen that the high value for standby power translates into a smaller comparative value for standby energy. This is because most external power supplies are not left on continuously; typically they are used for recharging the battery of a portable device such as a cellphone, and are not left connected to the supply when the recharging is not taking place. Another consideration is that the lifetime of the appliances being supplied is typically short — a cellphone that dates to the last century is considered antiquated — and new appliances tend to be supplied with new power supplies that are more efficient and draw less standby current.

Given the time typically taken to introduce mandatory energy efficiency measures for appliances, it was doubtful whether a MEPS for external power supplies would have any effect in practice. For this reason, action on this type of appliance was allocated a low ranking in New Zealand’s action list. It was not until Australia, without the benefit of an equivalent to HEEP, announced their intention of introduced a MEPS for external power supplies and New Zealand had the opportunity to introduce parallel measures with a reduced regulatory effort that the ranking increased [9]. The requirements, to come into effect in October 2007, are based on the joint Australian New Zealand Standard AS/NZS 4665 [10]. In New Zealand, mandating the Standard will probably have the effect of consolidating recent improvements in manufacture and performance and the associated savings, as distinct from making significant energy savings as a direct result.

Entertainment

A more important class of appliances that ideally demand swifter and more stringent energy efficiency requirements is the “entertainment” group. These tend to last for a longer time, to be more likely to be permanently connected to the electricity supply, and to have significant standby energy consumption. They also seem to be increasing in number. On the other hand, the complexity of the individual appliances in terms of the many different possible operating modes and even the likelihood of new types of entertainment appliance appearing make the introduction of mandatory requirements less straightforward. While some contribution is being made to a draft joint Australian/New Zealand performance standard for televisions, most entertainment appliances are merely being included in a New Zealand version of an Energy Star voluntary endorsement label campaign. At the time of writing, the campaign has had a positive effect on the fortunes of those in the advertising industry; the effect on energy consumption is yet to be determined. The potential for energy saving, however, was originally estimated to be in the Petajoule range (or about one third of a Terawatt-hour) which in New Zealand represents the best part of one percent of total national electricity use, and this appears to be a realistic estimate.

Small office/home office equipment

Similar considerations apply to home office equipment, except that the turnover of SOHO equipment is more frequent than for entertainment equipment, with even the Inland Revenue Department assuming a useful working life of between 4 years (computers) and 5 years (fax machines, printers) [11]. Such equipment is being included in the same Energy Star campaign as entertainment equipment.

Baseload energy savings

The situation with baseload is different in that baseloads tend to vary much more between houses.

Heated towel rails

Of the major components of baseload, electrically heated towel rails may be kept on all the time, part of the time or only occasionally. Often there are reasonable motives for leaving a towel rail on. In many New Zealand houses, condensation and damp in bathrooms is a problem that the use of a towel rail as a form of anti-condensation heater addresses to the user's satisfaction. The low-energy alternative solution can be difficult and expensive to implement, namely providing the bathroom with an extract fan, preferably plus wall, ceiling and floor insulation. Even fitting a heated towel rail with some form of automatic control — even a simple time switch — could double the initial cost of the appliance. The challenge is to provide the necessary information so the house owners are aware of the alternatives and of their costs. The larger challenge is to introduce and implement building requirements so that it is possible to operate houses in a more energy efficient manner.

Refrigerating appliances

The HEEP study has been used to separate into two classes the minimum power drawn by refrigerating appliance. Most refrigerating appliances exhibit a usage pattern similar to that shown in Figure 1. This has a power frequency peak below the median power consumption that corresponds to standby power use. For refrigeration appliances this is a combination of control circuit power, anti-sweat heaters and, in the case of traditional New Zealand models of refrigerator, butter conditioner. Reducing this power demand is not a matter for the user, but is a feature of refrigerator design. As the requirements of overall energy consumption by refrigerating appliances are governed by increasingly stringent minimum energy performance standards, such standby energy assumes greater significance and is being reduced by manufacturers.

But for a significant minority of refrigerating appliances the characteristic is that of a baseload, with near full power being drawn for extended periods (days, weeks or even months) especially during summer, or even all year round. These appliances are faulty, and could be suffering from one or several problems. The thermostatic control may not be working; door seals may no longer be sealing; refrigerant may have leaked; the compressor may have become worn; the appliance may be suffering from excessive build-up of ice due to not being defrosted. HEEP data indicates that around 7% of refrigerating appliances are running permanently, with a further 9% running for extended periods. So 16% of refrigerating appliances are consuming perhaps three times the electricity they should, meaning that the total energy consumed by refrigerating appliances is ~30% more than it should be. This figure may actually be even higher; the faulty appliances would tend to be the older ones, which have higher energy consumption than a new one of the same size.

Addressing this problem is not easy, as it requires raising the awareness of users, the majority of whom do not have a problem. While some signs can be looked for — Does the ice cream in the freezer crystallize quickly? Do the door seals look okay? Is the ice-box heavily frosted? — other faults are more difficult to discern without monitoring electricity use patterns or metering the electricity use by each individual appliance. The problem is further complicated by ownership patterns. Older refrigerating appliances being often with their second owner, who is typically less likely to be able to afford either a new replacement refrigerating appliance or to have major repairs undertaken.

Lighting

Replacing incandescent lamps used for continuous or overnight lighting with compact fluorescent lamps could reduce energy consumption, as could sensors or timers. The large-scale campaigns currently being undertaken to replace the most commonly used incandescent lamps in each house by good quality compact fluorescent lamps may have an impact here.

Conclusions

A full household energy end-use survey such as HEEP provides sufficient data and information to enable areas of potential energy saving to be identified accurately, and more importantly for accurate estimates of those savings to be made. This in turn enables appropriate energy efficiency programmes to be devised and implemented, and can prevent resources being wasted on programmes that may have little long-term effect.

Standby losses represent a significant portion of household electricity consumption, and a greater share of electricity savings potential. Entertainment appliances and small office/home office equipment are the most significant areas. But the complexity of these appliances means that simple energy efficiency programmes may not be effective.

In New Zealand non-standby baseloads are similar in scale to standby losses, but with greater variation between houses. The main baseloads are heated towel rails, faulty refrigeration appliances and overnight lighting. Reducing these loads will be a challenge, and will require separate strategies.

Acknowledgements

This research was funded by the Foundation for Research Science and Technology through the Public Good Science Fund, and by the Building Research Levy.

References

[1] Stoecklein A., Pollard A., Isaacs N., Camilleri M., Jowett J., Fitzgerald G., Jamieson T., and Pool F. 1999. Energy Use in New Zealand Households - Report on the Household Energy End-use Project (HEEP) - Year 3. Energy Efficiency and Conservation Authority (EECA), Wellington.

[2] Cogan D. *Dealing with Baseload Losses and What is Happening Elsewhere.* Presentation to a Seminar in Sydney, Australia on 9 March 2000.

[3] Camilleri, M.T., Pollard, A.R., Stoecklein, A.A., Amitrano, L.J. and Isaacs, N.P. 2001. *The Baseload and Standby Power Consumption of New Zealand Houses.* In *Proc. IRHACE Technical Conference*, March 2001 (BRANZ Conference Paper 100).

[4] Cogan D. *The Second Turn of the Energy Efficiency Spiral* in Bertoldi P, Ricci A and de Almeida A *Energy Efficiency in Household Appliances and Lighting* pp 508-517, Springer Verlag, Germany 2001 (Proceedings of EEDAL 2000 in Naples)

[5] Stoecklein A., Pollard A., Camilleri M., Amitrano L., Isaacs N., Pool F. and Clark S. (ed.), *Energy Use in New Zealand Households, Report on the Year 5 Analysis for the Household Energy End-use Project (HEEP*), BRANZ : Judgeford (SR 111) 2001.

[6] IEA 1999, *Conclusion of Task Force 1: Definitions and Terminology of Standby Power* Document developed and approved by the participants of Task Force 1 during a two-day meeting on 17 & 18 November 1999 in Washington DC, downloaded from webpage http://standby.lbl.gov/Definition/IEATaskForce1.html on 16 February 2006.

[7] Stoecklein A., Pollard A., Isaacs N., Camilleri M., Jowett J., Fitzgerald G., Jamieson T., and Pool F. *Energy Use in New Zealand Households - Report on the Household Energy End-use Project (HEEP) - Year 3*. Energy Efficiency and Conservation Authority (EECA), Wellington, 1999.

[8] Harrington L. *Standby Product Profile 2003/03, March 2004. Free-to-air Digital set top boxes (STBS)* Australian Greenhouse Office .2004 Available for download from http://www.energyrating.gov.au/library/pubs/sb200403-stbs.pdf (accessed on 24 February 2006)

[9] Energy Efficiency and Conservation Authority *Appliance and Equipment Energy Efficiency Forward Programme 2004-05*, June 2004

[10] Standards Australia/Standards New Zealand *AS/NZS 4665 Performance of external power supplies: Part 1:2005 Test method and energy performance mark; Part 2:2005 Minimum energy performance standard (MEPS) requirements*

[11] Inland Revenue Department *General Depreciation Rates IR265* March 2004. Available for download from http://www.ird.govt.nz/resources/file/ebbd7e41823cfbe/ir265.pdf (accessed on 24 February 2006)