Food Miles, Carbon Footprinting and their potential impact on trade[1]

Caroline Saunders, Andrew Barber and Lars-Christian Sorenson

Abstract

To obtain market access for NZ food exports to high value developed country markets exporters are having to comply and consider environmental factors such as carbon footprinting. This growth in demand for environmental attributes is shown in the rise of the food miles debate or concept. Food miles is a concept which has gained traction with the popular press arguing that the further food travels the more energy is used and therefore carbons emissions are greater. This paper assesses, using the same methodology, whether this is the case by comparing NZ production shipped to the UK with a UK source. The study found that due to the different production systems even when shipping was accounted for NZ dairy products used half the energy of their UK counterpart and in the case of lamb a quarter of the energy. In the case of apples the NZ source was 10 per cent more energy efficient. In case of onions whilst NZ used slightly more energy in production the energy cost of shipping was less than the cost of storage in the UK making NZ onions more energy efficient overall. The paper then explores other developments in market access to developed markets especially the rise in demand for products to be carbon footprinted and the introduction of carbon labelling. A review of latest methodology in carbon footprinting the PAS from the UK is reviewed and implications for trade assessed.

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Introduction

Historically trade policy has been one of the major factors affecting NZ exports. This is still important with NZ restricted by quotas especially for access into high value markets. Moreover, other potential markets for NZ have been affected by the competition from subsidised exports. The EU (European Union) has recently announced it is going to, even without the completion of current Doha round of the WTO (World Trade Organisation), remove export subsidies. This has huge potential for our products.

However, a great threat to our access especially into the high value markets is the growing concern about the environment. In particular the issue of climate change has grown in importance as seen through the application of the Kyoto Protocol and issues such as “food miles”. This paper outlines some of these threats. Whilst this concentrates upon the UK and EU markets there is growing evidence that this is not just an issue for those markets. Other markets are also showing increasing concern about these factors.

‘Food miles’ is a relatively recent issue which has arisen in the United Kingdom, Germany and other countries over food transportation. The argument is that the longer the transport distance (food miles), the more energy is consumed and carbon emitted.

New Zealand has attracted a lot of attention in the food miles debate, for three main reasons. Firstly, due to its geographical location relative to the UK; secondly the UK is an important high value markets for NZ exports; and thirdly, the similar climates of NZ and the UK means in theory imports can be substituted with home-grown produce.

In this study the energy and carbon emissions from key New Zealand products are calculated and compared to the next best alternative source for the UK market. The calculation of total energy use and CO_2 emissions uses life cycle assessment methodology from farm production to UK wholesaler, excluding packing and processing.

This report first reviews the literature, followed by the methodology used and then presents the results for the dairy, apple, onion and lamb sectors. There are two major groups of literature relating to food miles: firstly, literature concerned solely with food miles itself (although academic literature on this is minimal), and secondly a group of literature relating to energy use/life cycle assessment.

Literature on Food miles include a joint international report (OECD/IEA, 2001) which notes the possibility of more local and regional sourcing of goods to reduce energy use however they do not consider the production part of the life cycle of a product.

Garnett (2003) in her report focuses on food transport within the UK and the efficiency of various distribution networks including imported food. This study did not include energy use and emissions in the production phase of the product, just energy use in the packaging, marketing and delivery phase. This is recognised by Garnett who quotes a US study on the environmental costs of food transportation (Pirog et al., 2001) in which the contribution of transport to total food chain energy costs is about 11 per cent.

In a study evaluating the externality of transport Pretty et al (2005), calculated that in the case of imports this was only 0.005p per person per week compared to 75.7p per person, per week for domestic supply.

Smith et al., (2005) assessed whether a valid indicator of sustainability based on food miles could be developed. They concluded that one single indicator could not be developed, but multiple ones were needed to model the complexity of the issue. While the report focussed on the transport component of the life cycle of food, the authors recognise that the issue is also not as simple as just minimising food transport. They acknowledge the importance of the production phase of food and that if this is efficient, one product can be more sustainable environmentally than another which travels shorter distances.

An assessment of the environmental effects a product or service has during its lifetime, from cradle to grave, is known as life cycle assessment (LCA). Tan and Culaba (2002) report that early forms of LCAs were used in the late 1960s in the United States, but it was not until the 1990s that they emerged in their current form when international standards were imposed, first by the Society for Environmental Toxicology and Chemistry in 1991 and later by the

International Organization for Standardization (ISO) in the late 1990s and beyond. Currently it is part of the IS0 14040 series, which covers the principles, the analysis, interpretation and the reporting of the results.

LCA studies were originally developed for industrial products but are now being conducted on the primary sector, and also for manufactured foods and beverages. Cederberg and Flysjö in their LCA assessed the environmental impact of Swedish milk production, in terms of resource use and emissions. They surveyed 23 dairy farms in south-western Sweden, over three types: conventional high output farms, conventional medium output farms, and organic farms. They found that the total energy use of organic farms per unit of production was significantly less than each of the two conventional types of farms, while no significant difference was found between these conventional types. A similar picture emerged for CO_2 emissions.

Brentrup et al. (2004a) constructed a LCA approach for arable crop production which is applied to a theoretical system of winter wheat production, in a companion paper (Brentrup et al., 2004b). They showed that at low production intensities (low levels of nitrogen fertiliser), the overall environmental effects were moderate, but the land use impact contributed more than one-half of the total effect and aquatic eutrophication only a small amount. However, at high production intensities (high levels of nitrogen fertiliser) this situation was reversed, and the overall environmental impact was high.

In New Zealand, a number of energy use studies into agricultural production were carried out between 1974 and 1984, following the first ‘oil shock’ in 1973 (Wells, 2001). But from that time until the mid-1990s, very little energy use research into this sector was conducted. From the mid-1990s onwards the research programme resumed. Wells (2001) surveys the New Zealand dairy industry in terms of the production of milk solids and arrives at the average energy use and CO_2 emissions per kg of milk solids. In this study 150 dairy farms were surveyed across the major dairying regions in New Zealand, and which included both irrigated and non-irrigated farms. The quantities of the various inputs on each farm were converted and aggregated into primary energy and CO_2 emissions. Barber 2004 calculated the total energy and carbon indicators for arable and vegetable crops. Bassest-Mens et at (2005) undertook a LCA of NZ dairy farming and compared this with Swedish and German farms. In the case of energy use they concluded that NZ had approximately half the energy use and around 60 per cent lower global warming potential than conventional farms in Sweden or Germany.

Methodology

This study focuses on New Zealand’s exports to the United Kingdom and the comparable UK product. It uses the on-farm methodology developed by Wells, plus the inclusion of energy and emissions associated with transporting produce from NZ to the UK and storage.

Wells separated energy inputs into three major components: direct, indirect, and capital. Each of these resource inputs must be quantified and then the respective coefficients applied to obtain the total primary energy use and CO_2 emissions. Farm inputs in this analysis include factors such as energy used to power tractors, the energy embodied in capital items such as the tractors themselves, as well as the use of fertilisers, pesticides and supplementary animal feed.

The UK is an important export market for NZ products, taking 66 per cent of sheep meat, 57 per cent of apples; 33 per cent of onions; 21 per cent of butter and 10 per cent of cheese exports.

Moreover, NZ is a significant supplier to the UK providing 58 per cent of apples; 18 per cent of sheep meat; 14 per cent of butter. Imports of NZ sheep meat made up nearly 18 per cent of the UK’s total supply of sheep meat in 2002, while NZ butter contributed 14 per cent (GTI: World Trade Atlas (2005), Statistics NZ (2005), MDC Datum (2004), Defra (2005a)). Therefore the four products chosen for this study are dairy, apples, onions and lamb.

Energy component of key inputs into agricultural production

In agricultural production there are a number of inputs which are common across the systems. This section therefore calculates the energy component and CO_2 emissions associated with these common inputs and the values are then applied in later sections when estimating the energy and CO_2 emissions associated with agricultural output.

Direct energy is that energy used directly by the operation, for example, diesel, petrol and electricity. The definition of direct energy includes the energy contained in the fuel/electricity (consumer energy), plus the energy for extracting, processing, refining and supplying (e.g.

transportation for diesel) the fuel, and losses which occur through the process. The values of these are illustrated in Table 1. The primary energy content, which includes an allowance for the fuels production and delivery, adds an extra 23 per cent for all these types in NZ (Wells, 2001) and 16 per cent in the UK.

The carbon emission for NZ and UK fuel is very similar. The carbon emissions for electricity are higher in the UK due to the greater proportion of fossil fuel used whereas NZ generates 64 per cent from renewable sources.

Some of the UK farm budgets used to derive energy inputs had expenditure on contractors for such operations as mowing and cultivation. For the purposes of this study the fuel was assumed to be 12 per cent of the cost and this was then converted into litres of diesel.

Indirect energy inputs

Indirect energy inputs used in agricultural production include fertilisers, agrichemicals and supplementary animal feed. Table 1 illustrates the energy and associated emissions for the main inputs into agricultural systems. Fertiliser is the most significant indirect energy input. The energy component in fertiliser comes mainly from its manufacture and transport.

The energy component and the CO_2 emissions from fertilisers use the data presented by Wells (2001). It is assumed here that these are the same for the UK and NZ.

Table 1

Energy requirement for key inputs and the associated CO_2 emissions

	Energy Use (MJ/kg)		**CO_2 Emissions (kg CO_2/MJ)**	
	NZ	UK	NZ	UK
Diesel (per litre)	43,.6	41.2	68.7 [a]	65.1 [c]
Petrol (per litre)	39.9	37.7	67.0 [a]	61.3 [c]
Oil (per litre)	47.4	44.8	35.9 [a]	33.2 [c]
Electricity (per kWh)	8.14	10.37	19.2 [b]	41.5 [c]
N	65	65	0.05	0.05
P	15	15	0.06	0.06
K	10	10	0.06	0.06
S	5	5	0.06	0.06
Lime	0.6		0.72	
Herbicide (Paraquat, Diquat and Glyphosate) (kg ai)	550	550	0.06	0.06
Herbicide (other) (kg ai)	310	310	0.06	0.06
Insecticide (kg ai)	315	315	0.06	0.06
Fungicide (kg ai)	210	210	0.06	0.06
Plant Growth Regulator (kg ai)	175	175	0.06	0.06
Oil (kg ai)	120	120	0.06	0.06
Other (kg ai)	120	120	0.06	0.06
Concentrates (per tonne) (barley equiv)	3361	206.9		
Fodder	1.50		0.058	
Vehicles	65.5		0.09	
Implements	51.2		0.10	
Buildings (m^2)	590		0.10	
Shipping (per t km)	0.114		0.007	

As in the case of fertilisers the energy component of agrichemicals is mainly from their manufacture and transport. The energy component and carbon dioxide emissions were adapted from a detailed study of the energy in chemical manufacture and use, Pimentel (1980) and data on carbon dioxide emissions is from Wells (2001) and Barber (2004b). The energy requirement to manufacture agrichemicals ranges considerably as shown in Table1.

An important input into livestock systems in the UK is concentrate feed especially when compared to NZ. For the purposes of this study it is assumed that concentrates have the same energy profile as barley. This is likely to be an underestimate of the energy in the concentrate. A simple analysis of the energy and CO_2 emissions in producing barley feed was therefore undertaken and reported in detail in Saunders et al (2006). This gave a lower bound on the embodied energy in barley concentrate of 3,361 MJ per tonne of barley. The associated emissions are 207 kg of CO_2 per tonne of barley.

The energy emissions and carbon dioxide emissions for fodder were taken from Wells (2001) and this was 1.50 MJ/kg dry mater (DM) for grass silage and hay with an emission rate of 0.058 kg CO_2/MJ.

The energy and carbon dioxide emissions associated with machinery include the embodied energy of the raw materials, construction energy, an allowance for repairs and maintenance, and international freight (Wells, 2001). As Table 1 shows, the embodied energy of vehicles and implements used in this report is 65.5 MJ/kg and 51.2 MJ/kg respectively (Barber and Lucock, 2006). This is based on a simplification of the approach used by Audsley et al. (1997) and incorporates New Zealand data for steel and rubber. This is lower than the figure reported in Wells (2001) but more akin to that used by Doering (1980) who estimated a value of around 70 MJ/kg.

Table 1 also gives the energy coefficients and CO_2 emission rates for farm vehicles and implements. For both New Zealand and the UK a dairy shed model constructed by Wells (2001) was used. The capital energy of the dairy shed is related to a single parameter, the number of sets of milking cups.

Transport

As described in the methodology section due to the lack of data, the only transport distances for which analysis in this report will be done are on distances between countries, the export of the products. For all of the New Zealand commodities this involves sea freight to the United Kingdom, a distance of 17,840 km according to the Department for Transport (2003).

A review of the literature on the energy and emission coefficients for refrigerated sea transport did show general consistency with one or two exceptions and the figure chosen here is the 0.114 MJ per tonne km. This has been calculated from shipping having carbon dioxide emissions of 0.007 $kgCO_2$/t-km (Department for Transport, 2003), and the carbon content of diesel being 2.68 $kgCO_2$/L.[1] Dividing the shipping emissions by the carbon content per litre of diesel equals 0.0026 L/t-km. Multiplying this figure by the primary energy content of NZ diesel (43.6 MJ/L), given that the ships refill in NZ, gives a rate of 0.114 MJ/t-km.

Energy and carbon dioxide emissions associated with production in NZ and the UK

This section calculates the energy and carbon dioxide emissions associated with the production of NZ and UK dairy, apples, lamb and onions. This requires information on the outputs of the production system so that the energy and carbon dioxide emissions can be expressed per unit of output enabling comparisons to be made between the two countries. In general information on NZ production systems, including inputs, was available in more detail enabling a more thorough calculation of the energy embodied and emissions associated with production. However, this has led to the results underestimating the energy associated with production in the UK compared to that in NZ. Finally the shipping costs were calculated and added to the NZ production system.

Dairy

This section presents results for dairy; the unit for the dairy sector was tonnes of milk solids (tMS).

The NZ dairy information presented here is based upon the study conducted by Colin Wells in his 2001 study of the Dairy Industry (Wells 2001). This involved the comprehensive survey of 150 dairy farms in NZ.

No single source of information on dairy production systems in the UK was available giving the detailed information required to compare energy use in this sector with that in NZ. Therefore a number of sources have been used to obtain and verify the information used. The key sources were the report on the Economics of Milk Production, Colman et al. (2004), and this was supplemented with Nix's Farm Management Pocket Book (2004) and other sources as cited below.

The energy and carbon dioxide emissions associated with dairy production in NZ and the UK are summarised in Table 2.

Table 2

Total energy and carbon dioxide indicators for NZ and UK dairy production

Item	**Quantity/hectare**		**Energy MJ/Tonne MS**		**CO_2 Emissions kg CO_2/Tonne MS**	
	NZ	UK	NZ	UK	NZ	UK
Direct						
Fuel use (L of Diesel) (including contracting)		245		10,429		679.0
Diesel (L) (including contracting)	56.2		2,990		205.4	
Petrol (L)	22.4		1,093		73.2	
Lubricants (L)	0.9		50		1.8	
Electricity use (kWh)	545.4	378	5,425	4,053	104.0	163.5
Direct sub total	**-**	**-**	**9,558**	**14,482**	**384.5**	**847.1**
Indirect						
Nitrogen (kg)	72.0	149	5,712	10,003	263.7	500.1
Phosphorus (kg)	57.6	14	1,055	209	63.3	12.6
Potassium (kg)	56.0	38	684	394	41.0	23.7
Sulphur (kg)	62.4		381		22.9	
Lime (kg)	288.9	175	212	109	151.7	78.2
Pesticides (kg ai)	3.0	1.75	1,136	560	68.2	33.6
Cleaning Chemicals (kg)	3.1	3.1	458	384	27.5	23.1
Animal remedies (e.g. drench, bloat aids) (kg)	0.5		64		3.8	
Other chemicals (kg)	1.3	1.6	193	182	11.6	10.9
Forage, Fodder and Bedding (kg grass silage)	389	4,954	662	7,674	38.5	445.1
Cereals/concentrate (kg of dry matter)	83	3,849	231	13,362	13.5	822.6
Grazing-off (ha)	0.2	-	413	0	24.8	0
Aggregate (kg)	1,072		131		9.0	
Indirect sub total	**-**	**-**	**11,331**	**32,877**	**739.2**	**1,949.8**
Capital						
Vehicles (kg)	4.6		368		29.4	
Implements (kg)	5.4		336		30.2	
Dairy shed (cups)	-		527	549	52.7	54.9
Other farm buildings (m^2)	0.3	-	185	458	18.5	68.8
Fences (m)	3.9	-	169		17.0	
Races (m)	1.2	0.4	110	1	7.6	0.1
Stock water supply (ha)	0.0		85		7.1	
Irrigation (ha)	0.0		120		3.7	
Effluent disposal system (m^3)			123		7.7	
Capital sub total	**-**	**-**	**2,023**	**1,009**	**173.9**	**123.8**
Total Production	**-**	**-**	**22,912**	**48,368**	**1,297.6**	**2,920.7**
Yield (kg Milk Solids)	**819**	**968**				
Shipping (NZ to UK) (17,840 km)	-	-	2,030		124.9	
Total Production Energy Input/Emissions	**-**	**-**	**24,942**	**48,368**	**1,422.5**	**2,920.7**

Table 2 highlights the different production systems in the two countries with the first two columns of data identifying the quantity of input per hectare. The total energy use is presented in the third and fourth columns and shows that the UK uses considerably more energy per tonne of milk solids. In particular the UK uses 50 per cent more fuel per tonne of milk solids than NZ does although less electricity is used in the UK than in NZ. The major difference in energy input however is in the use of concentrates and forage feed which in the UK is significantly higher than that used in NZ, reflecting the different production systems.

In the UK a total of 48,368 MJ of energy is used per tonne of milk solid compared to 22,912 in NZ, over twice as much. Including shipping at 2,030 MJ per tonne milk solids still makes NZ production much more energy efficient at 24,942 at just over half that in the UK.

When the carbon dioxide emissions associated with dairy production in the UK are compared to that in NZ, even when transport is included from NZ to the UK, the UK emits over twice that of NZ. Thus, the UK emits 2,921 kilograms of carbon dioxide per tonne of milk solids compared to just 1,423 in NZ (including transport to the UK).

Apples

The data used to determine NZ’s total energy and carbon dioxide emissions was prepared with the assistance of horticultural consultant Greg Dryden (Fruition Horticulture), MAF Policy (2005a), and the CAE Guide (1996).

In the case of the UK a number of sources of data were used to calculate the production system. As in case of sheep meat (see below) the main source of data was Nix (2004) but this was supplemented by Tanton and Williams (2004), Chalmers et al. (2001) and the UK pesticide survey, Garthwaite et al. (2001).

To be able to meet the same market window as NZ apples, British apples are assumed to be stored for six months. For these storage periods the apples are chilled to around 2°C, in a refrigerated environment. No energy or emission coefficients were found for the UK, thus to estimate the energy associate with this storage the Wells and Scarrow (1997) cold storage of

NZ kiwifruit is used, which is 169 kWh/tonne, for pre-cooling and storage over 5 months. Of this 16 kWh/t were attributed to pre-cooling and 153 kWh/t to storage. Keeping the pre-cooling the same and increasing the storage component from 5 to 6 months equates to 200 kWh/tonne. The British electricity coefficients of 10.4 MJ per kWh (Table 1) and 41.5 gCO_2 per MJ (Table 1) is applied to the energy use:

The total energy is: 199.5 * 10.37 = 2,069 MJ per tonne of apples.

The corresponding CO_2 emissions are: 2,069*41.5/1,000 = 85.8 kg CO_2 per tonne of apples.

Comparison of NZ and UK apple production

The energy and carbon dioxide emissions associated with apple production in NZ and the UK are summarised in Table 3. The table highlights the difference in energy content in production of apples for direct and indirect inputs; no data was available for the UK for capital expenditure. However, NZ's capital component is relatively insignificant and we would expect this to be similar in the UK.

As Table 3 shows the direct energy in apple production in the UK is considerably higher, at 2,337 MJ/t, compared to 573 MJ/t in NZ. The NZ indirect energy is also lower at 300 MJ/t compared to 624 MJ/t in the UK. When the total energy component is calculated, including transport and storage costs, NZ apples remain lower than their UK equivalent at 2,980 MJ/t compared to 5,030 MJ/t for UK apples.

The carbon dioxide emissions per tonne of apples produced are also higher in the UK than in NZ, reflecting the higher energy use. Thus NZ apples delivered to the UK have emissions of 185 $kgCO_2$/t compared to local UK apples at 272 $kgCO_2$/t.

Table 3

Total energy and carbon dioxide indicators for NZ and UK apple production

Item	**Quantity/hectare**		**Energy MJ/Tonne apples**		**CO_2 Emissions kg CO_2/Tonne apples**	
	NZ	UK	NZ	UK	NZ	UK
Direct						
Fuel, Electricity and Oil – (L of Diesel equivalent)		794		2,337		152.1
Fuel use - Orchard (L of Diesel)	436		380		26.1	
Electricity Use (kWh)	1,180		192		3.7	
Direct subtotal	**-**	**-**	**573**	**2,337**	**29.8**	**152.1**
Indirect						
Nitrogen (kg)	80	78	104	362	4.8	18.1
Phosphorus (kg)	8	11	2	12	0.1	0.7
Potassium (kg)	60	55	12	39	0.7	2.3
Lime (kg)	1,042		13		9.0	
Herbicide (kg ai)	3.2	1.46	20	57	1.2	3.4
Fungicide (kg ai)	15.6	6.21	65	93	3.9	5.6
Insecticide - General (kg ai)	2.2	1.24	14	28	0.8	1.7
Insecticide – Oil (kg ai)	29.0	3.51	70	30	4.2	1.8
Plant Growth Regulator (kg ai)		0.17		2		0.1
Indirect subtotal	**-**	**-**	**300**	**624**	**24.7**	**33.8**
Capital subtotal	**-**	**-**	**78**	**-**	**5.6**	**-**
Total Production	**-**	**-**	**950**	**2,961**	**60.1**	**186.0**
Yield (tonnes)	**50**	**14**				
Post Harvest						
Cold storage (UK 6 months)	-	-		2,069		85.8
Shipping (NZ to UK) (17,840 km)	-	-	2,030		124.9	
Post Harvest subtotal	**-**	**-**	**2,030**	**2,069**	**124.9**	**85.8**
Total Energy Input/Emissions	**-**	**-**	**2,980**	**5,030**	**185.0**	**271.8**

Onions

There are some serious questions about the feasibility of the UK being able to supply the market during its winter, due to technical issues around storage. Therefore whilst this has been assumed possible here, as mentioned below, whether it is feasible to replace imports is questionable.

The New Zealand and UK onion crop has been compared based on supplying a crop into the same window of time, June to August, during the UK winter. The only way the UK onion crop can achieve this is by using cold and controlled atmosphere (CA) storage.

The key NZ source of information was the NZ onion industry report (Barber, 2004a).

The key source of information on the production system for UK onions was Nix (2004) as well as Chalmers et al. (2001) for fertiliser use.

Post production

Cold and controlled atmosphere storage

British onions are assumed to be stored for a minimum of nine months using a mixture of cold and controlled atmosphere environment. The onions used for storage are harvested in August and stored through to July.

The best data that was available for evaluating the energy cost of storage was the study conducted by Wells and Scarrow (1997) on the storage of kiwifruit. This is likely to underestimate the energy cost as the kiwifruit stores an ever decreasing volume of kiwifruit, hence decreasing energy load, over the 5 months that the stores are typically operated for. By contrast the volume of stored UK onions will remain the same over the 9 months required to get them into the same customer window in July.

Wells and Scarrow (1997) found that it took 0.614 kWh/tray, or 169 kWh/tonne, for pre-cooling and storage over 5 months. Of this 16 kWh/t were attributed to pre-cooling and 153 kWh/t to storage. Keeping the pre-cooling the same and increasing the storage component from 5 to 9 months equates to 291 kWh/tonne.

Based on the energy and carbon dioxide emission coefficients in Table 1 total energy use was 3,020 MJ/tonne onions. Carbon dioxide emissions were 125 kg CO_2/tonne.

Comparison of NZ and UK onion production

The energy and carbon dioxide emission associated with onion production in NZ and the UK are summarised in Table 4. The table highlights the difference in energy content in production of onions for direct and indirect inputs, as yet no data is available for the UK for capital expenditure. Likewise no energy data was found on UK onion curing in drying sheds. As a result the UK onion's energy input and associated CO_2 emissions are likely to be underestimated.

As Table 4 shows NZ onions, compared to the UK equivalent, have a higher direct energy input at 342 MJ/t compared to 245 MJ/t, although the UK figure does not include heating the onion drying sheds. The indirect energy inputs are also higher in NZ at 427 MJ/t compared to 367 MJ/t in the UK. Thus the energy associated with onion production in NZ is higher at 821 MJ/t compared with 678 MJ/t in the UK. When shipping costs are included, the NZ total rises to 2,889 MJ per tonne. However, when storage is included for the UK, so they can supply the same window in market as NZ, the UK energy costs rise to 3,760MJ per tonne, 30 per cent higher than those in NZ.

UK CO_2 emissions are lower compared to NZ, at 170 kg/t compared to 185 kg/t. The apparent anomaly of NZ having lower energy but higher CO_2 emissions is due to the different mix of energy sources.

Table 4

Total energy and carbon indicators for NZ and UK onion production

Item	**Quantity/hectare**		**Energy MJ/Tonne onions**		**CO_2 Emissions kg CO_2/Tonne onions**	
	NZ	UK	NZ	UK	NZ	UK
Direct						
Fuel, Electricity and Oil (L of Diesel equivalent)		208		245		16.0
Diesel Use (L)	332		322		22.1	
Lubricants (L Oil)	6		6		0.2	
Electricity Use (kWh)	78		14		0.3	
Direct subtotal	**-**	**-**	**342**	**245**	**22.6**	**16.0**
Indirect						
Nitrogen (kg)	135	104	195	193	9.0	9.7
Phosphorus (kg)	134	37	45	16	2.7	1.0
Potassium (kg)	105	86	23	25	1.4	1.5
Sulphur (kg)	77		9		0.5	
Lime (kg)	977		13		9.3	
Herbicide (kg)	10.9	8.17	80	72	4.8	4.3
Fungicide (kg)	8.9	9.04	42	54	2.5	3.3
Insecticide (kg)	3.0	0.40	21	4	1.2	0.2
Plant Growth Regulator (kg)		0.52		3		0.2
Indirect subtotal	**-**	**-**	**427**	**367**	**31.5**	**20.1**
Capital						
Farm buildings (m^2)	0.9	0.9	12	15	1.2	1.5
Tractors and implements (kg)	31.3	31.3	39	51	3.7	4.7
Capital subtotal	**-**	**-**	**51**	**66**	**4.9**	**6.2**
Total Production	**-**	**-**	**821**	**678**	**58.9**	**42.3**
Yield (tonnes)	**45**	**35**				
Post harvest						
Grading	215	215	39	62	0.7	2.6
CA Storage (UK 9 months)	-	-		3,020		125.2
Shipping (NZ to UK) (17,840 km)	-	-	2,030		124.9	
Post harvest subtotal	-	-	**2,069**	**3,082**	**125.6**	**127.8**
Total Energy Input/Emissions	**-**	**-**	**2,889**	**3,760**	**184.6**	**170.0**

Lamb

In the case of NZ most of the lamb information was gathered from a database developed by Andrew Barber as part of the ARGOS Project (www.argos.org.nz) during 2004/05. In mixed output farms (sheep and beef meat, wool and crops), a way of allocating energy use and carbon dioxide emissions is needed. Two common methods are to either allocate as a proportion of output weight or on the share of revenue. In this study sheep production has been allocated according to its contribution to revenue, which was 47 per cent.

All outputs are either per hectare or tonne of carcass weight. In order to estimate the carcass weight it was assumed that each lamb and ewe sold weighted 55 kg and that the dressing-out percentage, the percentage of carcass weight to live weight, was 42 per cent (Burtt 2004).

In the case of sheepmeat production finding sources of data on farm production systems was difficult given the fact there are few specialist sheep farms in the UK which do not have other stock or crops. Therefore the production system data for sheepmeat relied on Nix Farm Management Pocketbook data (Nix, 2004). There are also a number of sheepmeat production systems in the UK ranging from hill and upland to lowland farms. However, as typically it is the lowland farms where sheep are finished for meat, this is used as the system in the current report. This also closely matched the farming type modelled in NZ which were also the lowland farms.

As for dairy, to assess the energy and emission levels per unit of output, in this case tonnes of meat carcass, the level of output has to be obtained and then the inputs. The average stocking rate and output from a lowland spring lambing operation, is 11 ewes per forage hectare with 1.45 lambs are reared per ewe, Nix (2004). The average lamb carcass in the UK weighed 19.3kg in 2004, Defra (2005c). Therefore, the output of meat per ewe is the number of lambs produced at 1.45 multiplied by the average weight of lamb carcass produced, at 19.3 kg, giving 28 kg of meat per ewe, (1.45*19.3 = 28.0 kg). This is equivalent (assuming a stocking rate of 11 ewes per hectare) to 308 kg of meat per hectare.

The next section calculates the energy and emissions associated with sheepmeat production. However, when calculating energy and emissions from sheepmeat, the rates calculated need to be discounted further to allow for the fact that not just meat is being produced but also co-products in the system (e.g. wool), Keedwell et al. (2002). These authors allocated the products from sheep production according to their contribution to revenue. Therefore in this study the energy consumed by the various elements will also be attributed according to revenue (as will CO_2 emissions). The level of revenue per ewe is £55.10 for lamb sales, £1.80 for wool and £5.80 for culling of ewes and rams, which comes to a total of £62.70, Nix (2004). Lamb sales are therefore 87.9 per cent of revenue and therefore it will be assumed that 87.9 per cent of energy and emissions will be attributed to meat production. This will henceforth be referred to as the "co-product discount rate", and will be used to adjust all the calculations below.

Table 5

Total energy and carbon dioxide indicators for NZ and UK lamb production

Item	**Quantity/hectare**		**Energy MJ/Tonne carcass**		**CO_2 Emissions kg CO_2/Tonne carcass**	
	NZ	UK	NZ	UK	NZ	UK
Direct						
Fuel, Electricity and Oil (L of Diesel Equiv.)		128		17,156		1,116.9
Fuel use (L of Diesel) (including contracting)	15.5		3,565		244.9	
Electricity use (kWh)	13.8		594		11.4	
Direct sub total	**-**	**-**	**4,158**	**17,156**	**256.3**	**1,116.9**
Indirect						
Nitrogen (kg)	5.7	76	1,953	16,147	90.1	807.4
Phosphorus (kg)	12.5	7	985	336	59.1	20.2
Potassium (kg)	0.5	15	29	498	1.7	29.9
Sulphur (kg)	12.3		323		19.4	
Lime (kg)	22.3	87	71	170	50.6	122.7
Agri-chemicals (L ai)	0.6	1.5	338	1,549	20.3	92.9
Concentrate (kg of dry matter)		681		7,432		457.5
Forage, fodder and bedding (kg grass silage)		271		1,319		76.5
Indirect sub total	**-**	**-**	**3,698**	**27,452**	**241.3**	**1,607.1**
Capital						
Vehicles and machinery (kg)	0.8		273		25.4	
Farm buildings (m^2)	0.1	13.1	198	1,251	19.8	125.1
Fences (m)	1.9		194		17.5	
Stock water supply	-		66		3.0	
Capital sub total	**-**	**-**	**731**	**1,251**	**65.6**	**125.1**
Total Production	**-**	**-**	**8,588**	**45,859**	**563.2**	**2,849.1**
Yield (kg lamb carcass)	**190**	**308**				
Post Production						
Shipping NZ to UK (17,840 km)	-	-	2,030	-	124.9	-
Total Production Energy Input/Emissions	**-**	**-**	**10,618**	**45,859**	**688.0**	**2,849.1**

Comparison of NZ and UK lamb production

Table 5 compares the production, energy and carbon dioxide emissions for lamb production in the UK and NZ. This shows that NZ has considerably lower direct energy inputs per tonne of carcass at 4,158 MJ compared to 17,156 MJ in the UK. In case of indirect energy use the energy input in NZ are also significantly lower at 3,698 MJ per tonne of carcass weight compared to 27,452MJ in the UK. When the energy embodied in capital is included, NZ energy inputs are lower still with total energy associated with production 8,588 MJ in NZ compared with 45,859 MJ in the UK. Including transport to the UK market increases the energy used in NZ production but just to 10,618 MJ which is under a quarter of that in the UK. This reflects the extensive production system in NZ compared with the UK.

In the case of emissions NZ carbon dioxide emissions are lower at 688 kg CO_2/Tonne carcass compared to 2,849 in the UK.

This study aimed to compare, using the same methodology, production systems in the UK with those in NZ; specifically to assess the validity of the food mile argument. There are a number of areas where this research could be expanded. Firstly comparison across different production systems and different sources of supply to the UK would be of value. The inclusion of internal transport costs and processing would enable a more complete LCA to be undertaken. The lack of data on the UK was an issue leading us to underestimate resource use and emissions in the UK systems.

The analysis also assumed that the UK would be able to meet the shortage of supply if NZ did not supply this market which would mean diverting land from other uses. This additional land is also likely to be poorer quality and therefore may require greater inputs.

The food miles debate has highlighted the importance of the issue of climate change in consumers and politicians minds and the growing importance of reducing carbon emissions. Hence the movement towards carbon footprinting of individuals, supply chains and products.

This is an issue which is continuing to grow in importance. A variety of consumer concerns such as pollution and the use of non-renewable resources have crystallised around the issue of climate change and a general move towards reduction in carbon emissions. This is underpinned by government policy and targets. The UK has taken the lead in this area with the Climate Change Bill aiming to reduce total emissions in the UK by 60 per cent from 1990 to 2050 and has established a committee to aid achieving this. The EU proposes a reduction of emissions in the EU by 20 per cent by 2020 and by between 60 and 80 per cent by 2050. The US has agreed to reduce emission intensity (that is the ratio of emissions to output) by 18 per cent by 2012 and individual states have introduced their own level targets. California, for example, is aiming to reduce emissions to 1990 levels by 2020 and 80 per cent by 2050 and the NEG-ECP (Eastern US and Canada) to reduce emissions by 10 per cent by 2010. Japan also has announced a 50 per cent reduction in emissions by 2050.

The concern about climate change has been seen also through changes in markets and development of labelling schemes. The Carbon Trust in 2006 introduced a label called the Carbon Reduction Label with the proviso that products have to reduce emissions by 20 per cent over two years. Tesco has stated it is carbon footprinting 70,000 of its products and this has been followed by other major supermarket chains. The UK has established an enquiry into the environmental labelling under Environmental Audit Committee this is to focus on issues around labelling including feasibility of an international labelling scheme. This is an important initiative that shows that carbon footprinting is not just in the private sector but government involvement may well lead to regulation as has been seen with other labelling schemes.

Also significant is the initiative where the Carbon Trust, DEFRA and the British Standard Institute have developed a draft Publicly Available Specification (PAS) 2050:2008 to assess life-cycle greenhouse gas emissions of products and services. The PAS 2050:2008 draws on both the World Business Council for Sustainable Development (WBCSD)’s GHG protocol and the International Standardisation Organisation’s (ISO 14064) on GHG quantification and reporting. It aims to provide a standardised and consistent method that organisations can use to measure the GHG emissions embodied in their products and services, as there are currently different options for measuring GHG impacts at very specific or general levels. Unlike the traditional measurement process that takes up to three years to complete, PAS 2050 is a fast track process taking only 8 -12 months (Defra, 2007b). The PAS 2050:2008 standard has been designed to specifically focus on product-level carbon footprinting. Other standards such as

ISO 14064-1 have a less prescriptive and much broader approach as they include a wide range of potential environmental impact categories including global warming, eutrophication, acidification, human toxicity etc.

PAS applies to any organisation calculating the embodied GHG emissions of a product or service across its life cycle. According to Defra (2007b) and the guide accompanying PAS 2050:2008, the method:

- Applies to all products and services with consideration given to how and whether it may need customising for specific product groups, e.g. food, buildings, Energy Using Products
    - Considers all lifecycle stages along the supply/value chain of a product or service, that is, from raw materials to end of life
- Considers all GHGs
- Could be used by all sizes and types of organisations

The PAS 2050 method uses a multi step process that develops a lifecycle assessment of a product’s GHG emissions. An overview of this method is as follows (slight variations to the order of this method can occur in some circumstances):

1. Build supply chain process map- define the lifecycle inputs, outputs and unit processes
2. Define boundary conditions and identify data requirements- identify the entire product life-cycle and its sub-systems.
3. Collect primary and secondary data required to develop the mass balance and calculate the GHG emissions from each process step.
4. Calculate GHG emissions by supply chain process steps- develop a model and calculate the mass balance and GHG emission from each process activity step.
5. Assess uncertainty and precision of the analysis.

Other standards under development

Currently, the International Organization for Standardization is developing international standards on product-level carbon footprinting and so is the World Resources Institute. The standards from the World Resources Institute under the Greenhouse Gas Protocol Initiative are expected to be published by December 2010 and the publishing date for the ISO standard is expected to be March 2011. The WRI and ISO standards when they are developed are unlikely to vary much from PAS 2050:2008 for two main reasons. First, standards on GHG emissions have traditionally been harmonised and this will probably happen with these standards as well. Secondly, the Carbon Trust, who co-sponsored PAS 2050:2008, supports the development of the future standards from the World Resources Institute and the BSi British Standards who prepared the PAS are part of the ISO process.

Carbon labelling is not confined to the United Kingdom with a number of schemes developing across European countries. In Sweden a climate certification standard is being developed. In Switzerland products are being labelled ‘Climatop’ if they cause less damage to the environment than similar products. In France one retailer is planning to label 3,000 of its food items. Elsewhere in the world, Japan is trialling a scheme with the intention of introducing this in 2009. Carbon labelling is also being explored in Canada and in Australia. All of these schemes are under development and in their infancy. The UK retail and NGO sectors have taken the leadership in this area and has schemes further developed than other countries but other countries are catching up fast and the need for carbon footprinting will be required. Interestingly these schemes do not generally allow for offsetting but stress reduction in emissions so they require producers to reduce their footprint buy different amounts over a period or show they are more carbon friendly than competitor’s products. Thus whilst it is the private sector that has taken the initiative in developing carbon labelling schemes governments becoming involved in these as seen above in the UK but also in Japan. There are international standards to aid the development of measuring a carbon footprint and these include the ISO standards and also the Greenhouse Gas Protocol these provide the framework for undertaking a carbon footprint and guidance on the scope of footprint. However, there is still considerable discussion around the exact methodology over factors about data to be included, how data is to be collected and the coefficients to be used. An important factor to note is that, as stated above, the EU is highly likely to subsidise farmers to measure and reduce their carbon footprint using farm level data. This has implications for NZ exporters in that they will have to footprint without subsidies but also this may mean collecting data at the farm level as opposed to from secondary or modelling sources.

This is extremely important for NZ exporters, firstly because the markets above developing these schemes are important to NZ. In particular schemes in the UK, Australia and Japan would mean that supplying those markets producers would have to carbon footprint their products and reduce this. Moreover, given the growth and importance of international procurement chains standards developed in any important importing country generally become necessary to supply other markets as well.

These carbon labelling schemes stress reduction in footprints but there are also industry initiatives in the UK such as the Milk Road map which aims to have a reduction in emission from dairy of between 20 and 30 per cent by 2020 from 1990 levels (Dairy Supply Chain Forum, 2008). That report also states that methane emissions from dairy have fallen 13.4 per cent from 1990 and carbon emission by 23 per cent since 2000. This is significant for NZ dairy sector one of our most important emitters and emissions from this sector have been growing. Thus the need for footprinting and reduction in this sector will become more important.

Therefore, carbon footprinting and reduction in emission is set to become standard for our markets and likely to be introduced in the next few years. .

Other issues which have arisen are the rise in the debate about seasonal consumption and the debate of consuming locally produced foods. Studies in the US show that locally grown food labels play a great influence on consumers. Given a choice, consumers are more likely to purchase locally grown over organic foods produced in a distant region, even if the local foods were produced using some pesticides (Leopold Center for Sustainable Agriculture 2004). This is given impetus by the rise in popularity of local food markets.

Clearly, it is important for New Zealand agri-businesses to show they are ‘carbon-friendly’ and reducing their footprint. Interestingly it was the reduction which is being stressed rather than offsetting. Offsetting had lost some credibility in the UK firstly because it was seen as dodging the problem but also some schemes had been shown to be spurious and verging on fraudulent.

Another very important factor potentially to affect the issue of carbon footprinting and other environmental and social aspects of food production which may affect our market access is the interdiction of the Single Farm Payment in the EU. This is a huge change in policy from market based support (which has historically and still causes NZ hardship) to direct payments to farmers based on environmental criteria. The budget for this is huge with 75 billion Euros per year almost equivalent to NZ's national income.

The CAP 2003 reform includes a Single Farm Payment (SFP) in which subsidies are decoupled from production. That is farmers receive a payment irrespective of what and how much they choose to produce. The EU commission has recently announced that climate change issues will be included as part of these payments. This potentially means that individual farms in the EU will measure their carbon footprint and access to the payment will depend upon reducing this footprint. Consequently this may well mean we have to do the same in NZ and individually carbon footprint all farms. Whilst this may seem a huge undertaking it does have the advantage that farmers here are generally better place to do his than many of our competitors and moreover farmers generally find financial savings when these audits are undertaken (Agra Europe 2007).

The CAP reform of 2003 also brings the importance of environment, quality and safety issues into the EU agricultural support. To benefit from the SFP, farmers will have to comply with existing legislation on those issues (cross-compliance). Assistance in the form of advisory services for farmers is foreseen to help EU farmers to meet the standards. In addition the support for voluntary agri-environmental measures has increased. Incentives are foreseen for farmers who join food quality certification schemes and consumer information campaigns (EU 2003).

The introduction of the SFP and also the agri-environmental schemes in the EU has lead to greater emphasis on other environmental factors including biodiversity, water quality and wildlife. The payments will help to subsidise farmers to meet requirements for these on their farms and the market requirements may well increase for these attributes. This can already be seen in the growth of such schemes as EureGAP which include requirements or recommendations for environment and hygiene, environmental management including wildlife policy, groundwater, staff facilities, training and health and safety. Whilst not all of these are “must dos” at present the subsidisation of EU farmers to meet these requirements will enable them to become “must dos” sooner.

Conclusion

In conclusion NZ exporters have growing opportunities in the world market as export subsidies are reduced and removed. However, this opportunity may well rely on production meeting various environmental criteria especially to access high-value markets. Climate change is the most recent example of these criteria from which issues such as food miles have arisen. This is clearly an erroneous concept as it ignores the full energy and carbon emissions from production as the Lincoln AERU Food Miles report showed. Food miles, whist still having traction with the popular media and maybe consumers, has lost credibility with the supermarkets and government agencies who have turned their attention to carbon footprinting. The emphasis now is therefore on measuring the carbon footprint of products and currently DEFRA, the Carbon Trust and BSI are developing a method to do this. The key in factor is reducing carbon footprint over time.

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[1] (Defra http://www.defra.gov.uk/environment/business/envrp/gas/05.htm)

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