GUIDE TO AUSTRALIAN GREENHOUSE CALCULATOR: BASIC FEATURES, USE AND ASSUMPTIONS
Alan Pears - 14 February 2011

&

REFERENCE REPORT: FOOD, GROCERY & SERVICES – FOOTPRINT CALCULATOR
Tim Grant and Scott McCallister - 20 December 2010

DISCLAIMER

EPA Victoria will not be liable for any loss arising out of or incidental to use of Australian Greenhouse Calculator (AGC) or reliance on any information generated as a result of such use.

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Use of the AGC is for general indicative purposes only. Estimates of greenhouse gas emissions produced using the AGC are indicative only and may be at variance with a household’s actual emissions.

Should you wish to obtain specific information in relation to household greenhouse gas and other pollutant emissions and energy costs, please contact EPA Victoria.

EPA Victoria 2010
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INTRODUCTION

This document summarises the major sources of information, assumptions and approaches used as a basis for the calculation module of the Australian Greenhouse Calculator (AGC).

The algorithms are intended for educational and informational use, and provide indicative estimates only (that is, the level of accuracy is suitable for the intended purpose). Users should take care when applying them to real world situations.

In practice, variations in interpretations of options presented, and estimation of behavior and equipment characteristics by users can lead to significant variations in results. The impact of faulty appliances, variations in user behaviour, seemingly minor things such as windows left ajar, and many other factors can also influence outcomes.

The algorithms are complex and are based on research from a wide range of sources. The program is sensitive to even small changes by the user and is a powerful modeller of the household situation. A more complete picture of the user’s situation, and a picture of the potential to reduce emissions, will therefore be gained from creating and testing various inputs for a number of different household situations.

OVERALL FRAMEWORK

The AGC is designed to encourage householders and students to explore the impacts of behaviour change and product, technology and energy source selection on a household’s greenhouse gas emissions from:

- Non-transport energy use within the home
- Transport energy use, including cars, public transport and air travel
- Food and other forms of consumption associated with daily life
- Wastes, including decay of organic food wastes and changes in emissions through recycling and re-use of materials

The AGC is a ‘bottom-up’ calculator that incorporates models of the ways appliances, equipment and transport vehicles consume energy and generate greenhouse gas emissions as they are used to deliver services such as access, food storage, hygiene and comfort. So changes in behaviour or equipment selection and installation entered by the user affect the operation of these models, leading to changes in the resulting energy use and emissions. This approach means the overall emission impact of a variety of changes that interact with each other can be seen. For example, insulating a house will mean that an energy-efficient heater saves less energy, because less heating is required.

QUICK AND DETAILED DATA ENTRY SCREENS

The calculator has two levels of data entry: the ‘quick’ and ‘detailed’ screens. The ‘quick’ screens allow the user to enter basic information on each activity to gain a rough indication of their
emissions. The ‘detailed’ screens offer the user the opportunity to enter comprehensive information on many aspects of equipment characteristics and user behaviour. These screens also show the values for many variables that are assumed in the ‘quick’ scenario.

A user can shift from the quick screen to the detailed screen for an activity if they wish to enter more detailed information. However, if they go back to the quick screen for that activity, changes they have made in the detailed mode cannot be retained in the quick mode of operation. The file of data entered can be saved with a mix of quick and detailed modules to preserve user changes, but the full details will only be accessible in the detailed mode.

Users can have some activity screens in quick mode and others in detailed mode. For example, a user might go through the quick mode screens to gain an overview of their emissions and to identify areas that contribute most to their greenhouse gas emissions. They can then go into detailed mode for the activities of most significance or interest, to refine the estimates of emissions, and to explore options for reducing emissions.

Both levels of data entry use the same calculation engine, but the ‘quick’ mode uses default (or ‘typical’) values for all variables not covered by the basic questions asked in this mode of operation. These default values themselves vary based on whatever information is available. For example, the number of people in the household and the climate (based on location) will affect the assumed usage and performance of appliances and lighting, car air conditioning, etc.

In the detailed data entry screens, the user does not have to answer all the questions. The ‘typical’ or ‘don’t know’ selections apply default values to factors that are based on surveys of user behaviour, appliance ownership and typical installations, and these will apply to questions that are not answered by the user. This means a user can answer as few or as many questions in each screen as (s)he wishes. Of course, the more questions answered, the more accurately the result will reflect the user’s circumstances.

Also, in the detailed data entry screens, the user can enter data for multiple appliances and lighting types, or for varying usage patterns of the same appliance. For example, a household that uses its dishwasher three times each week on eco-wash and twice on normal wash can enter two identical dishwashers, with one used three times a week on eco-wash and the other used twice a week on normal wash. Where one appliance is used in several modes, the standby power usage of the second and subsequent appliances representing the same appliance used in different ways should be set to zero, to avoid double counting of standby power, as it is assumed that standby energy is used continuously in each line of data input.

Similarly, a user can roughly enter all lighting in one line (assuming one type of lamp and one level of usage) or, at the other extreme, could separately enter the type and usage of every lamp in the house (as well as outdoor lighting) by adding extra lines for data entry.

This form of data entry makes the Greenhouse calculator very flexible.

SAVING AND USING FILES

A user can save a file of data inputs at any time, and can re-open that file at a later date. Any saved file can be used for comparison against a new set of data. Initially, the ‘typical’ and ‘green’ files (which are stored in the list of saved files, and are protected) are used for the comparisons that appear on every screen. The comparison files can be selected when an existing file is opened.
A saved file (including the 'typical' or 'green' files) can be modified, to save time if only a few changes are to be made. To do this, open the saved file, then save it under another name. This new file can be modified and saved, as required.

**THE TYPICAL AND GREEN COMPARISON FILES**

Above the list of questions on each screen, there are three bars showing greenhouse gas emissions for the activities on that screen. One shows the result for the user, while the others provide benchmarks for comparison. By default these are the 'Typical' and 'Green' files.

The user can select the two comparison files to be displayed on screen from all those in the 'saved files' list, not just the Typical and Green files, so the most useful comparisons can be made: for example you may wish to compare changes you're making to a file of your existing emissions, to see how big a difference your selected changes might make.

The Typical and Green files are protected data files that are used as default comparison files to allow users to compare their emissions for each activity with two useful benchmarks. They can be saved and altered under another name, but not changed without changing the names.

The Typical file is not an average household: no single household can represent the Australian average household's equipment and behavior, climate, etc. For example, an average household has 2.6 people (we've used 3). Just over half of households have electric hot water services while over a third have gas, yet these types of HWS have very different levels of greenhouse gas emissions. So the selection of appliances in the Typical file generally represents what the majority of Australians own: if you open the Typical file and look through the screens, you can see the choices we made and, if you wish, you can create a new comparison file that better reflects typical homes in your area.

The Green comparison file is not an extreme scenario involving 'freezing in the dark'. The household has a wide variety of appliances and has a comfortable lifestyle. But it does have energy and water-saving appliances and equipment, and behaviour is environmentally conscious. So the people take fairly short showers, use public transport and don't drive their efficient car a lot. It is certainly possible to reduce emissions below the Green household!

Note that the Typical and Green household files can only be properly understood in the detailed mode, as they include energy saving options that are not available in the quick mode of operation.

The features of the Green and Typical files are shown below.
<table>
<thead>
<tr>
<th>GREEN 1</th>
<th>GHGs</th>
<th>For Sydney postcode 2000 and 3 people</th>
<th>TYPICAL 1</th>
<th>GHGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>2.766</td>
<td>Cars: medium hybrid and small diesel car driven total of 15,000 km/year with smooth driving. Low gh impact refrigerant in a/c's. Substantial use of train and bus. Also use bikes and walk to avoid local car trips</td>
<td>Transport</td>
<td>7.303</td>
</tr>
<tr>
<td>Air travel</td>
<td>0.357</td>
<td>One return interstate air trip (ie 2 trips) with emission impact taking into account indirect warming effect (but not cirrus cloud effect)</td>
<td>Air travel</td>
<td>1.427</td>
</tr>
<tr>
<td>Heating and cooling</td>
<td>1.211</td>
<td>Well-insulated and shaded home with high efficiency reverse cycle air conditioning for heating and cooling. Moderate use of heating and cooling due to good building design</td>
<td>Heating and cooling</td>
<td>2.444</td>
</tr>
<tr>
<td>Hot water</td>
<td>0.881</td>
<td>High performance solar-electric HWS, efficient front-loading clothes washing machine, efficient dishwasher used fully loaded, relatively short showers with water-efficient shower</td>
<td>Hot water</td>
<td>4.841</td>
</tr>
<tr>
<td>Clothes dryer</td>
<td>0.084</td>
<td>high efficiency heat pump dryer used only rarely in winter</td>
<td>Clothes dryer</td>
<td>0.258</td>
</tr>
<tr>
<td>Lighting</td>
<td>0.424</td>
<td>energy efficient compact fluorescent lamps, switched off when not needed</td>
<td>Lighting</td>
<td>1.109</td>
</tr>
<tr>
<td>Refrigeration</td>
<td>0.395</td>
<td>high star rating modern 450 litre two door fridge</td>
<td>Refrigeration</td>
<td>1.111</td>
</tr>
<tr>
<td>Cooking</td>
<td>0.621</td>
<td>electric induction cooktop and electric fan-forced oven, with regular use of microwave oven</td>
<td>Cooking</td>
<td>0.858</td>
</tr>
<tr>
<td>Other Appliances</td>
<td>0.509</td>
<td>two 7 star LED/LCD TVs, efficient games console, efficient small appliances with low standby power consumption, typically switched off when not needed</td>
<td>Other Appliances</td>
<td>1.972</td>
</tr>
<tr>
<td>Food &amp; Shopping</td>
<td>8.27</td>
<td>lower consumption of processed items, lower meat diet with more fruit, vegetables and carbohydrates, spend less than average on consumer goods</td>
<td>Food &amp; Shopping</td>
<td>12.359</td>
</tr>
<tr>
<td>Waste</td>
<td>-0.05</td>
<td>high rates of re-use, recycling and composting</td>
<td>Waste</td>
<td>-0.024</td>
</tr>
<tr>
<td>TOTAL</td>
<td>15.467</td>
<td></td>
<td></td>
<td>33.658</td>
</tr>
</tbody>
</table>
GREEN ENERGY

The calculator does not make provision for consideration of purchase of greenhouse offsets or GreenPower tariffs (where energy retailers offer part or full supply from renewable sources for a price premium) or renewable energy sources to reduce household greenhouse gas emissions. This is because such options can hide the impacts of personal action such as energy efficiency improvement and fuel switching.

EPA Victoria (www.epa.vic.gov.au) encourages households to think in terms of a hierarchy of action:

- Measure emissions
- Set objectives for emissions
- Avoid generating emissions
- Reduce emissions
- Switch fuel sources to lower emission options
- Sequester emissions (eg by planting vegetation on-site)
- Assess your residual emissions
- Offset residual emissions by purchasing green energy and/or sequestration credits

This calculator focuses on the first five steps of this model. The range of low emission fuel sources is limited to options that can be implemented in most households, such as switching to natural gas or LPG, solar hot water, and use of lower emission transport fuels in vehicles.

The effects of purchase of green energy from the grid and/or greenhouse offsets such as tree planting can be easily estimated by deducting the offsets from the total emissions estimated using the calculator, or by reducing the emissions of each form of energy by the percentage of green energy purchased. This can be done manually, or in a spreadsheet using the downloaded report.

If on-site renewable electricity generation is installed, metering normally measures the output, or estimates such as those provided by the Office of the Renewable Energy Regulator (www.orer.gov.au) or equipment suppliers can be used. To estimate the impact of this renewable generation on your household greenhouse gas emissions, you can select the ‘detailed small appliances’ screen, then enter an equivalent value for daily hours of operation at an average output. This INCREASES your reported annual ghgs by an amount equivalent to the amount of electricity generated by your renewable energy system. Record this value, then delete the change. You can then manually deduct this amount of greenhouse gas from your original reported total greenhouse gas emissions. For example, if a 1 kW array of solar cells generates 1300 kWh annually, that is 1300/365= 3.56 kilowatt-hours (3560 watt-hours) per day. So you could enter 356 watts for 10 hours per day in the ‘Power’ and ‘Time on’ columns to calculate the amount of greenhouse gas that would be avoided by this electricity generation.
INTRODUCTORY SCREEN

On this screen, the user enters some basic information that is needed to set values of a number of factors in the calculator.

- Postcode sets the greenhouse factors for electricity and gas, which vary from state to state, as well as selecting the climatic conditions used to determine heating and cooling requirements, and adjusting the consumption of appliances and lighting to reflect the climatic conditions.

- Number of people in the household influences the default values of many activities in the calculator, such as amount of cooking and number of showers. It is not possible to enter part of a person (eg 3.5 people) but selection of the rounded number of people who usually occupy the home is adequate, as the calculator allows a user to vary the level of each activity when entering data, so data entries can reflect actual levels of activity.

- Area of house affects some default values used in the calculator, such as default lighting energy.

OTHER DATA ENTRY SCREENS

TRANSPORT

Transport emissions are considered in three categories: public transport; personal transport (powered road vehicles); and air travel.

All land travel calculations are based on a model developed by the author (similar to the approach taken by McKay (2008)) that takes into account:

- Aerodynamic drag (influenced by drag coefficient based on vehicle design and impact of pack racks etc, frontal area and, for long vehicles, drag along the length of the vehicle (skin drag))

- Rolling resistance (influenced by tyre type and pressure, road surface roughness and vehicle mass and load)

- Inertia effects (influenced by frequency of stops and starts, speed from which stops occur, vehicle mass and load, and (for hybrid and electric vehicles) proportion of energy recovered)

- Where appropriate, engine idling

This model supports estimation of the emission impacts of many changes such as driving behaviour, mass, selection of vehicle, etc. In practice, vehicle manufacturers may optimize performance for various usage patterns, so the idealized model used here provides indicative outcomes only.

The model estimates the amount of energy required to move the vehicle. Greenhouse gas emissions are then calculated taking into account:

- engine or motor efficiency, which may vary with fuel type (eg diesel engines are more efficient than petrol by around 25%)
- drivetrain efficiency: this includes impact of selection of gearbox type and energy recovery system (e.g., in hybrid and electric vehicles)
- greenhouse intensity of fuel or electricity used

The user does not directly change the above variables, but can select from a range of options that change these variables in relation to their behaviour and vehicle features.

Users can directly enter their fuel consumption (in energy units per 100 kilometres, e.g., litres/100km or kilowatt-hours/100km), if known (e.g., from motor magazines or from the government's website www.greenvehicleguide.gov.au), in the 'Energy Consumption' box in the detailed screen. This bypasses the modelling and simply converts that fuel use to greenhouse gas emissions. However, it also includes assumed usage of an air conditioner as an additional component. This is because Australian Standard tests used to determine official fuel consumption ratings require the air conditioner to be switched off.

By switching between transport modes, the user can explore the greenhouse gas emissions from travelling by different modes. Individual trips or annual travel can be compared by selecting appropriate distances and travel conditions for each travel option.

Users can enter as many vehicles as they want. Where a vehicle uses two forms of energy (e.g., LPG and petrol, or petrol and grid-sourced electricity), this can be dealt with by entering two identical vehicles, each using the different energy source, with each allocated the appropriate share of distance travelled.

**Public transport**

The modes of public transport covered by the AGC include both urban and inter-city rail, trams/light rail, and buses. Taxi use can be addressed in the road vehicle section of the calculator, by selecting an appropriate vehicle such as an LPG 6 cylinder car and allowing for slightly higher distance travelled to reflect the fact that the taxi may have to travel some distance empty (apart from the driver) to pick up a passenger or return from dropping a passenger off.

The energy use of public transport vehicles was based on data from a number of sources from Australia and overseas. Kemp (2007) *Traction Energy Metrics* UK Rail and Safety Standards Board and Wikipedia were particularly useful.

The greenhouse gas emissions per person for public transport are very sensitive to how the total emissions are allocated to the passengers – as is also the case for air travel. For example, doubling the number of people on a train or bus almost halves the average greenhouse gas emissions per person. As the mass of the vehicle is large compared to that of the additional passengers, the overall emissions are little changed, and are spread over a larger number of people.

The default indicator for AGC public transport is the emissions per extra passenger on an existing service. This reflects a situation where the service would run, regardless of whether or not the passenger travelled, which is the case for most individuals when they change their behaviour. This option generally shows very small greenhouse gas emissions, as the effect of the extra mass of one extra passenger relative to a heavy public transport vehicle is very small.
Alternatively, the user may choose the ‘absolute’ emissions per passenger. This option simply divides the total emissions of the vehicle by the number of people on it. Occupancy can also be varied to reflect the average occupancy situation, a situation where the vehicle is well-patronised, or low occupancy travel. It can be seen that absolute emissions per passenger at low occupancy are very high, as the substantial emissions of the heavy vehicle are spread across a small number of people. This can be the case in off-peak periods, but the reality is that most public transport services at those times would run, regardless of occupancy, as a social service for those without access to a car. So in off-peak periods, the emissions per additional passenger on an existing service is a more appropriate indicator, as used for the default calculation.

Comparisons between ‘absolute’ ghgs/pass-km’ of public transport (particularly electric PT running on coal-fired electricity) and average emissions/pass-km for cars may show little or no benefit from shifting from car to PT. However, this comparison includes many under-utilised services that are really providing social services for those without access to cars or who are not allowed to drive (through disability or loss of licence). So it is more appropriate to compare emissions at the margin (that is, an extra passenger on an existing service), or for well-patronised public transport, with usage of cars.

Much use of cars involves unpaid ‘chauffeuring’ of people where the driver does not actually want to go to the destination. This artificially increases the estimated occupancy of cars and reduces the estimated emissions per passenger-kilometre, as the driver is not benefiting from the travel by going to a destination(s) they wish to travel to. This issue is not specifically addressed in this calculator. However, the issue can be explored, as the household’s annual emissions from car use for all activities can be compared with annual public transport usage, and users can vary both car use and public transport use to reflect different situations.

Research also indicates that when travellers shift from car to public transport, on average they travel fewer kilometres, as they typically plan their travel more carefully (Newman P, submission to Senate Inquiry on “Investment of Commonwealth and State Funds in Public Passenger Transport Infrastructure and Services”, Aug 2009). In this situation, the reduction in total distance travelled would reduce greenhouse gas emissions by more than is indicated by a simple comparison based on the same amount of travel. Since this calculator allows the user to specify distance travelled by each mode, the user is free to adjust for effects such as this by varying the distances entered.

**Personal Transport — road vehicles**

The baseline fuel consumption data for each vehicle type and age is based on unpublished historical data by vehicle class kindly provided by Bureau of Infrastructure, Transport and Regional Economics (www.bitre.gov.au). The fuel consumption in the model in the AGC is benchmarked to these values under standard driving conditions, then adjusted to take into account the effects of all selected behaviour and technology options. The base fuel consumption is therefore an average for each vehicle type, so it may not exactly match the rated consumption of a particular car or model. The user can adjust consumption by varying mass, aerodynamics or other appropriate factors to match more closely a specific real vehicle, then continue to vary other factors to explore the impact of behaviour or other changes.

It should be recognised that the Australian Standard fuel consumption is indicative only, and very few people actually use that amount of fuel, because of variations in driving conditions, user
behaviour, tyre pressures, road conditions, etc. Standard fuel consumption data for all cars sold in Australia back to 1986 is available at www.greenvehicleguide.gov.au

Issues: The AGC tool is very flexible, but modelling some features involves more advanced techniques:

- The hybrid option is accessed in the detailed mode through the ‘drivetrain’ options, as many types of vehicle (eg small and large cars and 4WDs) may now have hybrid features. Default hybrids are assumed to not only recover some energy (instead of converting it to heat through braking), but also have improved aerodynamics, low rolling resistance tyres, engine shutdown when stopped, and higher efficiency engines.

- Where two forms of energy are used by one vehicle (eg lpg/petrol or electricity/petrol for a plug-in hybrid) the calculator treats usage of the two fuels as two separate vehicles in the detailed mode. For example, an LPG/petrol car would be entered as a petrol car travelling the distance it runs on petrol and, separately, a car with the same features running on LPG for the distance it runs on LPG. A plug-in hybrid, which draws some energy from the electricity grid and some from petrol or other fuel, would be entered as an electric car for the distance it runs on grid electricity, and separately as a hybrid car for the distance it runs on fuel from its own tank. Note that a typical hybrid vehicle gains all its energy from its normal fuel (eg petrol): electricity is only generated when braking, so there is no externally supplied electricity.

- If a user's pattern of driving conditions does not match any of the profiles offered, in the detailed mode it is possible to set up multiple identical vehicles with ‘pure’ driving conditions (eg short trips, urban, suburban and highway), then vary the annual distances travelled in each type of conditions. The total emissions will include all the options.

Lower (or higher) emission fuels can be modelled by adjusting the greenhouse intensity of the fuel by an appropriate percentage.

The value of electricity use for the electric cars is drawn from p.138 onwards of MacKay (2008) Sustainable Energy – without the hot air. Ultra-light cars are 6 and cars range from 10-25 kWh/100 km under standard conditions, depending on size and efficiency.

The 15,000 km distance shown as the approximate annual travel of an Australian car is a rounded-up value. Recent ABS statistics show an average closer to 14,000 km. However, this includes significant numbers of rarely-used cars, so 15,000 km is considered to be a reasonable default value for most households. In any case, the Table is designed to allow the user to select a distance close to his or her usage, and also allows the user to enter an actual annual distance if it is significantly different.

Air conditioners affect emissions both as a result of their energy usage, which varies with climate and user selection, and the leakage of refrigerant from the air conditioner. Different refrigerants have very different global warming impacts.

Transport costs

Although public transport fares might completely represent the personal financial cost to a user of using public transport, fuel costs only represent a small part of the personal financial cost to a user of running a car: on average fuel is only about a third of car running costs. So the AGC does not attempt to compare transport costs. For the interested reader, motoring association magazines such as Royalauto publish comprehensive car running cost information each year, and on their websites. The Australian Bureau of Statistics also publishes surveys of household living costs that show components of transport costs (Cat nos 6530.0 and 6535.0).

It is possible to roughly calculate fuel costs from transport greenhouse gas emissions. For example, petrol generates around 2.75 kg of greenhouse gas per litre (including all direct and indirect effects including processing and transport of the fuel: the government fuel consumption label uses a lower value as it includes only direct warming effects). So if a litre of fuel costs $1.40, then the cost to emit a tonne of greenhouse gas from petrol is $1000/2.75*1.40 = $509. So to emit 5 tonnes of greenhouse gas over a year from transport means spending around $2500 on fuel, as well as other running costs.

Air Travel

AGC includes a calculator that estimates greenhouse gas emissions from air travel. The approach taken considers Landing-Take-Off (LTO) cycles and cruising as the two main components of energy use and greenhouse gas emissions. The Intergovernmental Panel on Climate Change (IPCC, 2006) has published values for these modes of operation for a selection of aircraft commonly used around the world, and these have been compared with limited Australian data to set the defaults used in the AGC. Since more fuel is used per kilometre during the LTO cycle than when cruising, having more landings and take-offs in travel over a given distance increases emissions.

The user can vary the emission efficiency of the aircraft. Default values of occupancy have been set based on data from AVFACTS (www.BITRE.gov.au). IPCC (2006) values of emissions for types of aircraft typically used in Australia have been used to set the default emissions. Data from Wilkenfeld (2002) indicates that Australian commercial passenger aircraft carry little commercial freight, unlike Europe, where estimates indicate around 20% of load on a typical commercial aircraft is freight. The calculator therefore uses a default value of 5% load being freight. This load factor can be varied in the detailed screen.

The AGC allows users to specify the distance they fly. The distance between locations is usually taken as the Great Circle distance (that is the shortest distance possible following the circumference of the Earth). In reality, trips may be longer due to weather conditions, airport congestion, etc. There are sites on the internet that advise how to calculate (or automatically calculate) Great Circle distances if the latitudes and longitudes of points of departure and arrival are known. Many airline websites also list travel distances between locations.

The AGC may produce different results from airline calculators. This is because AGC uses averaged publicly available data, while the airlines have access to accurate fuel consumption and
flying distance data for each route and aircraft, as well as the amount of freight carried on that route. Major airlines also typically own newer, more fuel-efficient aircraft, and may have higher than average occupancy. They also consider only the emissions covered under the Kyoto Protocol (see below). Calculators from other countries may use different values that reflect their circumstances, such as older aircraft fleets, higher freight loadings, different floor area per passenger, different occupancy factors, etc.

Emissions per passenger also depend on the number of people onboard (occupancy), and the amount of commercial freight being carried in the hold (to which a share of the emissions should be allocated). AGC also allows users to take into account their fare class: economy passengers occupy less space than business or first class, so their share of the aircraft's overall emissions is lower – although only part of the aircraft's fuel consumption depends on the number of people.

The AGC user can also choose to vary the greenhouse impact of fuel burning by aircraft. IPCC (2006) studies have shown that release of greenhouse gases and breakdown products from emissions high in the atmosphere create a greater warming impact than if they were burned at ground level. Further, indirect effects such as the creation of contrails (cloudy trails behind aircraft) and contribution to greater cirrus cloud formation can increase the total warming effect of aircraft at high altitude to 3-5 times those from the combustion CO2 alone. Since these enhanced effects largely occur at high altitude, for shorter flights the overall increase in warming will be lower than these values because they only apply to high altitude cruising emissions, not landing, take-off or on-ground activity. The enhanced effects are still considered uncertain (not whether they exist or not, but their size and under exactly what conditions they occur – hence the range of values stated above). Further, they are not included in the official Kyoto accounting method used for most emission inventories.

**Home Heating and Cooling**

The energy use and greenhouse gas emissions from heating and cooling homes depend on the design, construction and management of the building, as well as the types, efficiencies and usage of the heating and cooling equipment.

**Building**

Most Australian climates are quite mild by world standards, so relatively small changes in building design, construction and operation can lead to dramatic changes in heating and cooling energy use. For example, the average temperature difference between indoors and outdoors in winter in many parts of Australia may be only 5-10 degrees Celsius. So changing the thermostat setting by just one degree can change heating energy use by 10-20%. Behaviour can also have big effects: leaving two windows on opposite sides of a house open slightly can allow large amounts of heat to leave or enter the home, increasing energy use by a surprising amount.

For this reason, the AGC requires quite a lot of data input with regard to the building. It also means that there is significant uncertainty in the total heating and cooling emissions result. However, the impact of changes on emissions is less uncertain, so useful insights can be gained by exploring the impacts of changes in behaviour, appliances and building fabric.

The calculation engine for the building performance calculator is based on the methodology used in AS 2627, which takes into account major climatic factors, particularly ambient temperature and
solar radiation, when estimating energy use. This module was developed by Tony Isaacs at the RMIT Centre for Design, using the above methodology, but with new and more comprehensive values for Heating and Cooling Numbers calculated from the AccuRate weather files. The calculator’s results for a small sample of houses were compared with the benchmark house energy rating tool developed by CSIRO, AccuRate, which is used for estimating building energy use and assigning star ratings for regulations. The results from the two tools correlated well, typically within 10%, but only a small range of house types were studied. It is stressed that the AGC results are indicative only.

The major factors influencing building energy performance are:

- Insulation of ceiling, walls and floor: generally the more the better – but there is a law of diminishing returns so that adding more insulation has progressively less additional effect.

- Size, orientation, shading and types of windows and glazing: sunshine entering through windows is beneficial in winter, but can create serious discomfort on hot days

- Rate of air leakage out of or into the building through gaps around doors and windows, chimneys, exhaust fans, downlights, wall vents, and other gaps, such as between floor boards, or skirting boards.

- Effectiveness of ventilation (eg by opening windows when outdoor conditions are more comfortable than inside), which can cool or warm up a home if used appropriately.

- Mass of the building elements within the layer of insulation: higher mass tends to stabilise temperatures around the 24 hour average temperature for that time of year, so in climates where there is wide daily temperature variation, or where 24 hour average temperature stays within a comfortable range all year, mass can enhance comfort and reduce energy consumption.

All of these factors can be varied by the user, to explore their impact on performance. The overall outcome regarding greenhouse gas emissions will depend on building performance, appliance selection, and user behaviour.

As with other sections of the AGC, there are defaults for all variables required to operate the calculator, so users need only enter the data of most relevance to them.

As the building’s performance improves, the impact on greenhouse gas emissions of the area heated and thermostat settings becomes less significant.

**Home heating**

Australian households use a wide variety of heating equipment, from a portable electric heater to central heating. The AGC allows the user to select heater types and efficiencies for each area of the home, and to specify hours of usage and thermostat settings.

Default values for appliance efficiency were estimated from EES (2008), efficiency standards in relevant Australian Standards and in research reports at [www.energyrating.gov.au](http://www.energyrating.gov.au), as well as
utility data, surveys, and the author’s experience. For gas heaters and reverse cycle air conditioners, algorithms from appliance energy labelling standards were used. While resistive electric heaters are commonly considered to be 100% efficient, this only relates to their efficiency of conversion of electricity to heat. The accuracy of the thermostat, and the effectiveness with which heat is delivered where it is wanted affect the overall efficiency: for example, an oil filled column heater allows much of its heat output to rise towards the ceiling and out through nearby wall vents, instead of heating the people in the room. So an efficiency of 80% was used as the default for resistive electric heating.

Appliance efficiency, source of energy, area heated, duration of heating and temperature to which spaces are heated, as well as building performance, all affect energy use and greenhouse gas emissions. All of these issues can be explored using the AGC.

The star rating schemes for reverse cycle air conditioners in both heating and cooling modes were changed in 2010, but too late to be included in this version of the AGC. See below, under ‘cooling’ for a conversion equation to convert the new heating star rating into an equivalent star rating in the old scale, that can be entered in the AGC.

Cooling

The proportion of Australian homes that use air conditioning has dramatically increased over the past decade to almost 70%. Use of cooling equipment on hot days has been a major contributor to growth in peak electricity demand, which is expensive to supply. This demand also increases the risk of blackouts, as the electricity supply system struggles to cope with high demand and extreme temperatures. In some parts of Australia, the additional greenhouse gas emissions due to cooling may not be large, as cooling is used for relatively short periods. However, the impact on peak electricity demand on hot days can still be very significant.

Fans and evaporative coolers typically use much less energy than refrigerative air conditioners, although long hours of use throughout a home can still lead to high energy bills. Fans rely on creating a breeze that increases evaporation from the skin, providing comfort equivalent to being in a temperature a few degrees cooler. Evaporative coolers evaporate water to cool air which is then circulated through the house. Evaporative coolers work less effectively in high humidity, as little additional water vapour can be added to the air to cool it.

For refrigerative air conditioners, efficiency was varied according to the energy labelling algorithms, and default efficiencies for varying appliance age and type were drawn from EES (2008). The most efficient air conditioners are now twice as efficient as the minimum standard which, itself, is 50% more efficient than many older ‘box-type’ air conditioners. Using a ceiling or portable fan with an air conditioner can provide comfort at a higher thermostat setting by creating the effect of lowering the temperature by a few more degrees, saving on cooling energy.

The energy labelling scheme was revised during 2010, so that the star rating scale is now much more stringent. Many models rated well off the 6 star scale of the previous label, with the best products achieving the equivalent of 12-13.5 stars (but these were rounded down to the maximum 6 stars)! Due to time constraints it has not been possible to include the new star rating algorithms in AGC, but the following is provided for guidance.
If you know the new (2010) star rating (or Star Rating Index SRI) of your air conditioner (available at www.energyrating.gov.au), you can use the following conversion equations or graphs to convert this to the ‘old star rating’ that can be selected or entered into the AGC ‘user specify’ in the relevant screen. As at December 2010, the energyrating website lists both the previous and new energy star ratings for products that were on the market before the change in the labelling scale: but note that the old star rating has a maximum of 6 stars, which many products exceeded.

old heating stars in AGC (or SRI)=1.7307*(new heating stars or SRI)+1.1246

old cooling stars in AGC (or SRI)=1.7313*(new cooling stars or SRI)+2.1243

To use the graphs below, follow the example: draw a vertical line from the appropriate 2010 star rating on the horizontal axis, then a horizontal line from where that meets the graph line to the vertical axis. The value on the vertical axis is the pre-2010 star rating or SRI.
Note that the SRI is the Star Rating Index, which is just a more accurate indicator of star rating, as star ratings are rounded to the lowest half star, for example, an SRI of 5.3 would be rounded down to 5 stars on the energy label.

Appliance efficiency, area cooled, duration of cooling and temperature to which spaces are cooled, as well as building performance, all affect energy use and greenhouse gas emissions. All of these issues can be explored using the AGC. User expectations of comfort levels have a dramatic impact on cooling energy use. For example, changing the thermostat setting by just one degree can change cooling energy use by 5-20%.

**HOT WATER**

For Australian households with electric hot water, greenhouse gas emissions from hot water supply and use may be the largest single contributor to their household energy-related emissions. So this area is very important. The range of HWS options has expanded over recent years. Gas and electric instantaneous units (that only heat water when it is needed) have become popular alternatives to traditional storage units that have insulated tanks of hot water available for use. A variety of solar HWS units have also emerged, along with electric heat pump HWS units (which operate like a reverse cycle air conditioner, extracting heat from the ambient air and concentrating it to heat water). Solar HWS units typically have booster systems that use electricity or gas when there is insufficient sun, or when hot water demand is high.

This screen of the AGC estimates greenhouse gas emissions from:

- The hot water service (HWS), as it stores hot water and converts fuel or electricity into hot water
- Clothes washing: the washing machine uses electricity (to operate and, in many cases, to heat water), hot water imported from the HWS and detergent (emissions from manufacture), each of which contribute greenhouse gas emissions.
• Hand dishwashing, which uses hot water from the HWS

• Dishwasher use, which uses electricity (to operate and heat water, which in turn heats the contents of the dishwasher), hot water imported from the HWS (if connected to the hot water supply) and detergent

• Bathing: hot water is supplied from the HWS for showers and baths

**Hot Water Service**

Models of the main types of hot water service were developed by the author. The models include consideration of standby losses, marginal energy conversion efficiency and, where appropriate (for example for instantaneous gas HWS units), start-up energy and electricity used in standby mode and for additional components such as fans and pumps. For gas and electric units, data on standby losses and marginal efficiency (ie efficiency when heating an extra unit of hot water) were derived from various sources, including the *Rheem Hot Water Manual*, *Rinnai Technical Manual*, Szann (2008) and Australian Standards (AS/NZS4234 (2008), and AS/NZS 4552 for gas energy labelling algorithms). Adjustment factors to reflect the impact of varying climate on cold water supply temperature and heat losses from tanks were added.

For solar hot water system units, a simple approach is used where the user specifies the percentage solar contribution for the HWS type that is providing boosting. Some guidance is provided in the calculator information section regarding selection of an appropriate percentage solar contribution. The website of the Office of the Renewable Energy Regulator ([www.orer.gov.au](http://www.orer.gov.au)) and Sustainability Victoria ([www.sustainability.vic.gov.au](http://www.sustainability.vic.gov.au)) provide information on the number of RECs (Renewable Energy Certificates) credited to each model of solar HWS – the more the better and the higher the solar contribution. The SV website also shows percentage solar contributions for all products listed under standard test conditions: if you use less hot water, the percentage contribution of a given solar HWS will be higher.

For gas hot water systems, the energy labelling algorithms were used to vary efficiency with star rating. The author developed similar algorithms for other types of hot water systems, even though they do not have energy labelling schemes. It was considered important to allow users to vary hot water system efficiency, as there is a range of performance on the market, and users can also improve efficiency by fitting additional insulation, etc. Since resistive electric HWS units convert electricity to heat at near 100% efficiency, their efficiency is improved only by reducing standby losses (eg by adding extra insulation to the tank), as their conversion efficiency cannot be improved.

In the detailed mode, it is possible to specify up to two HWS units in the home: this requires the user to enter the percentage of total hot water provided by the second HWS. An increasing number of homes have a main HWS and a second one for the ensuite bathroom or guest room, and this option allows this scenario to be included.

For most households, provision of hot water for bathing, dishwashing and clothes washing is the dominant contributor to water heating greenhouse gas emissions. However, for small or efficient households, standby losses (mainly heat loss from tanks) and ‘dead water’ losses (energy wasted as hot water cools down in the pipes between the HWS and the point of usage) can be surprisingly
large, in some cases up to two-thirds of energy use and greenhouse gas emissions. These factors are considered in the calculator in various ways:

- **Standby energy losses are built-into the core calculation.** So a shift from a storage HWS to an instantaneous one will avoid this loss – although instantaneous units do waste some energy (and water) as they start each time hot water is drawn off.

- **Dead water losses can be taken into account when entering data.** For example, entering the time a shower actually runs, rather than the time spent under it, will take into account energy and water waste from the pipes. In the kitchen, the amount of time entered for rinsing under a running hot tap can be increased to take into account these losses.

Storage HWS units were assumed to maintain hot water at 60°C (apart from off-peak units, which were set to 65°C) while all units delivered hot water at 50°C: these are regulatory requirements to limit risks of legionella growth in tanks and scalding from hot water taps.

**Clothes washing**

Clothes washer energy use is very sensitive to the amount of hot water used, as only a small amount of energy is needed to run the motor and electronics. Depending on these factors, annual greenhouse gas emissions may vary from 50 to 500 kilograms each year for five washes per week.

Recent developments in washing machine technologies have complicated estimation of energy and water use and greenhouse gas emissions from their use. Traditional Australian top loading washers have dual water connections for both hot and cold water, and rarely have internal heating elements. Many new front loading machines have only one water supply pipe, which must be connected to the cold water supply. They have internal heating elements to heat their own water. Further, many new models, when used on cold wash, actually heat the water to 20-25°C, to ensure that detergent dissolves, and that the enzymes in modern washing detergents are activated. Lastly, many recent models have complex electronics, and therefore have standby power usage.

All types of clothes washers are improving in water efficiency and, when warm or hot programs are used, this also reduces energy use. Broadly, water heating dominates clothes washing energy use, so this should be minimised. Spin dry effectiveness is very important to reduce clothes drying time and energy use.

Major sources of data were the downloadable databases for clothes washing machines at [www.energyrating.gov.au](http://www.energyrating.gov.au) and [www.waterrating.gov.au](http://www.waterrating.gov.au), the Australian/New Zealand Standard for performance of clothes washers (AS/NZS 2040:2005), and manufacturer data downloaded from their websites. ABS 4602.0 (2007) p.50 and Wilkenfeld (2008) provided data on typical loading of washing machines, which is usually around half of rated capacity.

The clothes washer energy labelling scheme includes energy use by the motor, electronics and water heating, as well as an energy credit for reducing clothes drying energy through more effective spin drying. The approach taken to calculating energy use and emissions in the AGC was to estimate motor energy use, standby power and credit for spin drying effectiveness, then deduct them from the energy rating consumption value to determine the water heating energy.
requirement for a warm wash. Motor energy use and spin drying efficiency were correlated against energy star rating, using the energysaving database. Default standby power data for each type of washer was drawn from EES (2008) appendix B for each year up to 2007, when it was included in the energy labelling rating. Values for washer energy rating, type, capacity, usage, etc drawn from defaults or user selections were then used to calculate the electricity use and water heating energy use (which was allocated to the hot water service if supplied from an external HWS or to appliance electricity use if internal heating was used).

The emissions embodied in the detergent were estimated based on Saouter et al (2002) and Greene (1991), at 0.02 kg CO2e/litre of washing water only (ie not rinsing water). This assumes that the more water-efficient the washer, the less detergent it will use: it is the concentration of detergent, rather than the amount, that tends to determine cleaning performance.

Calculator users may be surprised to note that older washing machines using cold wash, or warm wash with heat sourced from a low emission HWS, may generate less greenhouse gas than modern high efficiency front loading washers that heat their own water using electricity. This is because heating water with electricity in the machine is a relatively high greenhouse impact option. But if a clothes dryer is used, the improved spin drying effectiveness of modern washers will offset the higher water heating emissions by saving on clothes drying greenhouse gas emissions.

The impact of variations in wash program and wash temperature was calculated based on the energy content of water at various temperatures and the fill volumes previously obtained from Choice magazine and manufacturer data.

Dishwashing (dealt with on two screens: ‘hand dishwashing’ and ‘dishwasher’)

Dishwashing can use a surprising amount of energy. Washing and rinsing items under running hot water is particularly wasteful: running a hot tap for a couple of minutes can use a sinkful of hot water. Just running a hot tap for 2 minutes a day can generate over 50 kg of greenhouse gas each year. Careful management of a modern dishwasher (washing full loads and using eco-wash) can reduce overall dishwashing energy use, but it is important to avoid pre-rinsing the dishes under running hot water before putting them in the dishwasher!

Estimates of energy use for hand dishwashing were based on measurements of the amount of water required to fill a kitchen sink and measurements of the amount of water released by a running tap. The energy content of the water is then calculated. Water efficiency of taps and typical usage of the sink were considered, based on research by Yarra Valley Water (2007) and Wilkenfeld (2008).

Estimation of the energy used by a dishwasher is a challenge, given that most calculator users will have limited knowledge about the detailed design of the machine. So the calculator methodology was based on either user entered, or default estimates of the energy star rating of the appliance
based on EES (2008). Other information such as capacity and usage were factored into this approach. The database downloadable from www.energyrating.gov.au provided more detailed information for development of the calculation methodology and appropriate values for variables.

Because manufacturers use different washing programs to comply with the energy rating, it was found that energy performance as measured by the star rating sometimes differed significantly from test results from Choice magazine who used ‘normal’ program for all tests. To deal with this situation, it was necessary to simulate a hypothetical dishwasher design and wash program used for the energy rating test, which varied wash temperature and water usage with star rating. The higher the star rating, the lower the wash temperature, the less water and the shorter the wash program used. Once this hypothetical dishwasher was specified, variations in user behaviour, tap connection, loading, etc selected by the user could then be modelled for this dishwasher. In practice, different manufacturers use varying design philosophies, so this calculation is only approximate.

Dishwasher energy use estimates are based on calculations from the algorithms published in the Australian Standard for dishwasher energy labelling (AS/NZS 2007.2) and data downloaded from www.energyrating.gov.au, data from Choice magazine’s tests, and manufacturer data from their websites. Estimates of the effects of connecting to cold, hot or hot and cold, and for different wash programs and loading are based on results from a computer model developed by the author for R&D work carried out with the RMIT Centre for Design and Dishlex.

Most manufacturers now advise against connecting a dishwasher to the hot supply because it can overheat delicate items or dishwasher components, as well as adversely affecting cleaning performance. The calculator also shows that this practice may be of limited effect in reducing emissions, because modern dishwashers draw off small amounts of water for each fill, so heat losses from hot water supply pipes can be significant. Further, if a single connection dishwasher is connected to the hot water supply, it will use hot water for fills (eg rinses) that would otherwise use cold water when the dishwasher is connected to the cold water supply. So up to twice as much heated water may be consumed on hot connect relative to cold connect. These factors can offset the emission benefits of supplying hot water from a low emission hot water service.

Calculator users should note that switching from a low star rating dishwasher to a higher rated one may not deliver the emission savings expected, unless they also change to a shorter wash. This is because, in general, the higher star rated products are tested/rated on shorter washes: when used on a longer wash they may use similar amounts of energy to lower star rated products. However, they are able to use the shorter wash in the energy rating test because their cleaning performance is better, so they are able to meet the dish cleaning performance standard on a shorter wash.

Spending more money on a better dishwasher detergent, so that the machine can clean dishes well on a shorter/lower temperature wash, not only cuts greenhouse gas emissions, but the energy and water savings offset the higher cost of the better detergent.

The amount of energy in any hot water imported from the hot water service (if any) is estimated, and fed to the hot water service calculation section. The emission value reported on the dishwasher screen is for electricity used in the machine (including internal water heating) and detergent embodied emissions.
Hand dishwashing energy is not reported in that screen, but it fed into the overall hot water result, because the greenhouse impact of using this hot water depends on the characteristics of the hot water service.

**Bathing**

The amount of hot water used for bathing has declined over recent years as more people have installed water-efficient shower heads and people have taken shorter showers in response to concerns about water availability as many parts of Australia have become dryer. Reports from Yarra Valley Water (2004 and 2007) provided field data on which the default values were based.

In detailed mode, the AGC allows a user to vary number of showers and baths, water efficiency of showers and amount of water per bath. If a home has more than one shower, or some people have shorter or longer showers than others, this can be dealt with by entering additional lines of data with the relevant usage patterns.

The amount of energy in hot water imported from the hot water service for baths and showers is estimated, and fed to the hot water service calculation section.

**CLOTHES DRYING**

A typical clothes dryer uses 2 to 5 kilowatt-hours of electricity per load. Usage varies widely, from very occasional to drying all the washing. Used just once a week all year, a dryer may generate up to 250 kg of greenhouse gas and cost up to $60 to run.

The main types of clothes dryer are:

- **Drying clothes on a clothes line or rack, which uses no energy.**

- **Timer controlled electric:** this is the typical tumble dryer. A motor rotates a drum so that the clothes are tumbled. An electric heating element and fan drive heated air into the drum. This heated air evaporates water from the clothes and leaves the dryer via an exhaust outlet (which may be ducted to the outdoors). The user selects a time and heat setting for the process using a timer control on the dryer.

- **Auto electric:** this is a tumble dryer with a sensor in the air outlet that switches off the dryer when the exhaust air is sufficiently dry, indicating that the clothes are dry. These models are typically around 10% more efficient than timer controlled dryers because the sensor avoids the possibility of over-drying the clothes.

- **Condenser dryer:** this is also a tumble dryer. In this case, it does not vent the water vapour removed from the clothes. Instead, in most cases it is connected to the cold water supply, and cold water is sprayed into the exhaust air: this cools it and condenses the moisture in it (because cooler air holds much less water vapour than hot air), and the liquid is drained away (in the same way that water vapour in the air of a heated room condenses on cold windows). The cooled, dried air is then reheated and recirculated through the dryer. These dryers consume large amounts of water. Some condenser dryers achieve very high efficiencies (and avoid water waste) by using heat pump technology, which is described below.

- **Combined clothes washer-dryer:** some front loading washing machines can also be used as clothes dryers. The functions are energy rated separately, so the calculator treats the
two functions separately, in separate screens. Most models use condenser drying (see above). Note that if a full wash/dry cycle is used, a lower-than-rated capacity load must be washed, as the drying cycle has lower capacity for the same sized drum, because the clothes must have enough room to tumble freely when drying.

- Heat pump clothes dryers are more efficient, as they use a system like that of an air conditioner to provide heat much more efficiently than a traditional electric heating element. They also recover the latent heat energy from the water vapour in the exhaust air by condensing it to liquid, improving efficiency significantly. The best heat pump dryers save half to two-thirds of the energy used by a typical 1-3 star dryer.

- Gas dryer: these are often used in Laundromats, but some homes have them. They use a gas burner to provide heat instead of an electric heating element. Since gas is lower in greenhouse impact than most Australian electricity, it has much lower greenhouse impact

Most of the energy used for clothes drying is to evaporate water remaining in the clothes after washing: the less water, the less energy is required. Also, the smaller the load of wet clothes, the less energy is required to dry them.

The water content of clothes being placed in the dryer is determined in the calculator from the user's selection of clothes washer type and energy efficiency. Typically front loading clothes washers have much higher spin speeds, and remove more water from the clothes than do top loaders, so clothes washed in them need less energy and time to dry (although some top loaders are improving).

Users can look at listings of clothes drying appliances on [www.energyrating.gov.au](http://www.energyrating.gov.au) to see the range of energy star ratings of products available on the market.

The energy consumption per kilogram of clothes was estimated using the algorithms from energy labelling (AS/NZS 2442:2000) for the range of timer and sensor controlled dryers (typically 0.75-1 kWh/kg of water removed for electric dryers). The efficiency of a heat pump clothes dryer was based on the energy rating data for heat pump dryers on the energy rating website, while gas dryer efficiency was estimated to be similar to that of a timer-controlled electric unit, as the flue gases are used directly to dry the clothes and efficiency is thus very high — around 95%. Typical usage was based on data from ABS 4602.0 (2005) and the typical loading (56%) is from EES (2008) p.91.

**LIGHTING**

Lighting energy use in Australian homes has increased rapidly in recent years, with wider use of large numbers of low voltage halogen lamps (which are not energy-efficient), larger homes, more outdoor lighting, and a tendency to leave lights on more. In some cases, annual greenhouse gas emissions from lighting can exceed 3 tonnes, with annual running costs of up to $1,000.

A lot is happening in the lighting market. The Australian government recently banned most traditional incandescent light globes, and these have been replaced by products that look similar, but use halogen lamp technology inside the traditional glass bulb to improve efficiency by around 30%. Halogen lamps are just slightly more efficient incandescent lamps (that is they provide light by heating up a wire until it glows). Low voltage halogen lamps are widely used – large numbers
of these are usually used in each room, because they give a narrow beam of light. While each halogen lamp is slightly more efficient than a traditional incandescent lamp, the large numbers installed, and the energy losses in the transformers needed to convert mains power to 12 volt (low voltage) power, mean they typically lead to very high lighting energy use and costs.

Compact fluorescent lamps and Light Emitting Diodes (LEDs) are generally much more efficient, and are improving in performance all the time. They also have much longer lives, so the lower energy use and longer life generally easily offsets higher initial costs and saves money overall.

Default values for the daily time lighting is used, and typical lighting power densities for different types of lighting (ie watts per square metre of lighting power) were based on EES (2008), but the user can also enter other values in the detailed mode.

In the detailed mode, separate hours of usage can be specified for summer and winter: with daylight saving and large variations in length of day over the year, summer and winter usage can be very different.

Where a lamp is dimmed, the user can enter the percentage of maximum light produced by the dimmed lamp: this will adjust the power usage accordingly. Typically, modern dimmers are quite efficient, so dimming does save energy.

The level of detail of data entry can be varied: the simplest option is to select the type of lighting used in most of the house and a typical value for daily hours of operation. But additional data entry lines can be added, so that groups of lights or even individual lights can be treated separately.

**Refrigeration**

A refrigerator or freezer is essentially an insulated box with a means of removing heat from it, so that food and drinks can be stored safely or at preferred temperatures. Most refrigerators use an electric motor-driven compressor and refrigerant gas to extract heat from the evaporator inside the appliance, and dump it as heat to the local environment, either through coils on the back of the appliance or, increasingly, through refrigerant pipes bonded to the inside of the sides and back (and sometimes top) of the appliance cabinet. So the cabinet acts as the heat transfer system, dumping heat: it is important to leave space around these appliances to allow the heat to dissipate.

A wide range of sizes and types of refrigerators are used in Australian homes, with the most common being two-door frost-free models. Most are covered by the appliance energy labelling program, but neither LPG fridges (which may also be run on electricity) nor thermoelectric models (see below) are required to carry energy labels. This is unfortunate, as these technologies can be very expensive and greenhouse intensive to run.

LPG fridges use the heat from a flame (or, when running on electricity, an electric heating element) to drive the ‘absorption’ cooling cycle to provide cooling. This cycle is quite inefficient, as it uses up to four times as much energy as a normal electric refrigerator.

Thermoelectric refrigerators use the Peltier Effect: when an electric current is run through two dissimilar metals in contact with each other, one becomes hot while the other becomes cold. So the cold part can be used to cool a refrigerator while the hot part dumps heat into the
environment. This principle is used for small portable cooling/warming products used in cars, but some household products also use it: for example, some wine coolers use thermoelectric cooling to avoid the vibration from a compressor, which some argue adversely affects wine quality over time. These appliances are usually very inefficient, although the Hydrocool process overcomes the inefficiency problem and has been applied by some refrigerator manufacturers. AGC does not include the Hydrocool approach because it is very rare. It is similar in efficiency to a typical conventional refrigerator of similar size.

Refrigerator efficiencies have improved dramatically over the past twenty years, so that modern appliances may use 70% less electricity than those made in the mid 1980s, even though they are bigger and have more features. Further developments are driving even higher efficiencies.

It should be noted that the energy labelling scheme for refrigerators and freezers has been updated twice, first in 2000, and again in 2010. In each case, the allowable energy use for a given star rating was reduced. So a refrigerator with 3 stars using the latest rating scale would have rated over 7 stars (that is, off the 6 star scale!) on the original scheme that ran until 2000. The AGC automatically selects the correct energy labelling scheme for the selected age of your appliance when entering a star rating.

Base energy consumption estimates for refrigerators and freezers were calculated from algorithms in energy labelling Standards (AS/NZS 4474.2) and regulations. The effects of increased usage due to larger numbers of people in the household, climatic effects, installation, usage and appliance condition were calculated using computer models developed by the author for R&D on refrigerators, or from published references. For example, EES (2008) includes an estimate of the impact of climate variation on refrigerator energy use, while Liu et al (2004) investigated the impact of door openings on energy use.

In the detailed screen, multiple refrigeration appliances can be added, each with its own features and usage.

Note that comparisons of options for chilling water, including refrigerators with built-in water chillers, are addressed in the ‘cooking’ section of the calculator in the detailed mode.

Calculator users can look up listings of refrigerator energy efficiencies at [www.energyrating.gov.au](http://www.energyrating.gov.au). In the ‘electronic library’ on that website, there are reports that describe the trends in appliance efficiency over time, as well as the details of energy efficiency programs.

**COOKING**

Greenhouse gas emissions from cooking may vary from 100kg to 2 tonnes of greenhouse gas annually, depending on the amount of cooking, cooking behavior, and the energy source and technology used.

The complexity of cooking equipment options is increasing rapidly, as combinations of gas and electric cooking modules are more widely used, a range of different types of electric cooking technologies has emerged, and increased use of specific purpose devices increases. A wider range of food is also now prepared, with an increase in salads, use of BBQs for cooking, more purchase of frozen and pre-prepared foods, etc.
The detailed screen in the calculator allows the user to enter a wide variety of equipment types and usage levels, so that this complexity can be dealt with.

This screen also includes questions on provision of boiled and chilled water for drinking purposes, as many people use kettles on cooktops or microwave ovens as alternatives to electric kettles or coffee makers to heat water. Chilled water was dealt with here for simplicity.

Energy use for cooking meals and relative efficiencies of gas and electric cookers are based on a number of references including tests carried out by AMDEL in South Australia for Monica Oliphant of ETSA in 1991, a study of small households by Oliphant (1999) and a statistical analysis of NSW household energy by Fiebig and Woodland (1994). These efficiencies were cross-checked against energy utility data, Choice magazine test results and a British study. Performance of microwave ovens was confirmed by testing at the author’s home, particularly for boiling water. There are no Australian Standards for energy rating or labeling of cooking equipment. Some European ovens specify energy performance.

Cooking greenhouse gas emissions are very sensitive to user behaviour. Boiling a large pan of water vigorously with no lid, for example, consumes a lot of energy: removing each litre of water from a pot by boiling on an electric cooker can generate up to 1.5 kilograms of greenhouse gas, with most of this due to the evaporation of the water itself.

It should also be noted that the default values for usage vary with household size, and include a fixed base amount of energy that reflects the energy required to heat up an oven or cooking equipment regardless of how much food is cooked.

**OTHER APPLIANCES**

Australian households have increasing numbers of small appliances and equipment, as well as increasing numbers of high energy consuming televisions and computers. While many of these items are used rarely, they are often left plugged in, consuming standby power. It is common for a home to have 40 or more items of equipment on standby, and these can consume up to 10% of total household electricity.

Over the past decade, there has been a strong trend towards ownership of large flat screen TVs, many of which consume large amounts of electricity: many large TVs consume more electricity than a family fridge! Indeed, some large, inefficient flat screen TVs can generate up to 1.5 tonnes of greenhouse gas each year. However, since the introduction of TV energy labels in late 2009, a new generation of high efficiency LED-backlit LCD TVs rating up to 8 stars has emerged that are far more efficient. Indeed, they use much less power than many older style large TVs. The calculator allows the user to explore the impacts of higher efficiency TVs, as well as varying usage.

We have also seen rapid growth in ownership and use of computers, ever more powerful gaming consoles (many of which use a lot of electricity), digital recording devices and home theatre sound systems.

Small cooking equipment is covered in the ‘cooking’ section of the calculator.

The calculator allows the user to explore selection and usage of a wide range of items of equipment. It uses three categories of energy use: operating energy (when the item is delivering a useful service), and two categories of standby power. ‘Active standby’ is when an appliance has
been used for its primary purpose, and left on. For example, a stereo, DVD player or video recorder may finish playing, then remain on: this mode of operation can consume surprisingly large amounts of electricity, in many cases nearly as much as when the appliance is operating. ‘Passive standby’ is when the appliance is switched off at the remote control or at the appliance (but it still has indicator lights or a display visible) and can be re-activated by a remote control. This uses much less energy than active standby, but it can be significant. Of course, the user can also switch items off at the power point when they are not needed: then they use no energy! If the nominated daily hours of usage for an item total to less than 24, the calculator assumes no power use for the remaining hours.

One way of telling if an item has high standby power consumption is by feeling its temperature (on the outside of the casing – don’t risk electrocution). The warmer it is, the more electricity it is wasting on standby.

The quality of data on the wide variety of home entertainment and other small appliances is very poor. And consumption can vary widely between seemingly similar products. So this section, more than others, can only provide an indication of typical outcomes, and the products in any specific home may perform differently.

In general, data on energy use were derived from the author’s own measurements and/or data published in Choice magazine, as well as information and literature from web sites of energy utilities and equipment manufacturers. Default values for standby power and some usage data were taken from research reports in the electronic library at www.energyrating.gov.au. In practice, standby power usage varies widely from one model to another, and it is difficult to tell how high it is unless it is stated in the manufacturer specifications or it is measured.

In the detailed mode, a user can enter any values for the energy consumption in the various operating modes, so the significance of this issue can be explored. A user can also add any number of items.

Typically, older appliances and equipment tend to have higher standby power usage than newer ones, as manufacturers have begun to pay attention to this issue in recent years. Switching equipment off with the remote or, even better, at the power point is also good practice, which reduces fire risk from faulty appliances as well as saving energy and cutting emissions.

This section also includes options for use of mowers and small petrol-powered equipment.

**Useful References for Non-Transport Activities**

A very large number of references was used in development of the AGC algorithms. Lack of space precludes a full listing here. However, some of the most useful references include:

**AMDEL (1990)** Report M2162/91 Energy Consumption of Cooking: testing of appliances Norwood South Australia

**Choice magazine (selected issues)** Australian Consumers Association, Chippendale


IPCC (various reports) [www.ipcc.ch](http://www.ipcc.ch)


Oliphant M (1999) *Energy Consumption in Small Households* ETSA Power South Australia


Yarra Valley Water (2004 and 2007) *2003 and 2007 Appliance Stock and Usage Patterns Surveys*

Websites:

[www.choice.com.au](http://www.choice.com.au) the Australian consumer website with many test reports on a wide range of household appliances and equipment. Reports usually include energy use data, and there are articles on various aspects of household energy and water usage. You must be a subscriber to access many reports, but public libraries often have hard copies or electronic access

[www.energyrating.gov.au](http://www.energyrating.gov.au) which includes many papers, reports, summaries of relevant Australian/New Zealand Standards of relevance

[www.epa.vic.gov.au](http://www.epa.vic.gov.au) information on eco-footprinting, carbon offsetting and many other relevant issues

[www.greenvehicleguide.gov.au](http://www.greenvehicleguide.gov.au) government data on fuel consumption of cars, hints for fuel efficiency improvement


[www.standards.com.au](http://www.standards.com.au) the location of all Australian Standards. Most documents must be purchased. University libraries generally have copies of Standards in their reference sections


[www.yourhome.gov.au](http://www.yourhome.gov.au) very useful government website on many issues relating to household energy, building design and environmental issues
www.yvw.com.au the website of Yarra Valley Water: this includes a number of reports on surveys of household water usage and water efficiency of appliances and fittings

**HOUSEHOLD ENERGY COSTS**

This calculator does not attempt to estimate energy costs of activities or total bills. With energy market reform, prices now vary significantly by location, over time, and according to retailer and contract structure. For example, many households are being shifted to ‘smart’ electricity meters that charge different prices at different times of day, and also vary with weather conditions! Fixed supply charges also vary with contract type and over time.

However, it is possible to roughly estimate your overall energy costs from the greenhouse gas emission results reported by this calculator, or to estimate your greenhouse gas emissions from energy bills to compare with your calculated results, as shown in the following Table.

<table>
<thead>
<tr>
<th>ELECTRICITY PRICE (from energy bill – subtract fixed charges then divide remaining cost by number of kWh)</th>
<th>COST $/TONNE CO2e (CENTS/KG CO2e)</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 cents/kilowatt-hour (typical off-peak)</td>
<td>$77/TCO2e (7.7c/kg CO2e)</td>
<td>To calculate electricity cost in $/ per tonne of CO2e: $/T=(cost in cents/kWh)*10/ghfactor (in kg CO2e/MJ, see Table below)/3.6</td>
</tr>
<tr>
<td>20 cents/kWh (typical day rate price 2010)</td>
<td>$154 (15.4c)</td>
<td>To calculate electricity cost in cents/kg of CO2e: c/kg=(cost in cents/kWh)/ghfactor (in kg CO2e/MJ, see Table below)/3.6</td>
</tr>
<tr>
<td>30 c/kWh (typical daytime price on time of use tariff)</td>
<td>$231 (23.1c)</td>
<td>To calculate ghgs in tonnes for the billing period from your electricity bill, subtract the fixed charges from the bill total, then divide the remaining cost by the value of $/tonne calculated above</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NATURAL GAS or LPG PRICE (from energy bill –)</th>
<th>COST $/TONNE CO2e (CENTS/KG CO2e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical natural gas 0.06 kg</td>
<td>Typical LPG 0.065 kg CO2e/MJ</td>
</tr>
</tbody>
</table>
subtract fixed costs and divide remaining cost by number of MJ)

<table>
<thead>
<tr>
<th>CO2e/MJ</th>
<th>$/T</th>
<th>$/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cent/MJ</td>
<td>$167 (16.7c)</td>
<td>$154 (15.4c)</td>
</tr>
<tr>
<td>2 c/MJ</td>
<td>$334 (33.4c)</td>
<td>$308 (30.8c)</td>
</tr>
<tr>
<td>3 c/MJ</td>
<td>$501 (50.1c)</td>
<td>$462 (46.2c)</td>
</tr>
<tr>
<td>4 c/MJ</td>
<td>$668 (66.8c)</td>
<td>$616 (61.6c)</td>
</tr>
</tbody>
</table>

To calculate gas or LPG cost in $/ per tonne of CO2e:
$/T=(cost in cents/MJ)*10/ghfactor (in kg CO2e/MJ, see Table below)

to calculate gas or LPG cost in cents/kg of CO2e:
c/kg=(cost in cents/kWh)/ghfactor (in kg CO2e/MJ, see Table below)

to calculate ghgs in tonnes for the billing period from your gas or LPG bill, subtract the fixed charges from the bill total, then divide the remaining cost by the value of $/tonne calculated above

It is useful to compare your estimated emissions from the calculator with the emissions calculated from energy bills to confirm the validity of your estimate. If there is a significant difference, review your responses to the questions. A difference may indicate that you have a faulty appliance, unseen flaws in building construction or appliances with unusually high standby power consumption. Or the meter may have been misread.

You may be able to borrow (some councils and community groups loan them) or buy a power meter to check equipment. Or you can monitor your energy meter’s rate of consumption as you switch off and on suspect items of equipment.

**GREENHOUSE COEFFICIENTS**

The greenhouse coefficients used were in general full-cycle coefficients for 2007 (updated to 2009) taking into account the effects of CO2, CH4 and N20 drawn from tables in the 2008 (updated from 2010) National Greenhouse Accounts (NGA) Factors Workbook Department of Climate Change, Canberra. It was considered more appropriate to use full-cycle coefficients (which take into account extraction and processing and delivery of energy) than the Scope 1 and 2 coefficients published in the National Greenhouse Gas Inventory and many other sources.

For information, Scope 1 emissions are those directly released from activities at a site: so for a home, natural gas combustion emissions are Scope 1, but emissions from electricity use are not Scope 1, as they are emitted from the power station that supplies the electricity. Scope 2 emissions include direct emissions from production of energy used at a site, so emissions from
electricity generation used at a home are included as Scope 2. Scope 3 emissions are less well defined, but also include emissions from delivery of energy to the site of end use. So full-cycle emissions include Scope 1, 2 and selected Scope 3 emissions, and are effectively all upstream emissions from extraction, processing and delivery of energy to the home.

Values used for energy sources in ACG (kg CO2e/MJ) where CO2e is the warming effect of all Kyoto gases using standard adjustments for variations in warming impact of each gas)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. NSW</td>
<td>0.295/0.298</td>
<td>0.0655/0.0655</td>
<td>0.0653/0.0599</td>
</tr>
<tr>
<td>b. Vic</td>
<td>0.364/0.382</td>
<td>0.0571/0.0553</td>
<td>0.0653/0.0599</td>
</tr>
<tr>
<td>c. Qld</td>
<td>0.289/0.283</td>
<td>0.0568/0.0599</td>
<td>0.0653/0.0599</td>
</tr>
<tr>
<td>d. SA</td>
<td>0.272/0.236</td>
<td>0.0699/0.0617</td>
<td>0.0653/0.0599</td>
</tr>
<tr>
<td>e. WA</td>
<td>0.271/0.257</td>
<td>0.0583/0.0553</td>
<td>0.0653/0.0599</td>
</tr>
<tr>
<td>f. Tas</td>
<td>0.037/0.096</td>
<td>0.0571/0.0557</td>
<td>0.0653/0.0599</td>
</tr>
<tr>
<td>g. NT</td>
<td>0.221/0.215</td>
<td>0.057/0.0557</td>
<td>0.0653/0.0599</td>
</tr>
<tr>
<td>h. ACT</td>
<td>0.295/0.298</td>
<td>0.0655/0.0653</td>
<td>0.0653/0.0599</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FUEL</th>
<th>NATIONAL 2007/2009</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stationary   Kg CO2e/MJ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPG</td>
<td>0.0653/0.0599</td>
<td></td>
</tr>
<tr>
<td>Kerosene</td>
<td>0.0738/0.0684</td>
<td></td>
</tr>
<tr>
<td>Heating oil</td>
<td>0.0744/0.069</td>
<td></td>
</tr>
<tr>
<td>briquettes</td>
<td>0.1043/0.094</td>
<td></td>
</tr>
<tr>
<td>coke</td>
<td>0.1257/0.105</td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td>0.02</td>
<td></td>
</tr>
</tbody>
</table>

Note: Wood emissions from Todd. Also stationary LPG is 25.7 MJ/litre (and 0.0599 kgCO2e/MJ) while transport LPG is rated at 26.2 MJ/litre and 0.0658 kg CO2e/MJ. This is believed to be because they use slightly different proportions of butane and propane. Given the limitations of the AGC, the stationary value is also applied to transport activity.
<table>
<thead>
<tr>
<th>Fuel Used</th>
<th>Fuelen MJ/litre m3 or kWh</th>
<th>Ghfact(fuel) – from CfD file</th>
</tr>
</thead>
<tbody>
<tr>
<td>Don’t know/default (petrol)</td>
<td>34.2</td>
<td>0.0749</td>
</tr>
<tr>
<td>Petrol</td>
<td>34.2</td>
<td>0.0749</td>
</tr>
<tr>
<td>Diesel</td>
<td>38.6</td>
<td>0.0752</td>
</tr>
<tr>
<td>LPG</td>
<td>25.7</td>
<td>0.0661/0.0658</td>
</tr>
<tr>
<td>CNG MJ/cubic metre</td>
<td>39.3</td>
<td>0.06083</td>
</tr>
<tr>
<td>Electric MJ/kWh</td>
<td>3.6</td>
<td>As for each state</td>
</tr>
</tbody>
</table>

**FOOD AND SHOPPING**

The Calculator is organised along similar lines to the aisles of a supermarket or grocer’s store. Estimates of money spent in each section of a person’s shopping are asked for in overall terms. The major areas are broken up into the following categories:

- Meat counter
- Fish counter
- Dairy fridge
- Bakery goods
- Fresh fruit
- Fresh vegetables
- Other fruit and vegetables
- Flour and grains, pulses, nuts and eggs
- Processed foods, confectionary, condiments, etc
- Non-alcoholic beverages
- Alcoholic beverages – take-away purchases
- Alcoholic beverages – consumed on licensed premises
- Other products
- Take-away food and dining out
- Occasional and special purchases (consumer goods)

The selection of categories is designed to cover the most common areas, the most environmentally significant purchases, and the majority of the consumption items. In the ‘Quick’ mode, product selection is made at the level of each ‘counter’. But in the ‘detailed’ screens, for some categories, the user can explore varying the mix of purchases from each counter. This
breakdown is shown as a fraction of the money spent in that category. For example, the meat counter is separated into individual types of meat such as beef, lamb, pork, chicken and processed meats, and the amount spent on each type can be varied, to explore the changes in greenhouse impact of selecting various foods and products with varying production energy and emissions. For other categories, the actual expenditure of items can be entered; these are categories with less homogenous products for which an overall expenditure makes little sense.

In each product category, in the 'detailed' screens users can select budget, standard and premium products. These selections may be used to adjust the greenhouse impact estimate of the product group. Because the impact of each factor of the product is presented as dollars of consumption, it is important not to add additional impacts of products bought from premium outlets simply because they cost more. On the other hand, it can be expected that premium products will have higher impacts than standard or discount products as the producers would be more selective about what to sell and may pay more to transport and store the best goods available for their supply.

Premium products are shown as having less impact per dollar, equivalent to half the difference between the prices of standard products and premium products. The same arguments can be used in reverse for budget products, with budget products having higher impacts per dollar equal to half the difference between budget products and standard products. For example, if you dine at a fast food café instead of an expensive restaurant, you may eat the same amount and type of food, but pay less. So your greenhouse impact per dollar would be higher at the café, but your overall impact may be higher at the restaurant because of its use of more exclusively sourced foods and lack of economies of scale.

More broadly, adjustment of the 'budget to premium' sliders can be used to reflect some degree of higher or lower greenhouse impact per dollar, to reflect your selection of a more or less environmentally focused supplier.

Several approaches can be used to estimate expenditure on each category of product:

- Shopping dockets can be collected over a period of a few weeks (to average effects of items bought less often)
- Actual items consumed or used over a period (e.g., a week) can be recorded in a diary, then priced at a local supermarket
- Data from the sources such as the Australian Bureau of Statistics on household expenditure can be used. ABS carries out a detailed survey every five years, and publishes details of expenditure of various types of households on goods and services. The most recent survey was in 2008-09, but results were not public at the time of preparation of this guide. A summary of main categories is published under ABS Cat 6530.0, and a more detailed list (also available as an Excel spreadsheet) under Cat 6535.0. These can be downloaded free from the ABS website.

The approach taken in this section differs from that of the energy sections. It was prepared by RMIT Centre for Design, and follows an approach similar to that used by Sydney University's Institute for Sustainability Assessment. Analysis of Input-Output Tables (financial flows into and out of each type of industry and their sources and destinations) produced by the Australian Bureau of Statistics are used to estimate the amounts of greenhouse gas emitted in each step of
the supply chains of food, goods and services. Where data are available, the ABS data are supplemented by more detailed Life cycle Analysis studies of the environmental impacts of specific products. This includes emissions on farms or at mines, transport, processing, packaging, conversion into saleable products, wholesaling and retailing.

So the greenhouse impact of the whole supply chain is captured, up to the point of retail sale. It does not include emissions from household transport to shops or activities, which can be entered in other parts of this calculator. The impact is captured by a value of greenhouse gas emissions per dollar spent on each product. So purchase of a dollar of ‘average’ meat incurs a ‘greenhouse cost’ of 2.1 kilograms of greenhouse gas, while purchase of a dollar of rice ‘costs’ 1.3 kilograms of greenhouse gas. Broadly, most products range from 0.13 kg of greenhouse gas per dollar to 2 kg/$. Beef is higher at 4.4 kg/$ due mainly to the large amount of greenhouse-active methane cattle burp up.

A large proportion of these emissions could be reduced by the many businesses in these supply chains, not just through consumer decision-making. For example, transporting goods by rail generates much less greenhouse gas than transport by truck. Energy efficient manufacturers and retailers can significantly reduce the greenhouse gas emissions associated with supply of food, goods and services. Some suppliers of given foods, goods and services may also emit much lower levels of greenhouse gases than other producers of similar products and services, for example some businesses claim to be carbon neutral. However, lack of detailed data means that the AGC cannot give appropriate recognition to these environmentally responsible suppliers. The sliders in the ‘budget to premium’ section of the detailed screens can adjust to some degree for environmental performance, as noted earlier: premium products generate less greenhouse gas per dollar, so selecting this option is equivalent to buying from a lower greenhouse impact supplier.

So the impacts in this section of AGC should be seen in perspective. They are broad average values, and individual suppliers may vary significantly.

Further, the range of products covered in this calculator is not comprehensive. We have not included purchase of cars, houses, etc. These are intermittent costs, and their lifecycle impact tends to be dominated by operating energy use, which is addressed elsewhere in this calculator. We have also ignored investments: the money you invest (eg in superannuation) may be spent expanding businesses that cut emissions, or those that profit from increasing emissions.

**WASTE**

The wastage of food is a major issue and opportunity for improving our environmental performance in relation to food and groceries. The impacts of food waste are represented in the Calculator through the purchases of additional food, above that which is actually consumed. Second, there are impacts of food waste in the disposal stage, although disposal is not necessarily an environmental negative. The use of food in composting helps fix additional carbon to soils and has the potential to offset the production of fertilizers. Landfilling of organic waste can lead to the production of methane emissions which can either be captured and used for power generation or, where not captured, are a potent greenhouse gas. In most cases, it is a balance between these two outcomes, with 30-70% of methane typically being captured in landfill. At 30%, the disposal of organic waste is a net negative, while at 70% capture the disposal can be a net positive.
The Calculator asks for a percentage of food discarded prior to cooking and after cooking. These two percentages are applied to the mass of food which is brought into the household, which is reverse calculated from food expenditures and assumptions about the price per kg of each product.

The disposal pathways for food waste are specified by the user, with any unspecified amount being assumed to go to landfill. Capture of methane from degrading organic waste at landfill is taken to be 55%, which is a typical assumption for Victorian landfills.

The results for composting are taken from a study of organic waste at landfill undertaken for Sustainability Victoria. Composting data assumed that 10% of the residual carbon in compost is retained in the soil profile when it is used. Commercial and home composting are treated the same here, although in reality home composting has a much more variable outcome due to variations in composting practice.

Feeding scraps to pets leads to the best outcome because the avoided pet food impacts are substantial as they generally contain meat and other cereals. Of course, if you don't have a pet and acquire one to eat your scraps, you go backwards from a greenhouse perspective as your total impacts increase with the purchase of supplementary food in the pet food section.

Composting gives a small greenhouse benefit (0.036 kg CO$_2$ e per kg food waste composted) with most of the carbon dioxide from the organic material being released to the environment through aerobic decomposition. Landfilling of organic waste generates significant impacts (0.164 kg CO$_2$ e per kg food waste landfilled) even after accounting for landfill gas capture and power generation.

Packaging and durables (eg appliances and building materials) waste does not generate greenhouse gas emissions after disposal. But recycling these materials reduces the amount of new material that must be produced, reducing overall greenhouse gas emissions.

The Calculator asks for a percentage of products reused and recycled. These two percentages are applied to the mass of products which is brought into the household, which is then reverse calculated from product expenditures and assumptions about the price per kg of each product.

For recycling, only the typical steel content is considered as this is the most commonly recovered material from durable products and steel recycling has significant benefits. This means the estimation of the benefits from recycling is conservative.

Reselling of products has the potential to compete with the purchase of new products, or at least defer their purchase. For this reason, reselling is awarded a credit equal to 25% of the original full production impact. This is based loosely on the prices of secondhand goods, being 25-50% of new products.

Landfilling durable goods mainly represents a loss of recycling and reuse opportunities, while the impact of landfilling these products is relatively small in comparison to other impacts.

As with food supply, different waste management operators may divert more or less material from landfill, and use it for varying purposes that offset differing mounts of greenhouse gas. Local circumstances can also affect the overall outcome. For example, if glass, paper and plastics must be transported long distances to recycling facilities by road transport, the net greenhouse benefit may be significantly reduced.
Tim Grant and Scott McCallister
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1 INTRODUCTION TO STRUCTURE

1.1 THE PRODUCT GROUPING AND QUESTION STRUCTURE
The Calculator is organised along similar lines to the aisles of a supermarket or grocer’s store. Estimates of money spent in each section of a person’s shopping are asked for in overall terms. The major areas are broken up into the following categories:

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The selection of categories is designed to cover the most common areas, the most environmentally significant purchases, and the majority of the consumption items. For some categories, a breakdown of the purchases is requested. This breakdown is shown as a fraction of the money spent in that category. For example, the meat counter is separated into individual types of meat such as beef, lamb, pork, chicken and processed meats. For other categories, the actual expenditure of items is requested; these are categories with less homogenous products for which an overall expenditure makes little sense.

1.2 CALCULATING THE GREENHOUSE FOOTPRINT
The greenhouse footprints are calculated using life cycle assessment (LCA). LCA is an internationally recognised approach for calculating the potential environmental impacts of products, taking account of all of the impacts from cradle to grave. There are two main approaches to undertaking LCA: a bottom-up approach called process analysis, and a top-down approach called input-output analysis.

Process analysis works with the individual processes required to produce a product. For instance, for wheat this involves looking at land preparation, seed, fertiliser and pesticide production, and then each of the farm operations needed to produce the crop. This is useful for
describing a technology but invariably excludes small supporting activities such as capital equipment and professional services.

Input-output analysis looks at the complete economic exchanges between sectors of the economy and uses these to determine what is needed to produce economic outputs from any given sector. This is useful for including all flows because anything which has had money spent on it will theoretically be included in the table. Environmental impacts are determined for each specific sector, and the impact is assigned to any product requiring input from that sector. The sector data is based initially on data collected by the Australian Bureau of Statistics (ABS). For example, wheat is grouped as part of the grains sector. The grains sector contributes direct emissions to the environment though combustion of fuels and fertiliser application. It also has inputs from the services to agriculture sector, the electricity sector, the metal products sector, the chemicals sector, the banking sector, and many others. The emissions from these sectors and their inputs from other sectors are all calculated through to the grains sector. The limitation of this approach is that each sector can contain many items which are not homogenous but are assumed to be in the input-output table. This is a problem in our example above where wheat is grouped with rice yet the impacts of the two are very different. The problem is exacerbated when the inputs to wheat from the chemical sector are averaged across a diverse group of industrial and agricultural chemicals.

This project tries to get the best of both process analysis and input-output analysis by combining them in a hybrid technique. Sectors are divided and refined to produce a more specific definition of products using data from process LCA.

The approach is in three stages:

1. The University of Sydney Integrated Sustainability Analysis initially took the ABS sector data and increased it from 106 sectors to 344 sectors, separating many of the sectors which include a heterogeneous mixture of processes. This was undertaken from a broad range of projects and not specifically targeted to the requirements of this calculation.

2. In the second stage, sectors where disaggregated further for products required for the Calculator. This focused on different fresh meat products and fruit and vegetable products and is referred to as an embedded hybrid approach because the disaggregated sectors are embedded in the table, assigning more detailed inputs to other sectors as well as providing better sector output results. (See Figure 1.)

3. In the third stage, data from specific sectors was given minor adjustments. This included calculating for additional transport, changes to key inputs, flows to products, and product variations (eg fresh versus canned fish). It also included correction of some input flows which are a function of the sector averaging or allocation of co-products within the table but which are not a realistic variable for increased demand from that sector. This is referred to as a tiered hybrid approach, as it sits a tier above the main table and does not loop back into the table as inputs. (See Figure 1.)

In each section of this report, the sector used for each food product is documented along with any additional manipulation of the data.
In this study, only greenhouse gas impacts are quantified, and the LCA is assessed from cradle to grave but excludes impacts in the use phase such as transport of the food by the consumer, cooking, and emissions from people or sewage treatment systems.

1.3 Budget, Standard and Premium Shopping

The price of goods varies substantially in different shops, which affects our estimates of the impacts. Users are asked to enter the types of places they shop in general, and at any point they can specify a different mix in each category for shopping items. The three types of shopping are listed in Table 1. In each product category, the prices of budget, standard and premium products are estimated, and these are used to adjust the impact estimate of the product group. Because the impact of each factor of the product is presented as dollars of consumption, it is important not to add additional impacts of products bought from premium outlets simply because they cost more. On the other hand, it can be expected that premium products will have higher impacts than standard or discount products as the producers would be more selective about what to sell and may pay more to transport and store the best goods available for their supply. To balance these two factors, premium products are shown as having less impact per dollar, equivalent to half the difference between the prices of standard products and premium products. The same arguments can be used in reverse for budget products, with budget products having higher impacts per dollar equal to half the difference between budget products and standard products.
TABLE 1: THREE CATEGORIES OF SHOPPING ESTABLISHMENT AND DEFAULTS ASSUMPTIONS

<table>
<thead>
<tr>
<th>Shopping Type</th>
<th>Types of products/ stores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premium shopping</td>
<td>Organic and boutique supermarkets and delicatessens – eg premium meat cuts</td>
</tr>
<tr>
<td>Standard shopping</td>
<td>Supermarkets – typical consumer products and food goods</td>
</tr>
<tr>
<td>Budget shopping</td>
<td>Local markets, bulk purchase and discount stores</td>
</tr>
</tbody>
</table>

Appendix B shows the price estimates used to scale up the premium shopping and scale down the budget shopping. The actual values in this appendix are only used in terms of their relative difference to each other. Premium is a fraction of standard, and budget is a fraction of standard. The amount actually spent is still based on what the user enters into the Calculator.

1.3.1 WHAT YOU ENTER INTO THE CALCULATOR

The Calculator requires you to input how much you spend on your food and grocery shopping. For most of the categories, this amount refers to your average weekly bill. Some categories refer to goods that do not feature in weekly shopping, and in these cases the Calculator asks for the average spent over the entire year.

For many categories, the Calculator already includes a percentage of the weekly amount spent for each product. For example, in the meat counter the percentage spent on beef is listed as 21%. This percentage is the amount spent by the average Australian and has been included as a guide to help if you are unsure of the amount you spend on each individual product. You are free to change these figures to better represent your spending patterns. Please note that while the Calculator does not require your percentages to add up to 100%, naturally they cannot add up to more than 100%.

1.3.2 ORGANIC FOOD

No specific question or category has been provided for organic food. From our research in each of the food groups, there is no clear correlation between organic products and savings or increases in greenhouse gases. Generally, organics will have lower inputs of chemicals and fertilisers, which have associated greenhouse emissions; however, increases in tractor operations can sometimes offset these savings. The organic food movement predates the advent of greenhouse gas concerns, and the positive aspects of organic farming have not changed. Further research on soil carbon benefits and competing demands for land are needed to see if either of these factors affect the greenhouse balance of organic farming techniques.
2 QUESTIONS REFERENCE

2.1 MEAT COUNTER

2.1.1 WHAT IS IMPORTANT ABOUT THIS PRODUCT GROUP?

Meat products are a central part of the average Western diet but are also a major component of the greenhouse footprint of that diet. Of special importance is the type of meat, as the greenhouse gas profile of different meats can vary by a factor of 10 or more. This question relates to meat and meat cuts such as bacon, salami and processed meats. Processed meals and products containing meat are dealt with in another section.

2.1.1.1 Beef

The main greenhouse gas impact of beef is from enteric fermentation. Ruminant animals such as cows and sheep have a rumen as the first part of their digestive systems, and this acts to break down the cellulose contained in plant matter such as grass and hay. This process is achieved through microbes living in the rumen, 3% of which are methanogens (methane producing bacteria). The methanogens take hydrogen produced by the other microbes and use it to convert CO$_2$ to methane. Their role is critical in the operation of the rumen as they keep the concentration of hydrogen low.

Methane is, however, a potent greenhouse gas, with 1 kg of methane having the equivalent global warming potential of 23 kg of CO$_2$. Scientists are currently working on ways to reduce the quantity of methane produced by these methanogens and are attempting to selectively breed cattle that give low emissions.

In the interim, studies have shown that grain-fed animals and animals that are grain-finished have a lower greenhouse gas impact than those on pastures. There are two reasons for this. Grain has a greater digestibility than grass, leading to a decrease in enteric emissions of between 38% and 70% (Harper, Denmead et al. 1999); and grain fed beef has a higher weight gain, resulting in the animals being slaughtered sooner (Peters, Rowley et al. 2010).

In some studies organic farming has been shown to produce beef with slightly less greenhouse gas impacts than regular farming (Wood, Lenzen et al. 2006; Alvarado-Ascencio, Schryver et al. 2008)(C., 2008 #6), whilst others show a higher impact (Williams, Audsley et al. 2006). The main difference in impacts between the two production systems is due to fertilisation; organic farming does not have the impacts of manufactured fertiliser, although this is offset by greater diesel usage for tillage.

The large impact of enteric fermentation is also the reason that there is little or no greenhouse gas advantage in buying locally produced beef (beef with low food miles). Contrary to popular opinion, transport has low greenhouse gas impacts, especially compared to enteric fermentation and farming. In addition, studies have shown that in some cases a more efficient farming system more than makes up for increased shipping (Schlich, Hardttert et al. 2008).
Regardless of the farming system and distance travelled to market, methane emissions from enteric fermentation still constitute the predominant greenhouse gas impact, resulting in beef having the greatest CO$_2$ impact of all farmed livestock.

2.1.1.2 Lamb
The main greenhouse gas impact of lamb is from enteric fermentation. Ruminant animals such as cows and sheep have a rumen as the first part of their digestive systems, and this acts to break down the cellulose contained in plant matter such as grass and hay. This is achieved through microbes living in the rumen, 3% of which are methanogens (methane producing bacteria). The methanogens take hydrogen produced by the other microbes and use it to convert CO$_2$ to methane. Their role is critical in the operation of the rumen as they keep the concentration of hydrogen low.

Methane is, however, a potent greenhouse gas, with 1 kg of methane having the equivalent global warming potential of 23 kg of CO$_2$. Scientists are currently working on ways to reduce the quantity of methane produced by these methanogens, and are attempting to selectively breed sheep that give low emissions.

Beef and lamb produce similar enteric methane emissions when considering carcass weight gain. Final differences in emissions between beef and lamb are due to farming practices, as sheep spend less time than cattle grazing before slaughter. One study has shown that organic lamb has less impact than non-organic lamb, assuming greater use of clover (which fixes nitrogen in the soil) in organic farms, although there is more diesel used for tilling (Williams, Audsley et al. 2006).

2.1.1.3 Pork
Unlike cattle and sheep, pigs are monogastric and therefore produce considerably less methane during digestion. The dominant greenhouse gas impacts therefore occur in production, and the largest contributors are methane emissions and to a lesser extend nitrous oxide from effluent treatment ponds (Wiedemann, Eugene. McGahan et al. 2010).

Crop production and subsequent milling for feed also contribute to greenhouse gas impacts, from nitrous oxide emissions originating from nitrogen and lime fertiliser applied to the soil as well as the impacts of fertiliser manufacture, from diesel in tractors used to till the feed crop, and from energy required for milling and feed manufacture. Energy use on pig farms and abattoirs is the last major contributor (Wiedemann, Eugene. McGahan et al. 2010).

Overseas studies from continental Europe have shown that organic pork has a greater greenhouse gas impact than conventionally farmed pork, due to the impacts of both crop feed and compost production and the use of the straw litter system (Basset-Mens and Van der Werf 2003; Alvarado-Ascencio, Schryver et al. 2008), although a UK study by Defra showed that organic pork has less impact than conventionally produced pork.

Regardless of the production system, pork per kilogram still has considerably less greenhouse gas impact than lamb or beef, and this could be reduced further if farming practices included the capture and flaring of methane from effluent ponds.

2.1.1.4 Chicken and Poultry
Chicken produces meat with one of the lowest greenhouse gas impacts. Like pigs, chickens are monogastric and not ruminants and therefore do not produce large quantities of methane as part of their digestion process. The main greenhouse gas impacts, therefore, originate from the production system rather than the animals themselves.

The major greenhouse gas impact of chickens originates in the production of feed, as chickens require high quantities of high quality protein. This feed production involves nitrous oxide emissions originating from nitrogen and lime fertiliser applied to the soil as well as the impacts of fertiliser manufacture, diesel in tractors to till the original feed crop, and energy required for milling and feed manufacture. Emissions from manure and energy used for housing and production also contribute (Katajajuuri 2007; V. Prudêncio da Silva Júnior, Soares et al. 2008).

Organic chicken has a greater greenhouse gas impact than conventionally raised chicken (Williams, Audsley et al. 2006; Alvarado-Ascencio, Schryver et al. 2008). This is due primarily to the impacts of feed production; organic chickens use more energy due to the chickens having a lower feed conversion ratio, which means that they eat more feed. Free-range chickens also have a higher impact than conventionally produced chickens, but it is still less than organic production (Williams, Audsley et al. 2006).

2.1.1.5 Rabbits
Rabbits are not ruminants, and no evidence is available to suggest that they produce significant methane during digestion. The production system for rabbits is modelled as being relatively low scale and low tech with few feed impacts and minimal husbandry.

2.1.1.6 Kangaroo
There have been no LCAs performed on the greenhouse gas impacts of kangaroo meat. It is, however, very likely that kangaroo has the least greenhouse gas impact of all the meats. Kangaroos are monogastric and therefore do not produce methane as part of their digestion process, unlike ruminants such as cattle and sheep. But unlike other monogastric animals such as pigs and chicken they do not require feed because they graze naturally on pastures. As feed production (fertiliser manufacture and usage, crop production, diesel use in tractors, milling and feed manufacture) is one of the dominant greenhouse gas impacts for pigs and chickens, without the need for manufactured feed, the greenhouse gas impact of kangaroos will be lower. Similarly, for the impacts associated with manure management, manure left on pastures has less impact than the effluent treatment ponds associated with pig and chicken production.

The major impact of kangaroo meat production is from the culling process. Kangaroos are managed under state-based Kangaroo Harvest Management Plans to ensure that the commercial harvest is ecologically sustainable. Kangaroos are shot by professional licensed hunters, dressed, and stored in portable chillers. Refrigerated trucks pick up the carcasses and transport them to a processing plant where they are inspected by a vet. The meat is then processed and packed.

2.1.2 Assumptions used in the calculator
The input-output data from the ABS includes a category for meat products which is an average of all meat products. This was separated into each of the main meat types: beef, lamb, pork, chicken, rabbit, kangaroo, and an additional category for processed meats. Processed meats were assumed to be produced predominantly from pork (75%) and beef (25%). Rabbit product was modelled in a similar way to poultry, based on the need for feed but very little land use and no
enteric methane. Kangaroo was modelled based on sheep farming but without enteric methane emissions.
2.1.3 *Summary Table - Meat Counter*

<table>
<thead>
<tr>
<th>Product</th>
<th>Impact kg CO₂ e per consumer dollar</th>
<th>Average percentage of meat counter expenditure</th>
<th>Assumptions/ Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef and veal</td>
<td>4.44</td>
<td>21%</td>
<td>Includes both emissions from enteric fermentation (cows burping), nitrous oxide from urine, and land clearing emissions adjusted on the basis of expected land clearing in 2010.</td>
</tr>
<tr>
<td>Lamb</td>
<td>2.21</td>
<td>10%</td>
<td>Includes emissions from enteric fermentations (sheep burping) and nitrous oxide from urine. Low grade wool and mutton allocated on economic basis.</td>
</tr>
<tr>
<td>Pork (other than bacon and ham)</td>
<td>0.911</td>
<td>6%</td>
<td>Includes methane emissions from waste water from piggeries.</td>
</tr>
<tr>
<td>Processed meats (ham, bacon, sausages, etc)</td>
<td>1.66</td>
<td>35%</td>
<td>Based on average meat products but dominated by pork with small amount of beef.</td>
</tr>
<tr>
<td>Poultry</td>
<td>0.613</td>
<td>20%</td>
<td>Poultry sector includes chickens, ducks and turkeys but clearly dominated by chicken.</td>
</tr>
<tr>
<td>Kangaroo</td>
<td>0.663</td>
<td>0%</td>
<td>Based on similar meat processing to sheep but with no emissions from enteric fermentation.</td>
</tr>
<tr>
<td>Rabbit</td>
<td>0.665</td>
<td>0%</td>
<td>Based on poultry impacts because rabbits are similar-sized animals eating similar food, with low land use requirements.</td>
</tr>
<tr>
<td>Other</td>
<td>2.078</td>
<td>3%</td>
<td>Weighted average of all items in the meat counter.</td>
</tr>
</tbody>
</table>

2.2 *Seafood Counter*

2.2.1 *What is important about this product group?*

The major greenhouse gas impact of fish originates from the actual fishing, which includes fuel use, consumption of ice, fishing equipment, cleaning agents, and boxes,
with fuel use being the dominant factor. There are considerable differences in greenhouse gas impacts of seafood, depending on the species and fishing technique.

2.2.1.1 LOBSTER

Lobster has the highest impact, due to low numbers captured with each fishing trip.

2.2.1.2 DEMERSAL AND BENTHOPELAGIC FISH

Demersal and benthopelagic fish have the next highest impact. These fish live on or near the bottom of the ocean and include flounder, sole, bass, and sharks. There is high fuel usage associated with catching these species due to larger ships and active fishing techniques (such as trawling) with heavily weighted nets that can penetrate the sea floor (Thrane 2004).

2.2.1.3 PRAWNS

Prawns have the next highest impact, regardless of how they are caught. Like fishing for demersal fish, a large amount of energy is required to trawl the seabed (Thrane 2004). Prawns from aquaculture farms in Southeast Asia have similar impacts, with greenhouse gas emissions arising from the production of feed (which includes dried fish squid and crustacean meal, marine and vegetable oils, wheat, vitamins and minerals), and energy used to keep ponds aerated (Mungkung and Gheewala 2007).

2.2.1.4 PELAGIC FISH

Slightly less impact comes from pelagic fish (fish that live in the water column), as line and seine fishing techniques use less energy compared to trawling. Species of pelagic fish include tuna, herring, mackerel, barracuda, sardines, squid, anchovies, trevally, marlin, swordfish, rays and sharks (Thrane 2004).

2.2.1.5 MUSSELS

Mussels have the least greenhouse gas impact of all the seafood (Thrane 2004), as there is little energy required for growing or harvesting them. They are grown in bays and estuaries on vertical lines or ‘droppers’ that hang from vertical lines suspended by buoys. Also, unlike other forms of aquaculture, they require no additional feeding, as all their nutritional requirements come from the environment.

2.2.2 ASSUMPTIONS USED IN THE CALCULATOR

The hybrid LCA model includes separate sectors for fish, lobster, prawns, and shellfish. The purchasing categories have been grouped into fresh local seafood, fresh imported seafood, frozen seafood, canned and bottled seafood, and finally other seafood for production. Table 2 shows the assumptions about how much of each seafood type is included in each product group. Additionally, each sector is adjusted based on the product group. All direct use of sheet metal products is allocated to canned fish. Frozen fish is assumed to have 20% higher direct electricity use for refrigeration. Fresh imported seafood includes additional air freight of 6000km assuming import from Southeast Asia.
Seafood products require inputs of animal feed, including by-products of the beef industry. In the data, this has the effect of showing that seafood products require significant inputs from the beef sector, which is an unlikely scenario. To rectify this, demand for animal feed was modelled using a marginal supply approach which says that increases in demand for animal feed will ultimately be supplied by feed crops, and not by waste products of the beef industry which are controlled by the level of beef production.

Frozen fish was based on fresh fish with double the direct electricity usage but less packaging. Canned and bottled fish have a higher proportion of steel packaging, with tinned tuna representing a large proportion of this. Note that the import impacts of tinned fish are relatively small, so there is no separation between local and imported tinned fish.

**TABLE 2: ASSUMPTIONS OF SEAFOOD INPUTS TO EACH PRODUCT GROUP**

<table>
<thead>
<tr>
<th></th>
<th>Fin fish</th>
<th>Lobster</th>
<th>prawns</th>
<th>Shellfish</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh</td>
<td>23%</td>
<td>20%</td>
<td>14%</td>
<td>43.0%</td>
<td>Fin fish component is taken to be less, as more than half of fin fish</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consumption is tuna, and much of this is assumed to be canned.</td>
</tr>
<tr>
<td>Frozen</td>
<td>58%</td>
<td>0%</td>
<td>18%</td>
<td>25.0%</td>
<td>Lobster is assumed to be mostly fresh, not frozen or canned.</td>
</tr>
<tr>
<td>Canned and bottled</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>Tuna, salmon and sardines are assumed to dominate canned products.</td>
</tr>
<tr>
<td>Average of</td>
<td>46%</td>
<td>0%</td>
<td>14%</td>
<td>40.0%</td>
<td>From IBIS 2009</td>
</tr>
<tr>
<td>seafood sector</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2.3 **RESULTS**

Raw fish production makes up 18% of the greenhouse gas impact of typical seafood production. A second major input is from oats, sorghum and other cereal grains, which are directly and indirectly part of the feed supply to the aquaculture industry. The indirect use of feed grain is via the substitution of meat by-products with cereal grains, in line with the modelling approach described in Section 2.2.2 on the modelling assumptions for fish and seafood. Other inputs include transport, wholesaling, and direct electricity used in processing.

2.2.4 **SUMMARY TABLE – FISH COUNTER**

<table>
<thead>
<tr>
<th>Product</th>
<th>Impact kg CO₂ e per consumer dollar</th>
<th>Average percentage of meat counter expenditure</th>
<th>Assumptions/ Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh (local)</td>
<td>0.248</td>
<td>21%</td>
<td>Based on input-output data for fish products. All animal food inputs.</td>
</tr>
<tr>
<td>Category</td>
<td>Value</td>
<td>Percentage</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------</td>
<td>------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Fresh (imported)</td>
<td>0.905</td>
<td>10%</td>
<td>Input-output data for fish products with additional 6,000 of air freight.</td>
</tr>
<tr>
<td>Frozen</td>
<td>0.961</td>
<td>6%</td>
<td>Based on the input-output sector for fish with additional electricity usage through supply chain.</td>
</tr>
<tr>
<td>Canned and Bottled</td>
<td>0.961</td>
<td>35%</td>
<td>Based on the input-output sector for fish with adjustment to packaging mix and less refrigeration.</td>
</tr>
<tr>
<td>Other</td>
<td>0.745</td>
<td>20%</td>
<td>Weighted average of other products.</td>
</tr>
</tbody>
</table>
FIGURE 2: GREENHOUSE CONTRIBUTIONS ALONG SUPPLY CHAIN OF SEAFOOD PRODUCTS – FOR AVERAGE WEEKLY CONSUMPTION OF SEAFOOD PRODUCTS

1 Weeks
Seafood counter, per week
100%

0.136 tkm
Air Freight,
International/AU U
16.6%
2.22 MJ
Aircraft engine,
international/AU U
13.6%
0.616 MJ
Transport
infrastructure, private
sector/AU U
2.98%

0.679 A$
Seafood (air freight),
cons. price
29.6%

0.0634 A$
Oats, sorghum and
other cereal grains
16.1%

0.0786 A$
Prawns
4.17%

0.00493 A$
Natural gas
4.1%

0.111 A$
Lobster
22.1%

0.034 A$
Shellfish
22.1%

0.111 A$
Prawns
22.1%

0.0649 A$
Steel and steel works manufacturing
22.1%

0.0684 A$
Grain, sugar and
other cereal grains
22.1%

0.225 MJ
Aircraft engine,
international/AU U
22.1%

0.616 MJ
Transport
infrastructure, private
sector/AU U
2.98%

0.037 MJ
Electricity supply
22.1%

0.084 MJ
Natural gas
22.1%

0.363 A$
Lobster
22.1%

0.0149 A$
Iron and steel
semi-manufactures
2.61%

0.027 A$
Electricity supply
22.1%

0.147 A$
Electricity supply
19.8%

0.065 A$
Wholesale trade
4.52%

0.921 A$
Road freight
3.02%

0.09 A$
Fish - canned /AU U
36.2%

0.248 A$
Fish - Frozen /AU U
3.3%

0.382 A$
Fish - Frozen /AU U
9.63%

0.382 A$
Fish - Fresh /AU U
27.1%

0.005 A$
Road freight
10.2%

0.005 A$
Road freight
10.2%

0.005 A$
Road freight
10.2%

0.005 A$
Road freight
10.2%
2.3  **DAIRY FRIDGE**

2.3.1  **WHAT IS IMPORTANT ABOUT THIS PRODUCT GROUP?**

The main greenhouse gas impact of milk comes from enteric fermentation. Ruminant animals such as cows and sheep have a rumen as the first part of their digestive systems, and this acts to break down the cellulose contained in plant matter such as grass and hay. This is achieved through microbes living in the rumen, 3% of which are methanogens (methane producing bacteria). The methanogens take hydrogen produced by the other microbes and use it to convert CO$_2$ to methane. Their role is critical in the operation of the rumen as they keep the concentration of hydrogen low.

Methane is, however, a potent greenhouse gas, with 1 kg of methane having the equivalent global warming potential of 23 kg of CO$_2$. Scientists are currently working on ways to reduce the quantity of methane produced by these methanogens and are attempting to selectively breed cattle that have low emissions.

In addition to the methane produced by milking cows, methane is produced by the cattle required to keep the dairy system viable, such as bulls and calves. Other sources of impacts associated with pasteurised milk include electricity used for milking and pasteurisation, fertiliser use and emissions, diesel usage, and packaging (Lundie, Feitz et al. 2003).

2.3.1.1  **Fresh milk**

Whilst some studies show greater greenhouse gas impacts associated with organic milk production (Williams, Audsley et al. 2006; Corson and Werf 2008), others show less (Grönroos, Seppala et al. 2006; Thomassen, Calker et al. 2008).

2.3.1.2  **Butter**

Many dairy products are made from reduced fat milk, leaving a surplus of cream, and this cream is often used to make butter and ghee. The cream is pasteurised and often vacuum de-aerated to remove volatiles. It is then chilled and aged to allow fat crystallisation to occur before churning (mechanical agitation), salting, and working (which distributes water in small droplets throughout the product).

Ghee, a concentrated form of unsalted butter, is produced in the same way until churning. From then, it undergoes a series of separation steps to reduce moisture to less than 0.1%.

Most of the greenhouse gas impact of butter arises from the impacts associated with raw milk production, with off-farm impacts arising from packaging, transport, and electricity and gas associated with manufacture (Lundie, Feitz et al. 2003). A typical process analysis impact for butter is 7.6 kg CO$_2$ per kg butter.

2.3.1.3  **Yoghurt and dairy desserts**

Yoghurt is made from a standardised milk (fat content and total solids) to which live bacterial cultures and, depending on the final product, thickeners, sugar, and flavourings
are added. To make the yoghurt, starter cultures are added to the milk, which is kept in fermentation vats at 37-43°C for 5-6 hours until the required level of acidity is achieved. It is then rapidly chilled, and if required, thickeners, flavourings, and sugar are added.

Most of the greenhouse gas impact of yoghurt arises from the impacts associated with raw milk production, with off-farm impacts arising from packaging, transport, and electricity and gas associated with manufacture (Lundie, Feitz et al. 2003).

2.3.1.4 Ice cream
Ice cream is made from milk fat, non-fat milk solids, sugar, emulsifiers, stabilisers, flavours, and colouring. These are mixed together as a batch, homogenised at high pressure to improve consistency, and then pasteurised at 83-85°C for 15 seconds before being rapidly chilled to 5°C and agitated for 3-6 hours. Additional flavours and colouring are added, a controlled amount of air is worked through the mix, and the mixture is rapidly frozen and packaged into tubs, bars, and cones. The ice cream then goes to a hardening tunnel at approximately -30°C to complete the crystallisation process.

The majority of the greenhouse gas impact of ice cream arises from the impacts associated with raw milk production including milk powders, although there is also a significant impact arising from electricity used for manufacture (Lundie, Feitz et al. 2003).

2.3.1.5 Cheese
Although there are a wide variety of cheeses, the initial steps are the same for all cheese manufacture. Milk is standardised for fat and protein content, pasteurised at 72°C for 15 seconds, cooled, and then pumped to a cheese vat. It is then inoculated with a bacterially started culture, followed by rennet, which acts to coagulate the milk. After 30 minutes, the coagulum is cut then heated and agitated to help develop acidity and expel moisture from the curd.

Once this has been achieved, the curds are separated from the whey by a draining and matting machine, and the curds are dry-salted and pressed to form a block of cheese. Other types of cheese may be salted in a brine solution after being moulded and pressed. The cheese is then packaged and placed in ripening rooms to develop flavour before being delivered to the retailer (Lundie, Feitz et al. 2003).

2.3.2 Assumptions used in the Calculator
The hybrid LCA model includes separate sectors for treated and untreated milk, cheese, butter, and dairy products.

Yoghurt was modelled based on treatment of milk (due to the low level of processing involved in yoghurt production). The dairy products sector was broken up into three further products groups: fluid milk cream and ice-cream. This was done by identifying the percentage of milk solids and sugar content of these three products and
then splitting the milk and sugar inputs to each product subgroup according to the shares shown in the table below.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Fluid milk</th>
<th>Ice cream and frozen desserts</th>
<th>Cream, butter oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy farm (milk) inputs $ per $ production</td>
<td>0.548</td>
<td>0.236</td>
<td>0.306</td>
</tr>
<tr>
<td>Milk solids multiplier (based on row above)</td>
<td>1.28</td>
<td>0.55</td>
<td>0.715</td>
</tr>
<tr>
<td>Sugar inputs $ per $ production</td>
<td>0.0068</td>
<td>0.023</td>
<td>0.0059</td>
</tr>
<tr>
<td>Sugar multiplier (based on row above)</td>
<td>3.33</td>
<td>0.87</td>
<td></td>
</tr>
</tbody>
</table>

Butter oil is anhydrous (without water) milk fat.

2.3.3 RESULTS

Figure 3 shows a network diagram which displays a week's purchase of an average mix of dairy products, and the greenhouse contributions through the supply chain for these products. The dominant greenhouse gas inputs for all dairy products derive from untreated milk production; in other words, the on-farm impact of cattle. Other major impacts in the supply chain are from electricity used in milk treatment, cheese production, and on-farm. The remaining impacts are from packaging materials and wholesale trade.

2.3.4 SUMMARY TABLE – DAIRY COUNTER

<table>
<thead>
<tr>
<th>Product</th>
<th>Impact kg CO₂ e per consumer dollar</th>
<th>Average percentage of meat counter</th>
<th>Assumptions/ Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Milk</td>
<td>1.11</td>
<td>48%</td>
<td>From hybrid input-output model sector for treated milk.</td>
</tr>
<tr>
<td>Fresh Cream</td>
<td>1.46</td>
<td>2%</td>
<td>From hybrid input-output model sector for dairy products, adjusted for milk solids input and lower sugar content.</td>
</tr>
<tr>
<td>Cheese</td>
<td>0.856</td>
<td>27%</td>
<td>From hybrid input-output model for cheese.</td>
</tr>
<tr>
<td>Butter</td>
<td>1.02</td>
<td>4%</td>
<td>From hybrid input-output model for butter oil.</td>
</tr>
<tr>
<td>Yoghurt</td>
<td>1.46</td>
<td>13%</td>
<td>From hybrid input-output model for treated milk adjusted for milk solids input.-</td>
</tr>
<tr>
<td>Ice cream</td>
<td>1.46</td>
<td>6%</td>
<td>From hybrid input-output model sector for dairy products, adjusted for milk solids input and higher sugar content.</td>
</tr>
<tr>
<td>Other</td>
<td>1.111</td>
<td>0%</td>
<td>From hybrid input-output model.</td>
</tr>
</tbody>
</table>
FIGURE 3: GREENHOUSE CONTRIBUTIONS ALONG SUPPLY CHAIN OF DAIRY PRODUCTS – FOR AVERAGE WEEKLY CONSUMPTION OF DAIRY PRODUCTS

- Beef cattle: 2.44% (2.88 A$)
- Untreated milk: 74.9% (0.129 A$)
- Hay: 4.16% (0.017 A$)
- Animal feed: 5.73% (0.0169 A$)
- Natural gas: 1.41% (0.286 A$)
- Cream, cons. price: 1.62% (0.859 A$)
- Fresh beef: 3.45% (0.156 A$)
- Paper containers: 1.27% (0.025 A$)
- Basic chemicals: 0.29% (0.098 A$)
- Plastic products: 2.29% (0.062 A$)
- Electricity supply: 19.6% (0.97 A$)
- Wholesale trade: 2.38% (0.018 A$)
- Road freight: 2.89% (0.059 A$)

Dairy counter, per week: 100%
2.4 BAKERY GOODS

2.4.1 WHAT IS IMPORTANT ABOUT THIS PRODUCT GROUP?

2.4.1.1 Bread
While we typically think of wheat and grain as the dominant inputs to bread, the impacts of bakery products are dominated by electricity and gas use at the bakery. Other major impacts are grain, beef products, and milk products.

2.4.1.2 Cakes
For cakes, wheat and grains make a much more important contribution to the total impact. The impacts of beef cattle arise due to minor use of dripping and other meat products, but as the impacts of beef are high in general, these impacts create a significant contribution. Electricity, milk and freight are also important impacts with cakes.

2.4.2 RESULTS
Figure 4 shows cumulative greenhouse contributions for sectors and processes required to produce the average weekly bakery goods. It shows the importance of energy in bread production through the inputs of gas and electricity. Wheat, flour, and flour mill products are also important contributors to the products from the weekly bakery shop.

FIGURE 4: GREENHOUSE CONTRIBUTIONS ALONG SUPPLY CHAIN OF BAKERY PRODUCTS – FOR AVERAGE WEEKLY CONSUMPTION OF BAKERY PRODUCTS

2.4.3 SUMMARY TABLE – BAKERY COUNTER
<table>
<thead>
<tr>
<th>Product</th>
<th>Impact kg CO₂ e per consumer dollar</th>
<th>Average percentage of meat counter expenditure</th>
<th>Assumptions/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bread</td>
<td>0.296</td>
<td>66%</td>
<td>Based on hybrid input-output sector for bread products.</td>
</tr>
<tr>
<td>Cakes</td>
<td>0.497</td>
<td>33%</td>
<td>Based on hybrid input-output sector for cakes.</td>
</tr>
</tbody>
</table>

### 2.5 Fresh Fruit

#### 2.5.1 What is Important about this Product Group?

The processes with the most significant impact in the fresh fruit product group include the wholesale trade process, application of basic chemicals on-farm, agricultural services provided to farms, and road freight and transport (Ref).

#### 2.5.2 Assumptions Used in the Calculator

The key drivers for on-farm impacts were determined from an LCA to be fertiliser inputs, principally nitrogen and phosphorous, tractor inputs, and water. An LCA was undertaken using gross margin estimates produced by Departments of Primary Industries from different Australian states. As it was not possible to include the full range of crops in each product group, the dominant product was chosen. From these LCA results, the input-output model was modified to allow for different levels of fertiliser, fuel and water requirements.

The post-farm impacts are typically wholesale and retail impacts, transport, and the total distance travelled from farm gate to shop. Some products have an imported component, and so the country of origin and method of transportation are important additional factors.

Australia’s climatic variations mean that many fruit are able to be grown all year. However, for the purpose of this report, a distinction has been made between ‘availability’ and ‘seasonality’. For a more detailed description of the seasonal profile of the fruit products, see Appendix 1.

The location of the main production areas has been determined so that the average distance travelled by each product can be ascertained. The primary growing regions for each fruit product have been grouped by state, and only the major growing regions have been included. Where specific regional data is not available, inferences are made based on the type of climate most suited to growth.

The average distance travelled by each product is calculated by measuring distances from the main growing region to each of the capital cities. Three assumptions are made: all produce is consumed in amounts proportional to population size, all consumption occurs in capital cities, and all domestic supply occurs in main growing regions. Once the distances have been measured, a weighted average is taken to determine the average distance from each of the growing centres.
Some of the products in this category have a percentage supplied by imported products (ABS, 2006). Where this is the case, the distance travelled by the product is calculated by determining the distance from the main airport in the exporting country to Sydney, Australia. If more than one country exports the product to Australia, then an arithmetic average is taken of the distances from these countries. If no data is available for the country of origin, and the ABS data registers that a percentage of supply has been imported, then a weighted average is determined from the percentage imported from the top ten source countries. The top ten source countries (and cities) for 2008/09 are China (Shanghai), NZ (Christchurch), USA (Los Angeles), Peru (Lima), Mexico (Mexico City), Thailand (Bangkok), South Korea (Seoul), Spain (Madrid), Argentina (Buenos Aires), and The Netherlands (Amsterdam) (ABS, 2009).

2.5.3 RESULTS

Figure 5 shows cumulative greenhouse contributions for sectors and processes required to produce the average weekly fruit products. It shows the importance of water, mixed and nitrogen fertilisers, fuels and oil, and of course electricity. Due to the long supply chains, expenditures in hotel and accommodation become significant mainly due to associated consumption of beef. This does not imply that farmers and truck drivers eat great quantities of beef while they are on the road, but points to an anomaly in the input-output table averages and the fact that beef has such high impacts even in small quantities.

2.5.4 SUMMARY TABLE – FRESH FRUIT COUNTER

<table>
<thead>
<tr>
<th>Product</th>
<th>Impact kg CO₂ e per consumer dollar</th>
<th>Average percentage of fruit counter expenditure</th>
<th>Assumptions/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrus</td>
<td>0.458</td>
<td>12%</td>
<td>Based on input-output sector for fruit, modified by process data for citrus fruit.</td>
</tr>
<tr>
<td>Stone fruit</td>
<td>0.396</td>
<td>10%</td>
<td>Based on input-output sector for fruit, modified by process data for peach production.</td>
</tr>
<tr>
<td>Apples &amp; Pears</td>
<td>0.396</td>
<td>20%</td>
<td>Based on input-output sector for fruit, modified by process data for apple production.</td>
</tr>
<tr>
<td>Berries</td>
<td>0.420</td>
<td>6%</td>
<td>Based on input-output sector for fruit, modified by process data for strawberries.</td>
</tr>
<tr>
<td>Grapes</td>
<td>0.396</td>
<td>8%</td>
<td>Based on input-output sector for fruit, modified by process data for table grape production.</td>
</tr>
<tr>
<td>Melons</td>
<td>0.396</td>
<td>6%</td>
<td>Based on input-output sector for fruit, modified by process data for watermelon production.</td>
</tr>
<tr>
<td>Tropica l fruit</td>
<td>0.396</td>
<td>10%</td>
<td>Based on input-output sector for fruit, modified by process data for mango production.</td>
</tr>
<tr>
<td>Bananas</td>
<td>0.396</td>
<td>16%</td>
<td>Based on input-output sector for fruit, modified by process data for banana production.</td>
</tr>
<tr>
<td>Other</td>
<td>0.396</td>
<td>12%</td>
<td>Based on average of all other groups.</td>
</tr>
</tbody>
</table>
FIGURE 5: GREENHOUSE CONTRIBUTIONS ALONG SUPPLY CHAIN OF FRUIT PRODUCTS – FOR AVERAGE WEEKLY CONSUMPTION OF FRUIT
2.6 Fresh Vegetables

2.6.1 What is important about this product group?
The considerations that are important to the fresh vegetables product group include the wholesale trade process, application of basic chemicals on-farm, agricultural services provided to farms, and road freight and transport. Factors that affect the impact of individual products include seasonality, location of the main production areas in Australia, and total distance travelled from farm gate to shop. Some products have an imported component, and so the country of origin and method of transportation are important additional factors. The percentage of products that are grown using organic methods rather than conventional farming methods is factored into the calculation.

2.6.2 Assumptions used in the calculator
The approach used in the fruit section was also used for vegetables with a process-based LCA conducted on key representatives of each group, which was used to modify the input-output table. Also, data on in-season and out-of-season impacts was added.

2.6.3 Summary Table – Fresh Vegetable Counter

<table>
<thead>
<tr>
<th>Product</th>
<th>Impact kg CO₂ e per consumer dollar</th>
<th>Average percentage of vegetable counter expenditure</th>
<th>Assumptions/ Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes</td>
<td>0.537</td>
<td>15%</td>
<td>Based on input-output sector for vegetables, modified by process data for potatoes.</td>
</tr>
<tr>
<td>Onions</td>
<td>0.292</td>
<td>6%</td>
<td>Based on input-output sector for vegetables, modified by process data for onions.</td>
</tr>
<tr>
<td>Other fresh root vegetables</td>
<td>0.360</td>
<td>9%</td>
<td>Based on input-output sector for vegetables, modified by process data for pumpkin.</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>0.245</td>
<td>13%</td>
<td>Based on input-output sector for vegetables, modified by process data for tomatoes.</td>
</tr>
<tr>
<td>Fresh flower vegetables (broccoli, cauliflower etc)</td>
<td>0.317</td>
<td>6%</td>
<td>Based on input-output sector for vegetables, modified by process data for broccoli.</td>
</tr>
<tr>
<td>Fresh leaf vegetables (spinach, lettuce etc)</td>
<td>0.248</td>
<td>11%</td>
<td>Based on input-output sector for vegetables, modified by process data for leafy greens</td>
</tr>
<tr>
<td>Other</td>
<td>0.348</td>
<td>13%</td>
<td>Weighted average of other vegetables.</td>
</tr>
</tbody>
</table>
2.7 OTHER FRUIT AND VEGETABLES

Other fruit and vegetables refer to fruit and vegetables other than fresh products. This includes canned, frozen, dehydrated and otherwise processed fruit and vegetables.

2.7.1 WHAT IS IMPORTANT ABOUT THIS PRODUCT GROUP?

Non-fresh fruit and vegetables have higher impacts per dollar than fresh fruit and vegetables (about 5% of total impacts), with the main impacts arising from packaging, wholesaling, and energy used in processing.

2.7.2 ASSUMPTIONS USED IN THE CALCULATOR

Fruit products, canned and bottled, have been modelled based on the average fruit production with a greater use of steel and glass used in packaging and less use of paper. Dried fruit is based on fruit products, with increased use of paperboard and less use of glass and steel in packaging. Frozen vegetable have increased use of electricity and less use of steel and glass. Other products are an average of the first three.

2.7.3 RESULTS

Figure 7 shows cumulative greenhouse contributions for sectors and processes required to produce the average weekly consumption of other fruit and vegetables. The main impacts of these products are in meat products mixed with them, packaging, legumes, and fruit and vegetable products. As usual, electricity, gas and wholesale trade add significant impacts to the group.

FIGURE 7: GREENHOUSE CONTRIBUTIONS ALONG SUPPLY CHAIN OF OTHER FRUIT AND VEGETABLE PRODUCTS – FOR AVERAGE WEEKLY CONSUMPTION OF OTHER FRUIT AND VEGETABLE PRODUCTS
2.7.4 **SUMMARY TABLE – OTHER FRUIT AND VEGETABLE COUNTER**

<table>
<thead>
<tr>
<th>Product</th>
<th>Impact kg CO₂ e per consumer dollar</th>
<th>Average dollars spent per week</th>
<th>Assumptions/ Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tinned and bottled fruit</td>
<td>0.398</td>
<td>$0.95</td>
<td>Based on tinned peaches using input-output sector for fruit products adjusted for increased use of steel packaging.</td>
</tr>
<tr>
<td>Dried fruit</td>
<td>0.359</td>
<td>$1.80</td>
<td>Based on sultanas using input-output sector for fruit products adjusted for increased use of paper packaging.</td>
</tr>
<tr>
<td>Frozen vegetables</td>
<td>0.28</td>
<td>$1.24</td>
<td>Based on input-output sector for vegetable products.</td>
</tr>
<tr>
<td>Other (dried vegetables etc.)</td>
<td>0.28</td>
<td>$1.59</td>
<td>Based on input-output sector for vegetable products.</td>
</tr>
</tbody>
</table>

2.8 **FLOUR, RICE, PASTA, CEREALS, GRAINS, PULSES, NUTS AND EGGS**

This group includes dry goods, which are predominantly crop-based cereals and grains manufactured into different products.

2.8.1 **WHAT IS IMPORTANT ABOUT THIS PRODUCT GROUP?**

This group of products make up a majority of the starch input to our diets and therefore constitute a significant proportion of our food expenditure and consumption.

2.8.2 **ASSUMPTIONS USED IN THE CALCULATOR**

Flours, rice, pasta, breakfast cereals and legumes are all taken from the hybrid input-output model, as they are disaggregated into these product groups with the exception of nuts. There was no specific data available for nuts in the input-output model. Stone fruit uses a similar cropping system, so stone fruit was used as a proxy for nuts.

2.8.3 **SUMMARY TABLE – FLOUR, RICE, PASTA, CEREALS, GRAINS, PULSES, NUTS AND EGGS**

<table>
<thead>
<tr>
<th>Product</th>
<th>Impact kg CO₂ e per consumer dollar</th>
<th>Average dollars spent per week</th>
<th>Assumptions/ Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flours</td>
<td>0.655</td>
<td>$4.74</td>
<td>Based directly on hybrid input-output sector for flour mill products.</td>
</tr>
<tr>
<td>Rice</td>
<td>1.29</td>
<td>$0.56</td>
<td>Based directly on hybrid input-output sector for rice.</td>
</tr>
<tr>
<td>Pasta</td>
<td>0.483</td>
<td>$1.14</td>
<td>Based directly on hybrid input-output sector for pasta.</td>
</tr>
<tr>
<td>Breakfast cereals</td>
<td>0.632</td>
<td>$2.63</td>
<td>Based directly on hybrid input-output sector for breakfast cereal.</td>
</tr>
<tr>
<td>Raw grains, beans,</td>
<td>1.89</td>
<td>$1.00</td>
<td>Based directly on hybrid input-output sector for lentils.</td>
</tr>
<tr>
<td>Item</td>
<td>Quantity</td>
<td>Price</td>
<td>Note</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>--------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>Nuts</td>
<td>1.6</td>
<td>$1.19</td>
<td>Based on stone fruit due to similarity in tree structure.</td>
</tr>
<tr>
<td>Eggs</td>
<td>0.156</td>
<td>$1.35</td>
<td>Based directly on hybrid input-output sector for eggs.</td>
</tr>
</tbody>
</table>
FIGURE 8: GREENHOUSE CONTRIBUTIONS ALONG SUPPLY CHAIN OF PROCESSED FOODS – FOR AVERAGE WEEKLY CONSUMPTION OF FLOUR AND GRAIN PRODUCTS
2.8.4 RESULTS
The results show that for these products the on-farm inputs represent a greater proportion of impacts than for other crop-based items. This is possible due to the simplicity of a number of these products that require minimal processing (rice, flours, legumes, rolled oats and wheat, grains and so on).

2.9 PROCESSED FOODS, CONFECTIONARY, CONDIMENTS, ETC
This product group contains sweet foods, spices and sauces, food additives, and canned spaghetti. Because of the generality and diversity of products in this group and their relatively small contribution to the overall footprint, the modelling of these products has been very generalised.

2.9.1 WHAT IS IMPORTANT ABOUT THIS PRODUCT GROUP?
These products will involve significant processing and contain a wide variety of ingredients in small quantities. It is this complexity and diversity which make it important to capture the range of product inputs. This is exactly the value of the input-output model which includes over 400 different sector inputs.

2.9.2 ASSUMPTIONS USED IN THE CALCULATOR
Sugar is modelled directly from the sugar production sector. Jams, honeys, syrups, chocolates and other confectionary are modelled from the confectionary products sector, while the remaining products are modelled from the other products sector.

2.9.3 RESULTS
Figure 9 shows the contribution to impacts of confectionary arising from the dairy and sugar industries. The major energy inputs are electricity and gas used for production of these products. The food products sector, which is used for spices, sauces and tinned spaghetti, have inputs from meat and grains, energy inputs, and wholesaling and freight impacts, as many of these products travel significant distance to market.
FIGURE 9: GREENHOUSE CONTRIBUTIONS ALONG SUPPLY CHAIN OF PROCESSED FOODS — FOR AVERAGE WEEKLY CONSUMPTION OF PROCESSED FOODS
2.9.4 Summary Table – Processed foods, Confectionary and Condiments COUNTER

<table>
<thead>
<tr>
<th>Product</th>
<th>Impact kg CO₂ e per consumer dollar</th>
<th>Average dollars spent per week</th>
<th>Assumptions/ Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar</td>
<td>0.461</td>
<td>$0.42</td>
<td>Based on input-output sector - sugar production.</td>
</tr>
<tr>
<td>Jams and sweets</td>
<td>0.276</td>
<td>$0.39</td>
<td>Based on input-output sector, - confectionary.</td>
</tr>
<tr>
<td>Honey and syrups</td>
<td>0.276</td>
<td>$0.43</td>
<td>Based on input-output sector – confectionary.</td>
</tr>
<tr>
<td>Desserts</td>
<td>0.465</td>
<td>$0.39</td>
<td>Based on input-output sector – food products.</td>
</tr>
<tr>
<td>Crisps and savoury confectionary</td>
<td>0.276</td>
<td>$2.25</td>
<td>Based on input-output sector – food products.</td>
</tr>
<tr>
<td>Chocolate</td>
<td>0.276</td>
<td>$3.98</td>
<td>Based on input-output sector – confectionary.</td>
</tr>
<tr>
<td>Other sweet confectionary</td>
<td>0.465</td>
<td>$6.10</td>
<td>Based on input-output sector – confectionary.</td>
</tr>
<tr>
<td>Spices, sauces and food additives</td>
<td>0.465</td>
<td>$4.36</td>
<td>Based on input-output sector – food products.</td>
</tr>
<tr>
<td>Canned spaghetti and baked beans</td>
<td>0.465</td>
<td>$0.41</td>
<td>Based on input-output sector – food products.</td>
</tr>
<tr>
<td>Packaged prepared meals</td>
<td>0.465</td>
<td>$4.48</td>
<td>Based on input-output sector – food products.</td>
</tr>
</tbody>
</table>

2.10 Non-alcoholic beverages

2.10.1 What is important about this product group?
Non-alcoholic beverages include cordial, juices, soft drink, tea and coffee. A substantial part of this industry is actually based around packaging and marketing rather than the beverages themselves, as the ingredients such as water, sweetened water and carbonated water are often minor.

2.10.2 Assumptions used in the calculator
The input-output data for soft drinks includes substantial purchases from the hotels and accommodation sector. This sector has high impacts from beef and other meat inputs, but this is considered an anomaly as purchases from the hotel sector are more likely to be drinks than food, so the meat input to hotels has been removed for this sector. Fruit juice has been treated as a fruit product, while for tea and coffee no sector data was available that was specific enough. Given the fact that much tea and coffee is imported, data from the USA input-output table for tea and coffee was used.

2.10.3 Results
Figure 10 shows high impacts for coffee and tea relative to its expenditure. Soft drink and fruit juice production are made up of sugar, and steel and glass products. The
impacts of fruit juice are also dominated by packaging, sugar, and fruit impacts. Coffee and tea impacts are taken from the USA input-output table. The major inputs here are from fruit production (assumed to be coffee beans) into coffee roasting as shown.
FIGURE 10 GREENHOUSE CONTRIBUTIONS ALONG SUPPLY CHAIN OF NON ALCOHOLIC DRINKS – FOR AVERAGE WEEKLY CONSUMPTION OF PROCESSED FOODS.
### 2.10.4 Summary Table – Non-Alcoholic Beverages Counter

<table>
<thead>
<tr>
<th>Product</th>
<th>Impact kg CO₂ e per consumer dollar</th>
<th>Average percentage of non alcoholic beverages expenditure</th>
<th>Assumptions/ Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft drinks, cordial</td>
<td>0.385</td>
<td>55%</td>
<td>Based on Australian input-output data for soft drinks but with adjustments to the hotel sector to remove beef inputs as this was considered an anomaly because purchases from the hotel sector are more likely to be drink-related.</td>
</tr>
<tr>
<td>Fruit juice</td>
<td>0.439</td>
<td>26%</td>
<td>Based on Australian input-output process for fruit products.</td>
</tr>
<tr>
<td>Tea and coffee</td>
<td>1.25</td>
<td>20%</td>
<td>Based on tea and coffee from USA input-output sector as no specific data is available in the Australian input-output sector.</td>
</tr>
</tbody>
</table>

### 2.11 Alcoholic Beverages

#### 2.11.1 What is Important about this Product Group?

Alcoholic beverages are analysed in two sections: one for take-away purchase and another for consumption on licensed premises. The only reason for doing this is that the difference in prices paid in these two sections affect the impacts per dollar of expenditure.

Alcohol is similar to other beverages with substantial inputs of packaging and marketing. However, there is also a substantial production process behind most alcoholic beverages, with alcohol always being produced through the fermentation of a grain or fruit and, in the case of spirits, distilled to concentrate the alcohol.

#### 2.11.2 Assumptions Used in the Calculator

The input-output data for soft drinks includes substantial purchases from the hotels and accommodation sector. This sector has high impacts from beef and other meat inputs but this is considered an anomaly as purchases from the hotel sector are more likely to be drinks than food, so the meat input to hotels has been removed for this sector. Fruit juice has been treated as a fruit product. There was no sector data available that was specific enough for tea and coffee. Given the fact that much tea and coffee is imported, data from the USA input-output table for tea and coffee was used.

#### 2.11.3 Results

Figure 10 shows high impacts of coffee and tea relative to its expenditure. Soft drink and fruit juice production are made up of sugar, and steel and glass products. The impacts of fruit juice are also dominated by packaging, sugar and fruit impacts. Coffee and tea impacts are taken from the USA input-output table. The major inputs here are from fruit production (assumed to be coffee beans) into coffee roasting as shown.
FIGURE 11: NETWORK DIAGRAM SHOWING THE GREENHOUSE GAS IMPACT OF 1 WEEK'S AVERAGE PURCHASES OF ALCOHOLIC BEVERAGES

- Mixed drinks consumption price: $0.167
- Oats, sorghum, and other cereal grains: 11.4%
- Barley: 24.5%
- Rice: 4.67%
- Grapes for wine: 3.57%
- Natural gas: 6.36%
- Paper containers: 4.14%
- Glass products: 3.32%
- Iron and steel semi-manufactures: 3.97%
- Sheet metal products: 5.84%
- Electricity supply: 29.9%
- Wholesale trade: 3.93%
- Road freight: 4.34%
- Hotels, clubs, restaurants, and cafes - no meat: 5.71%
- Soft drinks: 4.24%

- Beer and malt: 60.8%
- Wine: 14.1%
- Wine, consumption price: 13.6%
- Beer and malt, consumption price: 60.7%
- Spirits: 21.5%
- Spirits, consumption price: 11.5%

Total: 100%
2.11.4 Summary Table – Alcoholic Beverages Take-away Counter

<table>
<thead>
<tr>
<th>Product</th>
<th>Impact kg CO₂ e per consumer dollar</th>
<th>Average percentage of non alcoholic beverages expenditure</th>
<th>Assumptions/ Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beer</td>
<td>0.364</td>
<td>39%</td>
<td>Based on input-output sector for beer and malt.</td>
</tr>
<tr>
<td>Wine</td>
<td>0.123</td>
<td>38%</td>
<td>Based on input-output sector for wine.</td>
</tr>
<tr>
<td>Spirits</td>
<td>0.329</td>
<td>23%</td>
<td>Based on input-output sector for spirits.</td>
</tr>
<tr>
<td>Other (pre-mixed etc)</td>
<td>0.245</td>
<td>1%</td>
<td>Based on input-output sector for spirits and soft drinks.</td>
</tr>
</tbody>
</table>

2.11.5 Summary Table – Alcoholic Beverages Consumed on Premises Counter

<table>
<thead>
<tr>
<th>Product</th>
<th>Impact kg CO₂ e per consumer dollar</th>
<th>Average percentage of non alcoholic beverages expenditure</th>
<th>Assumptions/ Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beer</td>
<td>0.182</td>
<td>64%</td>
<td>Based on input-output sector for beer and malt.</td>
</tr>
<tr>
<td>Wine</td>
<td>0.0615</td>
<td>17%</td>
<td>Based on input-output sector for wine.</td>
</tr>
<tr>
<td>Spirits</td>
<td>0.1645</td>
<td>19%</td>
<td>Based on input-output sector for spirits.</td>
</tr>
<tr>
<td>Other (pre-mixed etc)</td>
<td>0.1225</td>
<td>0%</td>
<td>Based on input-output sector for spirits and soft drinks.</td>
</tr>
</tbody>
</table>

2.12 Other Products

2.12.1 What is important about this product group?

This product group contains consumable non-food products generally purchased at supermarkets. As the Calculator is focused on food materials, these other consumer products are broadly grouped together into four product groups: personal care, cleaning products, stationery, and pet food products.

Personal care products, cleaners and stationery all contain a mix of chemicals and plastics used largely in packaging, with stationery containing a significant amount of paper products. As they are highly manufactured products, energy, transport and wholesaling impacts are significant.
2.12.2 Assumptions Used in the Calculator

Each product group here had a unique input-output sector for its production, which was used without any modification despite the fact that some of the sectors are significantly broader than our product groups. For example, household cleaning products are represented by adhesives, inks, polishers, explosives and cleaners.
FIGURE 12 NETWORK DIAGRAM SHOWING THE GREENHOUSE GAS IMPACT OF 1 WEEKS AVERAGE PURCHASES OF OTHER PRODUCTS

1 Weeks Other products - per week
100%

- Food grains
  - 8.89% 0.903 USD
- Feed grains
  - 6.84% 1.44 USD
- Oil bearing crops
  - 9.85% 1.03 USD
- Soybean oil mills
  - 6.23% 0.896 USD
- Animal and marine fats and oils
  - 3.63% 0.3 USD
- Blast furnaces and steel mills
  - 1.84% 0.626 USD
- Metal cans
  - 2.33% 0.824 USD
- Trucking and courier services, except air
  - 1.74% 0.34 USD
- Electric services (utilities)
  - 6.15% 2.39 USD
- Advertising
  - 1.78% 0.179 A$
- Softwoods, conifers
  - 7.96% 0.0271 A$
- Forestry and services to forestry
  - 4.36% 2.85 A$
- Pulp, paper and paperboard
  - 19.4% 9.3 A$
- Printing, stationery and services to printing
  - 26.3% 2.23 A$
- Basic chemicals
  - 10.7% 2.11 A$
- Adhesives, inks, polishes, explosives and other chemical
  - 5.19% 0.678 A$
- Plastic products
  - 1.86% 0.78 A$
- Electricity supply
  - 14.4% 2.94 A$
- Wholesale trade
  - 2.91% 16.7 A$
- Hairdressing, goods hiring, film processing, laundry
  - 20.9% 17.9 A$
- Printing, stationery and services to printing
  - 25.1% 3.8 A$
- Adhesives, inks, polishes, explosives and other chemical
  - 3.65% 21.8 A$
- Dog and cat food
  - 50.4% 11.7 A$

- Metal cans
  - 2.33% 0.824 USD
2.12.3 Results
The results are shown in Figure 12 for a week’s consumption of other products. Chemicals, plastics and paper are three dominant sectors, and as usual electricity and wholesale trade impacts contribute significantly to these product groups. The pet food data was taken from an entirely different data source, and predictably its impacts are from ingredients to pet food (grains, soy meal and meat products) and the packaging and transportation requirements for these products.

2.12.4 Summary Table – Other Products Counter

<table>
<thead>
<tr>
<th>Product</th>
<th>Impact kg CO₂ e per consumer dollar</th>
<th>Average dollars spent per week</th>
<th>Assumptions/ Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal care products (hair care, dental products, fragrances and toiletries, etc)</td>
<td>0.277</td>
<td>$8.00</td>
<td>Based on input-output sector for personal care products.</td>
</tr>
<tr>
<td>Household cleaning products</td>
<td>0.281</td>
<td>$2.00</td>
<td>Based on input-output sector for adhesives, inks, polishers, explosives and cleaners.</td>
</tr>
<tr>
<td>Stationery</td>
<td>0.45</td>
<td>$3.00</td>
<td>Based on input-output sector for stationery and printing.</td>
</tr>
<tr>
<td>Pet products (pet food, etc)</td>
<td>1.13</td>
<td>$4.00</td>
<td>Based on input-output sector for animal food.</td>
</tr>
</tbody>
</table>

2.13 Take-away Food and Dining Out

2.13.1 What is Important about this Product Group?
Take-away food and dining out impacts arise from the type of food used and also any wastage at the restaurant, the restaurant’s running costs such as electricity and gas, and maintenance of the property (cleaning and maintenance etc).

2.13.2 Assumptions Used in the Calculator
Both take-away food and dining out are assumed to be from the same sector – hotels, cafes and restaurants. However, expenditure on take-away food is assumed to consume more product per dollar than dining out, given that the equivalent take-away food is cheaper than food consumed while dining out. No specific data was found, so take-away food was assumed to be 10% cheaper than the average for the sector while food consumed while dining out was taken to be 10% more expensive than the average for the sector.

2.13.3 Results
Food inputs dominate the results for this product group, possibly because we eat more meat when dining out but mostly because within average food consumption meat
products have a higher impact than other components of the diet. Electricity and gas also have an impact due in part to cooking but also heating and cooling of premises.
FIGURE 13 NETWORK DIAGRAM SHOWING THE GREENHOUSE GAS IMPACT OF 1 WEEKS AVERAGE PURCHASES OF OTHER PRODUCTS
2.13.4 Summary Table – Take-away Food and Dining Out

<table>
<thead>
<tr>
<th>Product</th>
<th>Impact kg CO₂ e per consumer dollar</th>
<th>Average dollars spent per week</th>
<th>Assumptions/ Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Take-away food</td>
<td>0.761</td>
<td>$8.00</td>
<td>Based on input-output sector for cafes and restaurants adjusted for cheaper prices of takeaway food.</td>
</tr>
<tr>
<td>Dining out</td>
<td>0.623</td>
<td>$2.00</td>
<td>Based on input-output sector for cafes and restaurants adjusted for higher prices when dining out.</td>
</tr>
</tbody>
</table>

2.14 Occasional and Special Purchases (Consumer Goods)

2.14.1 What is Important About This Product Group?
Durable goods have made up a significant part of our overall footprint as they contain valuable high impact materials and the manufacturing impacts are also significant.

2.14.2 Assumptions Used in the Calculator
There was a good match between the product groups and input-output sectors for these products because they are large groups of products which represent both a large part of our consumption and a significant part of Australia’s production of goods. No transformations were made for this data.

2.14.3 Results
Figure 14 shows a process network showing a typical year’s consumption of durable goods. Clothing impacts are dominated by wool products due to the high emissions of methane from sheep used to produce wool. Products such as electronics and household appliances have emissions largely derived from materials such as steel, plastic and precious metals. Freight and wholesaling and of course electricity input to manufacturing and other processes contribute significantly to all these products.
FIGURE 14 NETWORK DIAGRAM SHOWING THE GREENHOUSE GAS IMPACT OF 1 YEAR'S AVERAGE PURCHASES OF DURABLE GOODS
2.14.4 Summary Table – Consumer Goods

<table>
<thead>
<tr>
<th>Product</th>
<th>Impact kg CO$_2$ e per consumer dollar</th>
<th>Average dollars spent per week</th>
<th>Assumptions/ Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clothing</td>
<td>0.135</td>
<td>$400.00</td>
<td>Based on input-output sector for clothing.</td>
</tr>
<tr>
<td>Footwear</td>
<td>0.157</td>
<td>$400.00</td>
<td>Based on input-output sector for footwear.</td>
</tr>
<tr>
<td>Consumer electronics</td>
<td>0.332</td>
<td>$400.00</td>
<td>Based on input-output sector for household electrical appliances.</td>
</tr>
<tr>
<td>Household appliances</td>
<td>0.232</td>
<td>$300.00</td>
<td>Based on input-output sector for household appliances.</td>
</tr>
<tr>
<td>Kitchenware</td>
<td>0.3</td>
<td>$100.00</td>
<td>Based on input-output sector for ceramic products.</td>
</tr>
<tr>
<td>Furniture</td>
<td>0.168</td>
<td>$500.00</td>
<td>Based on input-output sector for furniture.</td>
</tr>
<tr>
<td>Other consumer goods</td>
<td>0.22</td>
<td>$500.00</td>
<td>Average of all above products.</td>
</tr>
</tbody>
</table>

3 Shopping Bags

Shopping bags are an important icon of the environmental impact of our shopping behaviour. The use of recyclable bags or reusable bags reduces the environmental impacts of shopping while degradable bags can reduce the impacts of the litter stream, and they can also have a small impact on greenhouse gas emissions compared with conventional polymers. ‘Green bags’ (non-woven polypropylene bags), available at most supermarkets, represent the best options when bags need to be used. The direct transfer of goods into a durable shopping jeep is assumed to have negligible impact.

3.1.1 Summary Table – Shopping Bags

<table>
<thead>
<tr>
<th>Product</th>
<th>kg CO$_2$ per year - 100% factors</th>
<th>Source, comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Normal’ shopping bags (single use hdpe)</td>
<td>16.1</td>
<td>From DEH LCA study on shopping bag options</td>
</tr>
<tr>
<td>Biodegradable shopping bags</td>
<td>13.9</td>
<td>From DEH LCA study on shopping bag options</td>
</tr>
<tr>
<td>Paper bags (single use)</td>
<td>24.8</td>
<td>From DEH LCA study on shopping bag options</td>
</tr>
<tr>
<td>Reused single use bags</td>
<td>8.05</td>
<td>From DEH LCA study on shopping bag options</td>
</tr>
<tr>
<td>‘Green bags’</td>
<td>1.68</td>
<td>From DEH LCA study on shopping bag options</td>
</tr>
<tr>
<td>Cloth/ calico bags</td>
<td>3.6</td>
<td>From DEH LCA study on shopping bag options</td>
</tr>
</tbody>
</table>
Shopper’s own basket, shopping jeep, pockets, arms, etc | 0 | Assumed to be negligible

4 AFTER USE

4.1 ORGANIC WASTE

4.1.1 WHAT IS IMPORTANT ABOUT THIS PRODUCT GROUP?

The wastage of food is a major issue and opportunity for improving our environmental performance in relation to food and groceries. The impacts of food waste are represented in the Calculator through the purchases of additional food, above that which is actually consumed. Secondly, there are impacts of food waste in the disposal stage, although disposal is not necessarily an environmental negative. The use of food in composting helps fix additional carbon to soils and has the potential to offset the production of fertilizers. Landfilling of organic waste can lead to the production of methane emissions which can either be captured and used for power generation or, where not captured, are a potent greenhouse gas. In most cases, it is a balance between these two outcomes, with 30-70% of methane typically being captured in landfill. At 30%, the disposal of organic waste is a net negative, while at 70% capture the disposal can be a net positive.

4.1.2 ASSUMPTIONS USED IN THE CALCULATOR

The Calculator asks for a percentage of food discarded prior to cooking and after cooking. These two percentages are applied to the mass of food which is brought into the household, which is reverse calculated from food expenditures and assumptions about the price per kg of each product.

The disposal pathways for food waste are specified by the user, with any unspecified amount being assumed to go to landfill. Capture of methane from degrading organic waste at landfill is taken to be 55%, which is a typical assumption for Victorian landfills.

The results for composting are taken from a study of organic waste at landfill undertaken for Sustainability Victoria. Composting data assumed that 10% of the residual carbon in compost is retained in the soil profile when it is used. Commercial and home composting are treated the same here, although in reality home composting has a much more variable outcome due to variations in composting practice.

4.1.3 RESULTS

Feeding scraps to pets leads to the best outcome because the avoided pet food impacts are substantial as they generally contain meat and other cereals. Of course, if you don’t have a pet and acquire one to eat your scraps, you go backwards from a greenhouse perspective as your total impacts increase with the purchase of supplementary food in the pet food section.
Composting gives a small greenhouse benefit (0.036 kg CO$_2$ e per kg food waste composted) with most of the carbon dioxide from the organic material being released to the environment through aerobic decomposition. Landfilling of organic waste generates significant impacts (0.164 kg CO$_2$ e per kg food waste landfilled) even after accounting for landfill gas capture and power generation.

### 4.1.4 Summary of Food Waste

<table>
<thead>
<tr>
<th>Food disposal</th>
<th>Defaults</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of food per household</td>
<td>250</td>
<td>Reverse calculated from expense</td>
</tr>
<tr>
<td>Fraction disposed prior to eating</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>Fraction disposed from plate</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Mass disposed</td>
<td>75</td>
<td></td>
</tr>
</tbody>
</table>

### 4.1.5 Summary of Greenhouse Impacts from Food Waste Disposal

<table>
<thead>
<tr>
<th>Food disposal</th>
<th>kg CO$_2$ e per kg disposed</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compost</td>
<td>-0.036</td>
<td>Based on updated data from Grant, James et al 2003 using enclosed composting of food waste.</td>
</tr>
<tr>
<td>Feed to pets</td>
<td>-0.452</td>
<td>Based on offsetting impacts of animal feel.</td>
</tr>
<tr>
<td>Dispose to garbage</td>
<td>0.164</td>
<td>Based on NGA emission factors.</td>
</tr>
<tr>
<td>Dispose in council green waste or food waste collection</td>
<td>-0.036</td>
<td>Based on updated data from Grant, James et al 2003 using enclosed composting of food waste.</td>
</tr>
</tbody>
</table>

### 4.2 Packaging

#### 4.2.1 What is Important about This Product Group?
Recycling of packaging materials has been a major success story in Australia, with high recycling rates for packaging materials from households. This is important for reducing waste to landfill and has a moderate benefit for overall greenhouse gas emissions from households.

#### 4.2.2 Assumptions Used in the Calculator
The Calculator estimates the packaging associated with each food commodity based on typical packaging materials which are associated with each food and product group. One average recycling value for packaging materials is used and is applied to each of the material streams calculated from the food purchased.

Landfilling of packaging goods mainly represents a loss of recycling opportunities, while the greenhouse impact of landfilling these materials is relatively small, except for paper products which have the potential to degrade in landfill and produce methane, a potent greenhouse gas.

#### 4.2.3 Results
Recycling benefits vary for each material as shown in the following table.

### 4.2.4 Greenhouse Gas Impacts for Waste Disposal - kg CO₂E per kg Disposed

<table>
<thead>
<tr>
<th>Material</th>
<th>Recycling GHG EF</th>
<th>Landfill GHG EF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass waste</td>
<td>-0.488</td>
<td>0.00383</td>
</tr>
<tr>
<td>Steel waste</td>
<td>-0.555</td>
<td>0.00383</td>
</tr>
<tr>
<td>Aluminium waste</td>
<td>-17.3</td>
<td>0.00412</td>
</tr>
<tr>
<td>Paper waste</td>
<td>0.169</td>
<td>0.00798</td>
</tr>
<tr>
<td>Plastic (recyclable) waste</td>
<td>-0.105</td>
<td>0.00383</td>
</tr>
<tr>
<td>Plastic (non-recyclable) waste</td>
<td>na</td>
<td>0.00383</td>
</tr>
</tbody>
</table>

(Grant, James et al. 2003)

### 4.3 Durable Waste

#### 4.3.1 What is Important About This Product Group?

Reuse and recovery of materials from durable products is an important strategy for dealing in part with our impacts of consumption. It is difficult to determine exact behaviours here as the timeframe between the purchase, use, storage and final disposal of a product can take many years. Durable goods are often stored for a long time after they cease to be of use.

#### 4.3.2 Assumptions Used in the Calculator

The Calculator asks for a percentage of products reused and recycled. These two percentages are applied to the mass of products which is brought into the household, which is then reverse calculated from product expenditures and assumptions about the price per kg of each product.

For recycling, only the typical steel content is considered as this is the most commonly recovered material from durable products and steel recycling has significant benefits.

Reselling of products has the potential to compete with the purchase of new products, or at least defer their purchase. For this reason, reselling is awarded a credit equal to 25% of the original full production impact. This is based loosely on the prices of secondhand goods, being 25-50% of new products.

Landfilling durable goods mainly represents a loss of recycling and reuse opportunities, while the impact of landfilling these products is relatively small in comparison to other impacts.

#### 4.3.3 Results

Recycling benefits vary for each product category depending on assumptions about the steel content in each product group. Reuse is simply a fraction of the original product purchase impact and is applied evenly to all durable goods.
### 4.3.4 Summary of Greenhouse Impacts from Durable Waste Disposal

<table>
<thead>
<tr>
<th>Durables</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recycling benefit</td>
<td>-0.55 kg CO₂/kg steel content product based on recovery of steel as the major recovered material from appliances.</td>
</tr>
<tr>
<td>Dispose to garbage</td>
<td>0.001 kg CO₂/kg disposed - based on transport impact to landfill.</td>
</tr>
<tr>
<td>Resold</td>
<td>0.5% of impact of total durables purchased is subtracted for each percent of reselling of durables.</td>
</tr>
</tbody>
</table>
## 5 Appendix A - Fruit and Vegetable Seasonality

<table>
<thead>
<tr>
<th>Fruit and Vegetable Category</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Potatoes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Brushed/Regalo</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>White/Desiree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Beans, French and runner; peas, green or blue</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Phase</td>
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<tr>
<td>Broad</td>
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<td></td>
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<tr>
<td>Green</td>
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<tr>
<td>Snowpea</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Cabbages, Brussels sprouts, cauliflowers and headed broccoli</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Chinese/Mom Belc</td>
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</tr>
<tr>
<td>Broccoli</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Cabbage</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pak Choi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red Cabbage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cauliflowers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brussels Sprouts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Carrots</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td>Carrots</td>
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<td><strong>Lettuces</strong></td>
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<td>Cherry Tomatoes</td>
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<td><strong>Mushroom spawn and vegetables for seed</strong></td>
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<td><strong>Other vegetables (incl. melons, fresh or chilled</strong></td>
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<td><strong>Grapes - table</strong></td>
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<td><strong>Apples - fresh and sun-dried</strong></td>
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<td><strong>Pears and quinces - fresh and sun-dried</strong></td>
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<td><strong>Stone fruit - fresh and sun-dried</strong></td>
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<td><strong>Kiwi fruit</strong></td>
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<td><strong>Bananas - fresh and sun-dried</strong></td>
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<td><strong>Pineapples - fresh and sun-dried</strong></td>
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<td><strong>Citrus fruit - fresh and sun-dried</strong></td>
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<td><strong>Orchard fruit nec - fresh and sun-dried</strong></td>
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<tr>
<td><strong>Almonds and macadamias</strong></td>
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<tr>
<td><strong>Edible nuts nec, Berries and small fruit nec - fresh and sun-dried</strong></td>
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*In Season (ideal)*
# APPENDIX B

<table>
<thead>
<tr>
<th>Product</th>
<th>Cost per kg budget</th>
<th>Cost per kg average</th>
<th>Cost per kg premium</th>
<th>Assumptions/ Comments</th>
<th>Discount multiplier</th>
<th>Premium multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef and veal</td>
<td>$7.00</td>
<td>$17.00</td>
<td>$32.00</td>
<td>Main impact on price is quality of cut, and thus categories differentiate by type of cut. (Australian beef, allocation of meats production on price. Average of Australian beef production including export beef.)</td>
<td>1.42</td>
<td>0.69</td>
</tr>
<tr>
<td>Lamb</td>
<td>$12.00</td>
<td>$23.00</td>
<td>$36.00</td>
<td>Main impact on price is quality of cut, and thus categories differentiate by type of cut. May need to consider quantity as there is some discounting for volume. (Economic allocation of lamb co products)</td>
<td>1.31</td>
<td>0.78</td>
</tr>
<tr>
<td>Pork (other than bacon or ham)</td>
<td>$8.50</td>
<td>$15.00</td>
<td>$23.00</td>
<td>Main impact on price is quality of cut, and thus categories differentiate by type of cut. (Economic allocation of co products)</td>
<td>1.28</td>
<td>0.79</td>
</tr>
<tr>
<td>Poultry</td>
<td>$4.50</td>
<td>$11.00</td>
<td>$16.00</td>
<td>Main impact on price is quality of portion. There is also a price reduction for buying larger quantity</td>
<td>1.42</td>
<td>0.81</td>
</tr>
<tr>
<td>Kangaroo</td>
<td>$8.00</td>
<td>$15.00</td>
<td>$19.00</td>
<td>Based on meat processing</td>
<td>1.30</td>
<td>0.88</td>
</tr>
<tr>
<td>Rabbit</td>
<td>$25.00</td>
<td>$25.00</td>
<td>$25.00</td>
<td>(Not available via Coles online – Tim's data here) based on poultry impacts as similar sized animal eating similar food.</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Processed meats (ham, bacon, sausages etc.)</td>
<td>$12.00</td>
<td>$18.00</td>
<td>$35.00</td>
<td>Budget is for basic sausages. All processed and preserved meats start at average price. (Based on average meat products but dominated by pork with small amount of beef.)</td>
<td>1.20</td>
<td>0.68</td>
</tr>
<tr>
<td>Fresh (local)</td>
<td>$9.00</td>
<td>$15.00</td>
<td>$30.00</td>
<td>Some discount for larger quantity purchases. Main price difference on type of fish. Not clear there is a price differential for imported fish types. (Australian beef, allocation of meats production on price. Average of Australian beef production including export beef.)</td>
<td>1.25</td>
<td>0.67</td>
</tr>
<tr>
<td>Fresh (imported from overseas)</td>
<td>$9.00</td>
<td>$15.00</td>
<td>$30.00</td>
<td>Same comments as for ‘Fresh Local’. In particular, some of the budget fish types are imported.</td>
<td>1.25</td>
<td>0.67</td>
</tr>
<tr>
<td>Frozen</td>
<td>$9.00</td>
<td>$15.00</td>
<td>$21.00</td>
<td>Variation estimated based on range of products</td>
<td>1.25</td>
<td>0.83</td>
</tr>
<tr>
<td>Canned and Bottled</td>
<td>$15.00</td>
<td>$20.00</td>
<td>$25.00</td>
<td>Most variation by package size rather than product type. That is red salmon (premium) versus generic tuna/sardines (budget) differences in price flow with package size above product 'premium-ness'. (Based on average meat products but dominated by pork with small amount of beef.)</td>
<td>1.14</td>
<td>0.89</td>
</tr>
<tr>
<td>Item</td>
<td>Budget</td>
<td>Average</td>
<td>Premium</td>
<td>Notes</td>
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<tr>
<td>Fresh Milk</td>
<td>$1.03</td>
<td>$2.00</td>
<td>$4.00</td>
<td>$1.03 for large package generic milk, $2.00 for branded milk, $4.00 for speciality/flavoured/small package. UHT very similar to fresh pricing.</td>
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</tr>
<tr>
<td>Fresh Cream</td>
<td>$4.10</td>
<td>$8.00</td>
<td>$11.50</td>
<td>‘No Name’ used for budget, ‘King Island’ used for premium.</td>
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</tr>
<tr>
<td>Cheese</td>
<td>$8.00</td>
<td>$15.00</td>
<td>$40.00</td>
<td>Estimate based on group of products</td>
<td></td>
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</tr>
<tr>
<td>Butter</td>
<td>$4.00</td>
<td>$9.50</td>
<td>$20.00</td>
<td>Lower the budget level to $4.00 to include generic margarine in budget category, and thus margarines into this category.</td>
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<tr>
<td>Yoghurt</td>
<td>$4.10</td>
<td>$8.00</td>
<td>$11.50</td>
<td>Estimate based on group of products</td>
<td></td>
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</tr>
<tr>
<td>Ice cream</td>
<td>$2.00</td>
<td>$4.00</td>
<td>$8.00</td>
<td>This ice cream category is for tubs. Stick and cone packaging covered in confectionary.</td>
<td></td>
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</tr>
<tr>
<td>Bread</td>
<td>$3.00</td>
<td>$5.00</td>
<td>$10.00</td>
<td>Loaves (including fruit breads) and flat breads only. Bread rolls, English muffins, crumpets etc and specialty styles, gluten free and other dietary breads in premium range</td>
<td></td>
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</tr>
<tr>
<td>Cakes</td>
<td>$5.00</td>
<td>$10.00</td>
<td>$15.00</td>
<td>Budget and average are reasonably defined product grouping. Premium is more difficult to quantify and includes a lot of small package products such as sweet muffins, biscuits etc.</td>
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</tr>
<tr>
<td>Citrus</td>
<td>$2.00</td>
<td>$4.00</td>
<td>$8.00</td>
<td>Bulk-packaged oranges are budget. There are no other budget citrus fruits unless in-season-surplus. Single items citrus are average price, including mandarins, grapefruit, single oranges. Premiums are exotic citrus types such as limes, and specialist grapefruits.</td>
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<tr>
<td>Stone fruit</td>
<td>$3.00</td>
<td>$8.00</td>
<td>$11.50</td>
<td>No stone fruits are listed at Coles Online at present. Tim's pricing at left.</td>
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</tr>
<tr>
<td>Apples and Pears</td>
<td>$3.30</td>
<td>$4.50</td>
<td>$6.00</td>
<td>Apples and nashi pears only. No pears available at Coles Online right now.</td>
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</tr>
<tr>
<td>Berries</td>
<td>$13.00</td>
<td>$25.00</td>
<td>$55.00</td>
<td>Seasonality is a major variant in price with freshness and quality being linked to this.</td>
<td></td>
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<tr>
<td>Grapes</td>
<td>$2.00</td>
<td>$4.00</td>
<td>$7.00</td>
<td>Estimate</td>
<td></td>
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</tr>
<tr>
<td>Melons</td>
<td>$2.00</td>
<td>$3.00</td>
<td>$5.00</td>
<td>Melons sold as whole or half on a per piece basis, not by weight. Watermelon estimate of weight given at Coles Online.</td>
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<tr>
<td>Tropical fruit</td>
<td>$3.00</td>
<td>$5.00</td>
<td>$10.00</td>
<td>Tim's pricings appear ok, but much of this fruit is sold per piece. Many of these fruits are an acquired taste or exotic so ‘premium’ is not a good descriptor of quality.</td>
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</tr>
<tr>
<td>Bananas</td>
<td>$3.00</td>
<td>$4.50</td>
<td>$6.00</td>
<td>Generic bananas must be a bit out of season right now. Also, some of the more exotic (e.g.: ladyfinger) are not available at Coles Online.</td>
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<tr>
<td>Potatoes</td>
<td>$1.00</td>
<td>$2.00</td>
<td>$4.00</td>
<td>Larger bags of potatoes and whole generic pumpkin are ‘budget’ items. There is a range of ‘average’ potatoes and pumpkin, and then specialist types.</td>
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</tr>
<tr>
<td>Category</td>
<td>Budget</td>
<td>Average</td>
<td>Premium</td>
<td>Budget Notes</td>
<td>Markup</td>
<td>Gross Margin</td>
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<tr>
<td>Onions</td>
<td>$2.00</td>
<td>$3.00</td>
<td>$18.00</td>
<td>Budget is bags of brown or red onions. Other onions, scallions etc are ‘average’. Premium is garlic and ginger.</td>
<td>1.20</td>
<td>0.29</td>
</tr>
<tr>
<td>Other fresh root vegetables</td>
<td>$1.90</td>
<td>$3.00</td>
<td>$6.00</td>
<td>Budget is generic carrots. average includes corn cobs, swedes, parsnip, turnips, and specialist carrots. Premium is parsnip, organics, baby corn.</td>
<td>1.22</td>
<td>0.67</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>$3.00</td>
<td>$6.00</td>
<td>$10.00</td>
<td>Estimate based on range of tomato varieties</td>
<td>1.33</td>
<td>0.75</td>
</tr>
<tr>
<td>Peas and beans</td>
<td>$2.60</td>
<td>$5.00</td>
<td>$13.00</td>
<td>Budget is generic tomatoes. Average is specific varieties and small pack sizes. Premium is vine ripened, trusses, exotics types and organics.</td>
<td>1.30</td>
<td>0.67</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>$1.00</td>
<td>$2.00</td>
<td>$4.00</td>
<td>Include with potatoes as pricings similar, and they are grouped at Coles Online.</td>
<td>1.48</td>
<td>1.00</td>
</tr>
<tr>
<td>Fresh flower vegetables (broccoli, cauliflower etc.)</td>
<td>$1.90</td>
<td>$3.50</td>
<td>$7.00</td>
<td>Budget is cauliflower, average is broccoli, eggplant, zucchini, and generic capsicum. Premium is most others such as chilies, coloured capsicums, and organics. Also, many sold ona per piece basis.</td>
<td>1.30</td>
<td>0.67</td>
</tr>
<tr>
<td>Fresh leaf vegetables (spinach, lettuce etc.)</td>
<td>$3.50</td>
<td>$10.00</td>
<td></td>
<td>Budget includes in-season green veg such as beans, brussel sprouts, celery. Average includes cucumber, peas, snow peas. Premium is undefined by Coles Online selection. Perhaps exotics are not available online? Lettuce and spinach sold per piece/bunch.</td>
<td>1.33</td>
<td>0.53</td>
</tr>
<tr>
<td>Tinned and Bottled fruit</td>
<td>$2.00</td>
<td>$4.00</td>
<td>$11.00</td>
<td>Generic/no name tins in budget. Average is for common fruits in larger tins. Premium includes exotic fruits and all single serve packaging.</td>
<td>1.33</td>
<td>0.53</td>
</tr>
<tr>
<td>Dried fruit</td>
<td>$12.00</td>
<td>$15.00</td>
<td>$20.00</td>
<td>Cannot find this at Coles Online.</td>
<td>1.11</td>
<td>0.86</td>
</tr>
<tr>
<td>Frozen vegetables</td>
<td>$2.00</td>
<td>$5.00</td>
<td>$7.00</td>
<td>Budget only includes generic peas and beans. Premium includes smaller package size, stir fry mixes, and more exotic types of vegetable.</td>
<td>1.43</td>
<td>0.83</td>
</tr>
<tr>
<td>Other (dried vegetables etc.)</td>
<td>$5.33</td>
<td>$7.00</td>
<td>$11.00</td>
<td>Budget is cauliflower and broccoli own brand. Average is branded products. Premium is small package such as ‘bowls’ of ready to microwave products. Could not find dried veg. At Coles Online.</td>
<td>1.14</td>
<td>0.78</td>
</tr>
<tr>
<td>Flours</td>
<td>$1.00</td>
<td>$2.50</td>
<td>$8.00</td>
<td>Budget is generic wheat flour. Average is branded wheat flour. Premium is non-wheat flours.</td>
<td>1.43</td>
<td>0.48</td>
</tr>
<tr>
<td>Rice</td>
<td>$2.00</td>
<td>$3.50</td>
<td>$38.00</td>
<td>Wild rice is very expensive - budget represents bulk buying normal rice product.</td>
<td>1.27</td>
<td>0.17</td>
</tr>
<tr>
<td>Pasta</td>
<td>$3.00</td>
<td>$4.00</td>
<td>$8.00</td>
<td>Bulk corn flakes represent budget and boutique mueslis represent premium products.</td>
<td>1.14</td>
<td>0.67</td>
</tr>
<tr>
<td>Breakfast cereals</td>
<td>$4.00</td>
<td>$8.00</td>
<td>$15.00</td>
<td>Bulk corn flakes represent budget and boutique mueslis represent premium products.</td>
<td>1.33</td>
<td>0.70</td>
</tr>
<tr>
<td>Category</td>
<td>Budget</td>
<td>Average</td>
<td>Premium</td>
<td>Alt Source Required</td>
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<tr>
<td>Raw grains, beans, lentils and other pulses</td>
<td>$3.50</td>
<td>$5.00</td>
<td>$9.00</td>
<td>Coles do not do a good line in pulses etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuts</td>
<td>$6.50</td>
<td>$13.00</td>
<td>$30.00</td>
<td>Coles do not do a good line in pulses etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggs</td>
<td>$3.60</td>
<td>$7.50</td>
<td>$12.00</td>
<td>Coles do not do a good line in pulses etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar</td>
<td>$1.00</td>
<td>$2.50</td>
<td>$5.00</td>
<td>Coles do not do a good line in pulses etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jams and sweets</td>
<td>$3.00</td>
<td>$7.50</td>
<td>$15.00</td>
<td>Coles do not do a good line in pulses etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Honey and syrups</td>
<td>$6.50</td>
<td>$11.00</td>
<td>$18.00</td>
<td>Coles do not do a good line in pulses etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deserts</td>
<td>$7.00</td>
<td>$10.00</td>
<td>$17.00</td>
<td>Coles do not do a good line in pulses etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crisps and savoury confectionary</td>
<td>$10.00</td>
<td>$20.00</td>
<td>$32.00</td>
<td>Coles do not do a good line in pulses etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chocolate</td>
<td>$15.00</td>
<td>$25.00</td>
<td>$40.00</td>
<td>Coles do not do a good line in pulses etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other sweet confectionary</td>
<td>$7.00</td>
<td>$13.00</td>
<td>$25.00</td>
<td>Coles do not do a good line in pulses etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spices, sauces and food additives</td>
<td>$7.00</td>
<td>$16.00</td>
<td>$30.00</td>
<td>Coles do not do a good line in pulses etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can spaghetti and baked beans</td>
<td>$3.00</td>
<td>$4.30</td>
<td>$6.50</td>
<td>Coles do not do a good line in pulses etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaged prepared meals</td>
<td>$8.00</td>
<td>$13.00</td>
<td>$20.00</td>
<td>Coles do not do a good line in pulses etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Description</td>
<td>Budget</td>
<td>Average</td>
<td>Premium</td>
<td>by my review and so Tim's estimate remains.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>--------</td>
<td>---------</td>
<td>---------</td>
<td>---------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft drinks, cordial</td>
<td>$0.65</td>
<td>$1.60</td>
<td>$2.90</td>
<td>Budget is generic cola/lemonade in large bottles. Average is branded soft drink in large bottles and bulk packs of cans (24). Premium is boutique brands and small package sizes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit juice</td>
<td>$1.10</td>
<td>$2.00</td>
<td>$8.00</td>
<td>Budget is generic juices in large packs, orange, apple etc. Average includes branded juices and bulk packs of smaller containers. Premium includes exotic berry juices, small/individual packs etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tea and Coffee</td>
<td>$15.00</td>
<td>$30.00</td>
<td>$80.00</td>
<td>Budget is basic loose black tea, or generic instant coffee. Average is branded tea bags and ground coffee in sealed packs. Premium is exotic teas and instant coffees (Moccona etc), including smaller pack sizes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beer</td>
<td>$5.00</td>
<td>$7.00</td>
<td>$10.00</td>
<td>Budget is basic local beers bough on bulk discount. Premium in boutique and imported beers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wine</td>
<td>$8.00</td>
<td>$15.00</td>
<td>$30.00</td>
<td>Budget is cheap bulk and cask wine. Standard is typical bottle wine and premium in more expensive local wines.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spirits</td>
<td>$25.00</td>
<td>$35.00</td>
<td>$60.00</td>
<td>Wide varieties of prices for different products – estimates used.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (premixed etc.)</td>
<td>$5.00</td>
<td>$7.00</td>
<td>$10.00</td>
<td>Based on input-output sector for spirits and soft drinks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal care products</td>
<td>$10.00</td>
<td>$15.00</td>
<td>$25.00</td>
<td>Estimate of price range of shampoo products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household cleaning products</td>
<td>$2.00</td>
<td>$4.00</td>
<td>$10.00</td>
<td>Estimate of price differences from range of products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stationery</td>
<td>$3.00</td>
<td>$5.00</td>
<td>$8.00</td>
<td>Estimate of price differences from range of products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pet products (pet food etc.)</td>
<td>$1.00</td>
<td>$2.50</td>
<td>$6.00</td>
<td>Estimate of price differences from range of products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Take away food</td>
<td>$15.00</td>
<td>$20.00</td>
<td>$30.00</td>
<td>Budget is fast food chain restaurants with premium being based on independent restaurants such as Indian food.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dining out</td>
<td>$30.00</td>
<td>$50.00</td>
<td>$90.00</td>
<td>Estimate of price differences from range of meals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clothing</td>
<td>$40.00</td>
<td>$100.00</td>
<td>$200.00</td>
<td>Estimate of price differences from range of products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Footwear</td>
<td>$40.00</td>
<td>$100.00</td>
<td>$200.00</td>
<td>Estimate of price differences from range of products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumer electronics</td>
<td>$40.00</td>
<td>$100.00</td>
<td>$200.00</td>
<td>Estimate of price differences from range of products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household</td>
<td>$40.00</td>
<td>$100.00</td>
<td>$200.00</td>
<td>Estimate of price differences from range of products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>Price 1</td>
<td>Price 2</td>
<td>Price 3</td>
<td>Estimate of price differences from range of products</td>
<td>Difference</td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------------------------------------------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>Kitchenware</td>
<td>$10.00</td>
<td>$20.00</td>
<td>$30.00</td>
<td></td>
<td>1.33</td>
<td></td>
</tr>
<tr>
<td>Furniture</td>
<td>$50.00</td>
<td>$100.00</td>
<td>$250.00</td>
<td></td>
<td>1.33</td>
<td></td>
</tr>
<tr>
<td>Other consumer goods</td>
<td>$36.67</td>
<td>$86.67</td>
<td>$180.00</td>
<td></td>
<td>1.41</td>
<td></td>
</tr>
</tbody>
</table>
7 References


Schlich, E., B. Hardtert, et al. (2008). Beef of local and global provenance: A comparison in terms of energy, CO2, scale, and farm management. Life Cycle Assessment in the Agr-Food Sector, Zurich, Switzerland.


