ACT Government

Buying Choices for a More Sustainable Canberra

Report for the ACT Commissioner for Sustainability and the Environment

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DISCLAIMER

The information in this report has been assembled from a number of data sources and studies of life cycles of individual or groups of consumer items. In many cases, analyses do not comprehensively cover the whole life cycle, nor is there much data available that specifically applies to goods and services purchased in Canberra. Generalisations from these findings may not apply in specific situations and the author takes no responsibility for readers' actions they take on the basis of the findings in the report.

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BUYING CHOICES FOR A MORE SUSTAINABLE CANBERRA

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INTRODUCTION

Canberra's ecological footprint

Canberrans have an average ecological footprint of 9.2 gha (global hectares) per person[1]. This is a measure of the area of land needed to supply all the resources and absorb all the waste of the average person in Canberra. The measure includes not only the obvious components like the energy to transport goods around, but also all the upstream inputs, like the energy used to make the truck that transports the goods and the land and water used for mining and processing the iron ore that's used to make the steel for the truck. Thus the full life cycle of a good (or a service, like a bank) is included in the footprint.

Canberrans have an average ecological footprint of 9.2 gha (global hectares) per person.

… the area we need to support all of us [in the ACT] is over 3 million global hectares, about 14 times the land area of the ACT.

Taking all the population of the ACT into account, the area we need to support all of us is over 3 million global hectares, about 14 times the land area of the ACT. At 9.2 gha per person, our ecological footprint is 13% larger than the average Australian footprint, more than three times the world average, and five times each person's share of bioproductive land globally (1.8 gha). Our high footprint is a consequence of high average incomes and high capacity to purchase large quantities of goods and services. In the longer run, and with an even larger world population, this size of footprint won't be sustainable.

The 18 items that contribute the most to this footprint are listed in Table 1[2]. Household energy consumption (electricity, air transport, petrol and gas) is the single largest group of items, accounting for 22% of the footprint; building and infrastructure construction for 9%; food for 6%; retail trade for 6% etc. This information provides very broad guidance to consumers who might want to reduce their ecological footprint.

Table 1 Items that contribute most to Canberrans' average ecological footprint of 9.2 gha.

The measure includes the impacts of all the inputs to each item.

Item	Footprint (gha/capita)	% of total
Electricity supply	1.07	12
Residential building construction	0.56	6
Retail trade	0.51	6
Hotels, clubs, restaurants, cafes	0.44	5
Air and space transport	0.35	4
Petrol	0.32	3
Other food products	0.29	3
Wooden furniture	0.25	3
Ownership of dwellings	0.24	3
Clothing	0.21	2
Electronic equipment	0.20	2
Beef cattle	0.17	2
Finished cars	0.16	2
Education	0.15	2
Non-building construction	0.14	2
Gas supply	0.14	2
Non-residential building construction	0.14	2
Wheat	0.12	1
SUBTOTAL	**5.46**	**59**

[1] Dey C (2010) *The 2008-09 Ecological Footprint of the Population of the Australian Capital Territory*. Integrated Sustainability Analysis Research Group, The University of Sydney. http://www.environmentcommissioner.act.gov.au/__data/assets/pdf_file/0015/211182/ACT_Ecological_Footprint_08-09_final_report.pdf. Accessed 17 May 2011.

[2] As above.

For example, reducing household electricity use by 10% from its average would reduce the footprint by 0.11 gha, about the same amount as giving up eating meat (beef accounts for 0.17 gha but giving this up would require eating more of other foods), or replacing electronic equipment half as often, reducing their footprint from 0.2 to 0.1 gha.

Footprints of individual consumer products

There might also be opportunities for reducing the environmental impact of our buying choices if we had more specific information about the individual products as they are delivered to and purchased in the ACT. The footprint calculations in Table 1 are based on actual buying patterns for the ACT, but the relationship between that data and the amounts of land, water, energy and materials consumed and polluted over the whole life cycle of products and services is based on Australian and global averages at an economic sector level, not an individual product level. Those averages potentially hide a wide range of variation in differences between products within a sector and in the environmental impacts of the same product, depending on how and where it was produced, distributed and purchased. This paper explores the origin and life cycles of a basket of common consumer goods ***as they are purchased and used in Canberra***. The items were chosen to represent some different types of products and different countries of origin, and are those where at least some aspects of their life cycle impacts have been studied. While each has its own particular life cycle, some of the issues explored are common to other consumer items. The basket contains bread, coffee, beef, tomatoes, televisions sets, paper books and AA batteries.

Products explored in the report:

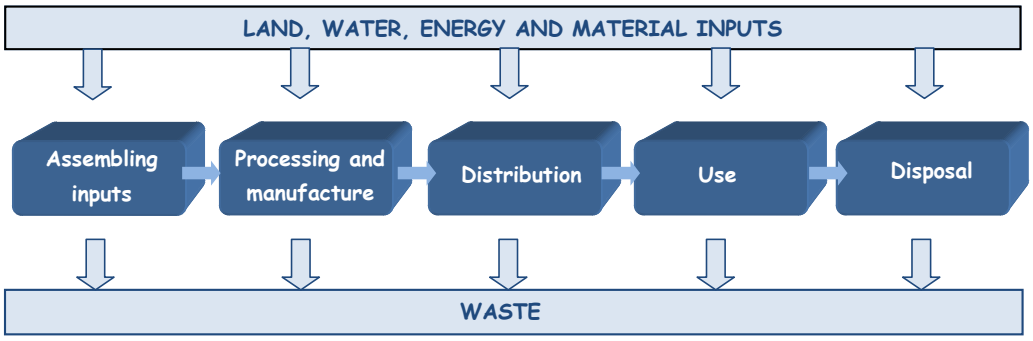
bread
coffee
beef
tomatoes
television sets
paper books
AA batteries.

Life cycle analyses

The basic framework of a product life cycle is shown in Figure 1. Essentially the life cycle consists of all the steps required from sourcing and assembling the raw materials through any processing or manufacturing processes, distribution of the product through various pathways to reach consumers, consumers using them and then disposing of them or their waste at the end of their life cycle. All along the way, inputs of land (e.g. to grow food or trees on, or to build shops or roads on), water (e.g. irrigation water to grow food or water to keep processing plants clean), energy (e.g. fuel and electricity in their direct manufacture or in their transport) and other materials (e.g. minerals or the steel to make the trucks that transport the product or packaging) are used and waste is generated.

Wherever these inputs come from and wherever the waste goes, there are environmental impacts. For example, use of land displaces or fragments biodiversity, use of irrigation water displaces its uses in wetlands and floodplains and disturbs living processes in rivers and use of fossil energy increases greenhouse gases in the atmosphere, changing global climate processes. Toxic materials sent to landfill can leak into groundwater and damage ecosystems (and humans). When global population was small and the use of technology limited, the environmental impact across the globe was also limited. That impact has now grown to the extent that there are concerns for the persistence of ecosystem processes that are important for supporting human life.

Figure 1 A generalised life cycle of a consumer product.



Calculating the environmental impact or footprint of the life cycle of a product is a challenging task because of the complexity of supply chains (which can change quite suddenly due to price changes or technological developments), lack of data and the many different ways in which impact can be assessed. Many studies have focused on just a few parts of the life cycle (e.g. the manufacturing step alone) or on just one or a few aspects of environmental impact (e.g. greenhouse gas emissions only, or water use only), so drawing broader conclusions from partial studies has to be done with caution.

Hotspots in the life cycle … the steps that make the largest contribution to a product's footprint and are therefore the places where the largest reductions might be found.

Information on the origins and routes of goods coming into Canberra is also patchy so it has not been possible in this report to apply a uniform approach to analysing each item, or to comprehensively compare impact across all phases of the life cycle of each product. Instead the report collates what is readily available, applies wider findings where they are known, and suggests the most obvious "hotspots" in the life cycle, that is, the steps that make the largest contributions to a product's footprint and that are therefore the places where the largest reductions might be found. Hotspots might be missed where information is lacking so these analyses are a first approximation, and a way of raising a range of issues that contribute to footprints, rather than definitive findings.

Purchasing decisions

The paper focuses on products where the act of purchasing is an obvious one. Less obvious "purchases" take place every time we turn on a device that uses electricity or gas or step into the car. Since non-renewable energy is the single largest component of ecological footprint in Canberra (see Table 1 and the discussion above), exercising choice about these 'purchases' remains a very powerful way of reducing ecological footprints.

Purchasing decisions are also influenced by people's social values about the ways in which products are made and delivered, and these are not usually assessed in a life cycle analysis (although some researchers have begun to develop methods for doing this). Concern for the treatment of animals in the production of food is one example, or concern about providing fair returns to producers in developing countries is another. This report suggests where issues like this might be particularly relevant but it is not the main focus of the analysis.

Purpose of the report

.. to provide information for Canberra consumers so … they can be more confident that their buying choices actually deliver sustainability benefits

The purpose of the paper is to provide information for Canberra consumers who want to exercise buying choices to reduce their ecological footprint. There are many general sets of principles for 'greener' living (e.g. on the Australian Conservation Foundation website[3] or the Australian Government website[4]) and these are good guidance if there is no specific product information, but they may not deliver the desired outcome in all circumstances. In fact they can sometimes produce the opposite effect: a "perverse" outcome. For example, encouragement to always buy local, on the basis of lower food miles, might require food to be produced in a heated glasshouse, when it could have been produced further away in natural sunshine with a reduced overall use of fossil energy. Intuition about the relative impacts of different steps in a product life cycle does not always produce the right answer.

Information alone is rarely sufficient to induce behaviour change, but it can raise awareness of and challenge routine behaviours that involve decisions made with little conscious thought. The *availability of accessible information* remains an important tool in supporting more sustainable decision-making:

> *Climate change, water use, health and safety and intellectual property rights are not usually in the forefront of the purchaser's mind when buying bread. However, although purchase decisions are often made in a matter of seconds they are not made in a vacuum. … Having access to the full upstream production costs of a loaf of bread presents a powerful capability. It can identify where in the supply chain we should concentrate efforts. When combined with a story that provides local and specific details such information has a chance of being heard. Thus more consumers will be able to make informed decisions and the more this information becomes part of life the more likely those decisions can be made in a matter of seconds.*[5]

[3] Australian Conservation Foundation http://www.acfonline.org.au/consumptionatlas/ Accessed 10 Jun 2011.
[4] Australian Government www.livinggreener.gov.au. Accessed 15 Jul 2011.
[5] Murray J, Dey C (2007) *Assessing the Impacts of a Loaf of Bread*. Integrated Sustainability Analysis Research Group, The University of Sydney. http://www.isa.org.usyd.edu.au/publications/ISA_on_Bread.pdf. Accessed 20 May 2011.

BREAD

Buying and use patterns

Australians buy about 60 kg of bread each a year

The typical loaf of bread is purchased in a supermarket or convenience store …

Most Australians eat bread and it is the major source of carbohydrate as well as some of the protein in our diets. Averaging across the whole population and including all types of bread products, we account for about 60 kg each a year, or roughly the equivalent of a large loaf and some rolls each a week. The typical loaf of bread is purchased in a supermarket or convenience store where most of the bread is supplied by two companies, Goodman Fielder and George Weston Foods, using a variety of brands. Together they supply about 60% of the overall bread market[6] but a higher proportion to such stores.

We actually eat somewhat less than 60 kg of bread a year as it doesn't have a long shelf-life. Especially in small households, stale and mouldy bread forms part of the considerable amount of food that is regularly discarded. An audit of Canberra's waste streams in 2003 discovered that 38% of all landfill garbage collected (ie excluding recyclables) was food and kitchen waste[7]; this amounted to about 2kg per person per week. Another Australian study calculated that we spend about $30 per fortnight on food that is not eaten[8]. The study also noted that the ACT was more wasteful than any other state, presumably because our income is higher, we buy more stuff and we can afford to waste more.

Not all discarded food represents pure waste. Some of it is inedible, like peelings and cores. Along with discarded fruit and vegetables, these can be composted at home and used to grow more food; or landfill waste can be used to generate energy via biogas capture; or waste from food manufacture, like fruit and vegetable skins, can be composted or fed to animals. Waste can occur in other steps in the food chain, but a study in the UK found that consumers are the hotspots for discarded food, accounting for over 50% of food losses after production. A third was lost in manufacture and a relatively small amount in retailing[9].

Product flow – paddock to plate

Wheat flour and water are the two main ingredients in a loaf of bread, so this account focuses on these alone. A fuller life cycle analysis would consider the small quantities of other grains, yeast, oil, extra gluten and vitamins that are commonly added to bread.

The major flows of flour and bread to consumers in Canberra are shown in Figure 2.

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[6] GoGrains. *History of the Bread Industry in Australia*. http://www.gograins.com.au/grainsnutrition/ie/ie16_1.html. Accessed 25 May 2011.

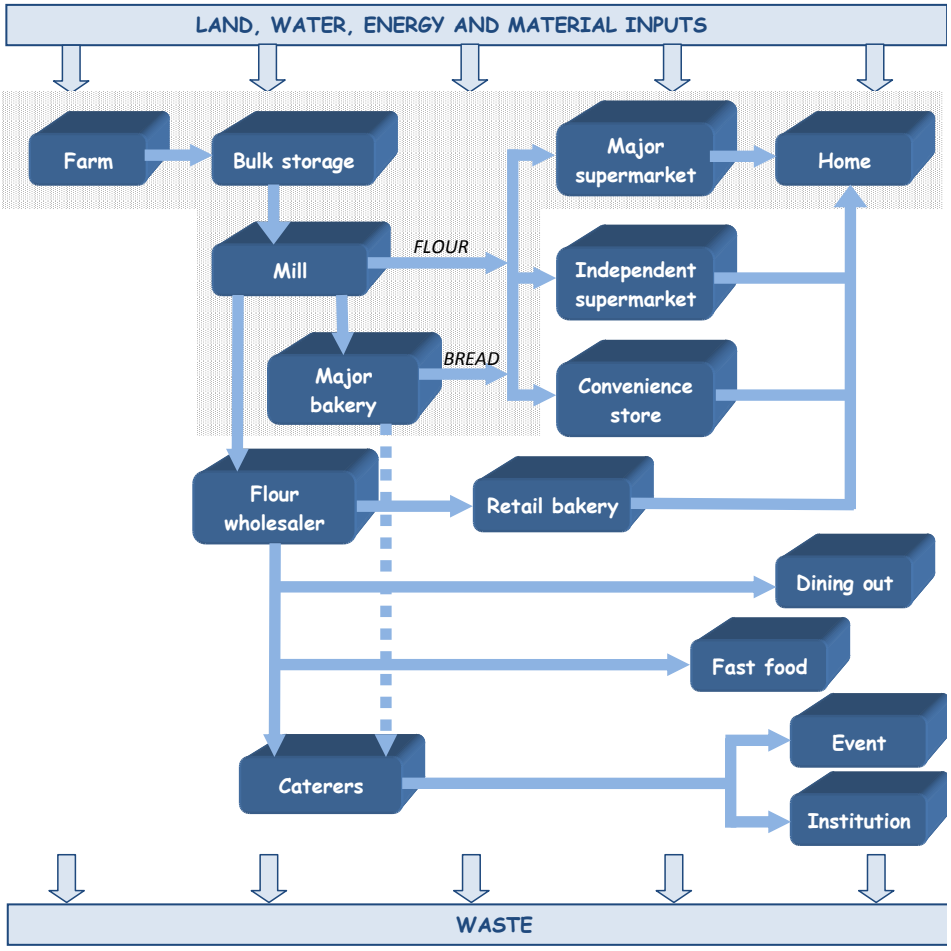
[7] APrince Consulting (2004) *Canberra Residential Waste Audit.* http://www.tams.act.gov.au/__data/assets/pdf_file/0009/136737/Canberra_Waste_Audit_Oct-Dec_2003.PDF. Accessed 30 May 2011.

[8] Hamilton C, Denniss R, Baker, D (2005) *Wasteful Consumption in Australia.* Australia Institute http://www.tai.org.au/documents/dp_fulltext/DP77.pdf. Accessed 30 April 2011.

[9] Department for Environment, Food and Rural Affairs (2007) *Report of the Food Industry Sustainability Strategy Champions' Group on Waste.* UK Government. http://archive.defra.gov.uk/foodfarm/policy/foodindustry/documents/report-waste-may2007.pdf. Accessed 12 May 2011.

Figure 2 Major flows of wheat and flour to produce bread eaten in Canberra.

The shaded area represents the largest volume of flow measure includes the impacts of all the inputs to each item.



Wheat production

It takes about 300 square metres to grow the wheat to make the flour from which each person's bread is baked every year.

Canberra's bread footprint … is … equivalent to 4% of the area of the ACT.

Our bread is made almost entirely from wheat and added grains grown in Australia. It takes about 300 square metres, roughly an area 17 metres by 17 metres, to grow the wheat to make the flour from which each person's bread is baked every year[10]. With its population of about 350,000, Canberra's bread footprint in terms of the area of land for growing the wheat, is about 10,000 ha, equivalent to 4% of the area of the ACT. However the soil and climate are not suitable for growing wheat in the ACT and bread eaten in Canberra is most likely to have made from wheat grown in New South Wales where a large grain growing area stretches in a broad band from the north to the south of the state, inland from the Great Dividing Range.

[10] Calculated from ABS data for population (ABS cat. no. 3235.0) and wheat production (ABS cat. no. 7113 0) in 2008 and flour production data from Flour Millers Council of Australia 2008 (cited in Department of Agriculture and Food (2009) *Overview of the West Australian Wheat Flour Industry and Potential Export Opportunities.* http://www.agric.wa.gov.au/objtwr/imported_assets/content/amt/wheat_flour_report_mar09.pdf. Accessed 12 May 2011.

Bread that is certified as organic might be a choice for people who are concerned about their environmental footprint. There were only about 440 certified organic cereal growers (this includes cereals besides wheat) out of about 30,000 grain growers nationally in 2003[11] so in fact, this is not a practicable choice for large numbers of people. A study comparing organic and conventional wheat farming in Australia found that the land impact of organic wheat was larger than for conventional wheat, but that its irrigated water and its greenhouse gas footprints were smaller[12].

… the land impact of organic wheat was larger than for conventional wheat, but … irrigated water and greenhouse gas footprints were smaller [found in one Australian study].

While numbers may have grown since then, by far the most wheat in Australia is grown using conventional methods involving manufactured fertiliser and herbicides. Nevertheless, there are many industry sponsored initiatives that encourage and support wheat farmers to farm in a more sustainable manner. For example, in response to the findings of research and promotion of more sustainable practices by industry bodies and governments, the majority of wheat in Australia is now grown in 'no-till' fashion[13]. Instead of burning the stubble of the previous year's crop and ploughing the soil several times for weed control before sowing the next crop, farmers are now leaving the stubble intact and sowing the seed directly into the soil. The benefits are mostly in terms of reduced costs (e.g. less fuel), improved soil conservation and improved soil moisture, which all have positive impacts on the environment. However, herbicide use is greater.

Some wheat is grown with irrigation water from the Murray and the Murrumbidgee Rivers, but most of it is grown with natural rainfall. The average NSW water footprint of growing 1 kg of wheat is about 86 litres[14]. This calculation includes any irrigation water, the water embodied in other farm inputs like fertiliser manufacture, and the water needed to dilute excess nutrients in drainage water to acceptable health levels, but not rainwater. Compared to food products grown almost wholly on irrigation water, this is a small water footprint and not a hotspot for a loaf of bread.

After harvest, wheat from individual farms is combined into similar types and grades and stored at local bulk handling facilities before being taken by train or truck to mills, if it is destined for domestic use, or to ports for shipping overseas. Both Goodman Fielder and George Weston Foods own flour mills as well as bakeries, so they have a direct supply chain from the mill to their bakeries and through contracts with major retailers, to supermarket shelves. There are only about 30 flour mills in Australia and most are located in metropolitan areas[15], so the flour in a typical loaf of Canberra bread probably travelled from country NSW to Sydney as wheat and was milled into flour in Sydney. Of the flour destined for bread for Canberrans, around

… the flour in a typical loaf of Canberra bread probably travelled from country NSW as wheat and was milled into flour in Sydney..

Around two-thirds [of that flour] is transported to Canberra for local baking … and about a third is baked into bread in Sydney … then brought to Canberra.

[11] Halpin D. (2005) *The Australian Organic Industry. A Profile.* Department of Agriculture, Fisheries and Forestry, Canberra. http://www.daff.gov.au/agriculture-food/food/organic-biodynamic/industry. Accessed 18 May 2011.
[12] Wood R, Lenzen M, Dey C, Lundie S (2006) A comparative study of some environmental impacts of conventional and organic farming in Australia. *Agricultural Systems* 89:324–348.
[13] Llewellyn RS, D'Emden FH (2010) *Adoption of No-till Cropping Practices in Australian Grain Growing Regions.* Grains Research and Development Corporation, Canberra. http://www.grdc.com.au/uploads/documents/GRDC_adoption_of_no-till.pdf Accessed 25 May 2011.
[14] Ridoutt and Poulton (2009) SAI Platform. Australia Water footprint Pilot Project: Wheat, Barley and Oats Grown in the Australian State of New South Wales. CSIRO. http://www.csiro.au/files/files/pvkh.pdf. Accessed 16 May 2011.
[15] Department of Agriculture and Food (2009). See footnote 10.

two-thirds is transported to Canberra for local baking (Goodman Fielder and local brands), and about a third is baked into bread in Sydney (George Weston brands) and the bread then brought to Canberra.

Baking

Making bread involves combining the ingredients (about 2/3 flour, 1/3 water, yeast and other additives), mixing the dough, shaping the product, allowing it to rise in a warm place, then baking it and cooling it. Large bakeries slice and wrap the loaves before distribution. In such bakeries these steps are highly automated[16] and allow George Weston, for example, to produce around a million baked products a day in just 14 bakeries across Australia[17].

Water and energy uses are potential hotspots in the baking process. Water is an ingredient in the loaf itself, but is also used for washing and cleaning in the bakery. In addition, water is used in growing or making other ingredients in the loaf, especially dairy products, and is embodied in the manufacture of the buildings and equipment in the bakery. In fact, the water used within the bakery is more than the irrigation water (but not rainfall) used to grow the wheat[18].

Energy use in bakeries is high because of the cooking process and the degree of automation in large bakeries. Natural gas and electricity are the main sources of energy; and in NSW and the ACT where our bread is baked, most of the electricity comes from burning coal and therefore embodies high greenhouse gas emissions.

Footprints across the life cycle

A life cycle analysis of a loaf of bread in Australia found that the retail and consumption phase contributed 55% of the total global warming impact (Figure 3)[19]. Included in the retail stage of this hotspot is the energy needed to control temperatures in retail stores, and included in the consumption stage is energy for freezing and toasting bread. The storage and processing stage (ie bakery) was the second largest contributor. This finding is consistent with a study of the proportion of the energy consumption in the wholesale and retail phase compared to the production phase (but not including consumption) for 400 commodities in the USA[20]. Depending on the product, between 20 and 50% of energy for these two steps was used in the wholesale and retail phase.

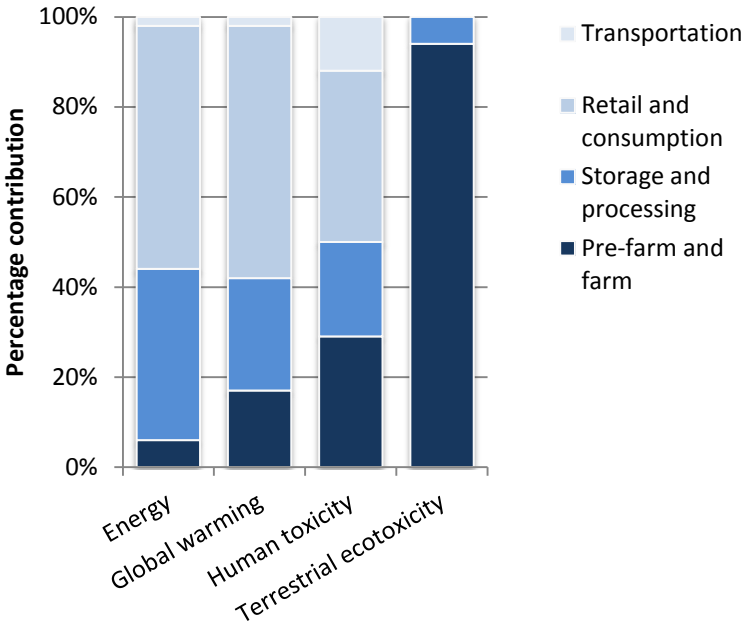
> *… the retail and consumption phase contributed 55% of the total global warming impact [of a loaf of bread, in one Australian study].*

[16] For a description of the automated process see IBIS http://www.foodmag.com.au/news/breaking-bread-habits-of-australias-manufacturers. Accessed 26 May 2011.
[17] George Weston Foods. http://www.georgewestonfoods.com.au/. Accessed 26 May 2011.
[18] Murray J, Dey C (2007) Footnote 5.
[19] Narayanaswamy V, Altham W, van Berkel R, McGregor M (2004) Application of life cycle assessment to enhance eco-efficiency of grains supply chains. *4th Australian Life Cycle Assessment Society Conference*, Sydney 2005. http://www.conference.alcas.asn.au/. Accessed 26 May.
[20] Norris GA, Della Croce F, Jolliet O (2003) Energy burdens of conventional wholesale and retail portions of product life cycles. *Journal of Industrial Ecology* 2003:59-69.

In the Australian study, transportation contributed only a few percent to energy use and global warming impact. This is broadly consistent with a study in Denmark that found that transport accounted for only about 10% of the whole energy footprint of bread[21]. It is also consistent with the USA study referred to above that found the transport energy uses to distribute goods between the place of production and the retail store accounted for only 9% of the total energy use prior to its purchase.

Figure 3 Contribution of phases in the life cycle of bread to some footprint measures.

Terrestrial ecotoxicity is a measure of the impacts of toxic materials on ecosystems. The figure is redrawn from data in the resource at Footnote 19.



Hotspots summary

Growing the wheat is a hotspot in terms of land impacts.

Energy use in retail and consumption is a hotspot for CO2e[22] emissions, followed by the energy use in **baking the bread**.

Social and ethical considerations

The main social and ethical issues that could be considered in the case of bread relate to regional employment. Over 40% of food processing jobs are in non-metropolitan areas[23] and these make a significant contribution to regional economies. As just a few companies dominate the bread baking industry, they have concentrated their mills and bakeries in metropolitan areas at the cost of regional jobs. This enables them to keep their production costs lower and bring consumers bread at cheaper prices because the socio-economic impact of employment location is not factored into the price, just as many environmental impacts are not factored into prices of food.

[21] Munksgaard J, Lenzen M, Jensen T, Pade L (2005) Transport energy embodied in consumer goods: A hybrid life-cycle analysis. *Energy and Environment* 16:27-45.
[22] CO2e is 'carbon dioxide equivalents'. This is a measure of the aggregate global warming potential of a number of gases, including carbon dioxide, expressed in terms of the global warming potential of carbon dioxide. Other greenhouse gases include methane and nitrous oxides. Per gram of gas, these have 25 and 298 times the warming potential of CO2 respectively, over a 100 year timeframe.
[23] Department of Foreign Affairs and Trade (2008) http://www.dfat.gov.au/facts/foodindustry.html Accessed 28 May 2011.

In the absence of food labelling that informs consumers about whole of life cycle impacts, a consumer could make an assessment about the commitment of the company to reducing the footprint of its products. Many companies report on sustainability initiatives in their annual reports or in other documents on their websites. For example, both a sustainability report and a waste report are available for Goodman Fielder[24,25]. Their sustainability report is based on an internationally recognised measurement system, Global Reporting Initiative, and includes a social dimension that addresses both their staff e.g. health, safety and well-being, and socio-economic and environmental aspects of suppliers e.g. of palm oil from developing countries.

On the basis of where company profits go, consumers could also make choices based on ownership of the major bakeries. Goodman Fielder is a company listed on the Australian stock exchange. George Weston is a wholly owned subsidiary of a very large international food company based in the United Kingdom. Franchisees of chain bakeries, like Bakers' Delight, and owners of small or boutique bakeries, tend to be local people.

Your choices

There is relatively little choice for Canberra consumers who might want to reduce the environmental impact of the bread they buy. In terms of land impacts, there is little organic bread produced, and the remainder is not differentiated or labelled according to where or how the wheat was grown or how the bread was baked.

… there is relatively little choice for Canberra consumers who might want to reduce the environmental impact of the bread they buy.

All bread is baked, so there is little leverage there, although the efficiencies of larger bakeries suggests that loaves from those bakeries have smaller footprints. An international review of studies of the life cycle of bread concluded that "A scenario combining organic production of wheat, industrial milling and a large bread factory is reported to be the most advantageous way of producing bread"[26].

Alternatively, sourcing bread from bakeries that can demonstrate that they've invested in sustainability initiatives will reduce the impact of a loaf of bread. A Victorian bakery company, Ferguson Plarre Bakehouses, has made changes to its energy and water supply and management, raw material handling and its vehicles and is offsetting its fossil fuel emissions, saving 5000 tonnes of CO2e emissions[27]. But to the author's knowledge, a choice like this is not available in Canberra.

[24] Goodman Fielder (2010) *Sustainability Report 2009-10*. http://www.goodmanfielder.com.au/sites/default/files/PDFs/Environment/2010%20Goodman%20Fielder%20Sustainability%20Report.pdf. Accessed 3 Jun 2011.
[25] Goodman Fielder (2010) *National Packaging Covenant Annual Report July 2008 – June 2009* http://www.goodmanfielder.com.au/sites/default/files/PDFs/Environment/Goodman%20Fielder%20NPC%20Annual%20Report%20F%2709.pdf. Accessed 3 Jun 2011.
[26] Roy P, Nei D, Orikasa T, Xu Q, Okadome H (2009) A review of life cycle assessment (LCA) on some food products. *Journal of Food Engineering* 90:1-10.
[27] Ferguson Plarre (2011) http://www.fergusonplarre.com.au/History/Greenhouse-Challenge.html#currentProjects. Accessed 20 Jun 2011.

The high greenhouse gas emissions in the retail and consumption phase offer a potential place to find reductions, but nearly every retail outlet in Canberra is air conditioned so that is not a practical option.

The best opportunities for reducing the footprint of bread are to minimise car transport in its purchase and to ensure that all the bread bought is eaten.

… the best opportunities for reducing the footprint of bread are to minimise car transport in its purchase and to ensure that all the bread bought is eaten.

COFFEE

Buying and use patterns

Australians account for over 2.5kg of coffee per person each year the equivalent of 1250 cups of instant coffee or 357 cups of espresso[28]. Most (83%) of the coffee consumed in the home is instant coffee[29], although this share has fallen since 2004 in the face of increasing sales and use of home espresso and capsule-based coffee machines. The Australian food service industry, however, is estimated to sell 1.26 billion cups of coffee each year, at a total profit of over $3 billion[30]. Ninety percent of the coffees ordered in cafés are milk-based, and 395 million of these are served in takeaway paper, foam or plastic-coated cups[31]. In total, Australians spend $10.7 billion dollars on coffee related products annually, with the 50% of Australians who drink coffee consuming an average of four espresso coffees per week[32].

Australians account for over 2.6kg of coffee per person each year.

… food service industry .. sells 1.26 billion cups of coffee each year

Product flow

Typical flows of three different types of coffee from the farm to the cup are drawn in Figure 4[33].

Production and processing

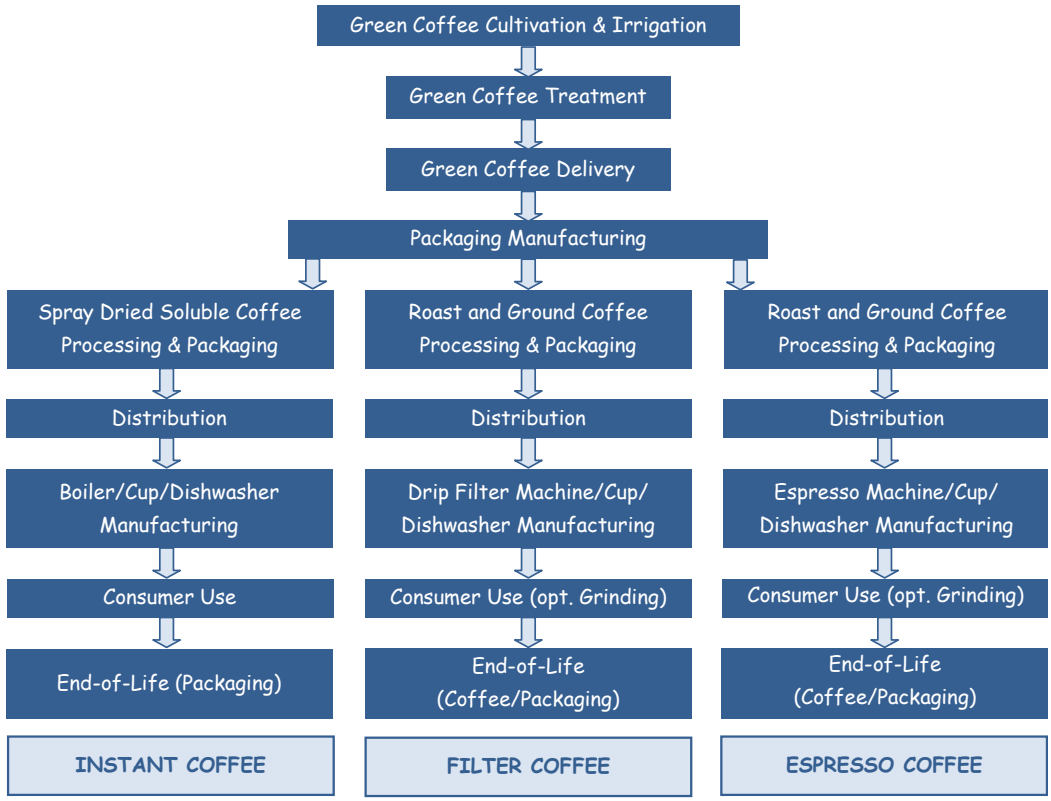
Global production of coffee is led by Brazil, which produces around 2.25 million tonnes of dry green bean, followed by Vietnam (961,000 tonnes) and Columbia (637,000 tonnes)[34]. Worldwide, it is estimated that 20-25 million people depend on income from coffee crops[35]. Australia imports coffee from over 65 countries. Most of it comes from Vietnam (17,123 tonnes), Papua New Guinea (10,298 tonnes) and Brazil (6,052 tonnes). Locally, far north Queensland produces around 800 tonnes, followed by north-eastern NSW (500 tonnes). The remaining Australian coffee growers produce approximately 300 tonnes annually[36]. However, half of Australian grown coffee is exported overseas, as it is targeted at the boutique 'single-origin' market[37].

… the origin of most of the coffee drunk in Australia is Vietnam or Papua New Guinea.

[28] Pacific Islands Trade and Investment Commission (2007) *Exporting Coffee from the Pacific Islands.* http://www.pitic.org.au/pdfs/exporting/coffee.pdf. Accessed 20th May 2011.
[29] As above.
[30] BIS Shrapnel (2006) *Coffee in Australia 2006-2008*. Industry Report, February 2006, Sydney, Australia.
[31] KeepCup Pty Ltd. (2010) *Environmental Footprint Calculator Considerations* http://www.keepcup.com/userfiles/files/KeepCup%20Calculator%20Considerations.pdf. Accessed 20 May 2011.
[32] BIS Shrapnel (2006) Footnote 30.
[33] Humbert S, Loerincik Y, Rossi V, Margni M and Jolliet O (2009) Life cycle assessment of spray dried soluble coffee and comparison with alternatives (drip filter and capsule espresso). *Journal of Cleaner Production* 17:1351-1358.
[34] As above.
[35] DaMatta F, Ronchi P, Maestri M, Barros R (2007) Ecophysiology of coffee growth and production. *Brazilian Journal of Plant Physiology* 19:485-510.
[36] Rural Industries Research & Development Corporation (2003) *R&D Plan for the Australian Coffee Industry 2003-2008*. Publication Number 03/056. https://rirdc.infoservices.com.au/downloads/03-056.pdf. Accessed 20 May 2011.
[37] Pacific Islands Trade and Investment Commission (2007) *Exporting Coffee from the Pacific Islands.* http://www.pitic.org.au/pdfs/exporting/coffee.pdf. Accessed 20 May 2011.

Figure 4 Typical flows of coffee from the farm to the cup.

The figure is redrawn from a figure in the resource at Footnote 33.



Coffee production involves a number of processes that vary significantly depending on the preferences of the end consumer. In the country of origin, the manner in which the coffee is produced has a significant influence on the environmental impacts of the production of coffee beans. Traditionally, coffee trees have been shade-grown, at a relatively low density per hectare and integrated with other crops and species. However, due to greater profit margins, higher-density 'full-sun' monoculture plantations have rapidly replaced traditional approaches in plantations established in the last 20-30 years[38]. Although these new plantations allow higher yields, they also cause soil degradation, need higher applications of chemical fertilizers and irrigation water and lead to destruction of the migratory bird habitats usually provided by coffee-based poly-cultures. Some other production differences can occur during the extraction of coffee beans from the coffee cherry, however there is little variation in either water or energy use between the 'dry' and 'wet' production methods[39].

At the destination country, green coffee beans go through a range of different roasting, processing and preparation stages. For example, espresso coffee is simply roasted and ground, whereas instant and capsule-based coffees undergo additional processing stages after roasting. The final preparation stage is also a significant source of CO2e emissions, with energy requirements and production of

[38] DaMatta et al. (2007) Footnote 35.
[39] Brommer E, Stratmann B, Quack D (2011) Environmental impacts of different methods of coffee preparation. *International Journal of Consumer Studies* 35:212-220.

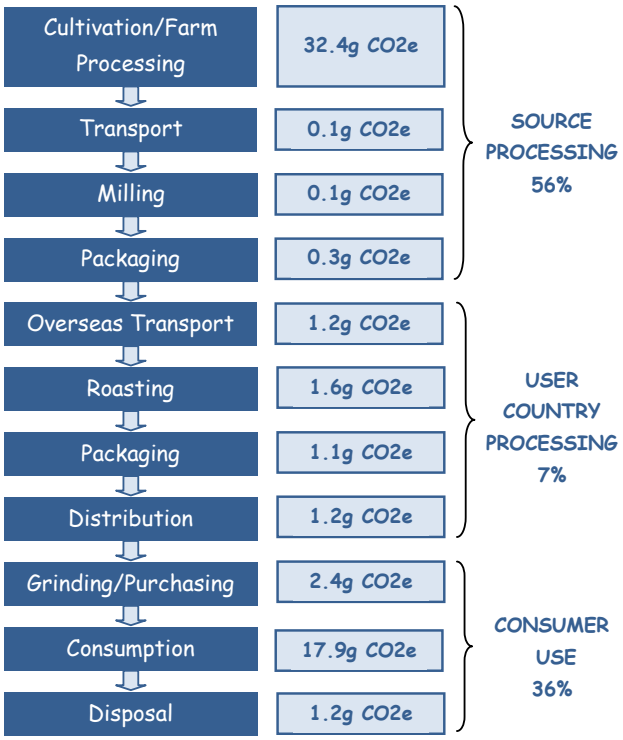
home espresso machines, kettles, other heating methods and the food service industry as a whole all having different impacts on the environmental impact of each cup of coffee[40].

The footprint of making coffee at home

The CO2e emissions of a standard home-made cup of black coffee, as estimated in a German life-cycle analysis are shown in Figure 5[41]. On average, a milk-free cup of coffee was found to have a carbon footprint of approximately 59 g of CO2e, with the bulk of emissions coming from two areas: on-farm cultivation and processing and the preparation for consumption. However, an espresso coffee based on cow's milk increases this basic carbon footprint significantly, with the espresso extraction process being estimated to produce 130 g of CO2e and the milk production and distribution for a standard 250 ml latte adding a further 230 g of CO2e[42]. This footprint is even larger for take-away or café-based coffees, with additional emissions occurring due to takeaway cup production, venue heating and lighting, staff transport and large commercial coffee machines. For example, production of one medium disposable takeaway cup, even before filling it with coffee, is estimated to emit 112 g of CO2e[43] – almost double that of a home-made black coffee.

Figure 5 CO2e emissions of a home-made cup of black coffee in Germany.

The figure is redrawn from a figure in the resource at Footnote 39.



The water needed to grow coffee then produce roasted beans has been calculated to be 20.4 kilolitres per kilogram of beans, most of which is used for irrigation during cultivation of the coffee plant[44]. Instant coffee requires more water per kilogram (39.4 kilolitres) because of the extra processing step, but as a lower weight of coffee product is used to make a cup of coffee, the water requirement per final cup is less than that of espresso. Eighty litres of water are needed overall for a

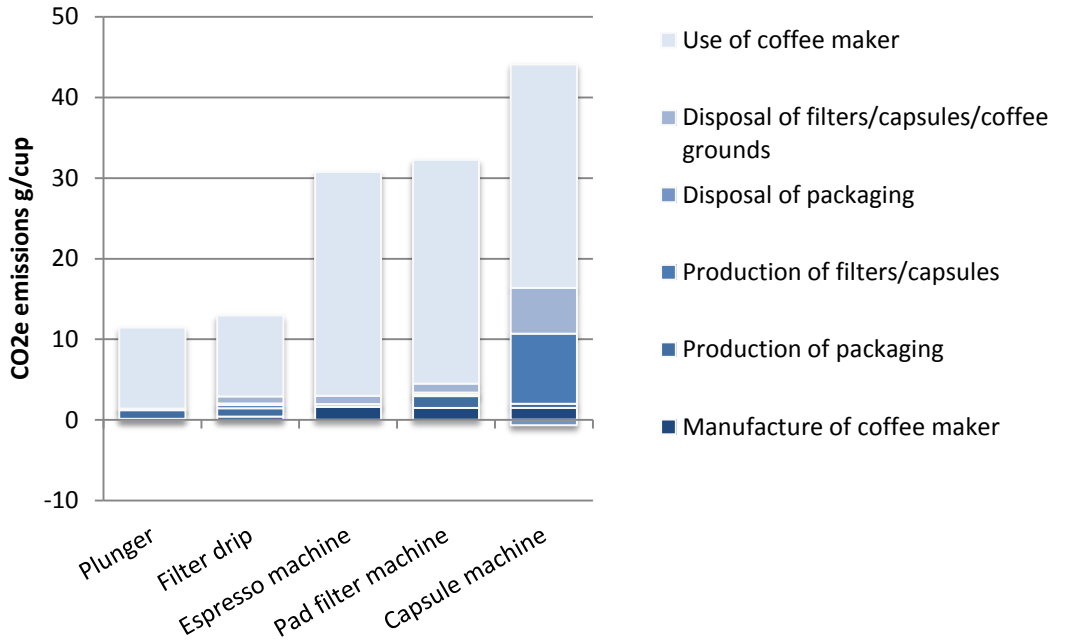
[40] Brommer et al. (2011) Footnote 39.
[41] As above.
[42] CleanMetrics Corp. (2011) *Coffee Drink: Latte (12 Oz) – Analysis Using FoodCarbonScope.* Presentation. http://www.cleanmetrics.com/pages/lattelca.pdf. Accessed 15 May 2011.
[43] Environmental Defense (2000) *Report for the Starbucks Coffee Company/Alliance for Environmental Innovation Joint Task Force.* http://www.edf.org/documents/523_starbucks.pdf. Accessed 13 May 2011.
[44] Chapagain AK, Hoekstra AY (2007) The water footprint of coffee and tea consumption in the Netherlands. *Ecological Economics* 64:109-118.

cup of instant coffee, but 140 litres are required to produce a single-shot cup of espresso[45]. The majority of this is used in the growing, washing and drying phase of producing green coffee beans.

The choice of coffee preparation method can significantly reduce or increase the environmental impact of a cup of coffee. Capsule-based coffee machines produce the most CO2e emissions, with most additional energy use due to production of the coffee capsules themselves (Figure 6[46]).

Figure 6 *CO2e emissions of different methods of preparing a cup of coffee in the home.*

The figure is redrawn from data in the resource at Footnote 44.



Emissions due to the energy requirements for electrical coffee-makers, shown above, are roughly equivalent to the entire on-farm production and processing emissions (shown in Figure 5), and around double the emissions from the preparation of coffee by manual methods such as filter, plunger or instant. In all cases, the energy used to brew the coffee is the hotspot compared to manufacture of the brewing device, and the packaging and disposal of waste. Another European study compared the life cycle impacts of instant coffee, drip and capsule coffee in the home and concluded that overall instant coffee has the smallest impact[47].

The footprint of purchased cups of coffee

Consumption of coffee at a café has a different environmental impact, and although there is no published research comparing the footprint of in-home and café-based coffee consumption, the ecological footprint of Canberra's 444[48] restaurants, clubs, drinking establishments and cafés is a

[45] Chapagain and Hoekstra (2007) Footnote 44.
[46] As above.
[47] Humbert *et al.* (2009) Footnote 33.
[48] ACTPLA (2011) *Planning for Canberra's Night-time Economies*. Research Paper. http://www.actpla.act.gov.au/__data/assets/pdf_file/0003/22665/Night-time_economy_research_paper.pdf. Accessed 10 May 2011.

significant hotspot for the ACT, making up 6% of the ACT's ecological footprint and ranking fourth amongst contributing sectors (Table 1). Of course coffee is only one item consumed at these places, but its footprint in the café or restaurant itself may be similar to most other food prepared and served in such places.

In the food service sector generally, most of the greenhouse footprint is due to the energy use for food preparation (34%) and heating and air-conditioning (28%).

In the food service sector generally, most of the footprint is due to energy use for food preparation (34%) and heating and air-conditioning (28%)[49]. More specifically for coffee, an emissions audit by a coffee supply company in Victoria (Figure 7) found that gas and electricity, machinery and parts, and paper cups were the three hotspots for CO2e emissions, taking all emissions from coffee roasting to serving the coffee, including transport, into account[50]. Adding the takeaway cups and the sugar and coffee packaging together represented 16% of emissions. Avoiding the use of single-sachet sugar packets, teabags and disposable coffee cups by consumers can therefore significantly reduce the carbon footprint of takeaway coffee, with use of low-carbon re-usable coffee cups over a year being calculated to use one-third of the water, half the carbon and half the energy of paper cups for the average Australian consumer[51].

Hotspots summary

In general and across the whole life cycle, the two hotspots for greenhouse gases are **on the farm**, especially in fertilisers and in **drying the beans**, and then in the **final use** phase. Not evident in the studies discussed here, but based on the evidence in other case studies in this report and in the Canberra context, the **car journey** to the shop or café is also likely to be a hotspot.

Within the final use phase, the use of **electronic coffee machines** is a hotspot, whether in the home or in a café or restaurant, and energy use for **heating and cooling cafes and restaurants** is also a hotspot when coffee is consumed outside the home.

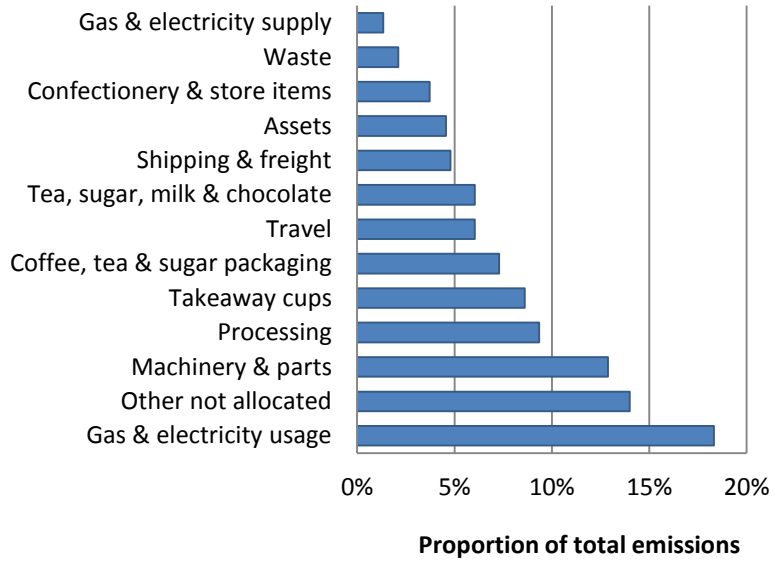
The footprint of **disposable cups** is significant.

The hotspot for water use is on farms where **irrigation** is used to grow the coffee.

[49] Victorian Employers' Chamber of Commerce and Industry (2010) *Small Business and Climate Change: What Affects You and What You Can Do.* Fact Sheet. http://www.vecci.org.au/IR_Advice/Tools-and-Templates/Business_Sustainability/Documents/041725_VECCI_FactSheets_Adjustment_V5.pdf. Accessed 10 May 2011.
[50] Jasper Coffee (2009) *Emissions Audit for Jasper Coffee*. https://www.jaspercoffee.com/about_us.jsp?id=9. Accessed 13 May 2011.
[51] KeepCup Pty Ltd (2010) Footnote 31.

Figure 7 CO2 emissions during a partial life cycle of a cup of coffee from its import to consumption in a café in Victoria.

The figure is redrawn from a figure in the resource at Footnote 50.



Social and ethical considerations

Because almost all the coffee drunk in western countries is imported from developing countries, concerns have been raised about employment conditions and prices paid to local farmers for their coffee. An international system, 'Fair Trade', accredits coffee produced under improved conditions for coffee farmers and workers and using more sustainable production methods (see below), but this accounts for only a small proportion of coffee drunk in Australia.

Your choices

About half the footprint of home-made black coffee is under the control of the producers and processors, and about half under the control of consumers in terms of choice of coffee making method and shopping patterns[52]. For home-made black coffee, not buying or using electronic coffee machines, especially the capsule type, is the most effective way to reduce emissions.

Adding cow's milk to coffee adds substantially to the footprint, so avoiding milk based coffees would be the most effective way of reducing the footprint of a cup of coffee. However, if the reduction in milk consumption is compensated for elsewhere in the diet with dairy products, for nutritional reasons, no saving is made.

For home-made black coffee … not buying or using electronic coffee machines, especially the capsule type

…avoiding disposable cups …

… shopping by car less often but in larger shopping baskets…

… using the car wisely in visiting cafes …

… consumers can choose to buy coffee that is accredited for the conditions under which the coffee is produced …

[52] Humbert et al. (2009) Footnote 33.

Avoiding disposable cups by choosing cafes that serve coffee in china cups, and using your own reusable cup for takeaways will also generally produce environmental benefits. Like other products for the home, shopping by car less often but in larger shopping baskets generally reduces footprints, and using the car wisely in visiting cafes will reduce the footprint of any car travel to them.

For those parts of the footprint that are outside the immediate control of the consumer, consumers can choose to buy coffee that is accredited for the conditions under which the coffee is produced (Table 2). Additionally, an increasing number of Australian cafés and coffee roasting companies are being accredited through the Carbon Reduction Institute, which acknowledges reduced or offset carbon emissions. Choosing to purchase accredited products also helps to build their market share and stimulate innovation across the sector. Some boutique coffee shops have also developed closer direct relationships with producers so that they can explain production methods and employment conditions to consumers.

Table 2 Choices of accreditation systems for coffee in Australia.

Title	Symbol	Key benefits
Rainforest Alliance www.rainforest-alliance.org		• Wide range of sustainable agriculture standards
FairTrade www.fta.org.au	Guarantees a better deal for Third World Producers FAIRTRADE	▪ Minimum coffee price for farmers ▪ Money is re-invested in community infrastructure • Restrictions on chemicals
No CO2 www.noco2.com.au	CERTIFIED LOW CO2	• Carbon emissions calculated and fully offset
NASAA Organic www.nasaa.com.au	NASAA CERTIFIED ORGANIC	• Grown without the use of chemical fertilisers, herbicides or pesticides.

BEEF

Buying and use patterns

Australians consume about 40 kg of beef and veal each a year, 18 kg of pork, 6 kg of mutton and lamb and 31 kg of poultry[53]. As beef is the most popular source of meat, this account will focus on beef produced for the domestic market to illustrate the sustainability issues involved in the processes from meat production through to its delivery to consumers in Canberra. Australia exports an even larger amount of beef; it leaves Australia as chilled or frozen meat or as live animals.

Australians consume about 40 kg of beef and veal each a year

… buy their beef from supermarkets (65%), butchers (27%) or markets and delis (8%).

… a third is eaten outside the home …

Australian consumers buy their beef from supermarkets (65% by volume), butchers (27%) or markets and delis (8%)[54]. The typical purchase is therefore from a supermarket where there are high degrees of vertical integration, especially in the largest two chains, Woolworths and Coles. This means that the retailer has often sourced its meat by direct contract from the grower, although auctions at saleyards remain an additional source when their contract supply is low or prices are attractive.

Beef bought for home cooking is only two-thirds of the total consumed in Australia. About a third is eaten outside the home (e.g. in cafés, restaurants and takeaways); at events like football matches; in institutions like hospitals and residential care homes; and in cafeterias in places like factories and mines, boarding schools, universities, prisons and defence establishments[55].

Statistics from the USA suggest that consumers there do not eat 30% of meat they buy, and that 7% of meat in supermarkets is not sold and is discarded[56].

Flows of meat from paddock to plate

The major routes used to produce and deliver beef to consumers in Canberra are shown in Figure 8.

Beef production

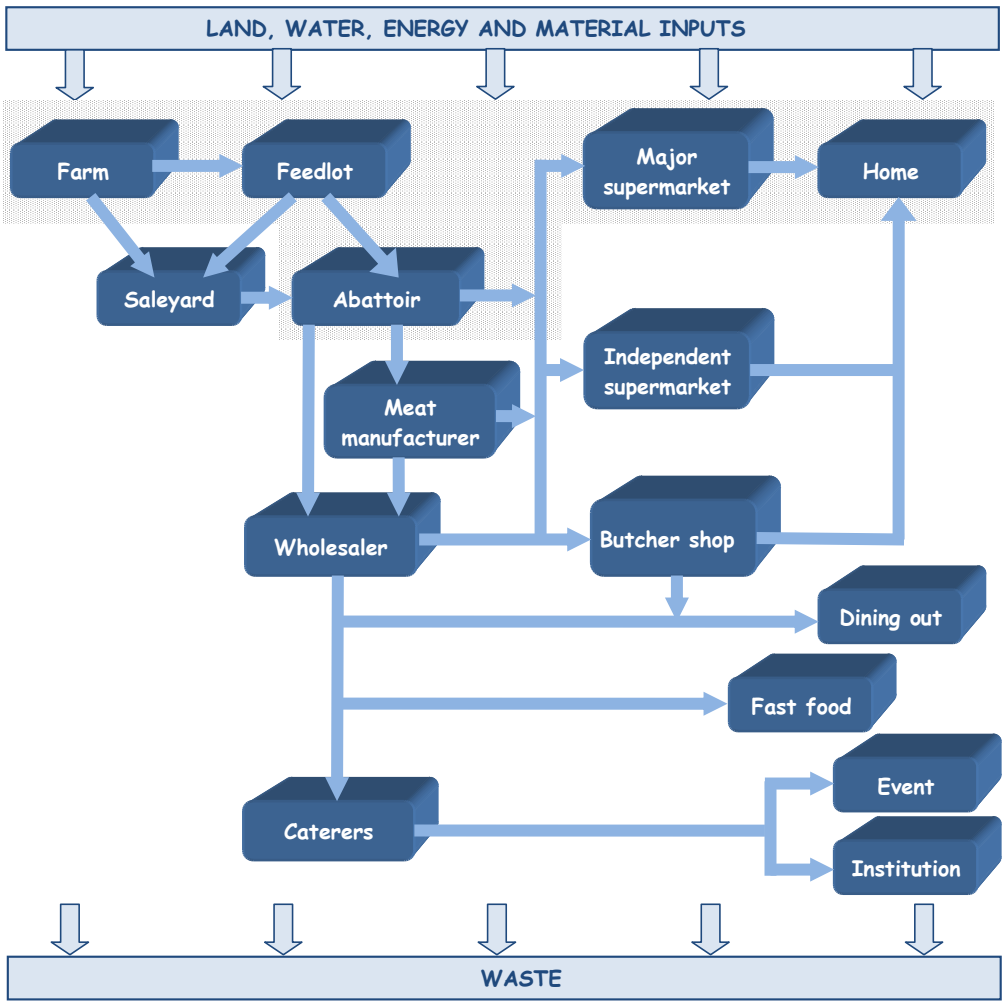
Typical beef production in south-eastern Australia is of grazing on improved pastures, and feedlotting to finish. A small number of beef cattle are grown in the ACT, but they are commonly moved to feedlots in the grain-growing regions to the west of the ACT to improve weight gain and

[53] ABS cat. no. 4306.0 *Apparent Consumption of Foodstuffs, Australia, 1997-8 and 1998-1999*. http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4306.0Explanatory%20Notes11997-98%20and%201998-99?OpenDocument. Accessed 2 Jun 2011.
[54] Meat and Livestock Australia (2010) *Australian Meat Purchasing Data July 2010*. http://www.mla.com.au/files/5f7836bd-05f8-4dbb-b162-9d9800e31f9e/australian-meat-purchasing-data-report-june2010.pdf. Accessed 3 Jun 2011.
[55] Freshlogic (2007) FOODmap. *A Comparative Analysis of Australian Food Distribution Channels.* Department of Agriculture, Fisheries and Forestry. http://www.daff.gov.au/__data/assets/pdf_file/0003/298002/foodmap-full.pdf. Accessed 3 Jun 2011.
[56] Economic Research Service (2008) *Food Expenditure Tables*. United States Department of Agriculture http://www.ers.usda.gov/Briefing/CPIFoodAndExpenditures/Data/Expenditures_tables/. Accessed 3 Jun 2011.

condition over several months before slaughter. Feedlots tend to be located nearer the source of grain and abattoirs and away from urban populations.

Figure 8 Major flows of meat from paddock to plate in Canberra.

The shaded area represents the largest volume of flow.



The major supermarkets largely purchase their beef directly from farms or feedlots and after slaughter move the meat through a small number of very large distribution centres. The typical piece of beef bought by consumers in Woolworths in the ACT was probably grown anywhere from the north to the south of New South Wales and travelled in refrigerated trucks to Canberra via distribution centres in Wodonga or Sydney[57]. Meat bought at a butcher is more likely to have been grown and slaughtered in a nearer region and purchased by the butcher from a wholesaler. Only a few specialty butchers and restaurants know which farm their meat has come from.

[57] Wooworths (2008) *The Facts About Grocery Retailing at Woolworths*. http://library.corporate-ir.net/library/14/144/144044/items/287977/FactsAboutGroceRetailingatWoolworths.pdf. Accessed 6 Jun 2011.

Grazing of animals on non-irrigated pasture has a large land area footprint but an otherwise relatively small environmental impact as there is little ground cultivation or pest or weed control and relatively little direct energy use on the farm. It takes about 210,000 ha (equivalent to 90% of the area of the ACT) of typical southern tableland grazing area to provide the beef eaten annually in Canberra. Most animals are sent to a feedlot for a final fattening where the direct land area impact is small but they are fed grain grown on agricultural land, which involves larger energy and chemical use. Their nutrient rich effluent can also impact the health of waterways. Emissions of nitrous oxide and ammonia from the manure are also greenhouse gases.

It takes about 210,000 ha (equivalent to 90% of the area of the ACT) of typical southern tableland grazing area to provide the beef eaten annually in Canberra.

A more significant hotspot in beef production comes from their emissions of methane, a much more potent greenhouse gas than carbon dioxide. Methane (CH4) is a by-product of fermentation by microorganisms in the stomach of cattle (and other ruminants like sheep) that enables them to derive adequate nutrition from grass, which is otherwise very indigestible. Because methane has 25 times the greenhouse impact of CO2, and sheep and cattle do emit large amounts of methane, they contribute about 70% of agriculture's contribution to emissions and about 10% of all of Australia's greenhouse gases[58].

Like organic wheat production, there are relatively few certified organic producers of beef: about 270 out of 50,000 producers in 2005[59]. An Australian comparison of organic and conventional beef production[60] found that organic beef production had a significantly higher land area footprint (per $ value of product) but lower CO2e emissions over its life cycle.

Transport

Considerable movement of live animals and then their meat is involved in bringing a steak to Canberra. The number of saleyards and abattoirs has declined significantly in the last decade, partly due to reduced animal numbers during the drought and partly due to market forces making smaller enterprises less profitable. There are now only 60 saleyards in New South Wales and 25 abattoirs[61]; just seven of these that process meat for the domestic market are in the Capital Region (Bega, Cooma, Cootamundra, Gundagai, Harden, Moruya and Young). Once slaughtered, all transport and storage of meat needs to be refrigerated.

Footprints across the life cycle

A study comparing the CO2e emissions profile of lamb produced in New Zealand and the United Kingdom found that even with the addition of shipping NZ lamb to the UK, the much more intensive

[58] Department of Climate Change (2009) *National Greenhouse Gas Inventory. Accounting for the KYOTO target May 2009*. http://www.climatechange.gov.au/en/climate-change/~/media/publications/greenhouse-report/national-greenhouse-gas-inventory-pdf.ashx.Accessed 17 May 2011.
[59] Halpin D (2005) Footnote 11.
[60] Wood et al. (2006) Footnote 12.
[61] Yellow Pages http://www.yellowpages.com.au/. Accessed 6 May 2011.

production system in the UK led to four times the overall emissions of NZ grown meat[62]. The shipping phase contributed 18% of the footprint of NZ lamb. These results highlight the relative importance of the production phase in the life cycle of meat, and the relatively small contribution that transport makes overall. Similar conclusions have been reached in European beef production systems[63].

An Australian comparison of wholly grass-fed cattle and cattle finished in a feedlot indicated that greenhouse gas emissions are about 18% less for meat from feedlotted animals, primarily because the high feed quality reduces their methane emissions[64].

Hotspots summary

The production phase dominates the footprint of meat. Hotspots are **the land area** required for raising the animals and the **methane** that contributes to greenhouse gas emissions.

Social and ethical considerations

Some people have an ethical position that animals should not be killed to provide meat for humans, or that animals should not be fed grain when people elsewhere in the world don't get enough to eat.

There are also animal welfare issues in raising, transporting and killing animals. Regulations about minimum standards of care are in place in Australia, but some would argue that these are insufficient, for example cattle can be kept confined in feedlots at high density, often without shade or winter shelter and with high concentrations of manure on the ground.

Your choices

There is insufficient environmental impact data and product labelling to make a general conclusion about the better options for general meat buying in Canberra. Meat from a butcher is more likely to come from a nearer region, and staff are more likely to be able to provide information about its origin than staff in a major supermarket.

Certified organic meat will have involved reduced on-farm impact in terms of chemical use, but not land use.

One choice that can be exercised over beef consumption is to reduce the amount eaten. Reductions in meat consumption, especially red meat, are commonly recommended for health reasons in Western countries. A study in Scotland indicated that changing from the average diet actually eaten to one that is nutritionally recommended, but

…insufficient data and labelling to make a general conclusion …

… reduce the amount eaten…

There is no uncertainty about the benefits of reducing the amount of meat wasted …

… use the car wisely for shopping …

[62] Saunders C, Barber A, Taylor G (2006) *Food Miles – Comparative Energy/Emissions Performance of New Zealand's Agriculture Industry.* Research Report 285. Lincoln University. http://www.lincoln.ac.nz/documents/2328_rr285_s13389.pdf. Accessed 16 June 2011.

[63] Wolf O, Perez-Dominguez I, Rueda-Cantuche JM, Tukker A. Kleijn R, de Koning A, Bausch-Goldbohm S, Verheijden M (2011) Do healthy diets in Europe matter to the environment? A quantitative analysis. *Journal of Policy Modelling* 33: 8-28.

[64] Peters GM, Rowley HV, Wiedemann S, Tucker R, Short M, Schulz M (2010). Red meat production in Australia: life cycle assessment and comparison with overseas studies. *Environmental Science & Technology* 44: 1327-1332.

still includes some meat and dairy, would reduce the ecological footprint by about 15%[65]. A healthy vegetarian diet would reduce the footprint a further 18% ie a 33% reduction from the current average diet – from 0.75 to 0.5 gha. A European study calculated a somewhat smaller decrease of 8% in the environmental footprint of food if the average diet shifted to a more Mediterranean diet containing less milk and meat, and more fish, fruit and vegetables[66].

Choosing other types of meat is another potential option for reducing the relatively high footprint of beef. For example, pork and chicken have lower methane emissions and higher feed conversion efficiencies, but they do rely on being fed grain for their whole lives, compared to beef cattle which graze predominantly on rainfed pasture in Australia. Kangaroos also have lower methane emissions.

A final option is to reduce the amount of meat wasted at home by eating leftovers or extending the life of purchased but unused meat by making it into soups or stews that can be stored or frozen for later use.

Finally, like the previous products, use the car wisely for shopping.

[65] Frey S, Barrett J (2006) The *Footprint of Scotland's Diet. The Environmental Burden of What We Eat*. http://www.wwf.org.uk/filelibrary/pdf/the_footprint_of_scotlands_diet.pdf. Accessed 10 Jun 2011.
[66] Wolf et al. (2011) Footnote 53.

TOMATOES

Buying and use patterns

Fresh tomatoes are the third most popular vegetable[67] in Australians' weekly shop, after carrots and potatoes[68]. Between home and eating out, we each account for about 6 kg of fresh tomatoes grown every year. In addition, we account for a further 20 kg of tomatoes that have been processed into products with longer shelf-life[69]. These include tinned and pureed tomatoes, tomato pastes and tomato sauce, and like fresh tomatoes, they're used in food both in the home and in eating out.

If you are a Canberra resident, you are most likely to shop for fresh tomatoes in a supermarket or grocery store. Sixty-six percent of the money we spend in Canberra on food is spent this way, and only 8% is spent in other retail outlets like greengrocers and markets. The other 26% of our food dollar is spent in cafés and restaurants (18%) and on fast food (9%)[70].

It is also highly likely that your fresh tomatoes have come from Queensland. Queensland grows nearly all the eating tomatoes sold in the wholesale markets of Brisbane, Sydney and Melbourne[71], or supplied directly from the grower to the major supermarkets in eastern Australia. Only 6% of Canberrans report that markets are their preferred place for food shopping[72] and where it is more likely that produce will have been grown locally.

Of the 20 kg of tomatoes used for processed products, 12 kg will have been grown in Australia and 8 kg overseas. Northern Victoria and southern NSW produce almost all Australian processing tomatoes[73], and Italy supplies 70% of imported processed tomatoes[74]. Italian tomatoes are mostly the Roma variety which is not suited to the high rates of mechanisation used in the Australian processed tomato industry. The life cycle analysis of the typical tomato eaten in Canberra therefore begins with the production systems typical of fresh tomatoes grown in Queensland, or of processing tomatoes grown in Victoria or in Italy.

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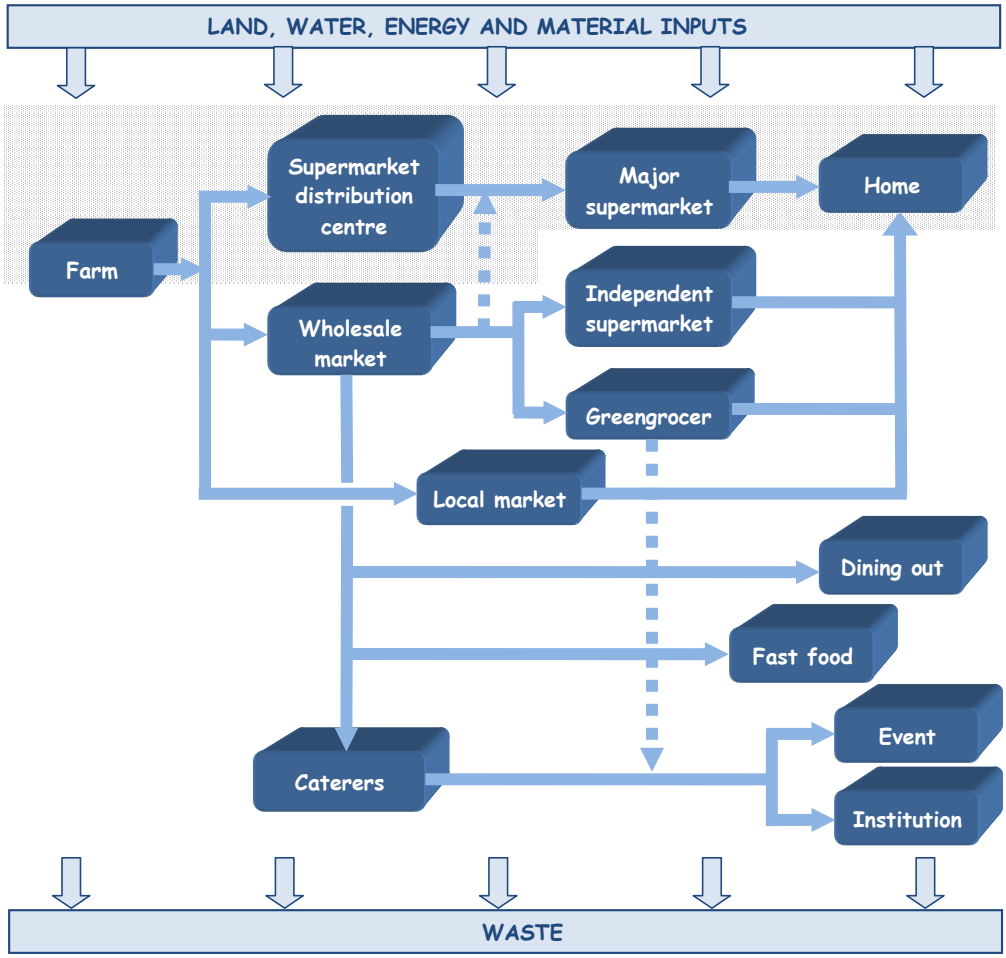
[67] Technically tomatoes are a fruit but they are eaten and classified for data collection as a vegetable.
[68] AUSVEG (2011) Top 10 most popular fresh vegetables revealed. http://ausveg.com.au/_webapp_781778/Top_10_most_popular_fresh_vegetables_revealed. Accessed 15 May 2011.
[69] Calculated from ABS population data cat. no. 3101.0, ABS agriculture data cat. no. 7121.0 2009/10 and Mann (2007) Annual Industry Survey. In *Australian Processing Tomato Grower* 28:5-7.
[70] Department of Agriculture, Fisheries and Forestry (2011) *Australian Food Statistics 2009-2010*. http://www.daff.gov.au/__data/assets/pdf_file/0011/1910819/food-stats2009-10.pdf. Accessed 12 May 2011.
[71] Fullelove G, Wright R, Meurant N, Barnes J, O'Brien R, Lovatt J (1998) *Tomato Information Kit.* Agrilink Series QAL9805. Department of Primary Industries, Brisbane. http://era.deedi.qld.gov.au/1655/. Accessed 8 May 2011.
[72] Sensis (2009) *Consumer Report.* http://about.sensis.com.au/IgnitionSuite/uploads/docs/March2009SensisConsumerReport.pdf. Accessed 15 May 2011.
[73] ABS cat. no. 7121.0 http://www.abs.gov.au/ausstats/abs@.nsf/mf/7121.0.
[74] Apted S, Berry P, Short C, Topp V, Mazur K, Van Mellor T (2006) *International Competitiveness of the Australian Vegetable Production Industry* ABARE eReport 06.5, Canberra. http://adl.brs.gov.au/data/warehouse/pe_abarebrs99001252/pc13401.pdf. Accessed 12 May 2011.

Product flow

The major routes that fresh tomatoes take to reach a consumer in Canberra are shown in Figure 9. The route for processed tomatoes is not shown but for Australian processed tomatoes it essentially needs an additional step between farm and distribution centre and the products are then distributed through the usual grocery distribution pathways. Imported processed products arrive at Australian ports and are then similarly distributed.

Figure 9 Major flows of fresh tomatoes from farm to the place of consumption.

The shaded area represents the most typical for Canberra.



Production

Tomatoes are very sensitive to frost and yield best in warmer climates. Most tomatoes grown in Australia are grown outdoors[75] because it is less costly than growing them in greenhouses and the climate is warm enough. Fresh tomatoes in Queensland are grown year round using different locations depending on the season. They are mostly grown on a trellised system and require hand-

[75] Rural Industries Research and Development Corporation http://www.rirdc.gov.au/programs/established-rural-industries/pollination/tomatoes.cfm. Accessed 2 Jun 2100.

picking as well as on-farm facilities for washing, ripening and keeping them cool; tomatoes for processing in Victoria are grown on the ground, irrigated with trickle irrigation, and picked just once by machine.

A detailed life cycle analysis of typical Australian grown tomatoes has not been done.

A detailed life cycle analysis of typical Australian grown tomatoes has not been done. Like most other horticultural crops, inputs of fertiliser, chemicals, water, equipment and labour are relatively high but the fact that most Australian tomatoes are grown outdoors means the footprint is likely to be less than in countries where tomatoes are mostly grown in greenhouses with higher embodied and operating footprints. Each of those inputs, like fertiliser, has its own upstream environmental impacts. Fertiliser manufacture requires considerable energy. One Australian study found that the energy used to transport fertiliser to a typical Australian farm is less than 1% of the energy used to manufacture the fertiliser[76].

There is also likely to be considerable variability between farms in their environmental impact, depending on their location and farm practices. Through their industry groups, vegetable farmers in Australia are encouraged to improve the sustainability of their farming practices. A grower body, Ausveg, provides a manual and self-assessment checklist of 171 farm activities that impact on sustainability[77]. Just ten of those 171 activities are shown in Box 1 to illustrate the types of activities that would have to be independently assessed on every farm and incorporated into a labelling system if consumers were to be able to choose between food produced in a more rather than a less sustainable fashion. However, this is a purely voluntary scheme which is not independently audited, and nor does the information accompany the product to market. Therefore consumers largely can't choose tomatoes whose production history is known.

While a small percentage of Australian farms do have their production systems certified as organic, and this is a choice for consumers willing to seek these products out, this doesn't apply to the bulk of food available. Organic vegetable farms do have significantly lower energy and water footprints compared to conventional vegetable farms[78].

An example of the variability between farms in tomato production comes from a comparative study of a hi-tech greenhouse production system in northern NSW and a medium-tech greenhouse system near Sydney. (These systems account for much less total production than the Queensland outdoor grown tomatoes.) The medium-tech system had a water footprint of 21 litres/kg tomatoes, compared to 2 litres/kg in the hi-tech system[79]. The difference was due partly to more recycling in the hi-tech system, and partly to inclusion in the footprint of data that relates to the relative availability of the water in the two places. However, moving production to northern NSW because its water footprint is lower would cause its transport energy footprint to increase because of a longer transport distance to Sydney.

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[76] Wood et al. (2006) Footnote 12.
[77] AUSVEG EnviroVeg Self Assessment http://ausveg.com.au/enviroveg/self_assessment.htm Accessed 19 May 2011.
[78] As above.
[79] Page G, Billoti B, Ridoutt B (2010) Using Life Cycle Assessment (LCA) to assess water use in tomato production. In: Food Security from Sustainable Agriculture. Edited by H. Dove and R. A. Culvenor. *Proceedings of 15th Agronomy Conference 2010*, 15-18 November 2010, Lincoln, New Zealand. http://www.regional.org.au/au/asa/2010/farming-systems/energy-balance/7142_page.htm. Accessed 8 May 2011.

Box 1 A selection of the detail considered in assessing the 'Water and Waterways' category of on-farm sustainability of vegetable production in Australia. Other categories include Energy, Soil, Biodiversity, Chemical Management, Waste, Pests and Diseases. From EnviroVeg self-assessment checklist (Ausveg website).

- Water for irrigation from sources that may cause environmental harm to land and soil, waterways and sensitive areas is managed or treated to minimise the risk of environmental harm.
- The irrigation schedule is based on: weather predictions; water stress symptoms; actual rainfall using rain gauges; wetting front detectors or soil moisture probes.
- The irrigation system is: efficient and minimises water use; causes minimal soil erosion, and minimises energy use.
- Incoming and drainage water in hydroponic systems is monitored for pH and electrical conductivity.
- Water loss is minimised by checking for and repairing leaks on a regular basis.
- Evaporation is minimised from storages and delivery systems.
- Water is recycled where possible.
- Pests are managed in water storages and waterways - including algae, weeds, pest animals and diseases.
- Water discharged from the property is managed or treated to minimise off-site environmental harm.
- Runoff and tail water is channelled into sumps, settling ponds or grassed channels before it goes into storage.

Such "tradeoffs" between different components of the footprint are common. Another example is installing more efficient irrigation systems that rely on pumps to pressurise and move water around. This achieves water savings but increases the use of energy. Unless the energy is coming from a renewable source, an improvement in this water footprint would come at the cost of an increase in greenhouse gas footprint. Storage of food in home freezers is another. This can reduce the number of shopping trips and wastage of food, but it increases energy use.

Transport

The long distances that our fresh tomatoes travel to reach Canberra would often be thought to be a hotspot in their footprint. However, despite the distance, the energy footprint of food transport is only a part of all the energy used to produce and process and deliver it, especially when the embodied energy of all inputs in the life cycle is included. The reason for this is that transporting goods in bulk is extremely efficient. While large articulated trucks emit more greenhouse gases per vehicle than cars (about 5 times more per kilometre) they carry on average about 28,000 kg in goods. Therefore, for the same quantity of emissions a car produces in travelling 10 km to and from the supermarket to purchase 1 kg of shopping, an averagely-laden articulated truck can travel about 50,000 km (Scenario A, Table 3)[80]. This is some 25 times the 2,200 km distance from Bowen in Queensland to Canberra via Sydney. Even if the 1 kg of tomatoes is bought as part of a 10 kg shop, the car shopping trip is still more than twice as costly in terms or emissions as the truck trip from Queensland.

[80] See Appendix 1 for statistics and data sources used in the calculations.

Table 3 Car and articulated truck transport scenarios.

See Appendix 1 for data sources and statistical bases of the calculations.

	Car	Articulated truck	Unit
SCENARIO A, Emissions from a 10 km car round shopping trip to buy 1 kg tomatoes and from 1 kg tomatoes being transported the same distance in an averagely laden articulated truck (the impact of its return journey is attributed to the goods it carries on another averagely laden journey).	2.656	0.00052	kg CO2e
SCENARIO A. Equivalent distance of transport by truck for the same emissions as car journey.	10	50,630	km
SCENARIO B, As for A, but in the car journey the 1 kg tomatoes are part of a larger 10 kg shopping basket and the footprint of the other 9 kg is assigned to the other items.	0.265	0.00052	kg CO2e
SCENARIO B. Equivalent distance of truck journey for the same emissions as car journey.	10	5,063	km

Other studies have reached similar conclusions. It takes more energy for a UK consumer to drive 6.5 miles to buy green beans than it takes to fly the beans from Africa[81]. In Victoria, in a "farm-to-fork" analysis of the greenhouse emissions from transport of fruit and vegetables within the state, 5.5 km was the critical distance (11 km return) for the shopping trip by car; if more than that, the car journey begins to outweigh the longer distances involved in bringing produce from the country to the city[82]. These findings are very dependent on the average distance that consumers travel to shop and the size of the shopping basket; if the distance is reduced or the number of trips in the week is reduced then the longer distances travelled to bring the product to the store do become significant.

It has already been noted (see bread case study) that freight transport accounts for a relatively small part of the life cycle emissions of food products. A study of the life cycles of a number of food products in the USA found that only 6% of the emissions footprint was due to freight transport (using 1500 miles as the average distance)[83]. Over 80% of the footprint was due to food production and processing. This analysis included the contribution of home cooking, which is not frequently done. They estimate this was responsible for 8% of emissions. Transport for shopping trips is not always included in footprint analyses because it is hard to estimate accurately.

These findings mean that using food miles and promoting local production solely because transport distances are reduced is a poor indicator of sustainability in terms of energy use and greenhouse gas.

[81] UK Cabinet Office (2008) Cited in Hogan L and Thorpe S (2009). *Issues in Food Miles and Carbon Labelling*. ABARE Research Report 09.18. http://adl.brs.gov.au/data/warehouse/pe_abarebrs99001677/foodmiles.pdf. Accessed 14 May 2011.

[82] Marquez, L Higgins A, Estrada-Flores E (2010) *Understanding Victoria's Fruit and Vegetable Freight Movements.* CSIRO. http://www.ecoinnovationlab.com/uploads/attachments/398_Understanding%20Vic%20F&V%20Freight%20Movements.pdf. Accessed 14 May 2011.

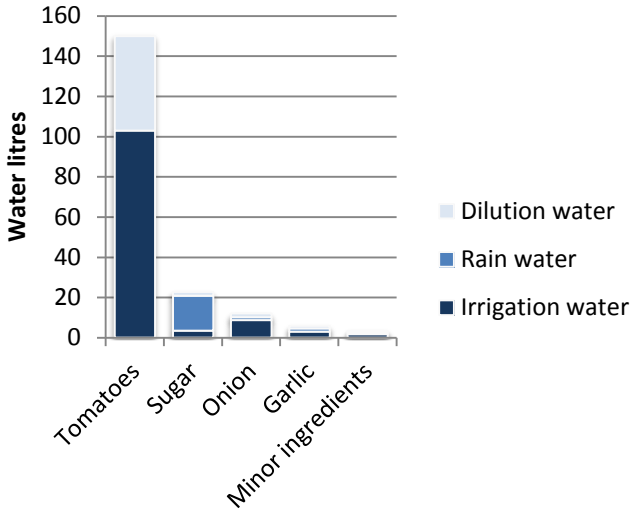
[83] Wakeland W, Cholette S, Venkat K (2011) Food Transportation Issues and Reducing Carbon Footprint. In *Green Technologies in Food Production and Processing* (ed: Arcand Y & Boye J) Springer. http://www.cleanmetrics.com/pages/Ch9_0923.pdf Accessed 3 Jun 2011.

Processing

For processed tomatoes there could be an additional footprint of the energy and water used in processing, and the upstream impacts of the added ingredients (e.g. salt, sugar, the buildings, machinery and packaging), the waste water from the factory and the disposal of the packaging. However, an Australian study[84] of the water footprint of an Australian pasta sauce found that it was dominated by the water used in irrigation to grow the tomatoes (Figure 10).

Figure 10 Water used during the life cycle of processed tomatoes.

The data refer to a 575 g jar of Dolmio© pasta sauce. Dilution water is the water needed to dilute excess nutrients from fertilizers to avoid damage to groundwater. Rainwater includes water used in the processing plant. The figure is redrawn from data in the resource at Footnote 34.



A study in Europe found that packaging and food processing were generally hotspots in the full life cycle of tomato sauce[85], depending on the measure of impact used. These steps had much larger impacts than transport, despite the tomatoes being grown and processed into paste in the Mediterranean, and then made into tomato sauce in Sweden. Like the examples mentioned earlier, this study also found that energy used by consumers in cars to shop for the product was larger than all the transport energy used in the steps before that.

Hotspots summary

For fresh tomatoes bought in Canberra, the hotspots for energy use and CO2e emissions are most likely to be in the final **retail and shopping trip**, followed by **fertiliser use** in the farming step.

For processed tomatoes the water hotspot is in **irrigation on the farm** and greenhouse hotspot is in the **final retail and shopping trip**; with an additional hotspot for the **processing step**.

Social and ethical considerations

A tomato consumer might also like to consider particular social aspects associated with the life cycle of tomatoes. In Australia, one study found that horticulture was a higher on-farm employer of people, per dollar value of product, than any other agricultural product[86], so buying Australian

[84] Ridoutt BG, Eady SJ, Sellahewa J, Simons L, Bektash R (2009) Water footprinting at the product brand level: case study and future challenges. *Journal of Cleaner Production* 17:1228-1235.
[85] Andersson K, Ohlsson T, Olsson P (1999) Screening life cycle assessment (LCA) of tomato ketchup: a case study. *Journal of Cleaner Production* 6:277-288.
[86] Wood *et al.* (2006) Footnote 12.

tomatoes does contribute to regional economies. There was little difference between employment on organic and non-organic farms for horticultural crops.

In relation to imported tomato products, which come mostly from Italy, their price competitiveness in Australia derives mostly from access to low cost labour from northern Africa and from Albania and a little from subsidies available within the European Union[87]. Even knowing this, a consumer would have to weigh up whether an employment opportunity for these people, even at low pay, outweighs no employment opportunity for them in their own countries. On the other hand, consumers might place more value on employment in Australia. As mentioned for bread, food processing in non-metropolitan Australia is a significant employer in some regional communities.

Your choices

Lack of Australian studies and … lack of labelling mean only very general conclusions can be drawn …

… reducing impact by reducing … car use for shopping

Lack of Australian studies of the life cycle impacts of tomatoes, and lack of labelling that reflects the particular life cycle impacts of tomatoes at the point of sale means only very general conclusions can be drawn about making more sustainable buying choices. Like many other consumer products, there is good leverage on reducing impact by reducing energy expenditure in the end steps of retailing and car use for shopping. Shopping less often but buying more each time is effective, as is combining shopping trips with other reasons for using the car. Using public transport, riding a bike or walking are other options.

Consumers might like to choose **fresh tomatoes** that were produced locally, in order to support the regional economy, but this is not an option for most Canberra consumers buying tomatoes from supermarkets. Farmers' markets do provide local and regionally grown tomatoes. As they are usually held outdoors or only semi-covered these markets provide an opportunity to avoid the energy involved in heating and cooling supermarkets and shops. However, the greenhouse impact of individual producers transporting produce in vans or small trucks with relatively high emissions means that their transport emissions in this case can become high if they come from some distance away. In this case, and all other things being equal (e.g. the tomatoes are all outdoor grown or all greenhouse grown, and used the same amounts of water and fertiliser), lower food miles will translate to lower greenhouse impact. Because there are few farmers' markets in Canberra, making a long car journey to shop at them is likely to significantly add to impact.

For **processed tomatoes** purchased in a shop, the country of origin must be stated on the label, so consumers can choose to buy either Australian or imported products. Imported tomato products will likely have higher transport emissions (although shipping is very efficient) and there's insufficient other information about the footprint of their production overseas to make a definitive conclusion about their whole life cycle impact compared to Australian processed tomatoes. Consumers can exercise this choice in a shop, but not when buying tomatoes as part of a meal e.g. in a pizza.

[87] Wood *et al.* (2006) Footnote 12.

TELEVISION SETS

Buying and use patterns

Australians own on average 2.4 television sets per household – almost exactly one television per person[88]. We also purchase over 3.1 million new television sets per year[89]. Each television is in use by at least one household member for between 5 and 8 hours each day, with average weekly use per person around 13.3 hours[90].

Australians own … 2.4 television sets per household.

The average lifespan of Australian televisions sets has reduced from 10 years in 1995 to an estimated 7 years in 2013.

The average lifespan of Australian television sets is decreasing rapidly. Due to the shift to digital and high definition television, as well as the introduction of new projection technologies such as liquid crystal displays (LCD) and plasma display panels (PDP), the lifespan of an average television set has reduced from 10 years in 1995 to an estimated 7 years in 2013[91] as older Cathode-Ray Tube (CRT) displays are rapidly replaced.

Production

The last Australian-made television sets were produced in 2006, before Panasonic shut down their last Australian television set manufactory[92]. Since then, all television sets bought in Australia have been produced overseas, with 74% of Australian sets being produced by Sony, Samsung, LG, Panasonic and Sharp. Australian households imported $3.251 billion of televisions in 2009 alone – an average of $147 per person[93].

The last Australian-made television sets were produced in 2006.

Manufacturing of television sets is an extremely complex production process, with assembly largely occurring in China[94]. Most individual components, such as the LCD displays, are made elsewhere in South-East Asia, with Korea and Taiwan having the largest shares of the LCD display manufacturing market with 44% and 34% respectively[95]. The LCD display alone contains glass, silicon dioxide, indium tin oxide, various polymers and the liquid crystal itself. Although by weight television sets are predominantly made up of glass and plastic (Table 4[96]), they also contain toxic and rare chemicals and metals, including lead, mercury, arsenic and cadmium[97].

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[88] The Australian Greenhouse Office (2007) *Television Energy Performance Standards and Comparative Energy Labels.* http://www.energyrating.gov.au/library/details2007-factsheet-tv.html. Accessed 12 May 2011.
[89] Environment Protection and Heritage Council (2009) *Decision Regulatory Impact Statement: Televisions and Computers.* http://www.ephc.gov.au/sites/default/files/PS_TV_Comp__Decision_RIS__Televisions_and_Computers__200911_0.pdf. Accessed May 2011.
[90] Nielsen (2008) *Aussie Internet Usage Overtakes TV Viewing for the First Time.* News Release. http://www.nielsen-online.com/pr/pr_080318_AU.pdf. Accessed 17 May 2011.
[91] Environment Protection and Heritage Council (2009) Footnote 89.
[92] As above.
[93] As above.
[94] Digitimes Research (2007) *FPD Report – Taiwan LCD Monitors.* http://www.digitimes.com/Reports/PDF/MONITOR4Q07.pdf. Accessed May 2011.
[95] Chen J and Chen Y (2009) *A System Dynamics Model of the TFT LCD Industry Development in Taiwan.* System Dynamics Society 2009 Conference. http://www.systemdynamics.org/conferences/2009/proceed/papers/P1171.pdf. Accessed 30 May 2011.
[96] Environment Protection and Heritage Council (2009) Footnote 89.
[97] As above.

Table 4 Major material composition of CRT (cathode ray) and FPD (flat panel) television sets.

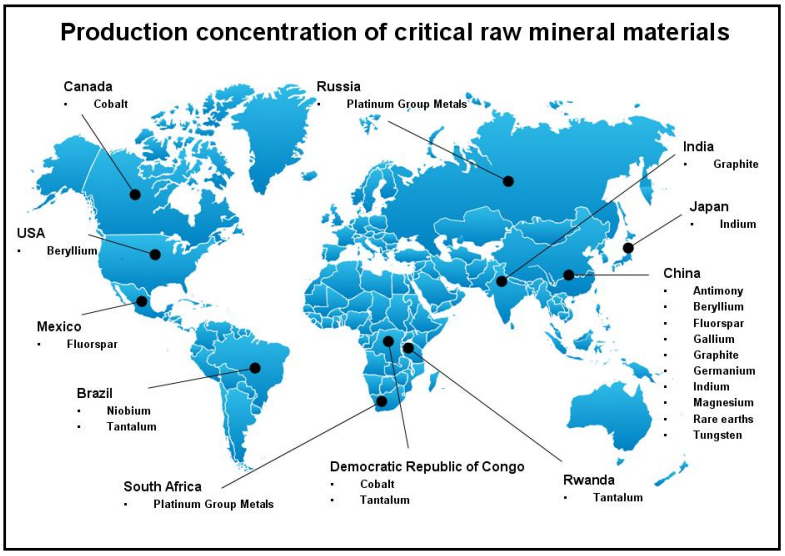
The data is from the resource at Footnote 96.

Material	CRT kg	% of total	FPD kg	% of total
Glass	17.80	67	6.27	22
Plastic	4.86	18	8.59	30
Copper	0.97	4	0.88	3
Iron	0.59	2	4.13	15
Aluminium	0.22	1	1.78	6
Steel/Other metals	0.09	0	5.92	21
Other	2.12	8	0.78	3
Total	**26.65**	**100**	**28.35**	**100**

These raw materials are sourced from all over the globe, and include rare minerals as shown in Figure 11[98]. A number of these materials are also in short supply, with lead supplies expected to run out in 42 years, and copper deposits expected to be depleted in 61 years.

Figure 11 Sources of rare minerals used in television sets.

The figure is reproduced from the resource at Footnote 98.



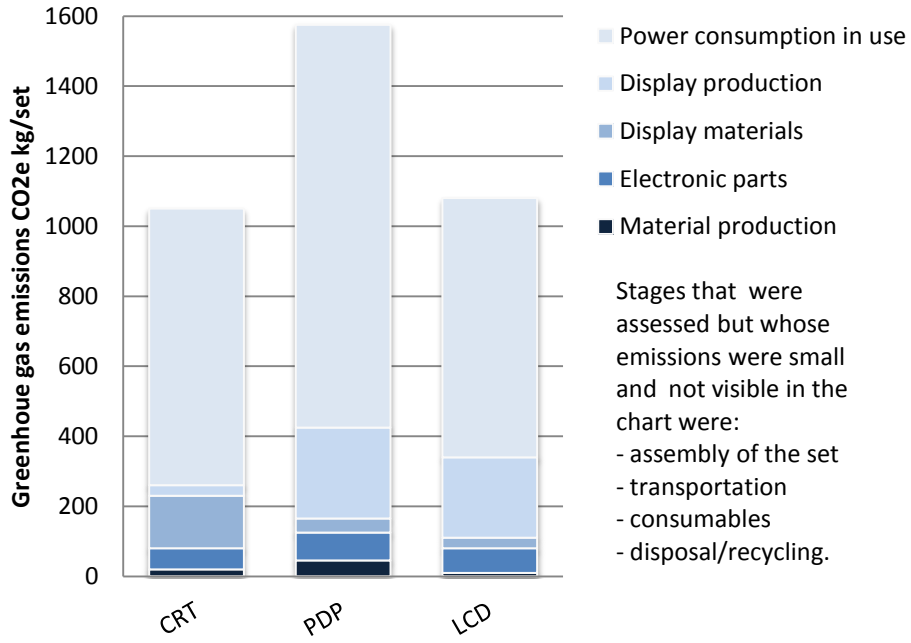
[98] Environment Protection and Heritage Council (2009) Footnote 89.

Footprints across the life cycle

There are a number of ways in which use and consumption of television sets impacts on the environment. Few television manufacturers calculate or disclose the carbon and water footprints of their products, however a recent analysis of a 29" LCD television set has estimated that its production, use and disposal has a footprint of 62,000 litres of water[99]. Data from another life cycle comparison of the average emissions of CRT, PDP and LCD televisions is shown in Figure 11, with another assessment calculating a total carbon footprint of 1241kg of CO2e for a 32" LCD television[100].

Figure 12 Greenhouse gas emissions from different types of television screens.

CRT=cathode ray, PDP=plasma, LCD=liquid crystal. The figure is redrawn from the resource at Footnote 100.



Although the lifespan of television sets is shortening, the energy required for both television use and the 'stand-by' mode of an LCD television comprises over 60% of the total CO2e emitted during a television's life-cycle[101]. This share is set to increase as Australians continue to buy larger, high-definition television sets, which consume much higher levels of electricity[102].

Although the carbon footprint of a television set varies significantly depending on screen size and display technology, the bulk of the emissions occur through consumer use, irrespective of the

[99] Symons D (2009) *Is Water More Important Than Carbon in a Climate Changed World*? *Environmental Law & Management* 21:142-144.
[100] Lin W (2009) *Experience Sharing of the Carbon Footprint of TFT-LCD Panels*. Presentation for AUO, Hsinchu, Taiwan http://www.ftis.org.tw/active/download/2_4.pdf. Accessed 27 May 2011.
[101] As above.
[102] Energy Consult Pty Ltd. (2009) *Baseline TV Power Consumption 2009.* Prepared for Department of the Environment, Water, Heritage and the Arts. http://www.energyrating.gov.au/library/pubs/200919-tv-power-consump.pdf. Accessed 4 May 2011.

television type[103]. As Australia is highly dependent on fossil fuels for electricity supply, the rates of both in use and standby power consumption should be the main environmental considerations when purchasing a television. In general, plasma displays range from 150 to 400 or more watts, whereas LCD displays range from 100-275W[104]. From 2009 television sets imported to Australia must display an energy rating, which states the television set's energy consumption in kilowatt hours, on average, per year[105]. Approximately 1kg of CO2 is emitted for each kWh consumed in the ACT, although households can choose to have their power supplied from renewable sources[106].

Disposal

Australians disposed of 1.5 million television sets in 2008, and are projected to dispose of 2.5 million in 2012. As a waste product, televisions contain a number of hazardous chemicals, such as lead, mercury, cadmium and brominated flame retardants[107]. Over 88% of Australian television sets currently end up in landfill[108], however in the ACT television recycling has been mandatory since 27 April 2010. A lack of regulation of e-waste recycling in the past has resulted in large quantities being processed in developing countries (Figure 13)[109]. A national E-waste recycling scheme is due to be rolled out in eight Australian cities, including Canberra, in 2011[110].

Figure 13 Global flows of e-waste.

The figure is reproduced from the resource at Footnote 109.

[103] Aoe T (2003) Case Study for Calculation of Facto X (Eco-Efficiency) – Comparing CRT TV, PDP TV and LCD TV. Discussion Paper for EcoDesign 2003. http://keskkond.ttu.ee/doc/Case%20study%20TV.pdf. Accessed 13 May 2011.
[104] Energy Consult Pty Ltd. (2009) Footnote 102.
[105] Department of Climate Change and Energy Efficiency (2000) *Fact Sheet – Mandatory TV Labelling and MEPS*. http://www.energyrating.gov.au/pubs/factsheet-tv-labelling.pdf. Accessed 1 May 2011.
[106] Blakers A (2008) *Deep cuts in household greenhouse gas emissions.* http://cses.anu.edu.au/files/0809_greenhouse_emissions_from_home.pdf. Accessed 21 May 2011.
[107] Environment Protection and Heritage Council (2009) Footnote 102.
[108] Australian Bureau of Statistics (2010) *Australia's Environment Issues and Trends.* http://www.ausstats.abs.gov.au/Ausstats/subscriber.nsf/0/41D729B432E03FA0CA2576B800164E89/$File/46130_2010.pdf Accessed 10 May 2011.
[109] UNEP/GRID-Arendal (2004) *Who gets the trash?* UNEP/GRID-Arendal Maps and Graphics Library, http://maps.grida.no/go/graphic/who-gets-the-trash. Accessed 2 June 2011.
[110] Department of Sustainability, Environment, Water, Population and Communities (2011) *National Television and Computer Product Stewardship Scheme – Consultation Paper on Proposed Regulations.* http://www.environment.gov.au/settlements/waste/ewaste/consultation/pubs/ps-ewaste-consultation-paper.pdf. Accessed May 2011.

Hotspots summary

The environmental hotspot for the average television bought and used in Canberra is in its **greenhouse gas impact through its use in the home** due to the high reliance in Canberra on fossil energy for electricity.

Social and ethical considerations

The major social concerns with television manufacture and disposal are the working conditions of people in developing countries who mine and process the raw materials that go into television sets, work in the factories that make the sets or their components, or are involved in their recycling. Many of these countries have poor health and safety regulations and consequently workers are often exposed to high levels of toxic chemicals. Workers may also have few other employment opportunities and be poorly paid. The country where the set is finally assembled is required to be identified by Australian labelling laws, but as discussed above, their components and their disposal touch a very large number of countries, mostly in the developing world.

Your choices

As most power consumption occurs through use, buying renewable energy at home is the most effective approach to reducing the environmental footprint of a television set. Power can also be saved by turning television sets, as well as set top boxes and home entertainment units off at the wall, rather than putting them on standby mode. Although television sets sold after 2012 in Australia must have less than a 1-watt stand-by mode, some older sets consume as much as 19.7 watts when on standby, which is more than some compact fluorescent light bulbs[111].

The second most effective choice for a television buyer is choice of screen type. Of the three dominant display types available, it is predicted that LCD will continue to dominate the global market[112], partly because plasma displays in general have higher electricity consumption for the same screen size[113] and partly because CRTs have become superseded by newer technologies and are bulkier and more costly to transport. If you are not using renewable energy in the home, an LCD screen probably has the lowest impact. If you are using renewable energy, your choice can be shaped by other preferences because there will be relatively little difference in impact of the different screen types.

… buying renewable energy at home is the most effective approach to reducing the environmental footprint of a television set.

Power can also be saved by turning television sets … off at the wall.

.. an LCD screen probably has the lowest impact..

… buy one that includes Automatic Brightness Control.

… not buying a set that is any larger than necessary for the viewing distance ..

… waiting a while to buy the next new set … or buying a second-hand one

[111] International Energy Agency (2009) *Gadgets and Gigawatts – Policies for Energy Efficient Electronics.* http://www.iea.org/textbase/nppdf/free/2009/gigawatts2009.pdf Accessed 2 May 2011.
[112] Park W, Phadke A, Shah N, Letschert V (2011) *Energy Consumption Trends and Efficiency Improvement Opportunities in Television.* Draft Working Document. http://ies.lbl.gov/drupal.files/ies.lbl.gov.sandbox/SEAD_TVAnalysis_Draft_Working_Document.pdf Accessed 22 April 2011.
[113] Hischier R, Baudin I (2010) LCA study of a plasma television device. *International Journal of Life Cycle Assessment* 15:428-438.

An additional feature to consider if purchasing a new television set is to buy one that includes Automatic Brightness Control. This adjusts the brightness of the display to suit ambient light and can cut backlight power consumption by as much as 30%[114]. Also, as screen size has a significant impact on energy consumption, impact can be reduced by not buying a set that is any larger than necessary for the viewing distance required.

Finally, waiting a little longer to buy the next new set (display technologies are rapidly changing and power consumption is quickly improving due to government regulation and technological innovation) or buying a second-hand one are also options for reducing the environmental impact of having a television.

[114] Texas Advanced Optoelectronic Solutions (2009) *Turning HDTVs Green.* http://www.lcdtvassociation.org/images/TAOS_Turning_HDTVs_Green_White_Paper10302009.pdf. Accessed 2 May 2011.

PAPER BOOKS

Buying and use patterns

Australians purchase over 80 million new books through Australian retailers (mostly from bookshops) each year, at a cost of $1.4 billion dollars[115]. Actual book consumption rates are higher than this however, with Australians increasingly purchasing books online through overseas suppliers, which are not included in Australian data. Australian titles account for roughly 60% of total book sales, although 4% of Australian published books are acquired through overseas suppliers[116]. On average, each Australian buys four new books per year, at a cost of $60[117].

… each Australian buys four books per year

Canberra residents are likely to buy more than this, due to their higher education and income levels.

A recent survey found that 54% of Australians read on a weekly basis, with 90% of readers having read a novel in the last year[118]. Respondents spent an average of 5 hours reading printed books per week, with 68% wanting to spend more time reading than they already did[119].

Increasingly, however, books are being read in digital formats, with 13% of Australians having downloaded an electronic book, or e-book, from a website, and 6% using a portable electronic reading device[120]. Although Australian consumption statistics are not available for electronic book formats, wholesale purchases of electronic books in the United States in 2010 were estimated to be worth over US$350 million, more than twice their value in 2009 and thirty times their value in 2005[121]. A similar trend is expected in Australia.

In the ACT in 2005, retailers of books, newspapers and stationery employed 419 people across 41 retail locations[122], although the recent closures of Borders and Angus & Robertson stores will have reduced this number significantly.

Product flow

A typical route for the production and use of a book is shown in Figure 14. Australia produces about one third (585,000 tonnes) of its printing and writing paper domestically and imports the remainder, over 1 million tonnes annually[123]. Much of this comes from Asia (Figure 15[124]). The origins of these

[115] Australian Bureau of Statistics (2005) *Book Publishers Australia 2003-2004*. ABS 1363.0 http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1363.02003-04. Accessed 5 Jun 2011.
[116] As above.
[117] Australian Bureau of Statistics (2005) *Book Retailers Australia 2003-2004*. ABS 1371.0 http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1371.02003-04. Accessed 5 Jun 2011.
[118] AMR Interactive (2011) *Get Reading! 2010 Campaign Effectiveness Research*. http://www.australiacouncil.gov.au/__data/assets/pdf_file/0015/102453/GR10_-_Final_Research_Report.pdf. Accessed 8 June 2011
[119] As above.
[120] As above.
[121] International Digital Publishing Forum (2010) *Additional eBook Statistics.* http://idpf.org/about-us/industry-statistics#Additional_Global_eBook_Sales_Figures. Accessed 8 Jun 2011.
[122] Australian Bureau of Statistics (2005) Footnote 117.
[123] A3P (2004) *Australian Paper Industry Production Statistics* http://www.a3p.asn.au/admin/assets/pdf/Stats/Statistics%20-%202003-04%20Paper%20Production.pdf. Accessed 8 June 2011.

imported paper supplies are often difficult to identify, with less than 12% of the global forestry industry certified under a sustainable forestry accreditation body such as the Forest Stewardship Council[125]. Ink is most commonly derived from petroleum extracts, although soy-based alternatives are also used[126].

Figure 14 Typical route for the production, distribution and use of a paper book.

Circled steps may take place in Australia or overseas.

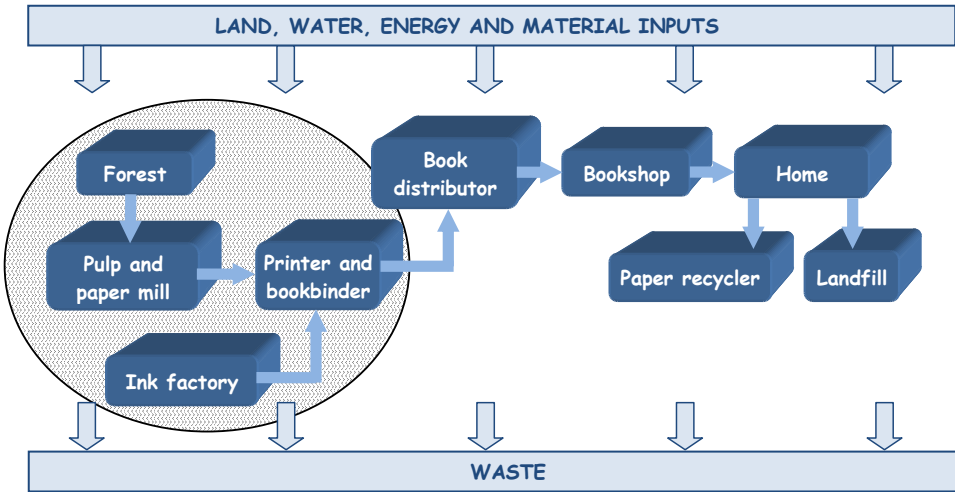
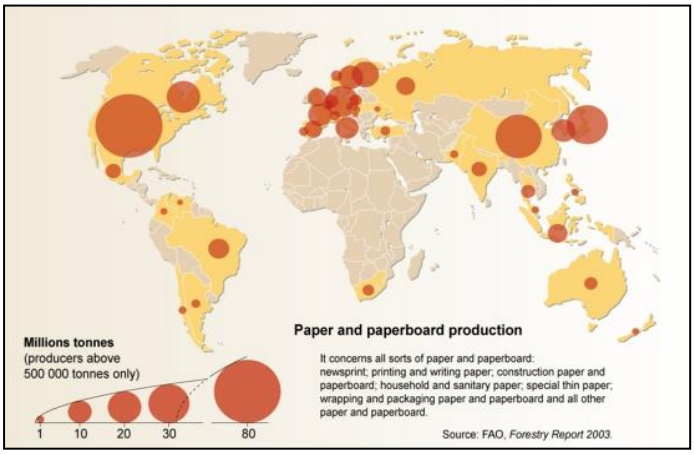


Figure 15 Global sources of paper and paperboard.

The circles represent the relative contributions from different countries. The figure is reproduced from the resource at Footnote 124.



[124] Food and Agriculture Organisation (2003) *Paper and Paperboard Production.* http://maps.grida.no/go/graphic/paper_and_paperboard_production. Accessed 8 June 2011.
[125] Forest Stewardship Council Australia http://www.fscaustralia.org/.
[126] Kozak G (2003) *Printed Scholarly Books and E-book Reading Devices: A Comparative Life Cycle Assessment of Two Book Options*. http://css.snre.umich.edu/css_doc/CSS03-04.pdf. Accessed 9 June 2011.

Book production

The production of printed books requires two primary components – paper and ink. Use of recycled paper in the book publishing industry is low (US estimates are between five and ten percent), with the remaining paper being sourced from both timber and wood 'waste' products, such as woodchip[127]. Relative to the entire timber harvesting industry, book publishing accounts for only 0.64% of timber harvests[128].

The printing phase of book production usually employs one of two methods: offset printing (which uses plates and inks) or digital printing. The latter is used for shorter print runs due to its faster and cheaper set-up time, while the former is commonly used in print-runs of over approximately 1000 copies[129]. Eighty-five percent of Australian print runs use offset printing methods[130]. Most single-colour books are printed in Australia, but non-urgent colour books are mostly printed in Asia[131].

Books are then distributed from the printing office to the publishers' warehouses, where they are re-distributed by truck to book retailers. Books purchased online require additional transport stages, being sent from publisher's warehouses to those of online retailers, who then post out purchases to individual consumers. These additional transport stages can, however, use less fuel than that used by an end consumer when travelling to a bookstore, which can outweigh the total emissions of the production of the book itself. Additional transport stages are also required for the 40% of Australian book purchases that are published overseas.

Footprints across the life cycle

The total carbon footprint of the global book publishing industry has been estimated to be over 12.4 million tonnes of CO2e[132]. In Australia, calculations are only available for the wider paper production industry, which is responsible for over 4.6 million tonnes of CO2e emissions and has a water footprint of 82 billion litres of water[133].

The carbon footprint of a book is highly dependent on its weight and number of pages, but even on a per kilogram basis, estimates vary between 0.6 and 6.3 kilograms of CO2e for each kilogram of book[134]. The most recent assessment of the carbon footprint of a 360 page, 0.6 kg book printed,

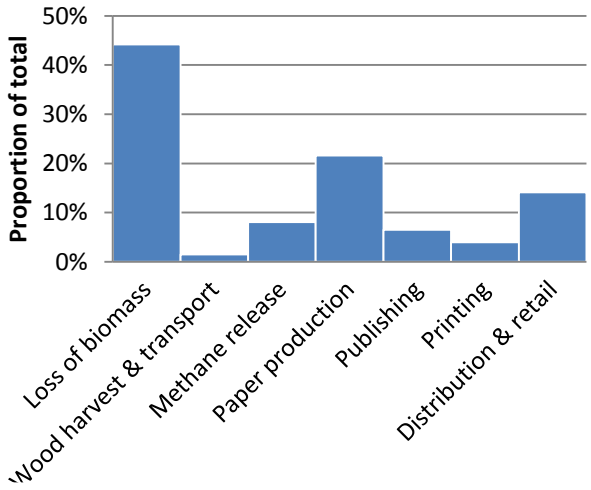
[127] iD2 Communications (2010) *EcoDesign Paper Facts*. http://www.id2.ca/downloads/eco-design-paper-facts.pdf Accessed 7 June 2011.
[128] Upton B (2009) *Forest Growth* http://www.greenpressinitiative.org/documents/MalloyOpinionArticle.pdf. Accessed 8 June 2011.
[129] SelfPublish Australia (2011), *FAQs*. http://www.selfpublish.com.au/book_publishing_FAQs.html. Accessed 8 June 2011.
[130] As above.
[131] Printing Industries Association of Australia and the Australasian Paper Industry Association Ltd. (2010) *Book Industry Strategy Group Joint Public Submission.* http://www.innovation.gov.au/Industry/BooksandPrinting/BookIndustryStrategyGroup/Submissions/463445_Printing_Industries_Association_of_Australia_and_Australasian_Paper_Industries_Association_Ltd.pdf. Accessed 7 June 2011.
[132] Green Press Initiative (2008) *Reducing Climate Impacts: A Guide for the Book and Newspaper Industries.* http://www.greenpressinitiative.org/documents/climateguide.pdf. Accessed 7th June 2011.
[133] A3P (2004) Footnote 123.
[134] Borggren C, Moberg A, Finnveden G (2011) Books from an environmental perspective-Part 1: environmental impacts of paper books sold in traditional and internet bookshops. *International Journal of Life Cycle Assessment* 16:138-147.

distributed, bought and disposed of in Sweden using paper from a Swedish mill found that the life cycle of the book caused 1.2 kg of CO2e emissions[135].

The waste forest biomass (excluding the book), followed by pulp and paper making are the two largest contributors of CO2e emissions in the book life cycle up to and including the retail stage (Figure 16[136]), based on mostly USA data. However, the Swedish study referred to earlier included personal transportation to buy the book in their life cycle analysis and found that driving a car 3 km to purchase the book resulted in the same amount of emissions as the rest of the book life cycle itself[137]. A life cycle assessment of the water footprint of books estimated that production of one 500 page book requires 94 litres of water, and produces 2.3 kg of solid waste[138].

Figure 16 Greenhouse gas emissions of steps in a book life cycle.

The figure is redrawn from data in the resource at Footnote 136.



Hotspots summary

Hotspots in greenhouse gas emissions are in the **forestry** step, in **paper production** and in the **retail and consumer transport** step.

Social and ethical considerations

The source of trees to make paper has environmental and social implications that are not picked up in the types of impact analyses used. Paper sourced from Australian native forests or plantations, or tropical forests or plantations in developing countries overseas, has implications both for biodiversity and the lifestyles or incomes of local people.

Are e-books a more sustainable option?

Whether e-books are a more environmentally-friendly way to read is highly dependent upon the measure of environmental impact used and how the e-book is used, including how many books are read from it during its lifetime[139]. The life cycle of an e-reader has been estimated to have an

[135] Borggren et al. (2011) Footnote 134.
[136] Green Press Initiative (2008) *Reducing Climate Impacts: A Guide for the Book and Newspaper Industries*. http://www.greenpressinitiative.org/documents/climateguide.pdf Accessed 7 Jun 2011.
[137] Borggren et al. (2011) Footnote 134.
[138] Kozak G (2003) Footnote 126.
[139] Moberg Å, Borggren C, Finnveden G (2011) Books from an environmental perspective – Part 2: e-books as an alternative to paper books. *International Journal of Life Cycle Assessment* 16:238-246.

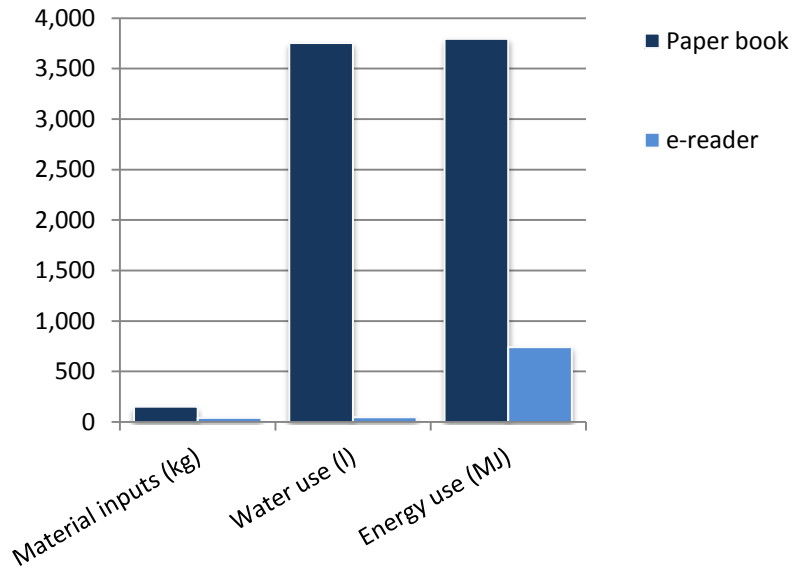
average footprint of 168 kg of CO2e[140], quite high compared to the paper book range of 0.6 to 6.3 kg cited earlier. However, as the device can download and store a large number of e-books, this footprint would be overtaken by the footprint of paper versions if a large number of new paper books were bought in the same life time. For example, a life cycle comparison of the books used in a 4 year university degree in the USA found that over that period, assuming that a student would require 40 text books and only purchased one e-reader, the environmental impacts of e-books were significantly lower (see Figure 17)[141]. However, for the average Australian who consumes only 3 new books a year, it is likely that an e-reader impact would outweigh that of the paper books.

In the case of multi-purpose readers, such as Apple's iPad, it is more difficult to determine the emissions directly attributable to book-reading as it is used for other purposes as well.

If e-books or multi-purpose readers are a preferred option for this or other reasons, purchasing renewable energy will help offset impacts, as 29% of emissions from the e-reader's life-cycle occur through customer energy use[142].

Figure 17 Relative inputs into a paper book and an e-book.

The figure is redrawn from a figure in the resource at Footnote 141.



Your choices

Apart from e-books, options for reducing the environmental impact of reading paper books is to borrow them or purchase them second-hand and share them or give them away afterwards. Like the other consumer products already discussed, any ways in which car journeys for the sole purpose of buying the product can be reduced will have significant benefit.

… for reducing the environmental impact of reading paper books …

borrow them

or purchase them second-hand

share them

or give them away afterwards.

Reduce car journeys for buying them.

[140] Cleantech Group (2009) *The Environmental Impact of Amazon's Kindle* http://cleantech.com/news/4867/cleantech-group-finds-positive-envi Accessed 1 Jun 2011.
[141] Kozak G (2003) Footnote 126.
[142] Apple Inc. (2011) *iPad 2 Environmental Report*. http://images.apple.com/environment/reports/docs/iPad_2_Environmental_Report.pdf Accessed 7 June 2011.

AA BATTERIES

Buying and use patterns

> *… each of us accounts for 11 [AA or AAA batteries] a year.*

AA batteries are a small but common consumer item whose sales have expanded rapidly as the number of portable electronic goods in households has grown. Remote controls are the single largest use, followed by toys, digital camera, torches, wireless mouses and keyboards and gaming consoles. About 250 million AA and AAA batteries are sold every year in Australia[143], suggesting each of us accounts for 11 a year. If Canberrans buy these batteries at the same rate as other Australians, it would suggest that some 3.8 million of them come to shops to be sold in Canberra every year, possibly even more due to our higher incomes (see Introduction). Nationally, over two thirds of small batteries end up in landfill[144].

Consumers have the choice of buying either disposable alkaline batteries or a battery recharger and nickel-cadmium (NiCd) or nickel-magnesium hydride (NiMH) AA rechargeable batteries. The initial outlay for the rechargeable option is higher but the cost is lower in the long run. Most small dry cell batteries are imported[145]; alkaline batteries are largely made in China and rechargeable batteries largely made in Japan.

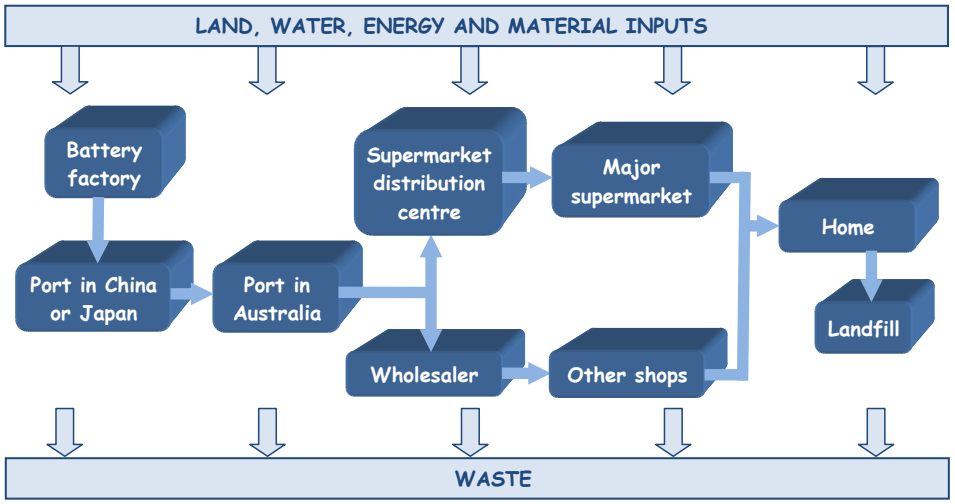
The choice between these two options has been explored in a life cycle analysis in the Australian context[146] and this forms the basis for the comparison here. Unless otherwise identified, this reference is the source of all the data quoted.

Product flows

The basic flow of batteries, whether alkaline or rechargeable is shown in Figure 18, although the nature of the inputs of materials, in particular, varies with the two different types.

[143] Planet Ark (2010) *Battery Use, Disposal and Recycling in Australia.* http://recyclingweek.planetark.org/documents/doc-513-battery-research-report-final.pdf. Accessed 15 Jun 2011.
[144] Australian Battery Recycling Initiative (2010) *Analysis of Battery Consumption, Recycling and Disposal in Australia*. http://www.batteryrecycling.org.au/wp-content/uploads/2011/06/Battery-consumption-recycling-and-disposal-in-Australia_Executive-Summary.pdf. Accessed 15 Jun 2011.
[145] IBISWorld. *Battery Manufacturing in Australia.* http://www.ibisworld.com.au/industry/default.aspx?indid=271. Accessed 8 June 2011.
[146] Parsons D (2007) The environmental impact of disposable versus re-chargeable batteries for consumer use. International Journal of Life Cycle Assessment 12: 197-203.

Figure 18 Major routes of AA alkaline or rechargeable batteries from the factory to their disposal after use.



Footprints across the life cycle

Like the television, batteries are a longer-lived product whose life cycle has to include their use in the home. To compare the three types of batteries, the analysis assumed delivery of the same total power over the life of each type of battery. Under typical conditions of use and with 50 recharge cycles for the rechargeable batteries, it takes 55 alkaline batteries to provide the same power as 1 NiMH rechargeable battery, or 29 disposable batteries to equal the power from 1 NiCd rechargeable battery.

… it takes 55 alkaline batteries to provide the same power as one NiMH rechargeable battery …

Countering the reduced number of rechargeable batteries required for the same power is the need for the recharger and the additional electricity use needed for their recharge. The additional energy use was calculated as 7.1 MJ for a NiCd battery and 6.5 MJ for a NiMH battery, and obviously nil for the alkaline battery. On the other hand, there is significant energy involved in lighting, heating and cooling retail stores and the analysis allowed 4 MJ per pair of batteries for this component. This would translate to an additional 2 MJ for a single NiMH rechargeable battery but based on the lifetime ratio above, 110 MJ for alkaline batteries. This retailing energy is many times the energy needed for recharging the rechargeable batteries and it represents a hotspot for the alkaline type.

Using these equivalences of battery numbers, standard manufacturing data for their components and for the battery charger, electricity use for recharging and assuming international transport from China to an Australian port, then 25km of domestic travel to a retail store, and 100km travel for the garbage truck (as most batteries are disposed to landfill in Australia), the analysis assessed environmental impact using a model called Eco Indicator 99. This assesses three aspects of impact: damage to human health (in terms of disability years), damage to the environment (in terms of land area affected by plant species disappearance) and an energy term reflecting the additional energy that will be required to extract minerals and fossil fuels as they become more scarce. In all categories, the impact of the alkaline batteries was a hundred or more times greater than that of rechargeable batteries (Table 5).

Table 5 Assessment of impact of different battery types delivering 1 KWh of power and disposed to landfill.

The analysis includes the recharger for the rechargeable batteries. The data is from the resource at Footnote 146.

	NiMH 50 cycles	NiMH 400 cycles	Alkaline
Number of batteries	18	2.3	834
Damage to human health index	15×10^{-6}	5×10^{-6}	1210×10^{-6}
Damage to ecosystem quality index	0.5	0.2	48.5
Energy for extra mined resources MJ	14.3	5.4	1070

An assessment was also made of the benefits of recycling the rechargeable batteries. The study found that compared to landfill, recycling made little difference to the impact on human health and ecosystems because most of the impact occurs before their use, but it did have a 20% beneficial impact on the energy term because some of the material is re-used. There was a health advantage in recycling NiMH batteries over recycling NiCd in terms of both human and ecosystem health because cadmium is toxic, and also in terms of the number of batteries required because NiMH batteries are more efficient.

… recycling made little difference … because most of the impact occurs before their use

but it had a 20% beneficial impact on the energy term.

This battery study didn't include the additional travel from Sydney, the presumed port for arrival of imported goods destined for Canberra, or the travel from home to the retail outlet in a car. Based on the efficiency of long-distance transport in articulated trucks (Table 3), which is the main mode of transport for bulk goods from Sydney to Canberra, this additional impact is likely to be small. However, as shown in some of the previous product case studies, life cycle analyses can be very sensitive to the car journey to do the shopping and this is a further potential hotspot for alkaline batteries which have to be bought much more often.

Hotspots summary

Hotspots for alkaline batteries are in the **non-renewable energy used in wholesaling and retailing**, followed by their **manufacture**. The **car journey for their purchase** is another potential hotspot not quantified in this study but evident from analyses of other consumer products.

The main hotspot for rechargeable batteries is in their **manufacture**.

Social and ethical considerations

Working conditions in the countries of manufacture of the batteries, recharger and their components could be a concern but there is little information about this available. Avoiding NiCd rechargeable batteries will help prevent the exposure of workers to the toxic effects of cadmium.

Your choices

There is clear evidence to suggest that buying and using rechargeable batteries has a significantly smaller footprint than buying alkaline batteries. NiMH rechargeable batteries are a better choice than NiCd rechargeable batteries because of their lower toxicity.

… buying and using rechargeable batteries …

NiMH rechargeable batteries are a better choice than NiCd rechargeable batteries

CONCLUSIONS

Across the products analysed there was only patchy information and technical analyses available about their specific life cycles in Australia. Combined with the absence of labelling about the origins of these (and most other) goods it is difficult for consumers to exercise properly informed buying choices for sustainability.

… patchy information and technical analyses available about specific life cycles … the absence of labelling about the origin of … goods [makes] it difficult for consumers to exercise properly informed buying choices for sustainability.

Australian governments are not currently inclined to increase labelling on products to indicate environmental impact.

Australian governments are not currently inclined to increase labelling on products to indicate environmental impact. A recent multi-government review placed labelling in relation to 'consumer values' (including sustainability) as last in a hierarchy of priorities where human health has the highest priority for government regulation on labelling. The review therefore recommended that labelling related to consumer values should be self-regulatory, that is done by the industries themselves, and that governments would only intervene if they were ineffective [147]. The accreditation, auditing and tracking systems that would be required to increase sustainability information on labels would undoubtedly add to their cost, although the technical capacity to track individual products through scanning technology is available and already often used for other purposes. Industries and governments are only likely to act on improving sustainability labelling when enough consumers demand it.

Despite the lack of specific information, some general themes did emerge from the analyses of just seven products in this report.

Food and fibre products tend to have more impacts in their agricultural/forestry phase; manufactured goods often have more impact in their use phase.

… low contribution of transport to footprints … suggests that the location of Canberra … is not a very significant component of our overall impact …

… our footprint is high because we buy more stuff.

- Food and fibre products tend to have more footprint impacts in their agricultural/forestry phase; manufactured goods often have more impact in their use phase.
- The generally low contribution of transport to individual footprints of the products analysed suggests that the location of Canberra away from major food and manufacturing locations is not a very significant component of our overall impact. As outlined in the ACT Ecological Footprint (see Introduction), our footprint is likely to be high because we have higher incomes than average and we buy more stuff.

[147] Department of Health and Ageing (2011) *Labelling Logic. Review of Food Labelling Law and Policy. Commonwealth of Australia.* http://www.foodlabellingreview.gov.au/internet/foodlabelling/publishing.nsf/content/48C0548D80E715BCCA257825001E5DC0/$File/Labelling%20Logic_2011.pdf. Accessed 25 Jun 2011.

- Within the transport footprint however, the shopping trip to purchase goods is often significant, particularly for food products that must be bought regularly, in contrast to items like televisions that are purchased less than once a year. The nature of Canberra, our dependence on cars and generally high incomes can mean that some shopping trips may be as significant, or even more significant, than the transport of goods some distance to Canberra.

Within the transport footprint, the shopping trip … is often significant …

… food miles are a relatively poor stand-alone indicator of footprint ..

... be aware of tradeoffs between different categories of environmental impact.

… certified organic food generally decreases greenhouse impacts but not impacts associated with the area of land

Packaging was rarely a hotspot for impact.

… around a half of the footprint … is under the control of the consumer…

- The same low contribution of transport to footprints means that food miles are a relatively poor stand-alone indicator of the footprint of a product, unless all other things are equal.
- Where other things are not equal, consumers need to be aware of tradeoffs that occur between different categories of environmental impact. For example, a product may have low food miles but have been produced with a high energy input, or a product might have energy ratings without water ratings. For this reason, stand-alone indicators should be treated with caution, as should claims about the sustainability of production methods (e.g. 'organic') that are not certified. They may not be substantiated and/or may be based on stand-alone indicators.
- Choosing to buy certified organic food generally decreases greenhouse impacts but not impacts associated with the area of land.
- Packaging was rarely a hotspot for impact for the products studied. But like all inputs to the life cycle, reducing the amount and choosing the kind that has least impact is better.
- Very generally, around a half of the footprint of these products is under the control of the consumer: the nature of the shopping trip, how the product is used in the home, the amount of food wasted or the disposal method of manufactured products. Improvements in those aspects outside the control of consumers rely on government and industry actions, although also influenced by consumer demand.
- General strategies to counter the impacts of the home consumption phase include: plan ahead and shop by car less frequently, buying more at a time; combine shopping with other purposes of using a car, use most of the food you buy, purchase renewable energy, keep material goods longer by resisting advertising and peer pressure to upgrade, and recycle where possible but without taking long car journeys to do it.

… strategies to counter the impacts of the home consumption phase include:

plan ahead and shop by car less frequently, buying more at a time

combine shopping with other purposes of using a car

use most of the food you buy

purchase renewable energy

keep material goods longer

recycle where possible but without taking long car journeys to do it.

Finally, this report focussed on finding those parts of product life cycles

that have the greatest impact, because this is where significant reductions are more likely to be found. This does not mean that even small impacts elsewhere should be ignored. Where the evidence is clear and the choice is available, many people frequently exercising small buying choices for sustainability in the longer term will make a difference in reducing the ecological footprint of Canberra.

Appendix 1

Transport statistics and calculations for car and truck travel for 2007. These are the basis for the scenario outcomes in Table 3.

	Cars	Articulated trucks	Unit	Reference
Total emissions per year	44,366	9,956	Gg CO2e	BITRE[148]
Total distance per year	167.04	6.77	billion km	BITRE
Number of vehicles	11,462,400	74,444		BITRE
Emissions per vehicle per year	3.9	133.7	tonnes CO2e	Calculated
Average distance per vehicle per year	14,573	90,941	km	Calculated
Emissions per vehicle per km	0.27	1.47	kg CO2e	Calculated
Average freight-distance per vehicle per year		2,068,700	tonne-km	ABS 9208.0[149]
Average laden distance per vehicle per year		73,800	km	ABS 9208.0
Average load when laden		28.0	tonnes	Calculated
Proportion of total distance that is laden		81%		Calculated

[148] BITRE (2009) *Greenhouse Gas Emissions from Australian Transport: Projections to 2020*. Working Paper 73. Bureau of Infrastructure, Transport and Regional Economics, Canberra. http://www.btre.gov.au/Info.aspx?ResourceId=744&NodeId=16 Accessed 15 May 2011.

[149] ABS cat. no. 9208.0 www.abs.gov.au