

Food Miles in Australia:

A comparison of emissions from road and rail transport

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CERES is an urban oasis on the banks of the Merri Creek, 5km North of Melbourne CBD in Victoria, Australia. Over the last 30 years the local community has transformed the 4 hectare landfill site into a thriving community environment park, which encompasses a wide range of enterprises. The site is open from dawn to dusk every day of the year, and attracts more than 300,000 people annually.

CERES exists to initiate and support environmental sustainability and social equity, with an emphasis on cultural richness and community participation.

This report was commissioned as an independent study by Consultanz PL, Brisbane and is available online at the CERES website: www.ceres.org.au

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Summary

The term 'Food Miles' is increasingly used to describe the geographic distance food products are transported between production and consumption. Food Miles are one important part of the larger complete life-cycle assessment that would be required to meaningfully compare the relative sustainability of individual items in food systems.

This report builds on the research completed by CERES in July of 2007 (updated February 2008), titled: *Food Miles in Australia: A preliminary study of Melbourne, Victoria (Bee Abraham & Gaballa)*. In that study data was collected to establish Food Miles and greenhouse gas (GHG) emissions estimates for a typical food basket in Victoria. In extension of that first study, this report offers research into the replacement of the road transportation of food items with rail transportation in each of four scenarios:

- A. Existing All Road – all food items transported by truck on primary roads.
- B. Existing Intermodal - all food items transported by a combination of primary road and rail freight, within the existing rail track and freight depot network, preferring rail wherever practical.
- C. Hypothetical Ubiquitous Intermodal - all food items transported by a combination of road and rail freight, within the existing rail track but with the addition of a much larger or 'ubiquitous' rail freight depot network, and preferring rail wherever practical.
- D. Hypothetical All Rail - all food items transported solely by a hypothetically complete rail freight network, assuming new rail track connects all producers to the existing rail track network at the nearest population centre.

Results indicate that transport of the 21kg food basket in this study produced an estimated 940 grams of GHG emissions if transported in scenario A (solely by existing road networks), 570g if by existing intermodal freight (scenario B), 451g if using a hypothetical ubiquitous road and rail freight (scenario C), and 438g if using hypothetical all rail (scenario D).

In considering emissions differences across the 4 scenarios, emissions reductions came from moving A-Existing All Road freight to B-Existing Intermodal freight: a 39% reduction. Moving to the C-Hypothetical Ubiquitous Intermodal freight depot network saved another 13% (from 39% to 52%), and building rail to each site of food production (D-Hypothetical All Rail), saved only another 1% (from 52% to 53%) of Existing All Road emissions. These findings suggest that transport planners aiming to reduce emissions, should focus more on increasing the network of freight depots rather than building new rail track.

The Food Miles and emissions estimates in this study highlight the strong link between transport choice and emissions outcomes, and indicates the vulnerability of our food supply system to existing transport costs and the price impacts of oil depletion. In addition, this study shows the importance of infrastructure planning within the rail and road transport system, indicating possible emissions savings being enhanced by the availability of well placed depots. As society moves to reduce carbon emissions resulting from our food supply system it is hoped that both infrastructure and transport mode choices are factored into planning decisions.

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Glossary

ABS: Australian Bureau of Statistics.

BTRE: Australian federal government Bureau of Transport and Regional Economics. Renamed in January 2008 to Bureau of Infrastructure, Transport and Regional Economics.

Joule: A unit of heat energy widely used for analysis of energy use across fuels and technologies.

Giga: An abbreviation of magnitude equating to 10^9 or billion units.

Greenhouse Gases (GHG's): For the purpose of this study, GHG refer to CO₂ (carbon dioxide) and the global warming effect of the relatively small quantities of CH₄ (methane) and N₂O (nitrous oxide)².

g CO₂-e : GHG Emissions are expressed in grams of CO₂ and equivalent gases, which includes CO₂ (carbon dioxide), CH₄ (methane) and N₂O (nitrous oxide)².

Healthy Food Access Basket (HFAB): The food basket used in this report representing a typical shopping basket. The range and types of foods included in the HFAB were selected by the Queensland Government to “represent commonly available and popular foods, rather than the nutritional ideal” (see Appendix 1).

Mega: An abbreviation of magnitude equating to 10^6 or million units.

Primary road: A primary road is one classified as a Federal Road (AusLink), as an M, A, B, or C class road by VicRoads, or the equivalent in other states.

Source:<http://www.vicroads.vic.gov.au/Home/RoadsAndProjects/TravellingOnOurRoads/Drivers+Guide+to+Rural+Victoria.htm>

Tonne Kilometres: The number of kilometres travelled by a freight truck (VKT) multiplied by the mass of freight (measured in tonnes) transported: TKMs = VKT x freight carried (t).

Transport scenarios: For which emissions are estimated:

- A. Existing All Road – all food items transported by truck on primary roads.
- B. Existing Intermodal - all food items transported by a combination of primary road and rail freight, within the existing rail track and freight depot network, preferring rail wherever practical.
- C. Hypothetical Ubiquitous Intermodal - all food items transported by combination of road and rail freight, within the existing rail track but with the addition of a much larger or ‘ubiquitous’ rail freight depot network, and preferring rail wherever practical.
- D. Hypothetical All rail - all food items transported solely by a hypothetically complete rail freight network, assuming new rail track connects all producers to the existing rail track network at the nearest population centre.

Weight: Used here interchangeably with mass.

1 Introduction

The industrialisation, commercialisation and globalisation of food systems have allowed millions of people access to a vast array of foods from all over the world. Diets for many Western consumers are no longer restricted by local environmental factors and seasonality of produce, due in part to advances in agricultural and food sciences, and in large part to fossil fuel energy subsidies in the cultivation, storage, processing and transport of food. The production of our most basic necessity has been globalised. However, the apparent savings at the cash register have come with a host of unseen costs.

Agricultural and food industries are heavy users of fossil fuels and producers of greenhouse gases, via the production and use of agrochemicals and fertilisers, the raising of livestock, the highly mechanised means of production, and the transportation, processing, packaging and retailing of food products. Global concern about the impacts of climate change and the price impacts of oil depletion are challenging both the legitimacy and viability of current food systems, and consumers and policy makers are seeking better information on which to base their choices.

This study is an effort to calculate greenhouse gas (GHG) emissions estimates from the transport of food from grower to retailer of a typical shopping basket. Readers are urged to view Food Miles as one part of the food system, and therefore only one part of a complete lifecycle assessment of food production. Such lifecycle assessment is beyond the means of this report.

Food transportation methods include road, rail, shipping and airfreight. Each method of transport produces GHG emissions, and this report focuses on the potential reduction in GHG emissions by replacing road with rail transportation of food freight.

1.1 Food Miles

The term 'Food Miles' describes the sum geographic distance food products are transported, between their cultivation, processing and to the consumer at point of sale. While Food Miles is used to describe the concept, this report uses the metric measurement of kilometres for food transport distances in Australia. Food Miles refers to a field of study rather than a particular measurement and the term is used here in keeping with global dialogue on this topic.

The simplest analysis of the embodied energy of food will show that food miles is only one input of a food provision system which produces GHG emissions at many, if not all, stages¹, and food miles alone

¹ The breakdown of US agricultural energy consumption is: 31 percent for the manufacture of inorganic fertiliser, 19 percent for the operation of field machinery, 16 percent for transportation, 13 percent for irrigation, 8 percent for raising livestock (not including livestock feed), 5 percent for crop drying, 5 percent for pesticide production, and 8 percent miscellaneous (McLaughlin et al., 2000 cited Pfeiffer, 2004). These figures do not consider the energy costs for packaging, refrigeration and transportation to retail outlets, or household cooking.

are an inadequate indicator of sustainability². Interested readers are referred to studies such as those by Caroline Saunders and colleagues at Lincoln University in New Zealand³ or Chris Foster and co. at the Manchester Business School⁴. Until such comprehensive embodied energy analyses become available, the authors hope the following will be a contribution to informed decision making by consumers and policymakers.

1.2 This Report

Building on the preliminary Food Miles research completed by CERES in July of 2007 (updated February 2008), titled: *Food Miles in Australia: A preliminary study of Melbourne, Victoria*", this report was commissioned as an independent study by Consultanz PL, Brisbane.

In the preliminary study, data was collected to establish food miles and greenhouse gas emissions estimates for a typical food basket transported by road. In extension of this first study, this report offers research into the replacement of road transportation of food items (scenario A) with rail transportation in three other scenarios: within the existing rail freight track and depot network (scenario B), within the existing track but with hypothetical ubiquitous freight depot network (scenario C); and within the hypothetical use of rail for every transport leg (scenario D).

In an effort to reduce repetition between the previous study and this report, where no additions or changes have been made the first report has been referenced, predominantly with regard to establishing the origins of food products.

² Department for Environment, Food and Rural Affairs (DEFRA) (2005), United Kingdom. *The Validity of Food Miles as an Indicator of Sustainable Development: final report*. Watkiss et al., AEA Technology Environment for DEFRA

³ Saunders, C.M. and Barber, A. (2007) *Comparative Energy and Greenhouse Gas Emissions of New Zealand's and the UK's Dairy Industry*. AERU Research Report No. 297 July 2007.
http://www.lincoln.ac.nz/story_images/3270_RR297_s10091.pdf

⁴ Foster Green et al 2006 Environmental Impacts of Food Production and Consumption : A report to the Department for Environment, Food and Rural Affairs. Manchester Business School. Defra, London.

1.3 Transport scenarios

This report aims to provide estimates of GHG emissions from the transport of 25 different food items from their rural sources via any processing centres to Melbourne's CBD, for four different transport mode scenarios.

The transport scenarios for which emissions are estimated are:

- A. Existing All Road – all food items transported by truck on primary roads.
- B. Existing Intermodal - all food items transported by a combination of primary road and rail freight, within the existing rail track and freight depot network, preferring rail wherever practical.
- C. Hypothetical Ubiquitous Intermodal - all food items transported by a combination of road and rail freight, within the existing rail track but with the addition of a much larger or 'ubiquitous' rail freight depot network, and preferring rail wherever practical.
- D. Hypothetical All Rail - all food items transported solely by a hypothetically complete rail freight network, assuming new rail track connects all producers to the existing rail track network at the nearest population centre.

See section 2 and 3 for more detail on these scenarios and the assumptions outlined for this study.

2 Methods

The methods outlined below detail research done for this report. This report is based on the preliminary research compiled by CERES in July 2007 (updated February 2008). Readers are strongly encouraged to view the preliminary report in addition to the following information, particularly with regard to the sources of information related to different food basket items. The preliminary report is accessible online at: www.ceres.org.au

The distance each food item travelled by road or rail under different transport scenarios was measured from the sources supplied by food industry bodies and companies, using spatial data describing road and rail networks. The resulting GHG emissions estimates were calculated using energy intensity, emissions factor constants, transport distance and mode data, and item weights.

2.1 The Food Basket

The shopping basket of food used in this study is drawn from the food items identified by the Queensland Government Public Health Services in their 'Healthy Food Access Basket' (HFAB) survey⁵. This shopping basket is representative of a typical Australian shopping basket and has the advantage for study purposes of identifying particular products and their brands, which is not possible with the ABS Consumer Price Index food basket⁶. Not all of the items in the HFAB are used in this study, with omissions due to irrelevance (items sourced overseas) and obscurity (insufficient information available on sources).

The twenty five food basket items used in this study can be grouped as follows:

Fruit and vegetables: Apples, oranges, orange juice, bananas, tomatoes, potatoes, pumpkin, lettuce, carrots, onions.

Meat and Dairy: Beef, chicken, eggs, sausages (deli), fresh full-cream milk, cheese.

Cereals and Legumes: White bread, cereal biscuits, rolled oats, rice, instant noodles, savoury biscuits, tinned baked beans.

Non-core Food and Beverage: Unsaturated margarine, white sugar, canola oil, black tea, chocolate, potato chips/crisps.

⁵ Queensland Health (2000) *The Healthy Food Access Basket Survey 2000*, Queensland Government, Australia p.12. <http://www.health.qld.gov.au/ph/documents/hpu/9134.pdf>

⁶ Australian Bureau of Statistics 2005 Australian Consumer Price Index: Concepts, Sources and Methods 2005.

2.1.1 Weights of food basket items

For most items the weights used in this study are the same as those specified in the HFAB. For those items where weight was not already specified, sampling at local supermarket provided the following: Orange Juice unit weight was estimated from a small sample of 1.5L juice bottles, weighed and averaged to a 1L unit equivalent.

Lettuce unit weight was estimated from a small sample of iceberg lettuce (pre-bagged), weighed and averaged to a single unit equivalent.

Unit weight for chicken is based on 1,000g. This unit weight has been assumed to be the same as the beef unit size indicated in the HFAB. This assumption has been made as the HFAB indicates a chicken unit size (size 11) instead of a unit weight.

Full cream milk unit weight was estimated from a small sample of 1L milk bottles, weighed and averaged to a 1L unit equivalent.

Unit weight for potato chips is based on 200g; this is not identified in the HFAB.

Canola oil unit weight was estimated from a small sample of 750ml canola oil bottles, weighed and averaged to a 1 unit equivalent.

2.2 Food Miles

This part of the methods describes how the distance travelled was determined for each item in each transport scenario.

2.2.1 Food sources

To determine the origin of food products, contact with the industry bodies and companies provided the dominant points of origin for the Melbourne market, along with any processing waypoints; with distance measured in kilometres. All information on food origin was reliant on information supplied by organisations and companies and the research results are therefore vulnerable to any incorrect information supplied. This is particularly true for company-supplied information, as many of the companies withheld information on their products and manufacturing processes that was deemed commercial in-confidence. In such cases, the most conservative assumptions were used to calculate the food miles for these products. The Melbourne CBD was used as the destination point when calculating the distance travelled by all foods.

For full details on the origins of food products, please refer to: Food Miles in Australia: A preliminary study of Melbourne, Victoria. Bee Abraham & Gaballa (July 2007, updated February 2008).

2.2.2 Transport scenarios

The transport scenarios for which distance and emissions are estimated are:

- A. Existing All Road – all food items transported by truck on primary roads.
- B. Existing Intermodal - all food items transported by a combination of primary road and rail freight, within the existing rail track and freight depot network, preferring rail wherever practical.
- C. Hypothetical Ubiquitous Intermodal - all food items transported by a combination of road and rail freight, within the existing rail track but with the addition of a much larger or ‘ubiquitous’ rail freight depot network, and preferring rail wherever practical.
- D. Hypothetical All Rail - all food items transported solely by a hypothetically complete rail freight network, assuming new rail track connects all producers to the existing rail track network at the nearest population centre.

Under scenarios A and B, road transport from the food producer to the nearest identified rail freight depot was assumed to be by rigid and articulated trucks over the most direct route on primary roads. The list of existing depots used in this study appears in Appendix 2, and was sourced from advertising and from a report by Meyrick & Associates 2006⁷, which provided valuable detail about which Victorian rail freight depots were actually in use by respective food producers.

The use of these four scenarios was prompted by the existing rail freight network in Australia, where an extensive rail track network must be accessed via a fairly sparse network of rail freight depots. In many instances producers are required to truck their freight considerable distances to reach a rail freight depot.

The viability of some existing depots is also in question. Freight operator Pacific National has announced plans to withdraw from Victoria⁸, a move that would reduce the ability of rail freight in cutting GHG emissions from transport.

⁷ Meyrick & Associates 2006 Rail Freight Task - Victoria <http://www.esc.vic.gov.au/NR/rdonlyres/3B59DDF0-1348-4F46-8E85-F81DB0B4D6C5/0/MeyrickReviewGeneralRailFreightTaskVictoria.pdf>

The final report of the Victorian governments Rail Freight Network Review is available online at <http://www.doi.vic.gov.au/DOI/Internet/Freight.nsf/AllDocs/5B0C5531BC594B12CA25730000003091?OpenDocument#call>

⁸ Victoria's biggest rail freight to end next month" Australian Broadcasting Commission 4th January 2008 website <http://www.abc.net.au/news/stories/2008/01/04/2132029.htm?section=business>
<http://www.abc.net.au/news/stories/2007/12/12/2116312.htm>

2.2.3 Transport routes

The distance each item was transported whether by road or rail, was derived from geospatial datasets describing the population centres, rail and primary road networks of Australia. All geospatial data was obtained from Geoscience Australia⁹ as shapefiles, with their metadata available online¹⁰. The level of geographic accuracy in those files was judged acceptable for the purposes of this study. These files were supplied in the geographical projection-WGS84, and projected into the Australian standard projection GDA94. Transport over the rail network was assumed to be via the routes described by Rail Maps Australia¹¹.

The distances travelled by both road and rail were obtained from the vector geodata. By extracting complete paths from food source to Melbourne CBD destination (via any applicable processing waypoints), the sum of line segment lengths comprising the paths were calculated. The available geodata was not useful for providing distances for road transport within cities, and so Google Maps queries¹² were used to provide those uniformly small distances.

⁹ Geoscience Australia: <https://www.ga.gov.au>

¹⁰ Railways: https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=61305

Roads: https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=61306

Population Centres: https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=61304

¹¹ Rail Maps Australia: <http://www.railpage.org.au/railmaps/>

¹² Google Maps: <http://maps.google.com.au> . Queries in the form “from:abc to:xyz” return detailed routes and distances.

2.3 Greenhouse Gas Emissions Estimates for transport

Equations and constants for this type of calculation are provided by the National Greenhouse Accounts Factors (NGAF) published by the Australian Department of Climate Change (the NGAF replaces the Australian Greenhouse Offices 2006 Factors and Methods Workbook¹³). Section 1.2 of the NGAF deals with transport emissions and gives the following general equation:

$$\text{Emissions} = Q \times EF$$

where:

GHG emissions is the quantity in tonnes of CO₂ –and-equivalent greenhouse gases (t CO₂-e) released by combustion of given quantity of fuel. CO₂-e includes carbon dioxide, methane and nitrous oxide.

Q is the quantity of fuel consumed in kL (thousands of litres) or GJ (billions of Joules).

EF is the fuel specific emission factor. Emission factors for combustion of transport fuels are supplied in Table 3 of NGAF in both kg CO₂-e per GJ and tonnes of CO₂-e per kL.

This equation requires data on fuel consumption. The fuel consumption of freight trains is influenced by a large number of factors, not least train length, network traffic, route gradient and number of stops, and the type and age of engines and rolling stock (Jorgensen and Sorenson 1997).

Fuel consumption data on a per-food-item or per-freight-weight basis was not available for this study, and so fuel quantity was replaced by factoring an Energy Intensity estimate (in Mega-Joules per net ton kilometre, or the energy cost of moving one ton of freight one kilometre) with the weight (in tonnes) of each Food Basket item and their distance travelled (in kilometres):

$$\text{Item Emissions} = (W \times D \times EI) \times EF$$

Item Emissions are the tonnes of GHG emissions from rail freight transport per Food Basket item (t CO₂-e).

W is the weight in tonnes of the food freight item.

D is the distance in kilometres the food item is transported by rail.

EI is the Energy Intensity of freight operations for given transport mode, Giga-Joules per Ton of freight moved a kilometre (GJ/T km).

EF is the diesel fuel Emission Factor, in kg CO₂-equivalent (CO₂-e) emissions per GJ of fuel energy consumed.

This equation was used for calculation of both rail and road transport emissions.

¹³ National Greenhouse Accounts Factors 2008 Australian Department of Climate Change
<http://www.climatechange.gov.au/workbook/index.html>

AGO Factors and Methods Workbook - For use in Australian greenhouse emissions reporting
Australian Greenhouse Office, Department of the Environment and Heritage, December 2006
<http://www.greenhouse.gov.au/workbook/index.html>

2.3.1 Rail Transport Emissions

The following equation using an average Energy Intensity for Australian rail freight was used to calculate GHG emissions estimates per Food Basket item when transported by rail freight:

$$\text{Rail Emissions} = (FW \times D \times EI^{RL}) \times EF$$

where:

Rail Emissions refers to GHG emissions from rail freight transport per Food Basket item (t CO₂-e).

FW is the weight in Tonnes of the food freight item.

D is the distance in kilometres the food is transported by rail from its source to its Melbourne CBD destination.

EI^{RL} is the Energy Intensity of rail freight operations, in GJ/T km.

EF is the diesel fuel Emission Factor, in kg CO₂-equivalent (CO₂-e) emissions per GJ of fuel energy consumed.

The Energy Intensity constant was sourced from rail industry consultants Apelbaum Consulting¹⁴ via C.Hodkinson of Consultantz Pty Ltd, Brisbane. This constant provides an average figure for the fuel energy required to move 1 tonne of freight a distance of 1 kilometre, averaging payloads, train lengths and engine efficiencies¹⁵. This was reported to the authors as being 0.26MJ/NT.km (where MJ is MegaJoules and NT.km is Net Tonnes of freight over one kilometre). This constant appears as 0.00026GJ or GigaJoules in calculations to match units with the AGO supplied Emissions Factor. The EF for diesel fuel is given as 69.8 kg CO₂-e/GJ on page 10 of the NGAF.

2.3.2 Road Transport Emissions

The following equation using an average Energy Intensity for Australian road freight was used to calculate GHG emissions estimates per Food Basket item when transported by road:

$$\text{Road Emissions (t CO}_2\text{-e)} = (FW \times D \times EI^{RD}) \times EF$$

where:

Road Emissions refers to GHG emissions from road freight transport per Food Basket item.

FW is the weight in Tonnes of the food freight item.

D is the distance in kilometres the food is transported by rail from its source to its Melbourne CBD destination.

EIRD is the Energy Intensity of road freight operations in Australia, provided in MJ/T km .

EF is the diesel fuel Emission Factor, provided in kg CO₂-equivalent (CO₂-e) emissions per GJ. Division by 1000 here converts kg to tonnes.

¹⁴ Apelbaum Consulting Group, 2007, Benchmarking the Energy and Greenhouse Gas Performance of Queensland Rail, p. 61. (Table 4.3a, Non-Bulk Interstate Direct Energy Intensity, 2005/06).

¹⁵ C.Hodkinson, Consultantz PL December 2007. Personal communication.

The Energy Intensity constant for road freight was sourced from a comparative study of intermodal and road freight by Affleck Consulting¹⁶. Table 4 of their report gives four Energy Intensity averages for different freight vehicles and routes, obtained from Australian road freight operators. A simple average of the first three figures supplied was used, as the authors estimated that they provided a better analogue for the food basket transport task, but it should be stated that including the fourth road freight EI in calculating the average would have reduced the resulting EI^{RD} constant by 13%. The Energy Intensity constants are restated in the following Table:

Table 1: Constants used in emissions calculations

Constant	Units	
Rail Freight energy intensity	0.26	MJ/t.km
Road Freight energy intensity	0.72	MJ/t.km
Diesel Emission Factor (Joule)	69.8	kg CO ₂ -e/GJ

Note that in the preliminary CERES Food Miles report, GHG emissions from road transport were calculated using an equation from the Australian Greenhouse Office, Factors and Methods Workbook (2006): Road Emissions = D x FCR x EF/1000 [where FCR is the Fuel Consumption Rate]. This equation has been replaced in this study by the preceding one, because it more closely matches the NGAF form and is less susceptible to complications of definition in statistics concerning the road transport industry.

¹⁶ Affleck 2002 *Comparison of Greenhouse Gas Emissions by Australian Intermodal Rail and Road Transport*, report by Affleck Consulting Pty Ltd, Brisbane, for Queensland Rail Network Access. http://www.networkaccess.qr.com.au/Images/Emissions_tcm10-2847.pdf

3 Assumptions

The lack of available data and the limited resources available forced a number of simplifying assumptions on the authors. Following is a breakdown of the assumptions made at different stages to make this study possible, and readers are advised to consider the findings with these limitations in mind.

3.1 Food Miles

For full details of food item source locations, established from industry bodies and companies, please refer to: Food Miles in Australia: A preliminary study of Melbourne, Victoria. Bee Abraham & Gaballa (July 2007, updated February 2008). A general assumption here that the named town or locality identified is the site of production, and the distribution of growers about the town is disregarded. Appendix 3 provides the individual source locations and ascribed weightings for each food item.

3.2 Greenhouse Gas Emissions Estimates

3.2.1 Road Transport Emissions Estimates

Many foodstuffs require refrigeration in transport, and this cooling can be provided by specialised trucks or by refrigerated containers/‘reefers’. Information about the proportionate use of trucks and reefers and their energy cost was unavailable and excluded from this study. All Scope 2 and 3 emissions, due to the exploration, extraction and refining of fuel, manufacturing of agricultural equipment and material input, maintenance of roads etc, have also been excluded from this study.

3.2.2 Rail Transport Emissions Estimates

It was assumed that sufficient rail capacity above and below track existed to carry the required freight over the identified routes. The viability of this assumption is open to further exploration, as freight handling and prioritisation issues are reported by users.

3.2.3 Transport Scenarios

The use of these four scenarios was prompted by the existing rail freight network in Australia, where an extensive rail track network must be accessed via a fairly sparse network of rail freight depots. Currently, many producers truck their freight considerable distances to reach a rail freight depot, the

assumption is that producers will continue to have access to freight depots in the existing and hypothetical scenarios.

The viability of some existing depots is also in question as freight operator Pacific National has announced plans to withdraw from Victoria¹⁷, a move that would reduce the ability of rail freight in cutting GHG emissions from transport.

4 Results

The results of this study are the road and rail transport distances for the twenty-five food basket items under each of four transport scenarios, and the emissions estimated from that transportation. These are presented in the following two tables, with further tables appearing in the discussion comparing the scenarios.

Table 2 provides the average transported distance of each item for each scenario. The shifting balance from road to rail freight across the scenarios is apparent in most but not all items, as some producers, such as for sugar and grain, have good rail access.

¹⁷ Victoria's biggest rail freight to end next month" Australian Broadcasting Commission 4th January 2008 website <http://www.abc.net.au/news/stories/2008/01/04/2132029.htm?section=business>
<http://www.abc.net.au/news/stories/2007/12/12/2116312.htm>

Table 2: Transport distance for different food transport scenarios

Food Basket Item	Item weight (kg)	Transport Distance (km) by Scenario					
		A- Existing All Road	B-Existing Intermodal		C-Hypothetical Ubiquitous		D- Hypothetical All rail
			Rail	Road	Rail	Road	
<i>Fruit</i>							
Bananas	1.000	2746	3131	113	3168	33	3200
Orange Juice	1.080	2384	3116	235	3249	18	3267
Tomatoes	1.000	1618	1519	213	1667	14	1680
Oranges	1.000	568	679	86	700	0	700
Apples	1.000	112	59	53	123	3	127
<i>Vegetables</i>							
Onions	1.000	602	646	110	724	7	731
Pumpkins	1.000	362	0	362	373	0	373
Carrots	1.000	312	0	312	318	3	320
Potatoes	1.000	156	0	155	155	0	155
Lettuce	0.700	55	0	55	47	0	47
<i>Meat & dairy</i>							
Cheese	0.500	689	0	689	429	271	700
Milk	1.080	348	0	348	452	57	509
Beef	1.000	298	0	298	309	9	318
Eggs	0.660	134	103	58	156	3	158
Chicken	1.000	84	0	84	62	12	74
<i>Cereals & legumes</i>							
Cereal Biscuits	0.750	915	3374	91	3258	12	3270
Rolled Oats	1.000	551	0	551	676	0	676
Bread	0.680	486	0	487	538	80	618
Rice	1.000	381	416	98	447	0	447
<i>Non-core food & beverage</i>							
Sugar	2.000	2316	2706	0	2706	0	2706
Potato Chips	0.200	2024	2088	51	2088	51	2139
Savoury Biscuits	0.250	1802	2922	161	2977	63	3040
Margarine	0.500	1464	1752	205	1886	40	1926
Instant Noodles	0.085	590	654	133	824	0	824
Canola Oil	0.735	304	291	72	319	8	327

Table 3 provides the emissions estimates, calculated from the transport of the food items over the given distances. An additional food group average has been inserted to aid interpretation.

Table 3: Estimated greenhouse gas emissions for different food transport scenarios

Food Basket Item	Item weight (kg)	Emissions for transport scenarios(g CO2-e)			
		A-Existing All Road	B- Existing Intermodal	C- Hypothetical Ubiquitous	D- Hypothetical All Rail
Fruit					
Bananas	1.000	137.9	62.5	59.1	58.1
Orange Juice	1.080	129.2	73.8	64.7	64.0
Tomatoes	1.000	81.2	38.3	30.9	30.5
Oranges	1.000	28.5	16.6	12.7	12.7
Apples	1.000	5.6	3.7	2.4	2.3
<i>average</i>		76	39	34	34
Vegetables					
Onions	1.000	30.2	17.3	13.5	13.3
Pumpkins	1.000	18.2	18.1	6.8	6.8
Carrots	1.000	15.7	15.6	5.9	5.8
Potatoes	1.000	7.8	7.8	2.8	2.8
Lettuce	0.700	1.9	1.9	0.6	0.6
<i>average</i>		15	12	6	6
Meat & Dairy					
Milk	1.080	18.9	18.9	12.0	10.0
Cheese	0.500	17.3	17.3	10.7	6.4
Beef	1.000	14.9	15.0	6.0	5.8
Eggs	0.660	4.4	3.1	2.0	1.9
Chicken	1.000	4.2	4.2	1.7	1.3
<i>average</i>		12	12	6	5
Cereals & legumes					
Cereal Biscuits	0.750	34.4	49.3	44.8	44.5
Rolled Oats	1.000	27.6	27.7	12.3	12.3
Rice	1.000	19.1	12.4	8.1	8.1
Bread	0.680	16.6	16.6	9.4	7.6
<i>average</i>		24	27	19	18
Non-core food					
Sugar	2.000	232.5	98.2	98.2	98.2
Margarine	0.500	36.8	21.1	18.1	17.5
Savoury Biscuits	0.250	22.6	15.3	14.3	13.8
Potato Chips	0.200	20.3	8.1	8.1	7.8
Canola Oil	0.735	11.2	6.5	4.5	4.4
Instant Noodles	0.085	2.5	1.6	1.3	1.3
<i>average</i>		54	25	24	24
Full basket emissions (g CO2-e)					
	Full basket weight (kg)	A-Existing All Road	B- Existing Intermodal	C- Hypothetical Ubiquitous Intermodal	D- Hypothetical All Rail
Totals	21.2	940	571	451	438

Table 4 provides an estimate of the emissions that would be avoided if transport of the given food item would move from scenario A-Existing All Road to the Existing and Hypothetical Intermodal scenarios B and C, and scenario D: Hypothetical All Rail.

Table 4: Estimated greenhouse gas emissions reductions for different food transport scenarios

Food Basket Item	Reduction in emissions (%) by change in scenario from		
	A-Existing All Road to B-Existing Intermodal	A-Existing All Road to C-Hypothetical Ubiquitous Intermodal	A-Existing All Road to D-Hypothetical All Rail
<i>Fruit</i>			
Bananas	55	57	58
Orange Juice	43	50	50
Tomatoes	53	62	62
Oranges	42	55	55
Apples	34	57	59
<i>Vegetables</i>			
Onions	43	55	56
Pumpkins	0	63	63
Carrots	0	62	63
Potatoes	1	64	64
Lettuce	0	69	69
<i>Meat & Dairy</i>			
Milk	0	37	47
Cheese	0	38	63
Beef	0	60	61
Eggs	29	56	57
Chicken	0	59	68
<i>Cereals & legumes</i>			
Cereal Biscuits	-43	-30	-29
Rolled Oats	0	56	56
Rice	35	58	58
Bread	0	44	54
<i>Non-core food</i>			
Sugar	58	58	58
Margarine	43	51	52
Savoury Biscuits	32	37	39
Potato Chips	60	60	62
Canola Oil	42	59	61
Instant Noodles	37	49	49
Full food basket average	39	52	53

5 Discussion

The distance that food items travel was the largest factor in the level of GHG emissions produced from their transport. The longest distances were for foods produced in sub-tropical climates such as bananas and sugar, and for processed foods such as biscuits, orange juice and potato chips. The emissions produced from transport varied also according to the road/rail balance, a balance or distribution determined by the assumptions of each transport scenario.

The distance by rail was usually further than that by road, as a more extensive road network allowed more direct routes. Changing the means of transport from road to rail however still reduced GHG emissions, due to their different Energy Intensity constants: 0.72 and 0.26 MJ/t km respectively. As rail requires almost one third of the energy of road for the same transport task, the more of the journey completed by rail, the resulting emissions were still lower.

The progression of scenarios from A-Existing All Road to D-Hypothetical All Rail shows then an unsurprising fall in GHG emissions. Of interest is where those falls in emissions occur: is it when rail track leads to every food producers' door, as is assumed for the Existing All Rail scenario? Table 5 is a matrix showing the percentage reduction in GHG emissions as transport is moved between scenarios:

Table 5: Estimated greenhouse gas emissions reductions (%) by change in transport scenario.

To			
From	B- Existing Intermodal	C- Hypothetical Ubiquitous Intermodal	D- Hypothetical All Rail
A-Existing All Road	39	52	53

From Table 5, it can be seen that emissions reductions came from moving A-Existing All Road freight to B-Existing Intermodal freight: a 39% reduction. Moving to the C-Hypothetical Ubiquitous Intermodal freight depot network saved another 13% (from 39% to 52%), and building rail to each site of food production (D-Hypothetical All Rail), saved only another 1% (from 52% to 53%) of Existing All Road emissions. These findings suggest that transport planners aiming to reduce emissions, should focus more on increasing the network of freight depots rather than building new rail track.

6 Conclusion

'Food Miles' is a term now commonly used to measure the transport distance travelled by food products between production and consumption. Food Miles is one important part of a larger full life-cycle assessment required to compare the sustainability of individual items in food systems. This study contributes to an improved understanding of the transport aspect of our current food system.

The results of this study should be viewed within the limitations outlined in the preliminary CERES food miles report and this report. A general assumption for this report is that sufficient rail capacity above and below track would exist to carry the required freight over the identified routes. The viability of this assumption is open to further exploration, as freight handling and prioritisation issues are reported by users.

Results indicate that the distance that food items travel was the largest factor in the level of GHG emissions produced from their transport. The longest distances were for foods produced in sub-tropical climates such as bananas and sugar, and for processed foods such as biscuits, orange juice and potato chips. The emissions produced from transport varied also according to the road/rail balance, a balance or distribution determined by the assumptions of each transport scenario.

Transporting the 21kg food basket in this study produced an estimated 940 grams of GHG emissions if transported in scenario A (solely by existing road networks), 570g if by existing intermodal freight (scenario B), 451g if using a hypothetical ubiquitous road and rail freight (scenario C), and 438g if using hypothetical all rail (scenario D).

In considering emissions differences across the 4 scenarios, emissions reductions came from moving A-Existing All Road freight to B-Existing Intermodal freight: a 39% reduction. Moving to the C-Hypothetical Ubiquitous Intermodal freight depot network saved another 13% (from 39% to 52%), and building rail to each site of food production (D-Hypothetical All Rail), saved only another 1% (from 52% to 53%) of Existing All Road emissions. These findings suggest that transport planners aiming to reduce emissions, should focus more on increasing the network of freight depots rather than building new rail track.

The Food Miles and emissions estimates in this study highlight the strong link between transport choice and emissions outcomes, and indicates the vulnerability of our food supply system to existing transport costs and the price impacts of oil depletion. In addition, this study shows the importance of infrastructure planning within the rail and road transport system, indicating possible emissions savings being enhanced by the availability of well placed depots.

As society moves to reduce carbon emissions resulting from our food supply system it is hoped that both infrastructure and transport mode choices are factored into planning decisions.

7 Appendices

7.1 Appendix 1: Healthy Food Access Basket, Queensland Health (2000)

The table in this appendix gives all the food items in the original HFAB 2000.

Table 1: The Healthy Food Access Basket 2000 – Foods And Quantities

Basket Item	Unit size surveyed	Total amount in HFAB	Basket Item	Unit Size Surveyed	Total amount in HFAB
Cereal Group			Meat/ Meat Alternatives Group		
loaves of white bread	680g	6800g	tinned corned beef	340g	340g
loaves of wholemeal bread	680g	6800g	tinned meat & onion/vegetables	400g-425g	820g
white flour	2kg	2.5kg	beef mince	1kg	1 kg
wholemeal flour	1kg	2.5kg	rump steak	1kg	1 kg
Weet-bix	750g	1500g	frozen chicken	size 11	2 kg
rolled oats	1kg	750g	tinned smoked oysters	85g-105g	170g
white rice	1kg	5kg	large eggs (min 50g)	680g	1320g
tinned spaghetti	420g-425g	1275g	sausages	1kg	1 kg
instant noodles	85g	1020g	tinned ham	450g	1 kg
Sao biscuits	250g	1kg	Dairy Group		
Fruit, Vegetable & Legume Group			fresh full cream milk		
apples	1kg	6 kg	fresh, reduced fat milk	1L	1L
oranges	1kg	11 kg	powdered milk, whole	1kg	1kg
bananas	1kg	5 kg	powdered skim milk	1kg	1kg
tinned fruit salad, in natural juice	400g-450g	3520g	long life milk	1L	4L
orange juice (100%)	2L	4L	cheese	500g	2kg
tomatoes	1kg	5 kg	Non-Core Foods		
potatoes	1kg	10 kg	unsaturated margarine	500g	1500g
pumpkin	1kg	1.5 kg	white sugar	2kg	3 kg
cabbage	half	1.5kg	canola oil	750ml	750ml
lettuce	whole	1.5			
carrots	1kg	2 kg			
onions	1kg	2 kg			
frozen vegetables	500g	2.5 kg			
tinned peas	420g-440g	880g			
tinned baked beans	420g-425g	1700g			
tinned beetroot	425g-450g	450g			

g = grams; kg = kilogram; L = litre;

Source: Queensland Health (2000) The Healthy Food Access Basket Survey 2000, Queensland Government, Australia p.12. See <http://www.health.qld.gov.au/ph/documents/hpu/9134.pdf>

7.2 Appendix 2: Existing Rail freight depots used in study

The set of Rail Freight Depots used in this study was pieced together from the services offered by the different freight operators.

State	Depot	State	Depot
NSW	Chullora, Sydney	QLD	Mackay
NSW	Dubbo	QLD	Mount Isa
NSW	Griffith	QLD	Rockhampton
NSW	Moree	QLD	Townsville
NSW	Newcastle	SA	Dry Creek South, Adelaide
QLD	Acacia Ridge, Brisbane	VIC	Ballarat
QLD	Biloela	VIC	Boort
QLD	Brisbane	VIC	Dynon Rd, Melbourne
QLD	Bundaberg	VIC	Horsham
QLD	Cairns	VIC	Merebin (Mildura)
QLD	Cloncurry	VIC	Shepparton
QLD	Gladstone/Mt Miller	VIC	Warrnambool
QLD	Innisfail	WA	Kewdale, Perth

7.3 Appendix 3: Food sources and weightings

The sources of particular food items varies with season, and so weightings were given to represent the number of months of the year that different sources dominated supply. Following is a table giving the set of sources used for each food item and their respective weights.

Food Basket item	Source	Weighting	Food Basket item	Source	Weighting	
Apples	Healesville	VIC	Onions	Griffith	NSW	0.125
	Shepparton	VIC		Jerilderie	VIC	0.125
	Officer	VIC		Werribee	VIC	0.188
Oranges				Gatton	QLD	0.313
	Leeton	NSW		Murray Bridge	SA	0.063
	Griffith	NSW		Swan Reach	SA	0.063
	Waikerie	SA		Mannum	SA	0.063
	Renmark	SA		Virginia	SA	0.063
	Berri	SA				
	Mildura	VIC		Beef		
Orange Juice				Mildura	VIC	0.500
	Griffith	NSW		W hittlesea	VIC	0.500
	Waikerie	SA				
	Mildura	VIC		Chicken		
	<i>via processing at:</i>			Balnarring	VIC	0.167
	Berri	SA		Moorooduc	VIC	0.167
	Lytton	QLD		Redhill	VIC	0.167
	Leeton	NSW		<i>via processing at:</i>		
	Smithfield	NSW		Somerville	VIC	0.500
	Bentley	WA				
Banana				Eggs		
	Inisfail	QLD		Tullamarine	VIC	0.450
	Tully	QLD		Balnarring	VIC	0.450
	Coffs Harbour	NSW		Toowoomba	QLD	0.033
	Carnarvon	WA		Young	NSW	0.033
		West Wyalong		NSW	0.033	
Tomatoes				Milk		
	Shepparton	VIC		Kiewa	VIC	0.125
	Bendigo	VIC		Corryong	VIC	0.125
	Bundaberg	QLD		Tatura	VIC	0.125
	Bowen	QLD		Kyabram	VIC	0.125
	Geraldton	WA		Stanhope	VIC	0.125
	Carnarvon	WA		Coburn	VIC	0.125
		Finley	VIC	0.125		
Potatoes			Tocumwal	VIC	0.125	
	Thorpdale	VIC	<i>via processing at:</i>			
	Gembrook	VIC	Bendigo	VIC	0.500	
	Leongatha	VIC	Rowville	VIC	0.500	
	Lindenow	VIC				
		Cheese				
		Jellat Jellat	VIC	0.450		
		Timbillica	VIC	0.450		
		Gerringong	VIC	0.050		
		Bairnsdale	VIC	0.050		
		<i>via processing at:</i>				
		Bega	VIC	1.000		

Appendix 3: Food Sources and Weightings, *continued*

Food Basket item	Source	Weighting
Bread	Swan Hill VIC	0.333
	Piangil VIC	0.333
	Murrayville VIC	0.333
	<i>via processing at:</i> North Melbourne VIC	1.000
	Dandenong VIC	1.000
Cereal Biscuits	Mackay QLD	1.000
	<i>via processing at:</i> Adelaide SA	0.333
	Cooranbong	0.333
	Berkeleyvale NSW	0.333
Rolled Oats	Griffith NSW	1.000
	<i>via processing at:</i> Wahgunyah VIC	1.000
Rice	Leeton NSW	0.500
	Denilliquin VIC	0.500
Instant Noodles	Griffith NSW	0.500
	Kensington VIC	0.500
	<i>via processing at:</i> Pakenham VIC	1.000
Savoury Biscuits	Swan Hill VIC	0.500
	Birchip VIC	0.500
	<i>via processing at:</i> Summer Hill NSW	1.000
	Huntingwood NSW	1.000

Food Basket item	Source	Weighting
Sugar	Mackay QLD	1.000
Canola Oil	Yarrawonga VIC	0.167
	Echuca VIC	0.167
	Borong VIC	0.167
	Horsham VIC	0.167
	Oaklands NSW	0.167
	The Rock NSW	0.167
	<i>via processing at:</i> Brooklyn VIC	1.000
Potato Crisps	Regency Park SA	0.333
	Canningvale WA	0.333
	Tingalpa QLD	0.333
	Dandenong	1.000
Margarine	Temora NSW	0.167
	Cowra NSW	0.167
	Forbes NSW	0.167
	Balladoran NSW	0.167
	Willow Tree NSW	0.167
	Moree NSW	0.167
	<i>via processing at:</i> Newcastle NSW	1.000
	Mascot NSW	1.000

7.4 Appendix 4: Data for Food Unit Weight

Samples were taken at Coles Supermarket in Northcote, Melbourne, Victoria, in December 2007. Supermarket scales were used for the sample measurements.

Sample #	Item Sample weights (g)			
	Lettuce -bagged (iceberg)	Orange Juice 1.5L	Milk, Full Cream 1L	Canola Oil 750ml
1	405	1,615	1,080	735
2	645	1,630	1,080	735
3	735	1,635	1,080	735
4	885	1,625	1,080	735
5	600			
6	940			
7	965			
8	925			
9	410			
10	925			
11	555			
12	500			
13	1010			
14	480			
15	520			
Total	10,500g	6,505g	4,320g	2,940g
Unit Average	700g	1,626g *	1,080g	735g
*Unit equivalent to 1L: 1,084g				