Estimating Stock Average Low Power Mode Attributes
Methodology for 4E Standby Annex

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Summary

The purpose of this report is to propose a uniform international methodology which can be used to determine stock average attributes for low power modes (nominally standby and other modes) based on information for new products and the total stock and turnover products in normal use. The methodology also allows determination of total energy consumption of products where additional information of the duration of mode each mode is available.

The methodology is general in nature and can be applied to any appliance or equipment types. This paper aims to provide the basis for a consistent approach which will allow accurate estimates of low power mode trends and will facilitate inter-country comparisons. The base data and proposed stock model could then be used as a common basis and analysis engine for the evaluation of program impacts.

The paper discusses the methodology itself and the format and sources of data that are required inputs.

This paper cover the following topics:

- General methodology and approach
- Estimating total stock of appliances in service – ownership (establishing time series, tracking data at a regional level)
- Determining the attributes (characteristics) of new products entering the stock each year
- Understanding the relationship between power consumption in individual modes and total energy consumption during normal use (assumed duty cycle)
- Assumed lifetime of appliances and retirement function
- Determination of the standby characteristics of the installed stock of appliances by year using a mathematical stock model which adds new appliances to the stock each year and retires older appliances.
- Summing data to give trends in low power modes by year.
- Need for assumed duration in each mode to get total energy estimates.

Model Overview

This report outlines a bottom-up energy end-use energy model that is applicable internationally and can be used as the basis of estimating the trends in low power modes for a wide range of appliance and equipment types. The end use model is generic in nature and can be applied to a wide range of product types.

To estimate power trends by mode, an appliance stock model is used. A stock model is a mathematical construct that draws new products into the existing stock (pool) of products each year. The characteristics (attributes) of these new products and the number entering the pool are weighted and added to the pool of existing products already in the stock. Each year, products are also retired from the pool of products according to the selected retirement function (age and distribution) for that product. The retirement function is based on a function which is used to define the average age of the product and how older products are removed from the stock. A range of possible retirement functions can be used (block, linear, normal distribution) (see section on assumed lifetime).

Products enter the stock and remain there until they are retired at the end of their life. All products in the stock are equally affected by the consumer usage factors which are applied each year to the installed stock (eg estimated time spent in each mode). The implied sales of new products in each year is estimated from the sum of the increase in the stock (based on ownership changes and household number increases) plus the replacement of retired stock.

Schematically the stock model can be depicted as shown in Figure 1. Average attributes for all installed products in the stock in each year are adjusted according to the consumer usage factors in that year that convert attribute data to actual use data (average time spent in each mode). The energy consumption in each mode for each year can be summed to give the total energy consumption for the product (where a share of time by mode is provided).

The stock of appliances in service at any one time can be depicted graphically as in Figure 2. The products installed in a particular year (called a cohort) are shown as a single colour (sloping wedges) and the stock in any particular year is made up of the stock that has been installed in previous years that is still remaining in the year of interest and is represented as a vertical line through the cohorts.

Figure 1: Schematic of End-Use Stock Model

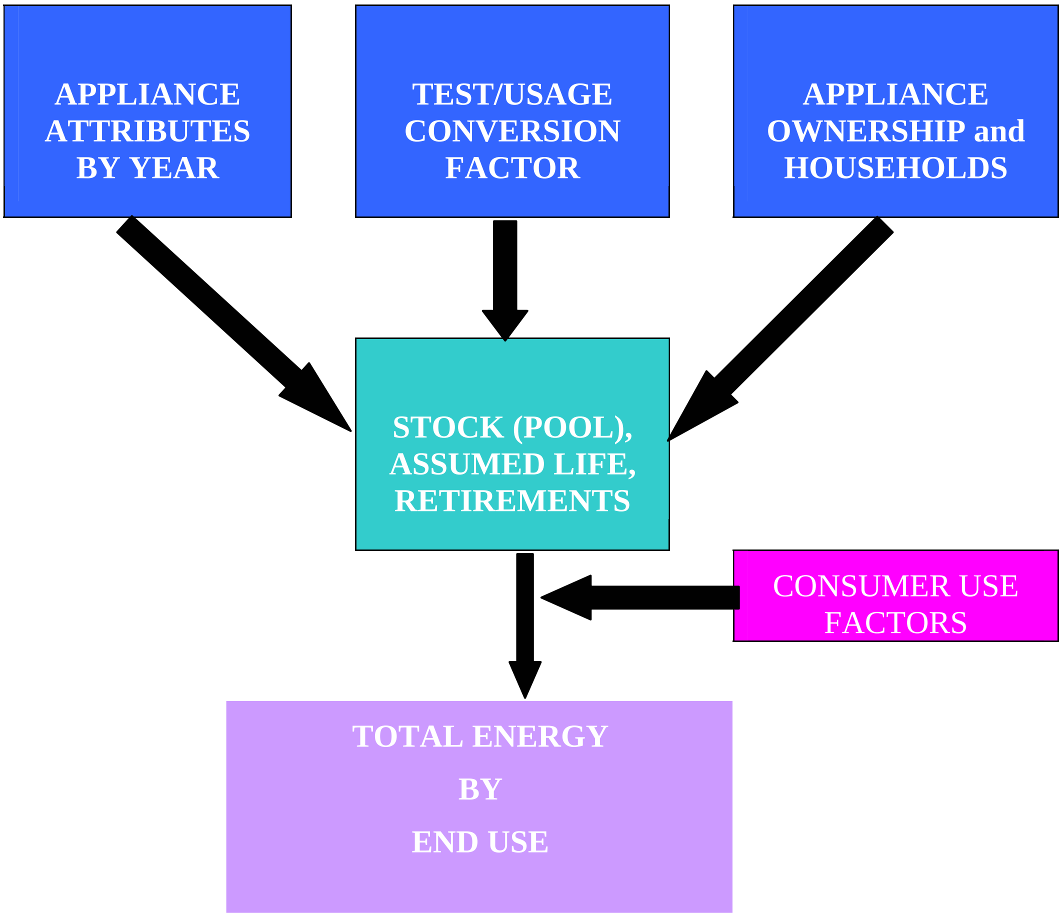
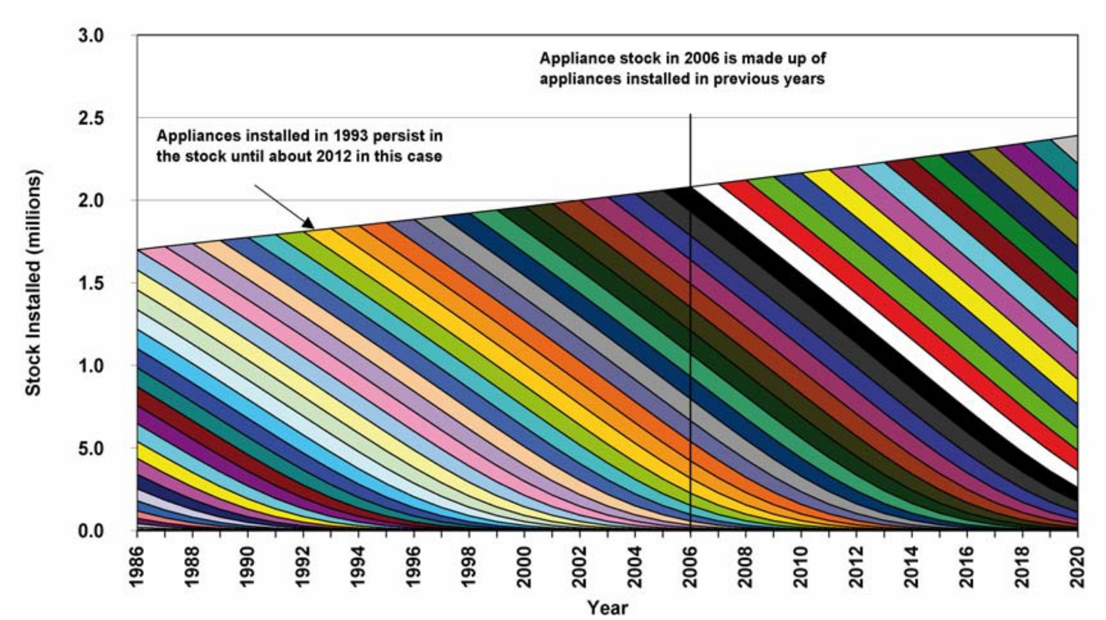


Figure 2: Graphical Depiction of the Stock Model



A more detailed mathematical description of how the energy stock model works is set out in Appendix A.

The end use energy stock model requires the following inputs when estimating energy consumption by end use:

- Number of households over time, including future projections.
- Number of each appliance type per household over time (ownership).
- Key characteristics (attributes) of new appliances entering the market each year (average power by mode for new appliances).
- Average appliance life and associated retirement function which is used to give a stock average value in each year.
- Data on usage patterns and other aspects of user behaviour and interaction that impact on energy consumption of appliances (duration and share of each mode). This is only required if the total energy consumption of the product is to be estimated. As a rule, duration of each mode (over a year) is desirable as power by mode is of little relevance without an understanding of its prevalence during normal use.

A more detailed description of each of these inputs and likely sources of the data required for the stock model are discussed in the following sections.

Estimates of number of households

A fundamental input into a stock model is a long time series of the number of households. It is preferable to have a time series that starts at least 20 years before the first year of model output is required (30 years is recommended) and projections of the number of households need to be made into the future to at least cover the period of modelling required (say to 2020 or beyond).

Most national agencies that are responsible for the collection of statistics will have data on the number of households, both historical and projected. Care is required that the historical and project time series are consistent at the point where they cross over as these are often published on a separate basis and may have different assumptions. It is important that projections of households (rather than population) be obtained.

Generally population data is available with household data and it can be useful to compile both time series at the same time from the same sources to track household sizes over time.

A number of different future projection scenarios for the number of households can also be examined – different households growth rates will affect total energy estimates. It is usually best if these projections are provided by the statistical agencies, as these types of projections are complex and need to take into account many factors. If modelling is to be done at a regional or state level, data on households must be also obtained at that same geographical level.

In Australia, the Australian Bureau of Statistics publishes this type of data at a state level. The type of data available and some special considerations regarding this data are outlined in Appendix B.

Ownership

The number of products in use will impact on the total energy consumption and the rate of change of the stock attributes or characteristics. In simplistic terms, higher ownership (more items in the stock) means more energy consumption (in most cases). The stock is usually estimated using ownership (which is the ratio of the total stock to the number of households) – this facilitates the assessment of the impact of different household number projection scenarios when they become available.

Ownership is data on the presence of the total number of products that consume energy in households – usually only products that are connected and used on a regular basis are counted within the normal ownership figures. Data on ownership should ideally be used for 1.5 times the average life of the product prior to the data when model outputs are required. For example, if a product has a life of 10 years and model outputs from 2005 are required, ownership data from 1990 should be used as an input into the stock model. Projections to 2020 are recommended as a minimum modelling input. A long sequence of ownership is also useful as it can be used to "train" the retirement parts of the model to be stable before outputs are required.

The following important definitions are used in this report:

Penetration – the proportion of households in which one or more of a particular appliance type is present (irrespective of the number of units of that appliance in the household). This value is usually given as a percentage and the maximum value is 100%.

Stock – the total number of a particular appliance type in use within households. This value is given as an integer (usually thousands or millions). The stock refers to the number of appliances in regular use, or a proxy for the number in regular use.

Ownership – the ratio of stock to the total number of households. This value is usually given as a decimal number and can exceed 1.0.

Saturation – the average number of appliances per household only for those households with one or more of the appliance. The minimum value is 1.0.

The following important relationships are used in this report.

$$\text{Stock} = \text{Ownership} \times \text{Number of Households}$$

$$\text{Ownership} = \text{Penetration} \times \text{Saturation}$$

For many products of interest, households may own several, so an accurate estimate of the ownership (rather than the penetration) is required.

If data is to be modelled at a regional level, it is preferable to have ownership data (together with estimates of household numbers) for the same geographical divisions.

For modelling purposes it is important that the future ownership of appliances be estimated. For products that have a high penetration and stable ownership, this could be straight forward. However, if the historical data is changing rapidly, accurately estimating future ownership could be difficult and this will require some judgement. Experts with a good understanding of the historical data and likely future trends within each country are best placed to undertake such estimates. As a simple first step, ownership can be projected into the future based on historical trends together with information on the sales and ownership of products where this is known. Care is required to make an assessment of likely saturation effects into the future.

End-use models can be kept relevant with regular updates to ensure that ownership data is based on the most current survey data when this becomes available.

As an alternative to collecting both households and ownership, a direct estimate of the total stock installed by year can be used directly in the model. This is usually less flexible as it is more difficult to take into account revised future household estimates when these become available. Ownership also provides a good visual check and changes in the prevalence of appliances in households over time.

Attributes

Appliance attributes are key parameters that affect, directly or indirectly, the energy consumption of a product. The main attributes of interest in this case are the average power consumption by mode for a particular product.

For each product type, the average attributes of new products that flow into the stock for each year of the modelling period need to be estimated. It is recommended that estimates of attributes be prepared to 2020. While there will be a distribution of mode power for products sold in each year, the stock model cannot take this into account – only an average value for each year can be used. In reality there will be products that use both more power and less power than the assumed average values. It is therefore important to model product groups that are similar in terms of key attributes and low power modes present where possible.

It is useful to separately model each type of product. The weighted average attributes of common modes for very similar products could amalgamated and used as single input into the stock model if a very large number of products is being modelling in parallel. However, if ownership and attribute data is available for each product individually, it is usually better to separately model each product separately.

Ultimately, the level of disaggregation will be dictated by the available data.

Factors that can affect attributes

At any one time in each country, there may be a range of energy programs in force or under development that are intended to influence the future power consumption of low power modes in appliances and equipment. The “business as usual” attribute profile for the past and the future will need to take account of programs implemented or proposed that influence the attributes of new products. Energy programs are assumed to affect the attributes of new products from the implementation date. Note that future programs cannot affect the attributes of the existing stock which is already installed when the energy program commences.

The preparation of different future attribute profiles that take into account the impact of different energy programs is a highly specialised areas and is the subject of a separate study to be commissioned by the 4E Standby Annex.

It is assumed that in general terms, energy programs do not affect ownership nor consumer usage of the appliances. An exception would be the case of accelerated retirement programs which aim to remove older products before the end of their normal life. This is effect is reducing the average life of a product over time, which is fairly complex to model mathematically.

One factor which is important to consider with respect to low power modes is the implementation of energy management facilities which automatically shift the share of time spent in each mode. To some degree this will occur irrespective of (poor) consumer behaviour. So energy management does not really affect the average power in each relevant low power mode, but it does affect the total time spent in each mode, which of course has a significant impact on total energy consumption.

End-use models can be kept relevant with regular updates to ensure that attribute data is based on the most current data when this becomes available.

Collecting attribute data

A good way to obtain data on power for low power modes is to undertake a systematic and ongoing campaign of measurement of new products in retail outlets. While there are limitations with this type of data collection, coverage of a wide range of products gives good information of trends by mode for new products. Some issues related to collection of data in stores and homes is set out in Appendix C.

Data on attributes can be obtained from a number of other sources. The availability of these sources will vary by country. Examples of data sources are:

- Government regulatory databases
- Voluntary program databases (eg Energy Star)
- Manufacturer declared data

In order to provide an accurate weighting of attributes, it is useful to match information on attributes with sales or shipment data from retailers or manufacturers. Ideally, sales data needs to be obtained at a model level and matched to known performance and energy consumption and efficiency data for each model. This data is then weighted by the sales or sales share of each model to get an average value.

A lower cost alternative to full sales weighting, where sales or shipment information in not available, is model weighting – in this approach the sales of each model are assumed to be equal. This generally gives an acceptable estimate of average attributes, although there will inevitably be some bias. A more sophisticated version of model weighting is where information on brand share may be available. In this case models of the same brand can be assumed to have equal sales and then the brands can be weighted in accordance with their known market share.

It is sometimes difficult to ascertain the attributes of products in the distant past (eg in the 1970's) and in many cases there will be no way to obtain this type of information now. Accurate estimation of attributes in the distant past is only important where the end use model is required to match and track historical energy consumption across time in previous years. However, the best available estimates for past attributes will give the most accurate energy consumption estimates from the stock model in the recent past to date. For example, in the Australian stock model (EES 2008), energy data estimated by the model was used from 1985 – this required a reasonable estimate of appliance attributes from about 1970. If an end use model is only being used to assess future mode power consumption and trends, accurate attribute data will only be required for the past 10 to 15 years. This will ensure that the current mode power estimates are reasonably accurate in the starting year of interest.

In some cases, values declared by manufacturers may be used to estimate attributes. In this case, any permitted tolerances within the test procedure and the tendency of some suppliers to systematically exploit such tolerances in their declared energy values may need to be considered. Ideally, permitted tolerances should be defined in a way that does not permit systematic understatement of declared energy consumption. However, where tolerances are abused and this has been documented, this can result in declared energy values being understated. This may require some explicit adjustment in the values modelled to determine stock average power consumption by mode.

Relationship between test data and actual use

Modelling user interaction with appliances which are included in an end use model is a critical factor in terms of energy consumption. Consumer usage determines the duration that a product spends in each mode, which in turn affects total energy consumption. However, the duration of each mode is not relevant if the trends in power consumption of each mode is the main attribute of interest (ie if total energy consumption is not of interest or is ignored).

Obtaining accurate data on the duration in each mode during normal use is generally quite difficult and this is often the weakest part of any stock model that attempts to estimate total duty cycle energy consumption. The most accurate way is to undertake end use metering of a large sample of products which can be used to establish the time spent in each mode (to do this good documentation on the individual products being monitored needs to be known – eg power consumption of each mode, so time can be allocated to each mode when the end use data is subsequently analysed). However, end use metering is expensive and large sample sizes are rarely possible.

Some indication of the prevalence of each mode can be obtained from intrusive household surveys (noting the mode in which each product is found during a site visit) and through questionnaires, although these can give biased answers as respondents tend to give answers that indicate “responsible” appliance usage even if this is not reflected in their actual use. Questionnaires can cover a large sample so have better accuracy in some respects if respondent bias can be eliminated.

For some products with low power modes there may be a large number present in households that are not normally connected to mains power and are rarely or infrequently used. Examples of these types of products may be cameras, mobile phones, power tools, some kitchen appliances and some personal care products. Intrusive surveys in Australia found about 20 such products per average household were not connected to mains power (about one third of appliance appliances and equipment) (EES 2006). For these products, the dominant mode will be “disconnected” (zero power use). Some care will be required on how these products are treated in terms of ownership and how their assumed modes are allocated if energy consumption estimates are required. Typically their energy consumption will be very small.

Trends in the share of time in each relevant mode is applied to the whole stock (not just the new cohort that has entered the stock in a particular year). Under a total duty cycle type analysis to determine annual energy consumption, active mode power needs to be included and the total usage in all modes needs to add up to 8760 hours per year. For modelling purposes, the assumed duty cycle over time should reflect actual average changes in consumer behaviour over time as far as possible in order to accurately estimate total energy.

Assumed lifetime of products

For some product types the average life is known with some certainty, but for most products, the average life is not well documented as this parameter is difficult to measure and few studies track the age of scrapped appliances that are finally leaving the stock as they are disposed. Many older appliances are retained and used or passed on to relatives/friends or sold, so effectively they remain part of the total stock until they are finally scrapped.

With respect to low power modes, some products have very short lifespans (eg mobile phones which are on average less than 3 years). Products with short lives and high turnover present special problems for a stock model. Care is required when selecting retirement functions for these types of products.

If there is uncertainty about the actual service life, one approach can be to adjust the estimated life to generate an implied sales stream from the stock model that matches approximately the known sales of products. This is useful where the ownership and sales trends are known with a degree of certainty. However, this approach can be difficult for products that are rapidly changing their ownership or where a substantial proportion of the sales go in to several sectors (in addition to the sector being modelled) (eg a substantial share of computers are sold into the commercial sector and the residential sector, so using sales data to imply life is usually difficult).

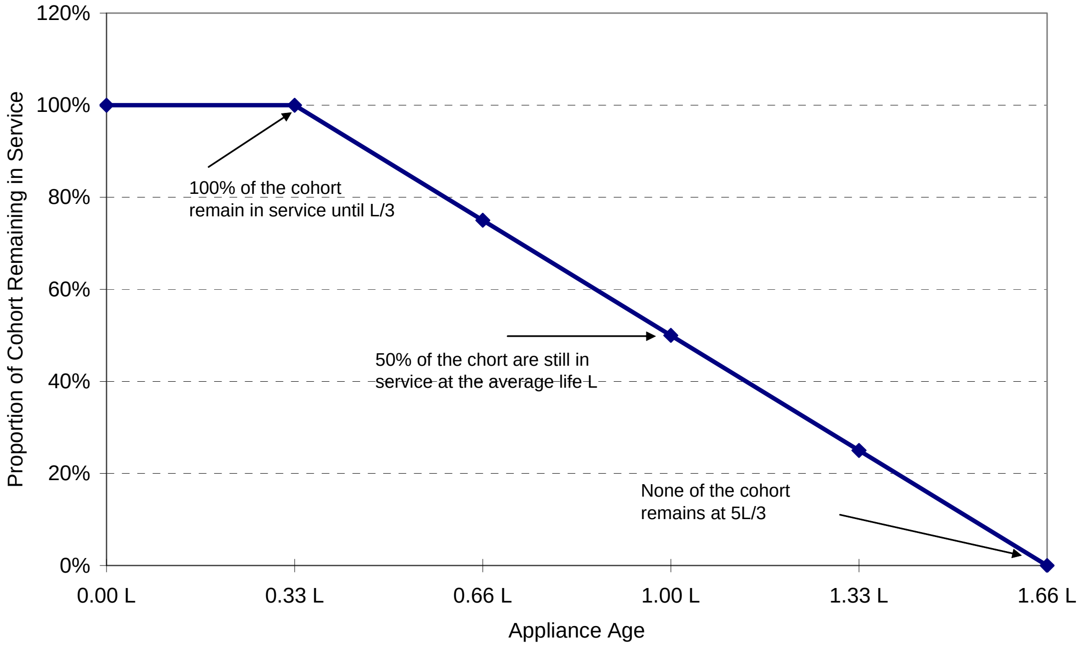
It is also important to note that actual sales in the real world vary from year to year depending on a range of factors such as the state of the economy. These external influences cannot be readily incorporated into a stock model, so when comparing the implied (virtual) sales stream to the actual sales stream, the general trend across years is more important than an exact match for each year where data is available.

There are a number of options with respect to retirement functions used in a stock model. The main types are block retirement, linear retirement and normal distribution retirement. In reality, the differences arising from these different retirement functions are generally small except where there are rapid changes in attributes and/or ownership.

The most simple (and least realistic) retirement function is to assume that all products in a particular year enter the stock and remain there for their average life and are removed as a block at the end of their life. For example, if we assume 100 televisions of a particular type enter the stock in 2005 and their life is 15 years, these same 100 televisions are removed from the stock in 2020. This is fairly crude but simple to model mathematically.

A more complex retirement function is a linear model. An example of this type of model is the assumption that all units remain in the stock until 1/3 of the average life and that units are retired uniformly until 5/3 of the average life. This ensures that 50% of units are retired at the average life. This is illustrated in Figure 3. In this case the average life is L. The slope of the retirement function can be “tipped” to be steeper or shallower – for example products could be retired from 0.66 L but the last unit would then have to be retired by 1.33 L. Any linear retirement function has to rotate around the point 1.00 L and 50% of the cohort remaining. The case where the retirement line is vertical is in fact an example of the block retirement function. A linear retirement function assumes the same number of units are retired each year. In our example of 100 televisions installed in 2005, this models assumes that 4 televisions are retired each year from 2010 to 2030.

Figure 3: Linear Function for Stock Remaining – Stock Model



The most complex and probably most realistic retirement function is based on a normal distribution. In this approach, any assumed product life and standard deviation of life can be used for a product in the stock model, although the practical lower limit of life using this approach is five years. The standard deviation needs to be limited for very short life spans so that some products do not have a negative life. Within the stock model, retirements are generated on an annual basis so these appear as a series of steps rather than a perfectly smooth curve (although in reality, sales and retirements are a continuous function). The stock remaining after year of installation and the retirements by year after year of installation are illustrated in the Figure 4 and Figure 5 for an example average life of 10 years. It is important to note that half the products will have a life longer than the average life and half will be shorter than the average life. Care is required in structuring a normal distribution where the life is an even number of years. While it is possible to model a life that is not an integer when using a normal retirement function, in practical terms it is usually best to select an integer.

Changing the life of a product in the stock model mainly changes its turnover profile and the rate of change of key energy attributes. Long-lived products have relatively low sales (for their ownership) and the rate of change in the stock average attributes is slow. Conversely, a short life means high sales and a rapid diffusion of new products and their attributes into the stock. Of course it is important to get the average life of products close to the actual service life so that the rate of change in energy efficiency and energy consumption is reflected as accurately as possible in the stock model and that the model generated sales stream matches the actual sales stream.

Figure 4: Normal Distribution Retirement Function – Stock Model (example for 10 year life)

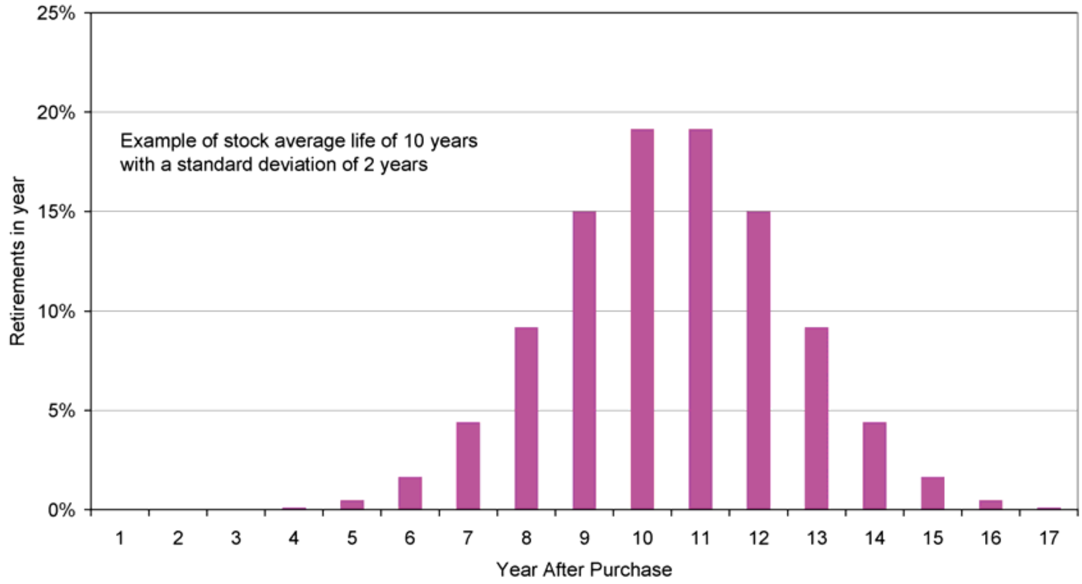
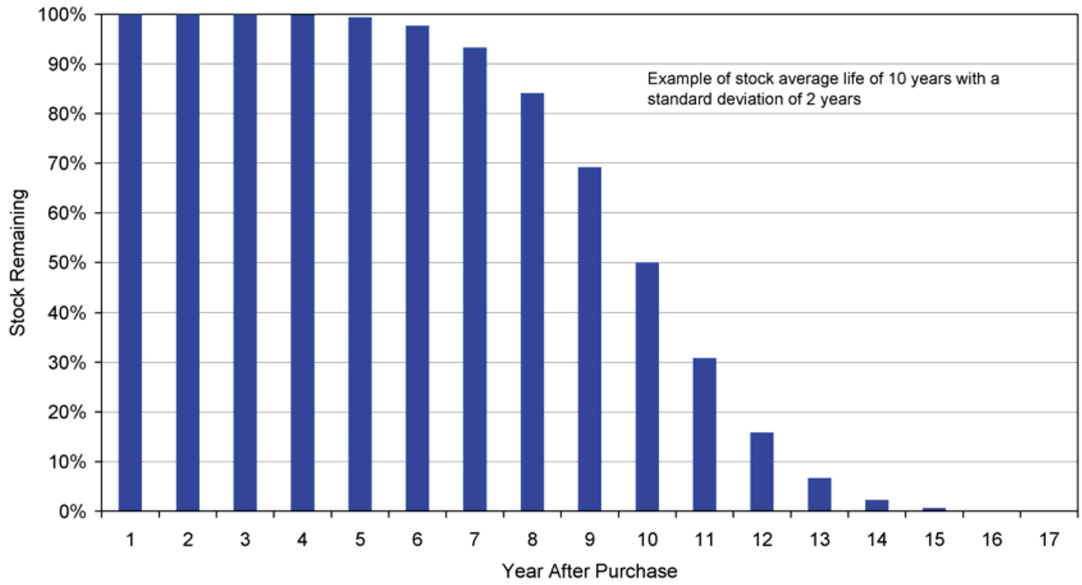


Figure 5: Normal Distribution Stock Remaining – Stock Model



The stock model only uses the stock turnover function to estimate the change in average characteristics (attributes) of the stock by year (average mode power by year). The actual historical ownership and the projected ownership and stock should always used to estimate the energy consumption of the product (not the implied stock numbers generated by the stock model). Of course, the ratio of actual stock to that projected by the model should be as close to unity as possible in all years.

References

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Appendix A: Energy Stock Model Parameters

This appendix sets out in some detail how a stock model can be constructed using software such as a spreadsheet. Some examples are also given to illustrate how data is manipulated.

Time Series of Stock of Appliances

An estimate of the number of appliances in service in the stock by year is required as the basis of the stock model. This is normally done by combining data on ownership with estimates of the number of households. Use of ownership as the key parameter allows different household projection scenarios to be easily used. However, a direct estimate of the number of appliances in service is also acceptable. If ownership and households are used, the following equation applies:

Stock = Ownership × Number of Households

Ownership should be an estimate of the number of appliances in active use. Typically the stock of appliances should be estimated for at least 15 years before energy estimates are required and should projected as far into the future as energy estimates are required (typically to 2020).

Retirement Function

As set out in the main report, there are three main retirement functions that can be selected: block, linear or normal distribution. The most important parameter used in the stock model is the stock remaining function. An example of stock remaining for a 10 year life (standard deviation of 2) for the 3 types of retirement function are set out in the table below.

Year after installation	Normal	Linear	Block
1	1.000	1	1
2	1.000	1	1
3	1.000	1	1
4	0.999	1	1
5	0.997	0.917	1
6	0.988	0.833	1
7	0.960	0.75	1
8	0.894	0.667	1
9	0.773	0.583	1
10	0.599	0.50	1
11	0.401	0.417	0
12	0.227	0.333	0
13	0.106	0.25	0
14	0.040	0.167	0
15	0.012	0.083	0
16	0.003	0	0
17	0.001	0	0

The retirement function selected is applied to each cohort of new appliances (appliances installed in a particular year) that enter the stock. An example of how this can be set out for a normal distribution is shown below.

Install Year=> Current Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1985	0.997	0.999	1.000	1.000	1.000	0.000	0.000	0.000	0.000	0.000
1986	0.988	0.997	0.999	1.000	1.000	1.000	0.000	0.000	0.000	0.000
1987	0.960	0.988	0.997	0.999	1.000	1.000	1.000	0.000	0.000	0.000
1988	0.894	0.960	0.988	0.997	0.999	1.000	1.000	1.000	0.000	0.000
1989	0.773	0.894	0.960	0.988	0.997	0.999	1.000	1.000	1.000	0.000
1990	0.599	0.773	0.894	0.960	0.988	0.997	0.999	1.000	1.000	1.000
1991	0.401	0.599	0.773	0.894	0.960	0.988	0.997	0.999	1.000	1.000
1992	0.227	0.401	0.599	0.773	0.894	0.960	0.988	0.997	0.999	1.000
1993	0.106	0.227	0.401	0.599	0.773	0.894	0.960	0.988	0.997	0.999
1994	0.040	0.106	0.227	0.401	0.599	0.773	0.894	0.960	0.988	0.997
1995	0.012	0.040	0.106	0.227	0.401	0.599	0.773	0.894	0.960	0.988
1996	0.003	0.012	0.040	0.106	0.227	0.401	0.599	0.773	0.894	0.960
1997	0.001	0.003	0.012	0.040	0.106	0.227	0.401	0.599	0.773	0.894
1998	0.000	0.001	0.003	0.012	0.040	0.106	0.227	0.401	0.599	0.773
1999	0.000	0.000	0.001	0.003	0.012	0.040	0.106	0.227	0.401	0.599
2000	0.000	0.000	0.000	0.001	0.003	0.012	0.040	0.106	0.227	0.401
2001	0.000	0.000	0.000	0.000	0.001	0.003	0.012	0.040	0.106	0.227
2002	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.012	0.040	0.106
2003	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.012	0.040
2004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.012
2005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003
2006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001

Normal distributions with an average life that is an even number of years have to be effectively split symmetrically around a value that is 0.5 year more or less than the average life. Care is required to ensure that the total retirements from any one cohort add up to 1.000.

Attributes by Year

Key attributes by year for the appliances being modelled needs to be estimated for each year where data inputs are required. If an accurate estimate of power or energy is required for the current year, then attributes should be estimated for at least 15 years before energy estimates are required as should projected as far into the future as energy estimates are required (typically to 2020).

Using the Stock Model to Estimate Stock Attributes

The first part of the model to set up is a stock turnover module. The historical time series of the actual stock is used as an initial basis. The implied virtual sales of new products in each year can be estimated as:

Sales = Stock increase from previous year + estimated retirements

Where the total stock is steady, the estimated retirements is simply the stock divided by the average life. Usually the total stock is increasing over time, so the estimated retirements will be higher than this static value. Some judgement and trial and error is needed to set estimated retirements early in the stock series until the point where the retirement function can be applied.

The total stock increase plus the estimated retirements sets a virtual sales stream into the stock model by year. If the assumed life is shorter, the retirements and the virtual sales stream is higher. Conversely if the assumed life is longer, the retirements and the virtual sales stream is lower. Where possible, data on known life and actual sales should be internally consistent with the virtual sales stream generated by the model.

This virtual sales stream is then used to weight the attributes of new appliances that enter the stock in each year. This is done by taking the average attributes by year and multiplying this by the stock remaining function and the virtual sales stream. This produces a stock weighted average attribute for each year over the period of interest. The average attribute for each year is weighted by the sales the previous corresponding years in accordance to the stock remaining function.

Excel has a matrix multiplication function which makes calculation of the stock average pool relatively simple. An example is given below:

```
{=SUM($B$104:$AY$104*$B361:$AY361*$B$177:$AY$177)}
```

In this case, the input parameters are:

$B$104:$AY$104 – the attribute of a new appliance for each year from 1966 to 2020

$B$177:$AY$177 – virtual sales stream of the appliance generated from the stock model for each year 1966 to 2020

$B361:$AY361 – the stock remaining function for years 1966 to 2020 for stock installed in the year 1985. The cell below would be $B362:$AY362 and would apply to stock installed in 1986.

The matrix function is Excel is activated by using <Ctrl><shift><enter> when exiting edit mode for the cell.

A good check is to estimate the stock using the stock model (which can be done by multiplying the virtual sales stream and the stock remaining function) and compare this to the actual stock (derived from the ownership and household data). These should be close 1.000.

Once stock weighted attributes have been determined from the stock model, the actual stock numbers can then be used to estimate the energy associated with these attributes as required.

Any consumer related parameters (such as time spent in each mode over a year) are normally applied to the whole stock in each year. For example, if a an average television set was estimated to be in on mode for 1500 hours, in standby mode for 4600 hours, in off model for 2450 hours and in disconnected mode for 210 hours over a year (total 8760 hours), then these parameters are applied to the total stock which is installed in that year (units installed in the current year and stock from all previous years that remain in service). Effectively these are applied to the stock weighted attributes for these models in the nominated year. These can then be summed to give energy consumption.

For example, in the case above, if the stock weighted power values for each mode were as follows:
On mode: 117 W
Standby mode: 2.3 W
Off mode: 0.2 W
Disconnected mode: 0.0 W

Then the average energy consumption of televisions in that year would be:

(117 × 1500 + 2.3 × 4600 + 0.2 × 2450 + 0.0 × 210)
= 186,570 Wh per year or 186.57 kWh per year.

Generating outputs from the stock model

The projected attribute input data for future years can be adjusted for different scenarios in order to examine the energy impact of different efficiency programs. As noted, this is a highly specialised area and is the subject of a separate 4E Standby Annex study.

A stock model can provide data on capital purchase costs of products by year, energy consumption and energy costs by year as well as greenhouse emissions associated with energy consumption. Where applicable, an actual or shadow cost of carbon can also be included in the economic parameters calculated using the model outputs.

It is also important to understand the dynamics of the stock model. If we examine the impact of installing new efficient televisions to say 2020, then the purchase cost of these new efficient televisions to 2020 will need to be taken into account in the cost side of the equation (assuming the more efficient products are more expensive – this is not always the case). On the benefit side of the equation, the energy savings from new efficient televisions installed to 2020 will continue to accrue while those televisions installed to 2020 remain in the stock. Under normal modelling parameters and lifetime assumptions, this means that energy savings will peak at about 2020 (when the maximum number of new televisions has been installed) but the savings will persist until about 2040 while some of the televisions installed as late as 2020 remain in the stock. If only energy savings to 2020 are considered, about half of the total savings from the new efficient models will be counted, which is a gross understatement of total savings.

Appendix B: Examples of Australian household estimates

The definition of a household used by the Australian Bureau of Statistics (ABS) in its appliance surveys is "a group of persons who are the usual residents of a dwelling and who have some common provision for food and other housekeeping arrangements" (ABS4602.0).

One source of historical source of data for households was the Australian Bureau of Statistics Census of Population and Housing, which has been held at 5-yearly intervals since 1961. Household types listed in the census include private, non-private (hotels, institutions, barracks, staff quarters etc) and unoccupied. It is recommended that estimates be based on values for occupied private households. Prior to 1986, caravans were counted as non-private dwellings, but from 1986, they have been included as private occupied dwellings. The census also generally gives some limited information on the dwelling structure.

If census type data is used to estimate historical households by year, care is required to correct the numbers to cover households only (not visitors or tourists).

A dwelling is a building or structure in which people live. This can be a building such as a house, part of a building such as a flat, or it can be a caravan or even a tent. Houses under construction, derelict houses or converted garages are not counted as dwellings in the census.

A private dwelling is normally a house, flat or even a room, but it can also be a house or rooms attached to shops or offices. Private dwellings can be either occupied or non-occupied. It is recommended that non-occupied private dwellings be excluded. Occupied private dwellings can have more than one household, but this is fairly unusual in Australia, so households are seen as a proxy for dwellings.

Non-private dwellings are those dwellings not included in private dwellings, which provide a communal or transitory type of accommodation. These dwellings include hotels, motels, guest houses, prisons, religious and charitable institutions, defence establishments, residential parts of educational institutions, hospitals (including staff accommodation) and other communal dwellings. It is recommended that non-private dwellings be excluded from the household estimates. These are generally associated with commercial sector energy consumption and include such things as prisons, hospitals and residential accommodation in commercial buildings.

Appendix C: Limitations of Standby Data Collected in Homes or Retailers

While low power mode data collected in homes and retail outlets is highly valuable in establishing trends in stock and in the market for new appliances and equipment, there are a number of possible limitations with respect to individual readings, which must be considered by users of the data when this is examined at an individual record level.

- As a general rule, simple meters are usually used for field measurements – while these usually have good accuracy under most conditions, there may be some readings where they may give a higher level of uncertainty (very low power levels, very poor power factor or high current crest factor).
- For field measurements it is not possible to regulate supply voltage, harmonics or other test conditions during the measurement. While these factors generally have a small influence on the measured result, they can cause some differences on some products. For products like televisions, on mode power can be strongly influenced by the picture displayed during measurement.
- Product behaviour cannot normally be not monitored for a long period in the field due to the limited time available as there is a need to cover a large number of products. While a valid reading can be obtained for most products within a few minutes, some products may take longer to stabilise because they go through a start-up sequence once the power is first connected: this may or may not be obvious to the user or via the power meter. Some products may wait in a different state when the power is first connected (eg some products may download an EPG when the power is initially connected or monitor other inputs for a period).
- As a rule it is not possible to assess the behaviour of power management facilities in the field or to measure temporary (short duration) modes that may occur when products access a network or a broadcast stream (say once a day) to download data. Such modes require a good understanding of the product and possibly a special configuration in a lab to obtain an accurate measurement.
- In retail outlets, remote controls or other accessories are sometimes not available (these may be locked up for security purposes) so some product modes may not be accessible for some products.
- Some products of interest which are on display in retail outlets may be hard to access for measurement if they are locked up for security purposes. This usually applies to small, high value products like mobile phones and portable music devices. Some larger high end products are sometimes installed in a manner where power connections are not readily accessible (eg home theatre systems).
- While the methodology used for most store surveys is to measure all available floor stock in all available low power modes, the presence and prevalence of a model on display in a retail outlet does not necessarily reflect its sales or prevalence in the stock of installed products. So data collected in retail outlets may need to be adjusted to obtain a more accurate estimate of stock trends in standby power.