The embodied energy and carbon footprint of food transport as illustrated by a direct comparison of the ingredients of a diet either organically or conventionally produced

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
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Vienna, November 18, 2011

Affidavit

I, **Antonia Maedel**, hereby declare

1. that I am the sole author of the present Master's Thesis, "The embodied energy and carbon footprint of food transport as illustrated by a direct comparison of the ingredients of a diet either organically or conventionally produced", 65 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and

2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Vienna, 15.11.2011

Signature

Abstract

The following paper will look at the carbon footprint and embodied energy of food transport, as illustrated by comparing the ingredients of a set diet designed to feed a four person household. It will be assumed that all food is locally sourced, though the effect of different modes of transport on the carbon footprint and embodied energy of transport will also be analysed. A survey will be circulated to endeavour to gain some insight into the level of awareness with which people shop.

The data, which was collected using a programme, named Gemis, was then evaluated and analysed and the conclusions drawn were based on this. In general though it became clear that organic food production had a lower carbon footprint and embodied energy than conventionally produced food which was a somewhat counter-intuitive result and did not support the original hypothesis formulated.

The conclusion was that these values could very easily be reduced if a more seasonal dietary style were to be re-introduced and adopted by the majority of people. Also creating more awareness of these values and how they increase with the distance over which goods are transported could help decrease the environmental impact of this, because as the survey shows people will prefer locally sourced goods over imported ones.

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The embodied energy and carbon footprint of food transport as illustrated by a direct comparison of the ingredients of a diet either organically or conventionally produced.

1. Aim

"Systematic study of the energy cost of modern food production started only in the early 1970s … but the literature increased so rapidly that soon there was no shortage of comprehensive overviews or detailed case studies…but subsequently there was a major decline in publishing on these topics...[1]*"*

The aim of this paper will be to analyse and evaluate the carbon footprint and the embodied energy of food transport. In order to limit the scope of the investigation certain parameters will be introduced, and these will be explained in detail in a later section. In order to have a clear picture of what the results represent the paper will look at one diet, where the components will be produced by traditional farming methods in one scenario and by organic farming methods in the other in order to see which of the two is more energy-intensive. In each case the assumption is that the foodstuffs are locally produced (within Austria's borders), though for each scenario a theoretical case will also be presented illustrating the values obtained should the food have been imported. Using the data obtained this way and comparing it to actual dietary habits will allow for conclusions to be drawn about where energy might be saved in this cycle.

[1] Smil, V. Energy in Nature and Society: General Energetics of Complex Systems (2008) pp. 291-292

2. Hypothesis

While both national governments and the European Union (EU) are encouraging organic farming, the hypothesis is that diets based solely on organic products have a much higher energy intensity than those produced using non-organic farming methods. In part this is due to the fact that organic holdings are, on average, considerably smaller than non-organic holdings and so the output is lower, while in energetic terms economies of scale do not appear.

While governments and the EU encourage organic farming by incentivising farms to switch to organic methods, this is not necessarily good for the consumer because, on average, organic products are more expensive than conventional products. This will possibly deter lower income households from following organic diets. The potential problems arising from this discrepancy are negated by the fact that only a relatively small percentage of all usable arable land is used for organic production.

3. Definition of Terms:

Embodied Energy:

"the total primary energy consumed during the life time of a product, [where] ideally the boundaries would be set from the extraction of raw materials (incl. fuels) to the end of the products lifetime (including energy from: manufacturing, transport, energy to manufacture capital equipment, heating & lighting of factory...etc.)… It has become common practice to specify the embodied energy as Cradle to Gate, which includes all energy (in primary form) until the product leaves the factory gate. The final boundary condition is Cradle to Site, which includes all energy consumed until the product has reached the point of use"[2].

Carbon Footprint:

Carbon Footprint is the measurement of the total emission of greenhouse gases (GHG) by any given system, where the size of the system can vary from the production of a single product to an entire organisation or network.

Organic Farming

Put simply, organic farming is an agricultural system that seeks to provide you with food while respecting natural life-cycle systems. To achieve this, organic farming relies on a number of objectives and principles, as well as common practices designed to minimise the human impact on the environment, while ensuring the agricultural system operates as naturally as possible[3].

Conventional Farming

An industrialised agricultural system characterised by mechanisation, monocultures, and the use of synthetic inputs such as chemical fertilisers and pesticides, with an emphasis on maximising productivity and profitability[4].

[2] http://www.bath.ac.uk/mech-eng/sert/embodied/; last viewed 27.04.2011
[3] http://ec.europa.eu/agriculture/organic/organic-farming/what-organic_en; last viewed 11.07.2011
[4] http://ucce.ucdavis.edu/files/filelibrary/1068/8286.pdf; last viewed 11.07.2011

Gemis:

"Global Emission Model for Integrated Systems" which is a life-cycle analysis program and database for energy, material, and transport systems. It will be the primary source of data for the entire paper.

4. Background

It is well known that the production of food for the human population requires large amounts of energy.[5]

The interesting thing about the opening quote is that, while the authors contend that the considerable energy requirement of food production is well known, and while this may be true for a small group of scientists, in general it should be noted that most people give very little thought about the processes involved in supplying their dietary habits. This is slowly changing because of two main factors: firstly, consumers are becoming more aware and more interested in energy considerations in general; and secondly, because large supermarkets, such as Aldi[6], have started to include the carbon footprint of a product in the packaging of their own products.

Now, while carbon footprint is a term which most people are familiar with, it is not the only way to measure the energy requirement of a good or service. Another way of doing this is by looking at the embodied energy of said system. Embodied Energy is a term of which few people have heard. This is, in part, due to the fact that what it measures is less easy to understand than what is represented by carbon footprints. In a very general sense it can be explained as the "quantity of energy required by all the activities associated with a production process, including the relative proportions consumed in all activities upstream to the acquisition of natural resources … i.e. direct plus indirect energy."[7] The reason both the carbon footprint and the embodied energy will be analysed in this paper is because, in combination, they give a more complete picture both of the energy intensity of food transport and the environmental impact this actually has. The link between the two can be more clearly explained in the following way: "Some of this energy is naturally occurring and is required to

[5] Coley, D.A., Goodliffe, E. and Macdiarmid, J., 1998. The embodied energy of food: the role of diet.Energy Policy 26 6, pp. 455–459
[6] http://www.lebensmittelkennzeichnung-blog.de/index.php/component/content/article/37-news-business/139-hofer-aldi-oesterreich-gibt-co2-fussabdruck-an; last viewed 11.07.2011
[7] Graham Treolar, 1994

fuel the bio-chemical processes within the relevant plant or animal; however, additional energy is required for the production and application of agricultural chemicals and the transportation, processing, retail and preparation of the food item in question. This second category of energy expenditure is likely to contain inputs from fossil fuel sources and can therefore be connected with emissions of gases linked to global climate change".[8]

Initially food-transport may seem like a somewhat obscure sector to analyse; it should be noted that it is not. This is because firstly, everyone has to eat and secondly, because the vast majority of people buy their food. While both these statements appear glaringly obvious, very little consideration is ever given to how food is produced (beyond the basic question of organic vs. non-organic methods) or how it gets into the supermarket. It should come as no surprise that food embodied energy increased with industrialization and manufacturing, just as did transportation, housing and the many products and services the modern era provides.[9] On average food has travelled around 1000 miles (=1609.35 km) before it reaches the home of the final consumer[10] and every calorie in the store has, on average required 10 calories of energy in its production and transport[11]. In monetary terms this can be imagined such that every euro spent on food represents about 1kWh of energy.[12] It is estimated that any city has at any given time merely enough food stored to supply its citizens for three days and this statement then is the answer to the question "why look at the embodied energy and carbon footprint of food transport".

[8] Coley, D.A. Emission factors for human activity. Energy Policy Vol. 30 Issue 1 (Jan 2002) pp. 3-5
[9] Murphy,P. Plan C: Community Survival Strategies for Peak Oil and Climate Change (2008) P.136
[10] http://faircompanies.com/news/view/the-embodied-energy-carried-our-food/; last viewed 06.05.2011
[11] http://techcrunch.com/2011/04/24/ali-partovi-fix-food/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+Techcrunch+%28TechCrunch%29&utm_content=FaceBook ; last viewed 26.04.2011
[12] http://www.bemakeshift.com/catalogue/38/server.html; last viewed 26.04.2011

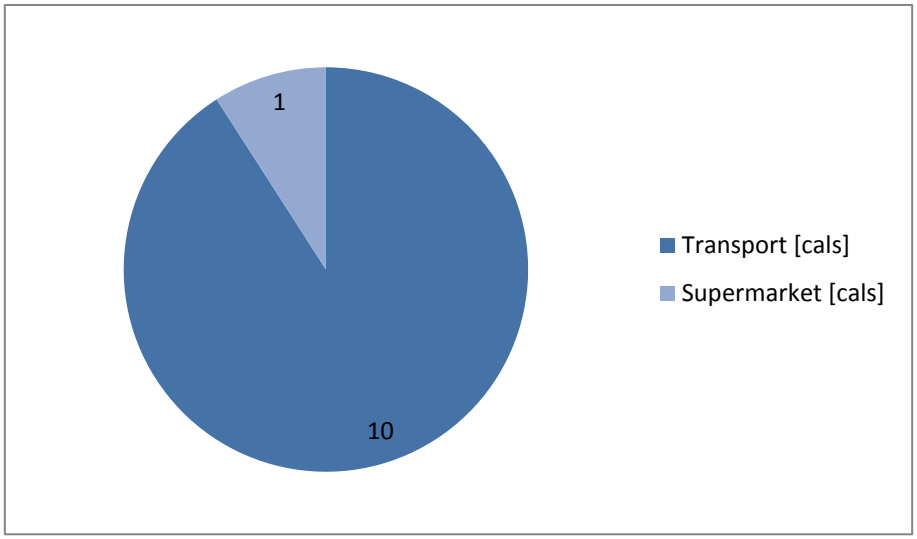


Figure 1: Diagram illustrating the amount of energy required in the transport of food

5. Food Sector in Austria

5.1 Relevant Definitions

Livestock Unit (LSU)[13]:

The livestock unit, abbreviated as LSU (or sometimes as LU), is a reference unit which facilitates the aggregation of livestock from various species and age as per convention, via the use of specific coefficients established initially on the basis of the nutritional or feed requirement of each type of animal. The reference unit used for the calculation of livestock units (=1 LSU) is the grazing equivalent of one adult dairy cow producing 3000 kg of milk annually, without additional concentrated foodstuffs.

Agricultural Holding[14]:

A single unit, both technically and economically, which has single management and which produces agricultural products. The holding may also provide other supplementary (non-agricultural) products and services

.

[13] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Livestock_unit; last viewed 12.07.2011
[14] Comission Regulation (EC) No 1444/2002

Utilised Agricultural Area[15]:

Agricultural area, abbreviated to AA, (or utilised agricultural area, abbreviated to UAA) describes the area used for farming. It includes the land categories:

- arable land;
- permanent grassland;
- permanent crops;
- other agricultural land such as kitchen gardens (even if they only represent small areas of total UAA).

The term does not include unused agricultural land, woodland and land occupied by buildings, farmyards, tracks, ponds, etc.

5.2 Overview of the Food Sector

The Austrian food sector has an annual turnover of € 55 bn (2006). This value is equivalent to 14% of the gross national product and the industry as a whole (production, processing and trade) accounts for one in six jobs[16]. As will be explained in more depth in the next section the success of the Austrian food sector can no longer be doubted, with annual incomes of € 7,7 bn and an export rate of 60%, making it a key driver of exports.

As a proportion of household spending, expenditure on food, beverages and tobacco declined marginally from 14% in 2004 to an estimated 13.8% in 2008. Total consumer expenditure on food, beverages and tobacco in Austria was an estimated US$30.8bn in 2009, up from US$22.1bn in 2004. The value of consumer expenditure on food, beverages and tobacco is forecast at US$30.7bn in 2014. In local-currency terms, expenditure on food, beverages and tobacco is expected to rise at an average rate of 2.2% per year over the forecast period[17].

The market is dominated by three main players (Rewe Austria (27,5%); Spar Austria (24,6%); Hofer (Aldi) (15,4%)[18]) which account for roughly 67% of the total sales volume. There is a well-developed processed-food sector in Austria, although most domestic firms have merged

[15] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Utilised_agricultural_area_(UAA); last viewed 12.07.2011
[16] http://sitemap.lebensministerium.at/article/articleview/58436/1/8386; last viewed 15.09.2011
[17] Economist Intelligence Unit, Austria
[18] www.igd.com/analysis/datacentre; values for 2010; last viewed 20.09.2011

with larger national and international companies in order to survive[19]. Pre-Packaged food accounts for roughly one third of all food expenditures and this share is expected to keep increasing as the number of single-person-households also increases.

Traditionally fresh and quality foods have played an important part in the Austrian diet, with a wide variety of regional foods available. This is a taste the supermarkets tend to cater for with long delicatessen counters present in most larger and even in some smaller supermarkets.

The success of the organically produced foods sector can in part be attributed to the citizens' strong distrust of genetically modified foods, which by EU-legislation cannot be included in foods branded as being organic. As of summer 2010 the EU has introduced a new logo for organic foods. The introduction of this logo was accompanied by the introduction of a new slogan: "Organic farming. Good for nature, good for you."[20]

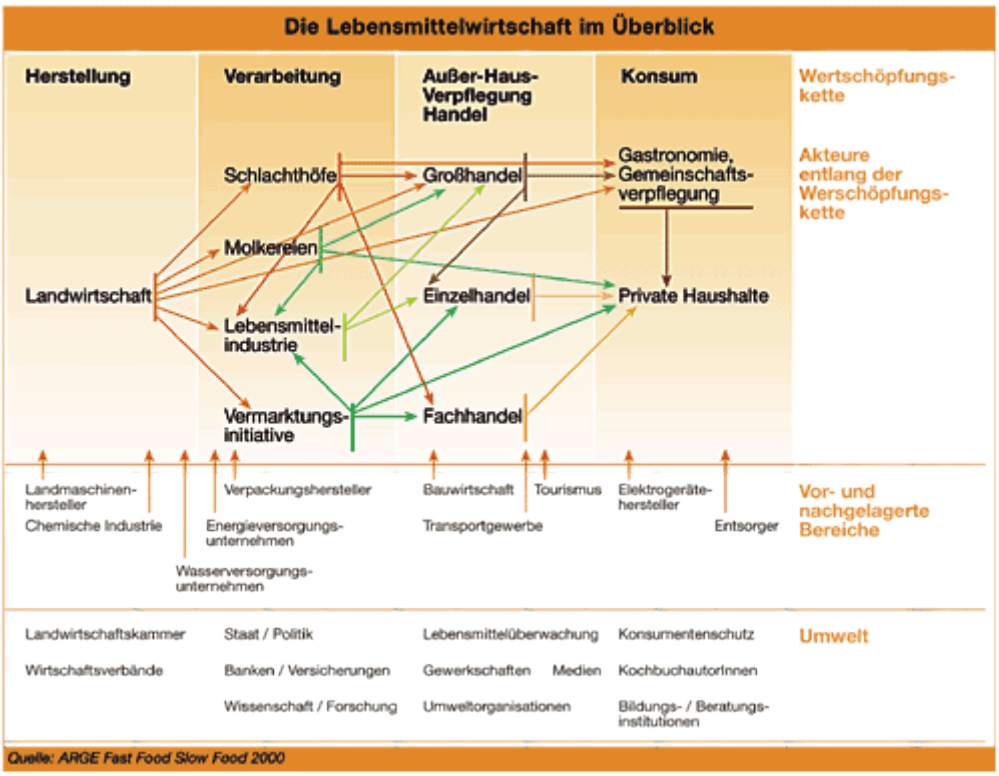


Figure 2[21]: Overview of the supply of foodstuffs

[19] Economist Intelligence Unit, Austria
[20] http://ec.europa.eu/agriculture/organic/toolbox/messages-slogans_en; last viewed 17.09.2011
[21] http://www.lebensmittelnet.at/article/articleview/30545/1/8341; last viewed 05.09.2011

Figure 3[22]: The European Union logo for organically produced foodstuffs

5.3 Overview of the Agricultural Sector

Economic growth was low or negative in OECD countries due to the global recession, which moderated demand pressures, in particular for higher value-added products such as dairy and meats. A positive supply response to higher prices in 2008 came at the same time as growth for food demand was easing.[23] However, it should be notes that the EU states that ““In times of high commodity prices, the incentive to increase the volume of production should not be used as an excuse to lower standards.[24]” While this is a very general statement which applies to all OECD countries, it is interesting to keep this global trend in mind when looking at the development of the agricultural sector in Austria specifically.
As in most industrialised countries, the overall importance of agriculture has been declining, which means that while the total amount of agricultural holdings has been declining in recent years the number or organic farms has been increasing rapidly. This can be attributed to various incentives as created by local governments, the Austrian government and the EU. To name just one example the EU-15 premium for organic or conversion land is set at 185 €/ha as compared to 91 €/ha for land used for conventional farming[25].

In Austria specifically the number of agricultural holdings decreased by 3.1% between 2005 and 2007, and the UAA (2.58 mil ha = 25800 km2 = 30,8% of total area) decreased by 4.2% in the same amount of time. During this period the number of LSU’s increased by 1%[26]. It can be assumed that 57.5% of the value generated by these holdings is attributed to crop products

[22] http://ec.europa.eu/agriculture/organic/toolbox/messages-slogans_en; last viewed 17.09.2011

[23] OECD Agricultural Policies in OECD Countries in 2010: At a Glance
[24] Green Paper on Agricultural Product Quality: Product Standards, Farming Requirements and Quality Schemes; (Brussels; 15.10.2008; COM(2008) 641 final)
[25] http://ec.europa.eu/agriculture/organic/files/consumer-confidence/consumer-demand/facts_en.pdf; last viewed 11.07.2011
[26] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Farm_structure_in_Austria; last viewed 12.07.2011

and 47.2% to animal products[27]. What is particularly interesting though is that while the UAA decreased the number of organically producing agricultural holdings increased by 6% and 13% of all holdings were classified as practicing organic farming[28].

6. Legal Framework (E.U.)

The reason only the EU regulations are outlined is because all regulations and standards introduced by the EU automatically become part of the Austrian legal system. While Austria may have additional rules and legislations in place the ones issued by the Commission can be considered as the minimum requirements that need to be fulfilled in the producing and selling of food.

The following list of relevant EU legislation only includes legislation from this year (2011). This is because most of these supersede past legislation and because including all relevant legislation would make a very long list.

6.1 Relevant Definitions

Organic Production:

Organic production is an overall system of farm management and food production that combines best environmental practices, a high level of biodiversity, the preservation of natural resources, the application of high animal welfare standards[29]

Food[30]:

For the purposes of this Regulation, 'food' (or 'foodstuff') means any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans.

[27] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Farming_structure_and_accounts_at_regional_level; last viewed 12.07.2011
[28] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Farm_structure_in_Austria; last viewed 12.07.2011
[29] EU Legislation Summary (20.07.2007; Official Journal of the European Union; L 189/1); Council Regulation (EC) No. 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No. 2092/91

[30] EU Definition

'Food' includes drink, chewing gum and any substance, including water, intentionally incorporated into the food during its manufacture, preparation or treatment. It includes water after the point of compliance as defined in Article 6 of Directive 98/83/EC and without prejudice to the requirements of Directives 80/778/EEC and 98/83/EC.

EU Directive:

A directive is a legislative act of the European Union which requires the achievement of a particular result, without dictating the means through which this is to be achieved. Directives, at least in principle, need to be transposed into national law.

EU Regulation:

A regulation is a legislative act which becomes legally enforceable in all states simultaneously.

EU Decision:

A decision is a legal instrument which is binding for the individuals or institutions at which it is addressed.

6.2 Overview

The main aim of the EU is quality assurance and the creation of a system that protects both the producer and the customer. It should be noted that the basis for all regulations relating to food is the *Codex Alimentarius* which is a Commission that was created in 1963 by the FAO and WHO to develop food standards, guidelines and related texts such as codes of practice under the Joint FAO/WHO Food Standards Programme[31].

REGULATION (EC) No 178/2002 : laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety

COMMISSION IMPLEMENTING REGULATION (EU) No 931/2011 of 19 September 2011 on the traceability requirements set by Regulation (EC) No 178/2002 of the European Parliament and of the Council for food of animal origin

[31] http://www.codexalimentarius.net/web/index_en.jsp; last viewed 06.06.2011

COMMISSION IMPLEMENTING REGULATION (EU) No 914/2011 of 13 September 2011 amending Regulation (EU) No 605/2010 laying down animal and public health and veterinary certification conditions for the introduction into the European Union

COMMISSION IMPLEMENTING REGULATION (EU) No 799/2011 of 9 August 2011 amending Annex I to Commission Regulation (EC) No 669/2009 implementing Regulation (EC) No 882/2004 of the European Parliament and of the Council as regards the increased level of official controls on imports of certain feed and food of non-animal origin

COMMISSION IMPLEMENTING REGULATION (EU) No 739/2011 of 27 July 2011 amending Annex I to Regulation (EC) No 854/2004 of the European Parliament and of the Council laying down specific rules for the organisation of officials controls

COMMISSION REGULATION (EU) No 619/2011 of 24 June 2011 laying down the methods of sampling and analysis for the official control of feed as regards presence of genetically modified material for which an authorisation procedure is pending or the authorisation of which has expired

COMMISSION DECISION of 17 June 2011 amending Decision 2006/197/EC as regards the renewal of the authorisation to place on the market existing feed produced from genetically modified maize line 1507 (DAS-Ø15Ø7-1) pursuant to Regulation (EC) No 1829/2003 of the European Parliament and of the Council

COMMISSION DECISION of 17 June 2011 authorising the placing on the market of products containing, consisting of, or produced from genetically modified maize MON 89034 × MON 88017 (MON-89Ø34-3xMON-88Ø1 7-3) pursuant to Regulation (EC) No 1829/2003 of the European Parliament and of the Council

COMMISSION IMPLEMENTING REGULATION (EU) No 590/2011 of 20 June 2011 amending Regulation (EC) No 1235/2008, laying down detailed rules for implementation of Council Regulation (EC) No 834/2007 as regards the arrangements for imports of organic products from third countries

COMMISSION IMPLEMENTING REGULATION (EU) No 576/2011 of 16 June 2011 amending Regulation (EC) No 543/2008 laying down detailed rules for the application of Council Regulation (EC) No 1234/2007 as regards the marketing standards for poultry-meat

COMMISSION IMPLEMENTING REGULATION (EU) No 426/2011 of 2 May 2011 amending Regulation (EC) No 889/2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control

COMMISSION DECISION of 14 April 2011 on the members of the advisory group on the food chain and animal and plant health established by Decision 2004/613/EC

COMMISSION IMPLEMENTING REGULATION (EU) No 342/2011 of 8 April 2011 amending Annex II to Regulation (EU) No 206/2010 laying down lists of third countries, territories or parts thereof authorised for the introduction into the European Union of certain animals and fresh meat and the veterinary certification requirement

COMMISSION IMPLEMENTING DECISION of 4 April 2011 implementing Council Directive 97/78/EC as regards transhipment at the border inspection post of introduction of consignments of products intended for import into the Union or for third countries

COMMISSION REGULATION (EU) No 234/2011 of 10 March 2011 implementing Regulation (EC) No 1331/2008 of the European Parliament and of the Council establishing a common authorisation procedure for food additives, food enzymes and food flavourings

REGULATION (EU) No 182/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 February 2011 laying down the rules and general principles concerning mechanisms for control by Member States of the Commission's exercise of implementing powers

COMMISSION REGULATION (EU) No 150/2011 of 18 February 2011 amending Annex III to Regulation (EC) No 853/2004 of the European Parliament and of the Council as regards farmed and wild game and farmed and wild game meat

COMMISSION REGULATION (EU) No 151/2011 of 18 February 2011 amending Annex I to Regulation (EC) No 854/2004 of the European Parliament and of the Council as regards farmed game

COMMISSION REGULATION (EU) No 10/2011 of 14 January 2011 on plastic materials and articles intended to come into contact with food

COMMISSION REGULATION (EU) No 16/2011 of 10 January 2011 laying down implementing measures for the Rapid alert system for food and feed

7. Method

As mentioned previously the data will be gathered from Gemis.

In order to be able to evaluate the meaning of the data collected several constrictions will have to be imposed upon the investigation and several assumptions will have to be made.

Firstly the calorie intake must be considered. It is assumed that the household consists of four, reasonably active adults requiring 2000 calories a day. It is further assumed that one meal a day is not consumed at home and so the daily sum of calories that the diet needs to provide is set at 5000 (1250 cal/day/person) instead of at 8000 cals/day.

As the household consists of reasonable active adults it can be assumed that a healthy diet is being followed. A healthy diet should consist of:

55% (= 2750 cals/day = 19250 cals/week)	carbohydrates
20 % (= 1000 cals/day = 7000 cals/week)	fruits and vegetables
15% (= 750 cals/day = 5250 cals/week)	proteins
10% (= 500 cals/day = 3500 cals/week)	fats and sugars.

In order to make a direct comparison of the carbon footprint and embodied energy involved in both organic and conventional sourcing of these foodstuffs the diet will be kept the same in both calculations. It will further be assumed that all foods are sourced from within Austria's borders (this is to be considered locally produced for the duration of this paper). However, for each food-group one example will be arbitrarily chosen to illustrate the difference between a locally sourced and an imported product. In this example the impact of different means of transportation (train/aeroplane will also be examined and a direct comparison will be made. The values obtained will be deemed representative values for the entire food-group.

In order to see at which point in the system the most energy is consumed the arbitrarily chosen product will not only be used as an example to illustrate the embodied energy and carbon footprint of that product, but the supply tree for this product will be analysed on a step-by-step basis to determine this. Again the values obtained this way will be assumed to be representative of the entire group.

Using these representative values, calculations for the energetic values of the diet will be made. These approximations will then show how the values would differ were the diet not locally sourced but imported. It is important to note that neither the wholly locally sourced nor the wholly imported scenario give an overview of the current system but that is a combination of the two.

In order to take this into account, a control survey will be circulated. The aim of this survey is not to examine the quantitative value of the carbon footprint and embodied energy of actual consumers, but rather to qualitatively demonstrate how much the concept of energy intensity has entered into the consciousness of the consumer; the contention being that " Significant reductions in embodied energy are possible from a qualitative shift in diet (i.e. choosing alternative foods) without lowering calorific intake and, incidentally, without government-lead changes to agricultural, transportation, or retail practices. The implied assumption of both studies [Vringer 1995; Coley 1998] is that, provided the functionality and service remain the same, consumers can be encouraged to change what goes into their consumption baskets in an environmentally favorable direction. Given the necessary information and motivation, consumers could presumably initiate change on their own.[32]"

[32] Goldblatt, D.L. Sustainable Energy Consumption and Society: Personal, Technological, or Social Change? (Alliance for Global Sustainability Bookseries)(2005) p. 28

7.1 Dietary Plan

The following diet was designed to provide 5000 calories a day for a household consisting of four, reasonably active adults. In order to include as broad a range of products as possible it will be assumed that the diet is kept the same from week to week.

Product	Calories per [kg]	Weekly Amount [kg]
Bread	2500	1,5
Butter	7200	0,25
Free-range Eggs	2500	
Chicken	2000	1
Beef	2800	1
Pork	2900	1
Mixed Meat-conventional	2850	1
Mixed Meat-organic	2400	1
Vegetables	357,14	7
Yoghurt	600	2
Potatoes	786,67	1
Cheese	3071,71	1
Milk	700	1,5
Curd and Cream-cheese	3535,71	0,5
Cream	3450	0,5
Ham	1678,57	0,2
Oil	8888,89	0,5
Pasta	2857,14	1
Sugar	3214,28	0,125
Sum-conventional	35065,04	
Suma-organic	34615,04	

Table 1: Dietary Plan

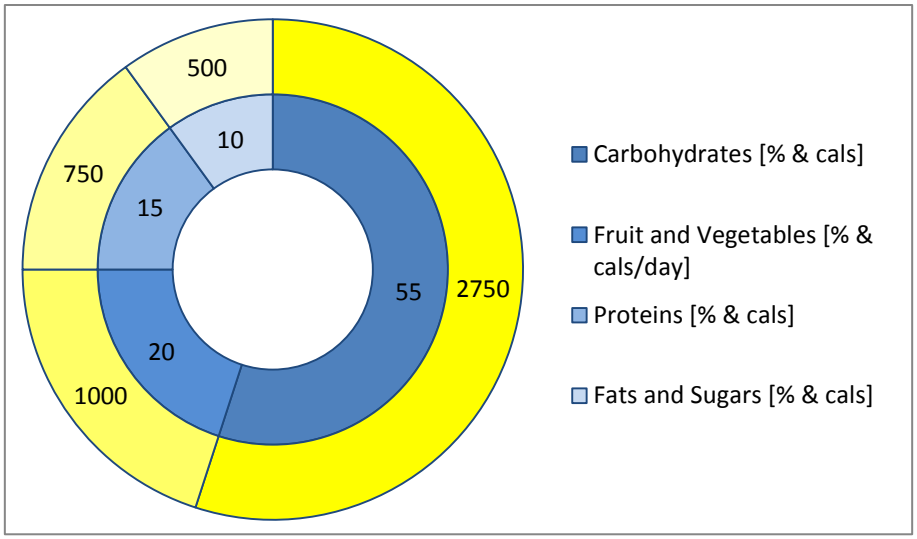


Figure 4: Diagram illustrating the percentage of a diet a food group should represent and how many calories/day/4-people-household this is equivalent to

8. Quantitative Data Analysis

Relevant Definitions:

Carbon Dioxide Equivalent (CO_2e):

Carbon dioxide equivalent is a measure used to compare the emissions from various greenhouse gases based upon their global warming potential. For example, the global warming potential for methane over 100 years is 21. This means that an emission of one million metric tons of methane is equivalent to emissions of 21 million metric tons of carbon dioxide[33].

No Transport:

The values given at this point usually include some form of transport over minimal distances ranging from 100-200km. (A graph showing the actual differences between this minimal transport and no transport will be presented later)

Transport by air:

The values calculated for these data sets assume a small agricultural plane as used in the USA ('Flugzeug-US-Klein (Landwirtschaft)'). The assumption is also made that the goods are only transported once in the supply chain.

Transport over land:

The values calculated for these data sets assume the goods were transported using a generic lorry (‘Lkw generisch’). The assumption is also made that the goods are only transported once in the supply chain.

Transport by sea:

The values calculated for these data sets assume the goods were transported using an oversea freighter ship (‘Überseeshiff-2010’). The assumption is also made that the goods are only transported once in the supply chain.

[33] http://stats.oecd.org/glossary/detail.asp?ID=285; last viewed 01.09.2011

8.1 Carbon Dioxide Equivalent (CO_2e; 'CO_2 äquivalent')

Air:

This graph clearly shows several thing: firstly, that when the goods are not transported the values of CO_2e are lowest, which was to be expected. Secondly, it shows that the values more than double when the goods are transported either 2000km or 5000km. Interestingly this doubling of the CO_2e when the goods are transported does not hold for the difference between the values given when the goods are not transported and then they are transported 2000km. In fact the base values (no transport) don't seem to stand in any sort of relation to those gathered in the case of transport.

Land:

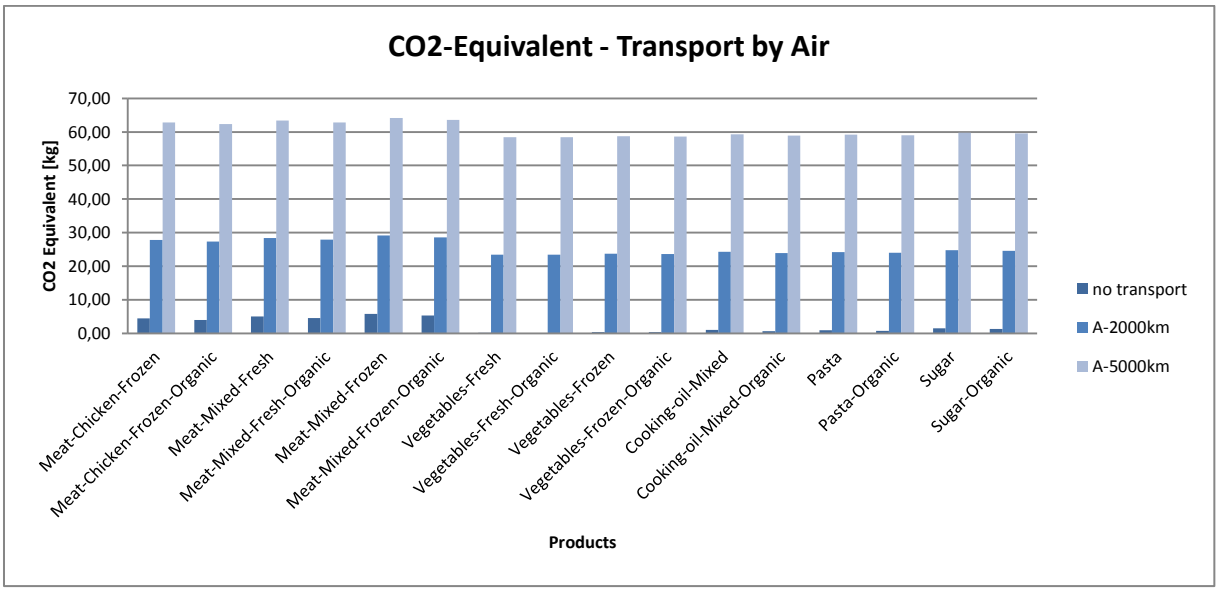
What is particularly interesting about this graph is that there seems to be no pattern to the data at all. While in the case of some goods the expected ascendancy, from the lowest value for no transport to the highest values for 5000km, of CO_2e values is demonstrated, there are just as many where this is not the case. However, there are just as many products where this is most definitely not the case. In fact there are several where the values of CO_2e are considerably higher when the goods are not transported than when they are transported over a distance of 2000km over land, just as there are some instances where the values are highest when the goods are transported 2000km.

Sea:

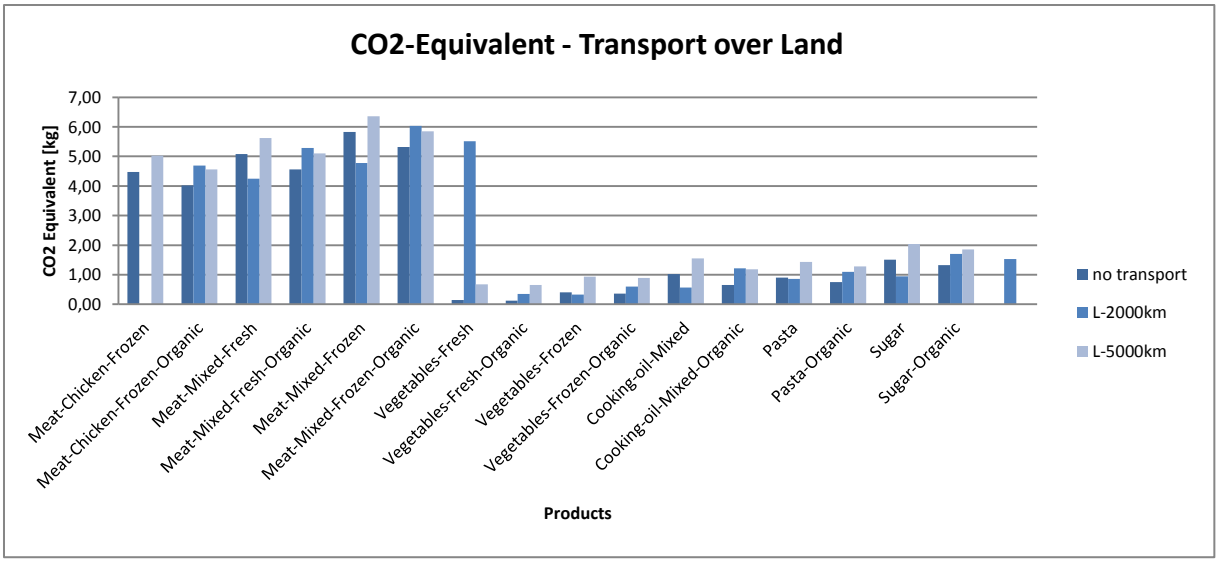
The average amounts of CO2e emitted by this mode of transport are by far the lowest of any of the three means analysed. In fact the variation in the values gathered is minimal at best, which would seem to imply that it makes very little difference whether the goods are not transported or transported considerable distances over water. Though again there is no clear ascendancy of the values such as would reasonably be expected, though given that the variations are so small that would hardly seem to be matter and can thus be considered negligible.

Summary:

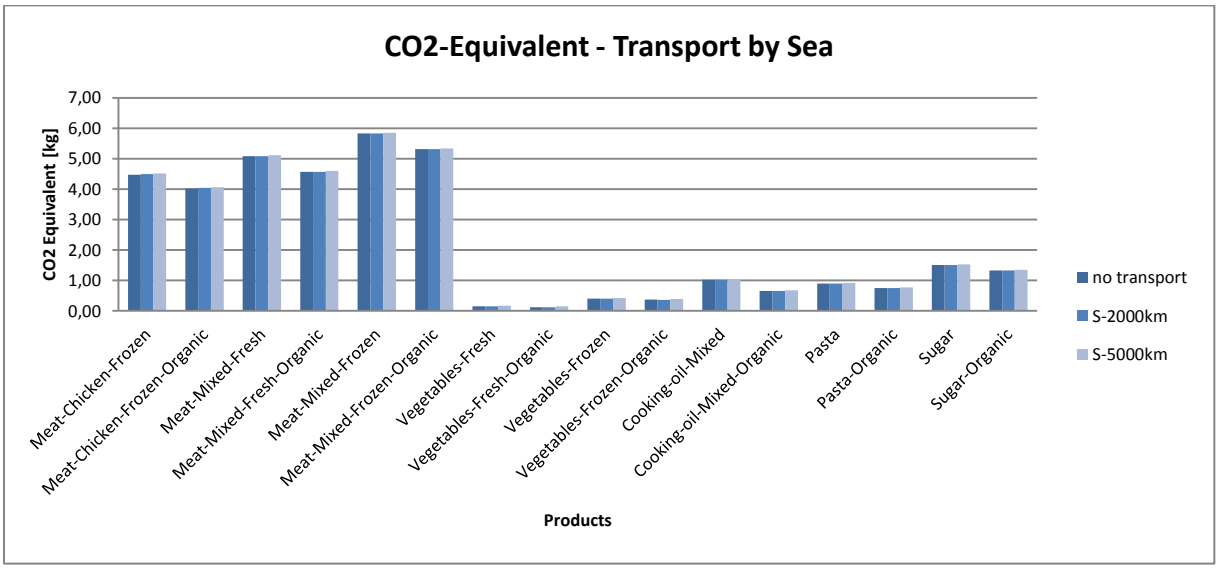
The CO_2e of transport by air is larger than that of any other mode of transport; in fact the values are larger by a factor of 10. Now, wheile this is very significant in itself, it is also interesting to note that it is the only method of transportation where the values gathered correspond to the intuitive assumption that the CO_2e values increase in some sort of relation proportional to the distances over which goods are transported. This assumption, logical as it may be, is most dramatically overthrown in the case of over-land transport, which, as mentioned previously, shows no clearly or otherwise discernible pattern whatsoever. Given that this is one of the most common forms of transport this is somewhat surprising. While the values of CO_2e emitted in the case of transport over land or by sea are very similar, especially when compared to transport by plane, the values given for transport by ship are considerably more constant, though they do show the same irregularities as overland transport.



Graph 1: CO_2e -Transport by Air



Graph 2: CO_2e – Transport over Land



Graph 3: CO_2e - Transport by Sea

8.2 Carbon Dioxide (CO_2)

Air:

As expected the values of CO_2 are lower than those of the CO_2e. However, they show the same proportional increases as exhibited previously and again there seems to be no clear relationship between the values gathered for the scenario for no transport compared to those for when the goods are transported considerable distances.

Land:

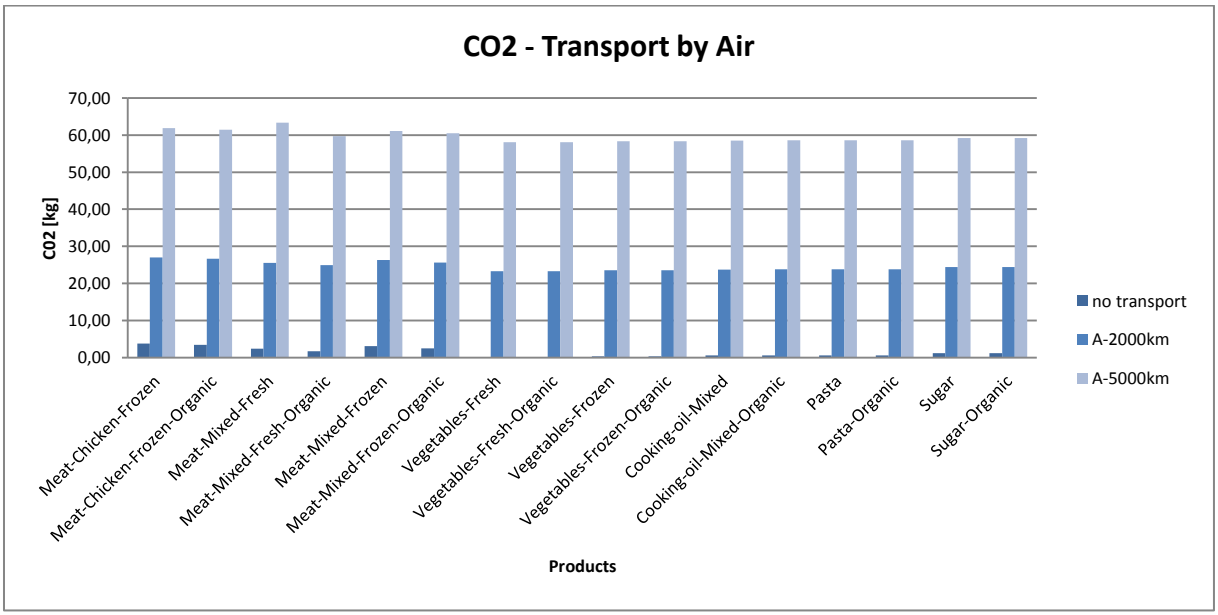
The values are lower than those gathered for CO_2e. Unlike its predecessor however this graph shows a much clearer pattern. Not only are there clear increases in CO_2 as the distance over which the goods are transported increases, these increases are more or less uniform across all products analysed. It is interesting to see that while the values for CO_2 exhibit such a clear uniformity, they did no such thing in the case of CO_2e, indicating wild fluctuations in the emissions of other green-house-gases (GHG).

Sea:

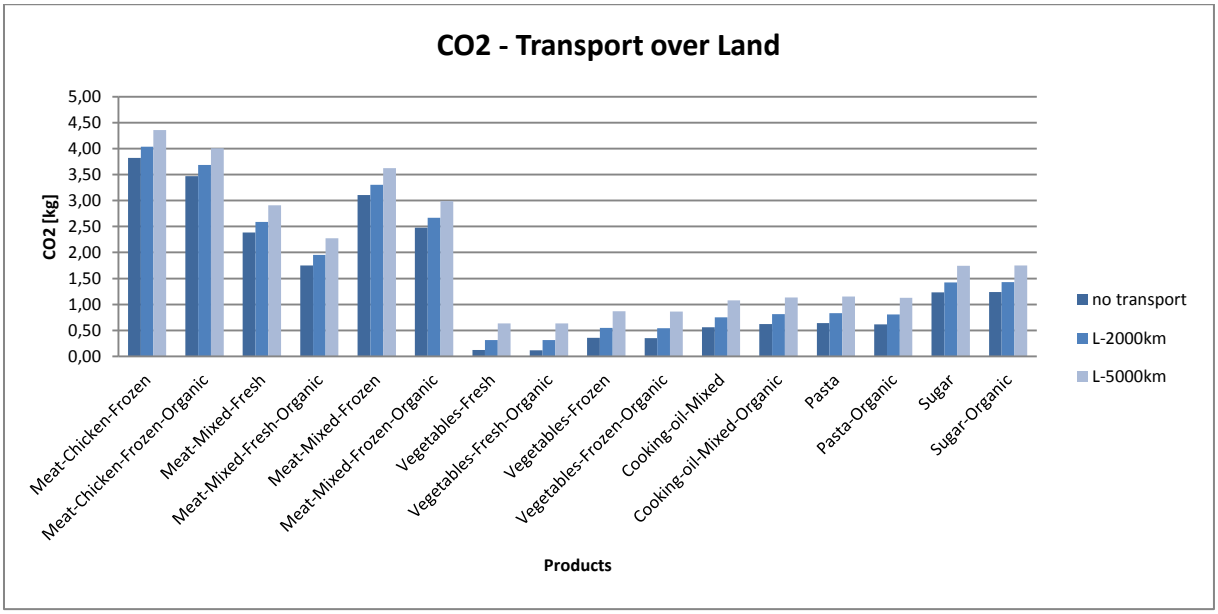
As in the previous graph the differences in CO_2 shown barely differ as the distances over which goods are moved increase. However, unlike the previous two graphs (CO_2 air and CO_2 land) this one does not show the expected increases in values as distance increases, rather it exhibits the same irregularities as were present in the values for CO_2e. While this sort of consistency in the data would usually be something to be considered desirable, there seems to be no explanation for these fluctuations in the case of some of the products analysed (meat-mixed-frozen; vegetables-frozen; pasta-organic and sugar) where the values are lowest when they are transported a distance of 2000km.

Summary:

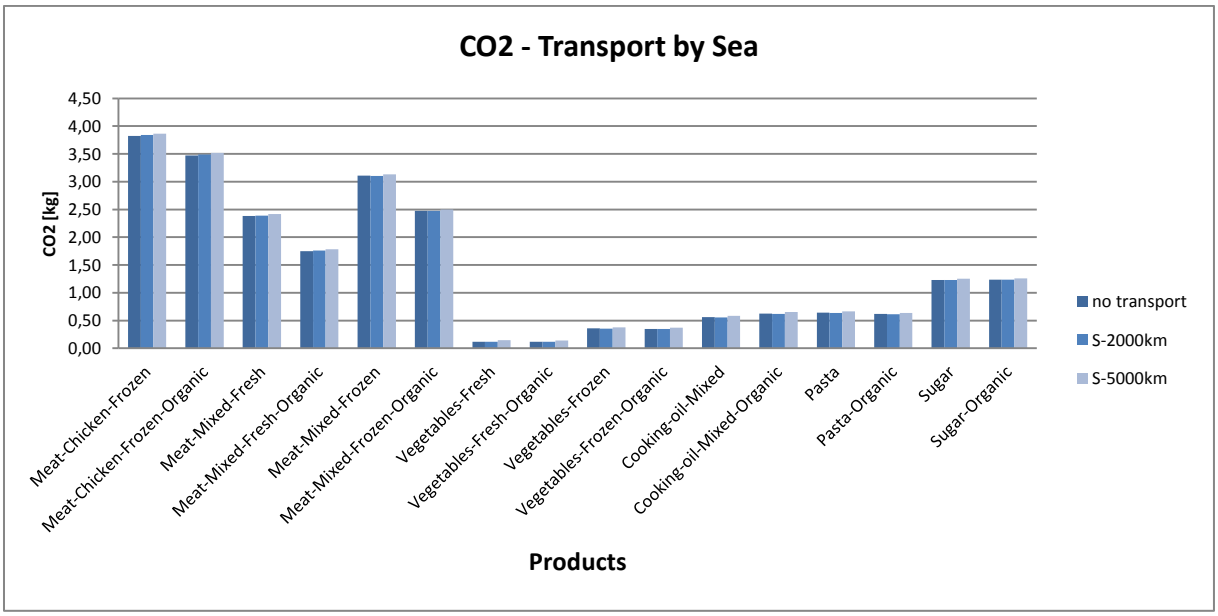
In this case the data tends to show an increase in the amount of CO_2 emitted as the distance over which the goods are transported increases. The amounts by which these values increase however vary widely between the modes of transport. In the case of transport by air they more than double in an absolute sense, indicating a set amount of CO_2 per kilometre travelled. In the case of transport by land the increase in CO_2 also doubles but not in the same absolute sense that's shown in the case of transport by air. Rather the comparative increase doubles, thus indicating that the increase in CO_2 per 2000km is approximately 0,25kg (land) as compared to the estimated 25kg differences shown in the case of transport by plane. Again the smallest differences are exhibited in the case of transport by ship (0,025kg), which remain more or less uniform throughout.



Graph 4: CO_2 – Transport by Air



Graph 5: CO_2 – Transport over Land



Graph 6: CO_2- Transport by Sea

8.3 Cumulative Energy Input ('Kumulativer Energie Aufwand (KEA)')

Air: no transport → (≈ +75 kWh) → 2000km → (≈ +100 kWh) → 5000km

Land: no transport → (≈ +1 kWh) → 2000km → (≈ +1kWh) → 5000km
km

Sea: no transport → (≈ +0,25 kWh) → 2000km → (≈ +0,25kWh) → 5000km
km

All modes of transport exhibit increases in the cumulative energy input (CEI) as the distances over which the goods are transported increases. In the case of all three these increases are more or less uniform, though admittedly the magnitude of the values differs widely between the methods of transportation. Given the previous graphs this result comes as no surprise. As with all the markers looked at previously the values for air transport are significantly higher.

What is very interesting though is that for all the products analysed the contribution to the CEI by renewable resources seems to be almost the same throughout, regardless of product. There are three exceptions to this: both organic and conventionally produced cooking oils and conventionally farmed sugar. It remains unclear what is included in "other" resources, however in the case of each product analysed the contribution from these sources is very small and so there is no need to give it more detailed consideration in the case of this particular paper.

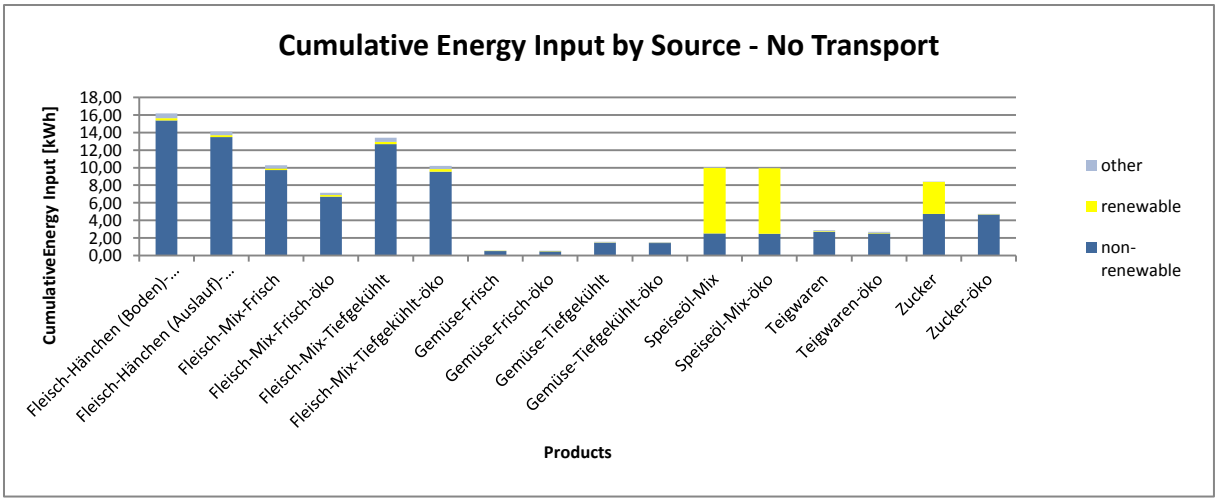
As the values above show the increases in the values of the CEI are approximately constant, and the steps outlined above hold true for all products analysed. Again this is what was expected, and again it remains unclear why the values of the CO_2e of transport over land were so irregular.

As with the previous graphs, the CEI of the organic products is lower than that of the conventionally produced counter-parts. The differences which can be seen in the following graphs closely mirror those seen in the previous graphs, thus again illustrating the direct correlation between carbon footprints and embodied energy. The only case for which no direct correlation can be found is when the values shown graphically below are compared to those of the CO_2e of overland haulage.

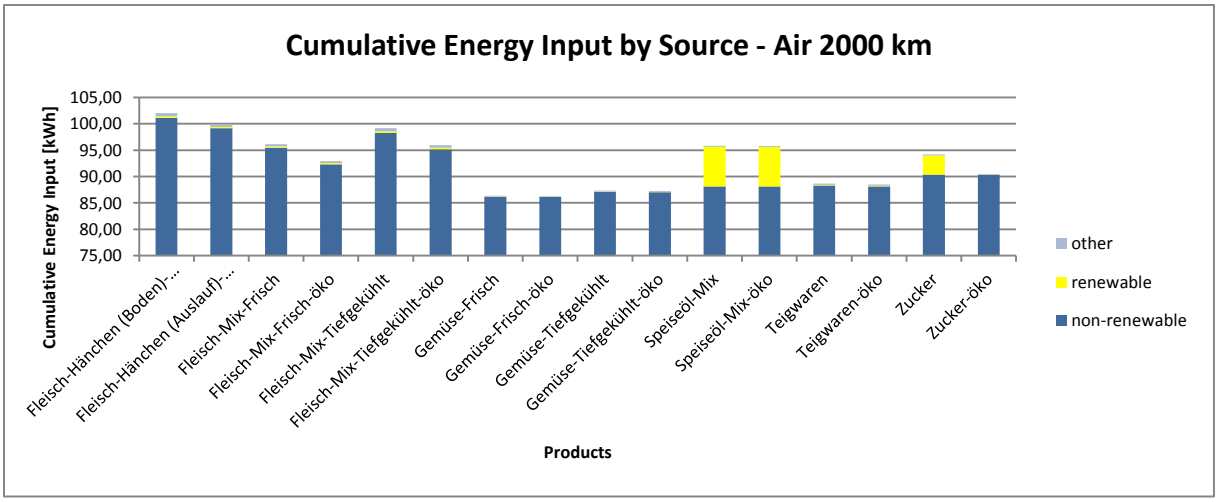
The following table will give an overview of all results mentioned so far:

AIR	No Transport		2000 km		5000 km
CO_2e	→	≈ +25 kg	→	≈ +30kg	
CO_2	→	≈ +25 kg	→	≈ +30kg	
CEI	→	≈ +75 kWh	→	≈ +100 kWh	
LAND					
CO_2e	→	n/a	→	n/a	
CO_2	→	≈ +0,25 kg	→	≈ +0,25 kg	
CEI	→	≈ +1 kWh	→	≈ +1 kWh	
SEA					
CO_2e	→	≈ +0,05 kg	→	≈ +0,05 kg	
CO_2	→	≈ +0,025 kg	→	≈ +0,025 kg	
CEI	→	≈ +0,25 kWh	→	≈ +0,25 kWh	

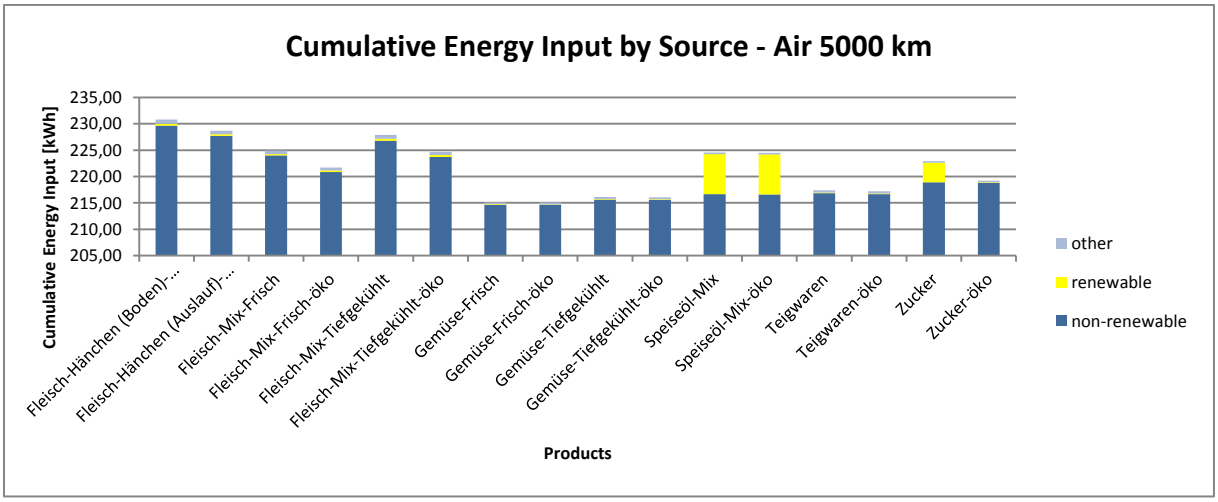
Table 2: Differences in Values as Distance of Transport is varied



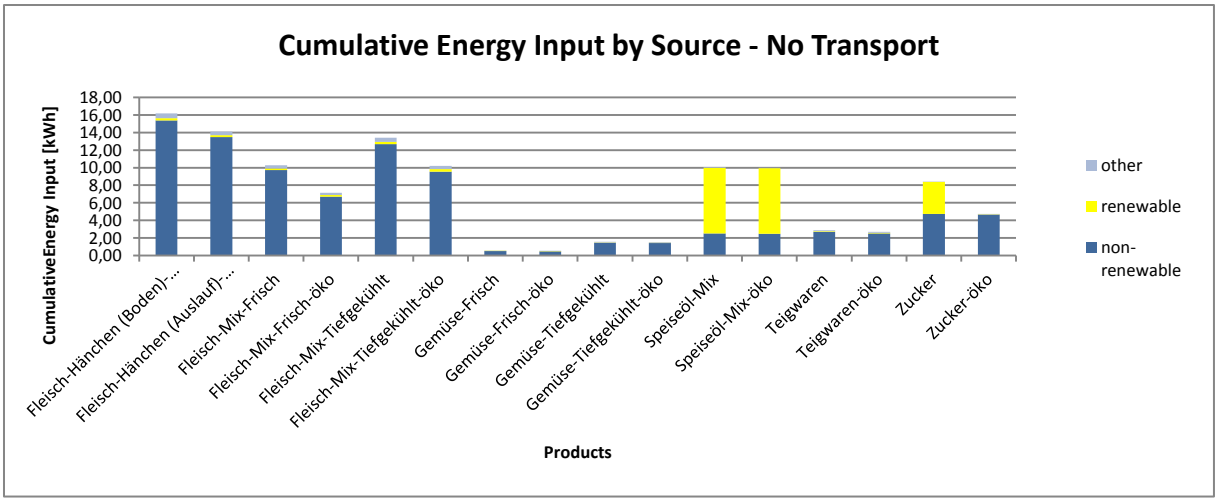
Graph 7: CEI by Source – No Transport



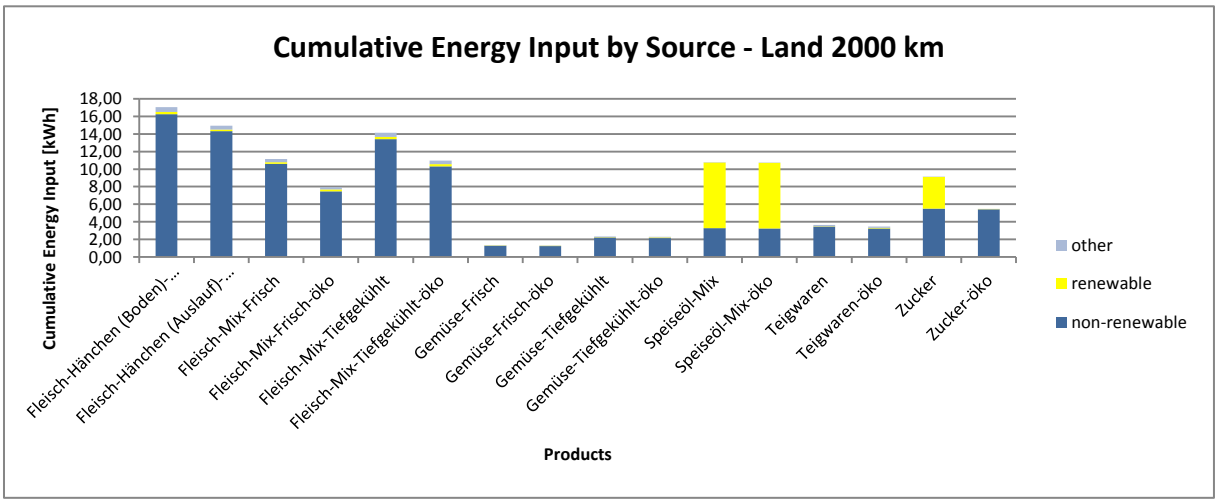
Graph 8: CEI by Source – Transport by Air (2000 km)



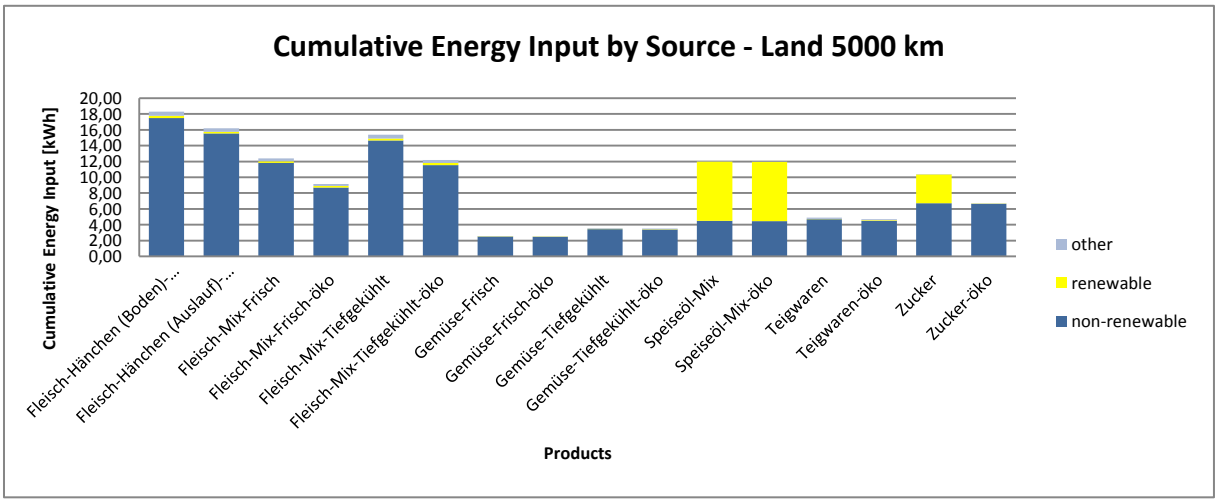
Graph 9: CEI by Source – Transport by Air (5000 km)



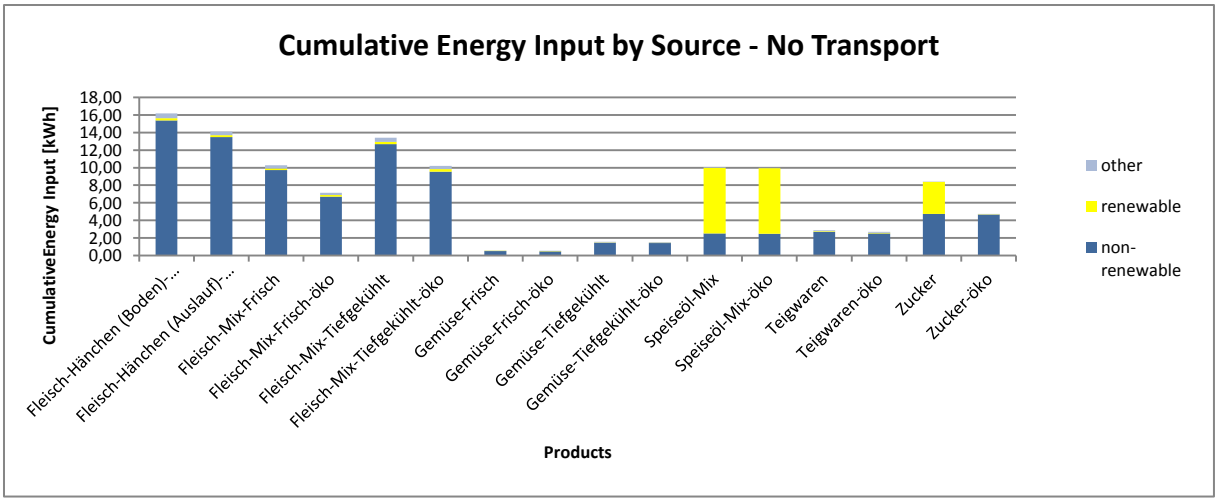
Graph 10: CEI by Source – No Transport



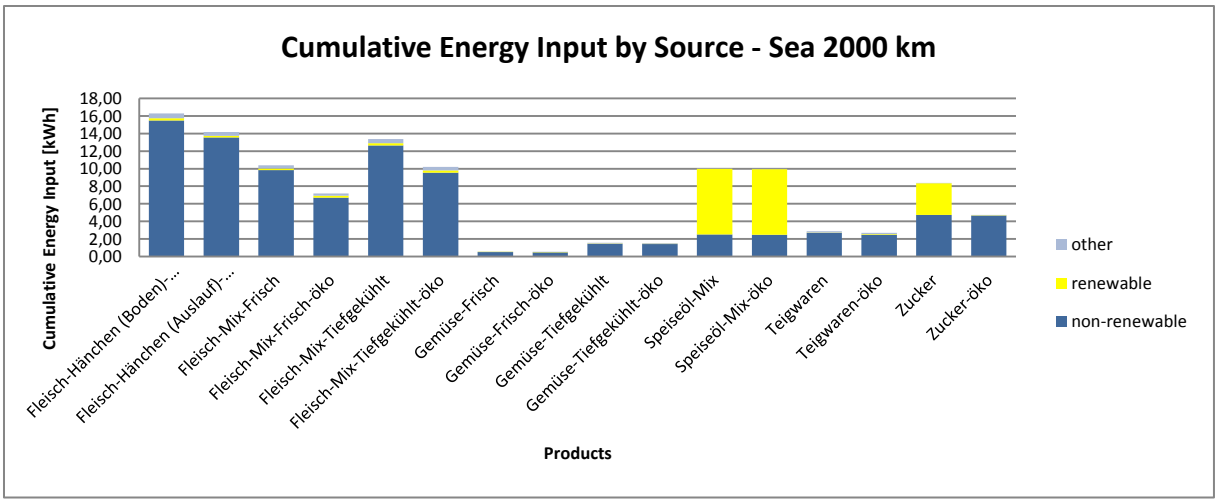
Graph 11: CEI by Source – Transport over Land (2000 km)



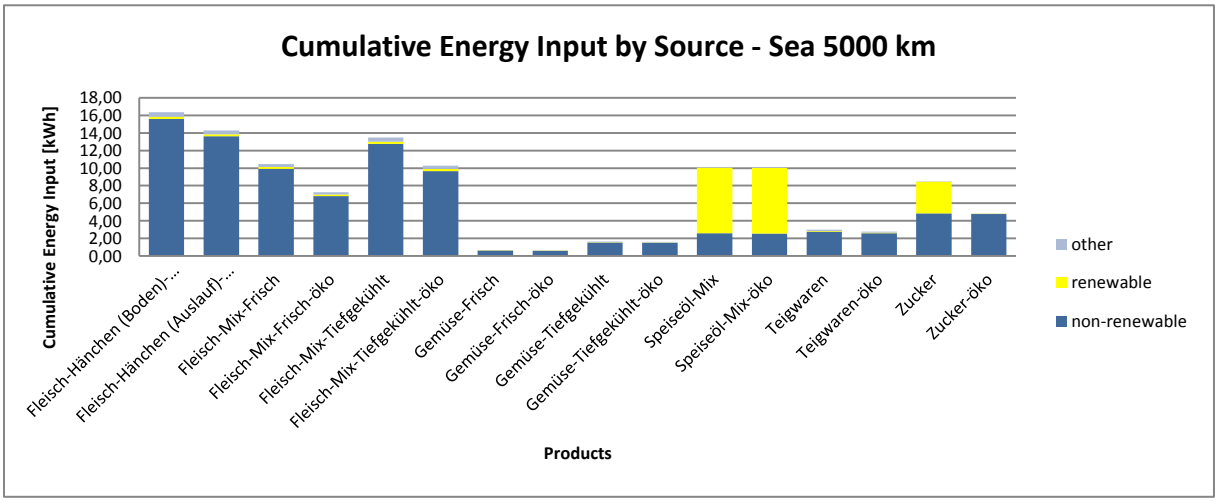
Graph 12: CEI by Source – Transport over Land (5000 km)



Graph 13: CEI by Source – No Transport



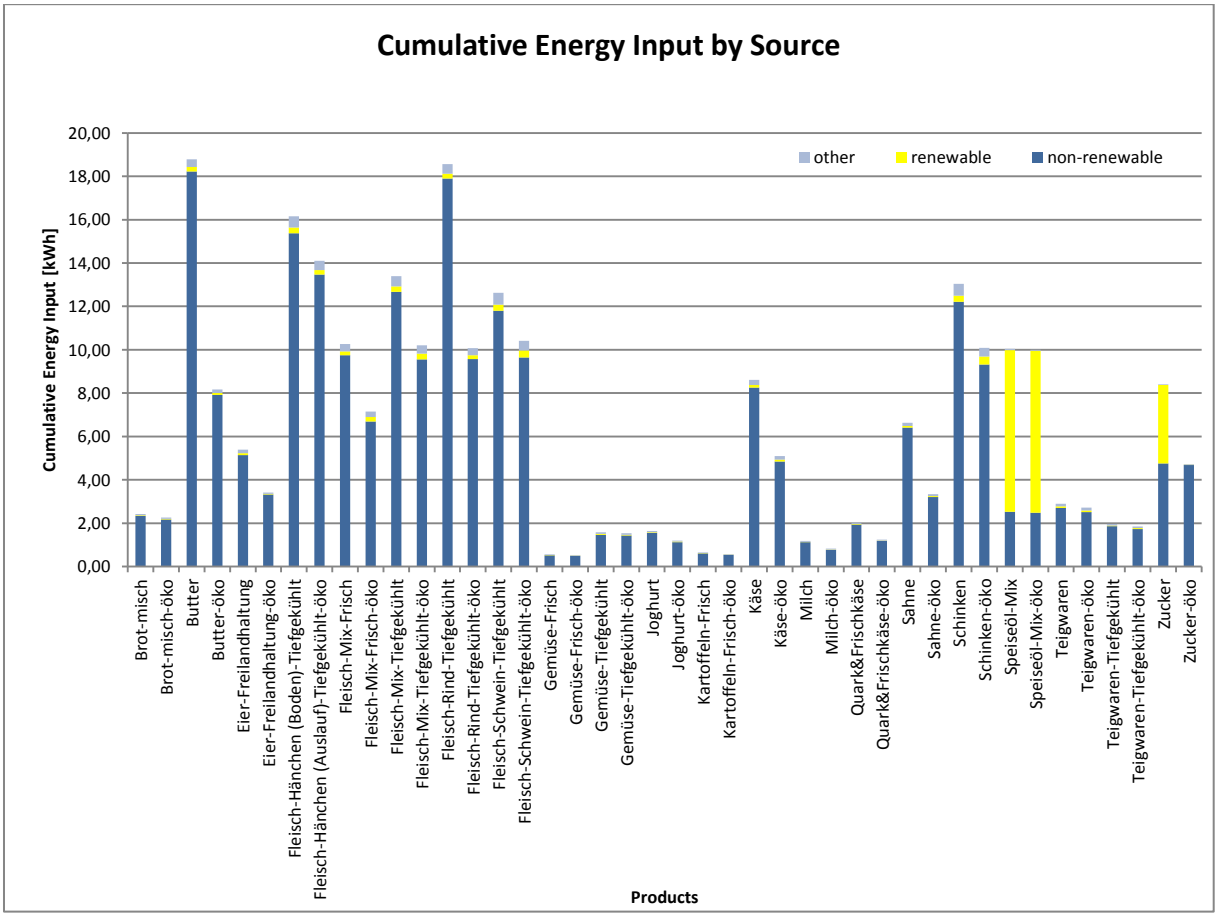
Graph 14: CEI by Source – Transport by Sea (2000 km)



Graph 15: CEI by Source – Transport by Sea (5000 km)

While the above graphs give a more thorough insight into hoe the CEI changes as goods are transported it is also interesting to look at the CEI of all products before they are transported across any mentionable distances. The values in this case range from roughly 1kWh to 19 kWh, where potatoes have the minimum value and frozen beef/butter take the maximum value. These values are all given for the scenario of making 1kg of the listed product available to the consumer (to put this in perspective 1kWh allows a 40W bulb to be on for 25 hours[34])

What this graph also illustrates is that there are huge differences even within food-groups and that, except for meat, no generalisations can be made about the CEI of any one group, though again it clearly underlines the statement made earlier that the contributions from renewable sources remain more or less constant across all products, thus clearly showing that the largest contribution comes from non-renewable energy sources and that despite efforts by the EU to increase the amount of energy provided by renewable sources, this push has clearly not reached the food-industry.



Graph 16: CEI by Source Overview (No Transport)

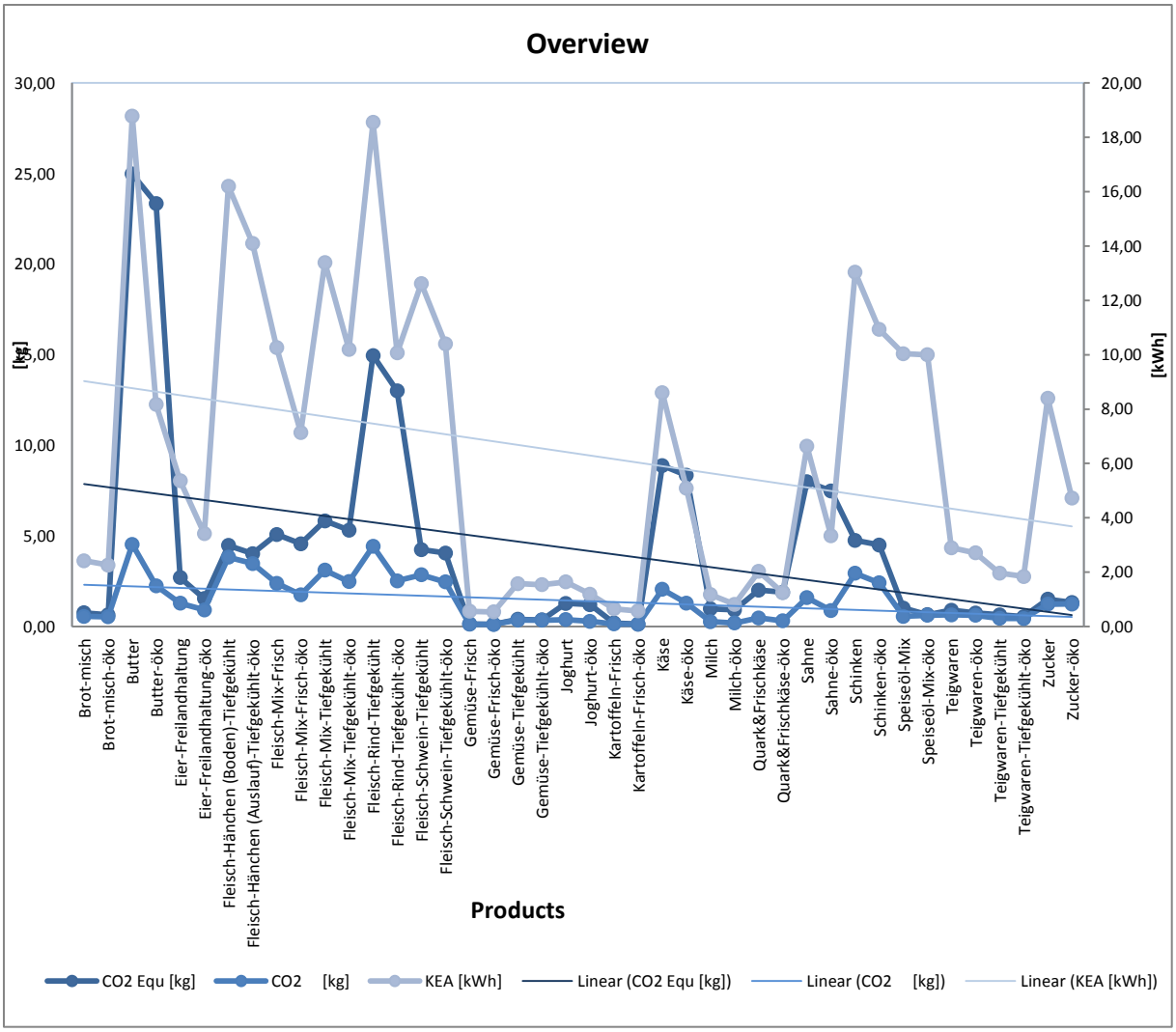
[34] http://www.energimyndighete.se/en/Energy-efficiency/Household/How-you-can-save-energy/How-far-will -1-kWh-go/ ; last viewed 12.09.2011

Conclusion:

The following graph shows all indicators analysed above on one graph. In each case this is for the scenario of no or minimal transport. While the graph may look somewhat confusing at first, the results mapped here clearly show the conclusions drawn so far.

The linear trend lines for both the CEI ('KEA') and the CO_2e are parallel indicating that these results mirror each other. This illustrates the relationship between the carbon footprint and the embodied energy of these products as well as clearly showing that the results are proportional to each other. In the case of these two, the gradient of these trend lines is what will be used as the indication of this conclusion, mainly because both are measured in different units and so no direct comparison of the values is possible.

What is very surprising is how high some of these values are as it must always be considered that in the case of each product the scenario in which these values are calculated was constructed in such a way as to always be representative of 1 kg of food ready for sale to the final consumer. The next step will be to look at the supply chains of these products in detail and see at which point the most energy is used and the most CO_2 and CO_2e are emitted.



Graph 17: Overview of all Indicators analysed (no transport)

8.4 Process Chains ("Prozessketten")

Relevant definitions:

Process Chain/ Chain of Production[35]*:*

A process chain is the combination of several processes to form a network, the components of which form together for a particular use (product or service). In this context the terms process and product require further explanation:

Process[36]:

This is an activity during which a product is either transformed, transported or made available for other services.

Product[37]*:*

The in- and outputs linked to a process. They are, depending on the process type, energy carriers, emissions, residues, resources or materials and services. The most relevant are emissions, GHG, solid wastes, liquid effluents and services (freight and transport, monetary services).

Utilisation Ratio ("Nutzungsgrad")[38]*:*

this is the quantitative ratio of a process to its inputs (excluding additional energy or material inputs), calculated annually.

Cumulative Energy Input[39]*:*

This is a measurement/value used as an indicator for the total energy input (primary energy) used in the making available of a good or service.

<u>The following things should be noted in advance:</u>

[35] http://www.oeko.de/service/gemis/de/glossary.htm; last viewed 10.09.2011
[36] http://www.oeko.de/service/gemis/de/glossary.htm; last viewed 10.09.2011
[37] http://www.oeko.de/service/gemis/de/glossary.htm; last viewed 10.09.2011
[38] http://www.oeko.de/service/gemis/de/glossary.htm; last viewed 10.09.2011
[39] http://www.oeko.de/service/gemis/de/glossary.htm; last viewed 10.09.2011

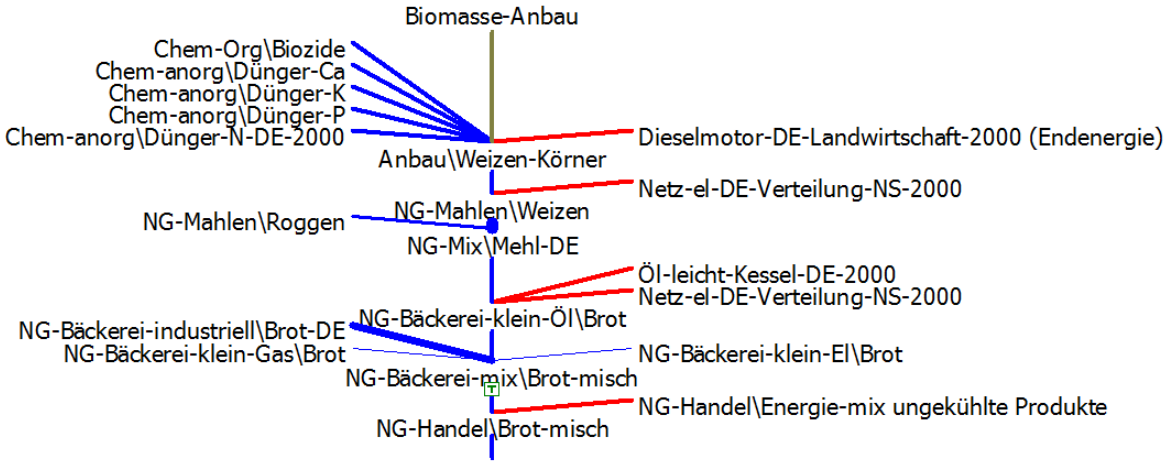
The process chain shown for each product is that for the conventionally produced product, unless there are significant differences between it and its organic counterpart in which case both will be shown. These diagrams show the steps involved in making a product available to the final consumer. A small green 'T' denotes the points at which a good is involved in some form of transport. Given that these distances are almost negligible (100-200km) the values given will be considered to be equivalent to those should the good have not been transported, though again where these differ significantly both values will be shown.

The utilisation ratio is given for most products, except where these values were not available (usually when the final product is comprised of mixed components). These values in part explain the differences in cumulative energy input.

Below each diagram is a table giving the values of the cumulative energy input at each step in the process chain. These values are calculated for the production of 1kg of the final good at each step and so it must come as no surprise that the sum total of all values usually far exceeds that of the value given in the final step.

Some energy differences are negative. While this may appear strange this merely means an energy decrease in the amount required to produce 1kg of the good at that point.

For Example: Bread (For all other products see Appendix)



PRO-DUCT	SUM-CEI-CONVENT.	SUM-CEI-ORGANIC	EFFICIENCY RATIO % (CONVENT.)	EFFICIENCY RATIO % (ORGANIC)	Δ CEI-CONVET.	Δ CEI-ORGANIC

Conclusions:

As was briefly mentioned previously the cumulative energy inputs cannot be summed up to be equivalent to the value given at each final step in the process chain. This has several reasons, the first of it being that the values are calculated for the production of 1kg of each good at each step. It is interesting to look at the differences between these values, and to analyse at which point the largest differences occur. This is usually at the point where the good is transferred from its production to its storage. Oddly enough these maximum differences do not always occur at the same point in the process chain of the conventionally and the organically produced food, though admittedly this is only rarely the case.

The utilisation ratios are also included in the tables above; at least they are for the goods for which the data was available. This was the case for all products that were made out of a single basic ingredient, for those goods made of several input-materials there were no values available. Two things were interesting about these ratios: firstly, the fact that the values are in general identical for the conventionally and the organically produced good and, secondly, that there were some products for which the value given exceeded 100%. The latter was particularly unexpected as this would seem to indicate that the produce far exceeds the input materials which, however counter-intuitive this may seem, does appear to be the conclusion to be drawn from the data. The low utilisation ratios of some processes is the reason for the relatively high cumulative energy inputs at these points, given that a much higher input is required to produce 1kg of its output.

In the case of the various meat products (chicken, beef, pork) a low utilisation ratio is to be expected given that during slaughter and other steps of transformation there are considerable material losses (waste products). These high losses, and hence the higher input requirements to produce the same amount of the final product as with other goods, in part explains the high carbon dioxide and carbon dioxide equivalent values for these goods.

The largest differences in cumulative energy usually occur at the point where the transition from raw materials to final good occurs.

In the case of several products there are values given for no transport of the good. The reason these generally differ significantly from those where the goods are transported over negligible distances is because when the process chain was redesigned half the processes disappeared

and so these very low values of the cumulative energy input can be deemed inaccurate and are only included for the sake of a more complete idea of the current situation.

8.5 $C0_2$, CO_2e and CEI Overview as it Relates to the Dietary Plan Outlined

Method:

The CO_2, CO_2e and CEI values are always given for 1kg of the final product at the point at which it is sold. In order to generate the following graph the values have been calculated to be representative of the amounts of each food included in the diet.

In the case of the graphs illustrating those values for which the goods were transported the values were calculated to take this into account for the products for which this data was available. When the values hadn't been generated the values for the scenario "no transport" were used. The goods for which the values were available were: chicken, mixed meats, vegetables, oil, pasta and sugar.

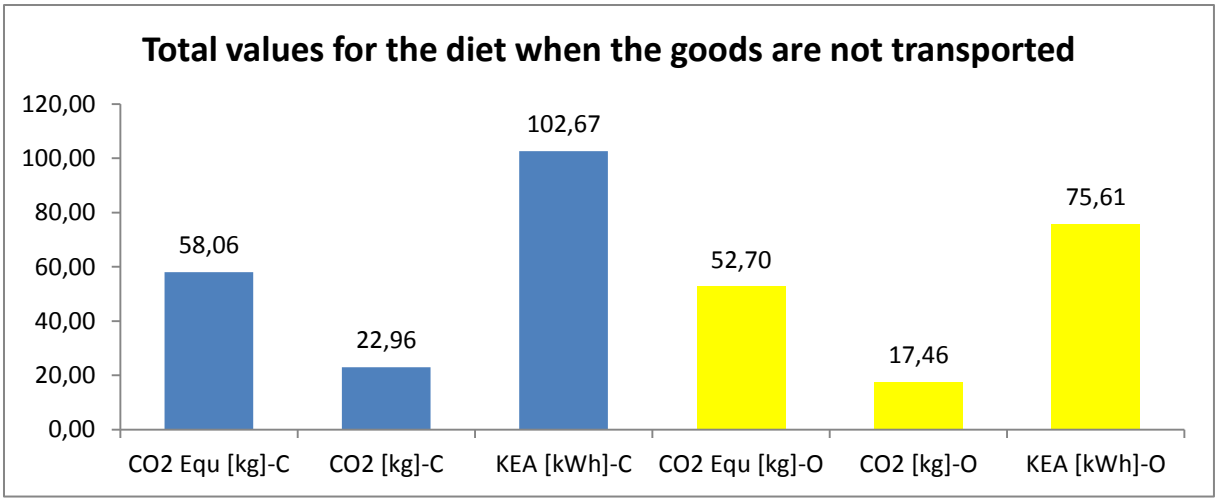
The yellow bars always represent the values for the organically produced goods.

Conclusion:

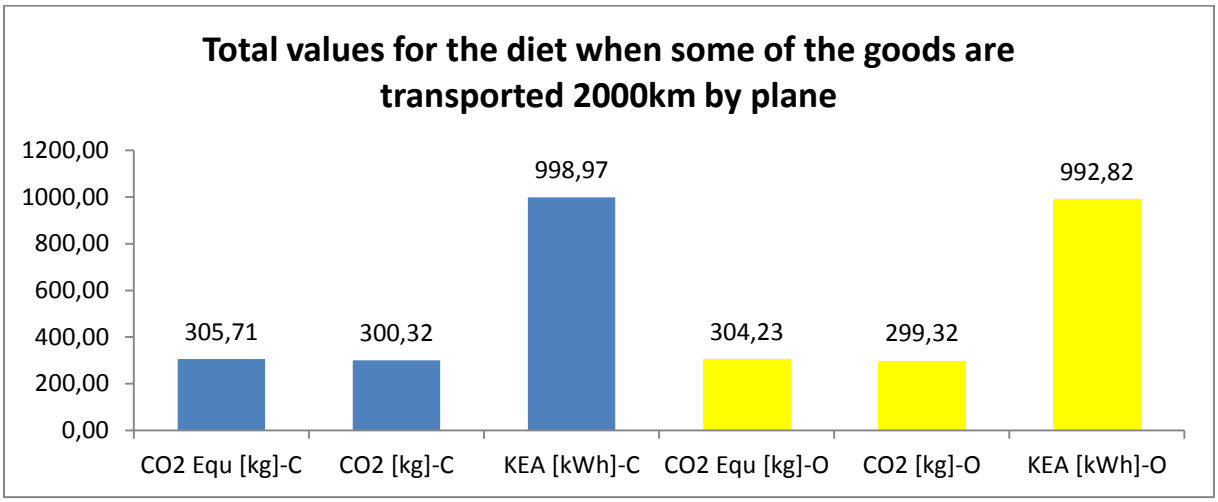
Again these values clearly show there is very little difference between the conventionally and organically produced goods. As this has clearly been outlined in the case of the individual goods, the fact that this is also the case when there is a summation of these values was to be assumed.

The graphs clearly show the same pattern that emerged previously, namely the steady increase of the values with distance over which the goods are transported. Again plane is the most energy intensive, then transport by lorry and lastly transport by freighter.

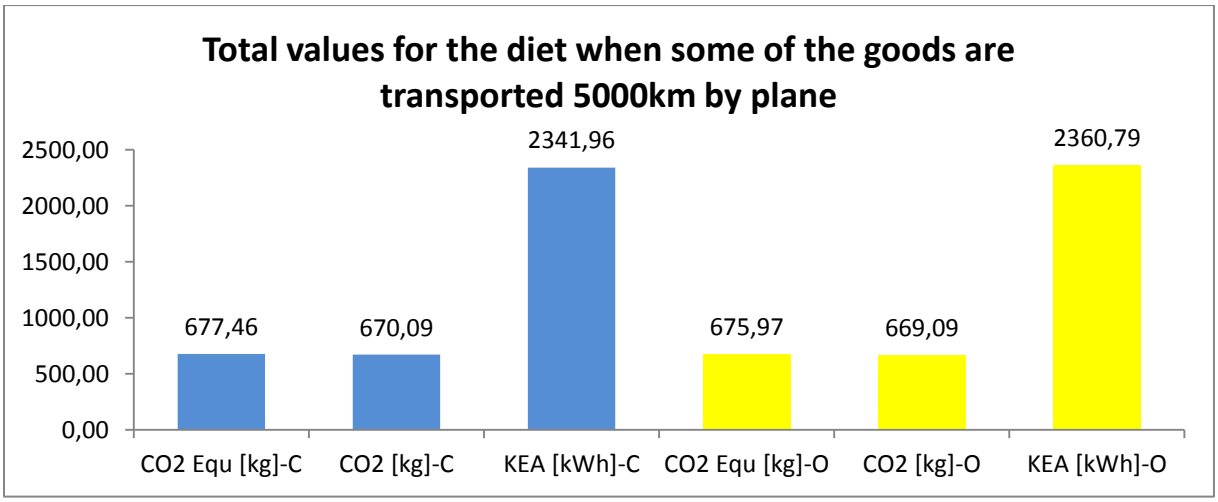
What becomes very clear is how much smaller the carbon footprint and embodied energy of locally sourced food is. In fact it is at best a third of that of transported goods at worst a little more than 5%.



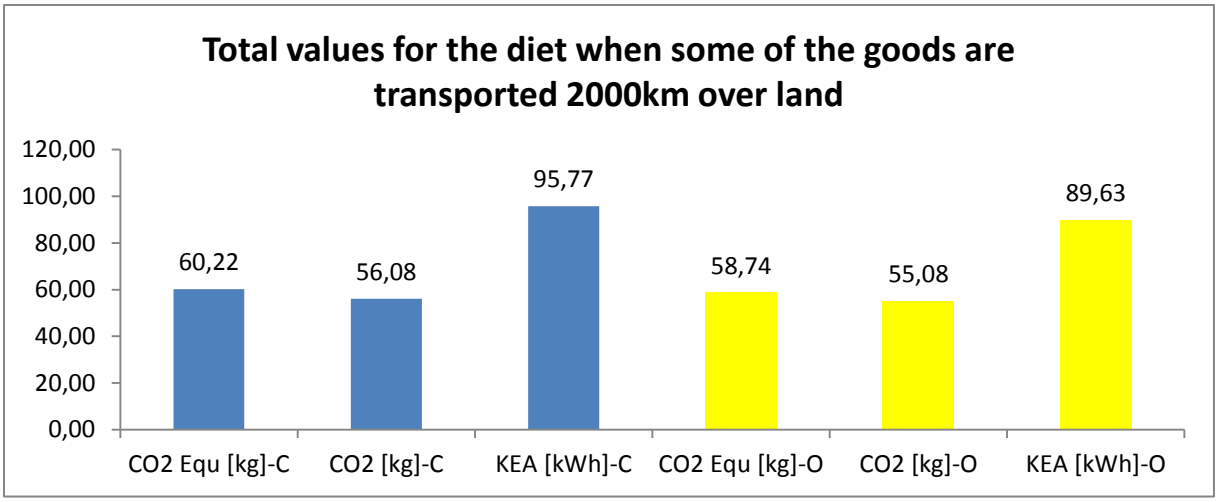
Graph 18: Total Values – No Transport



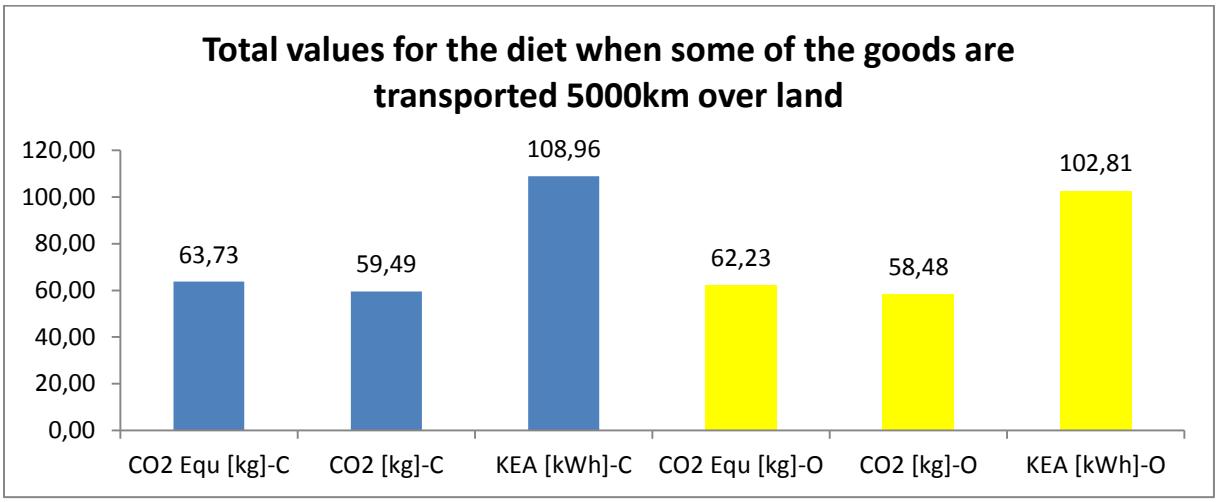
Graph 19: Total Values – Transport by Air (2000 km)



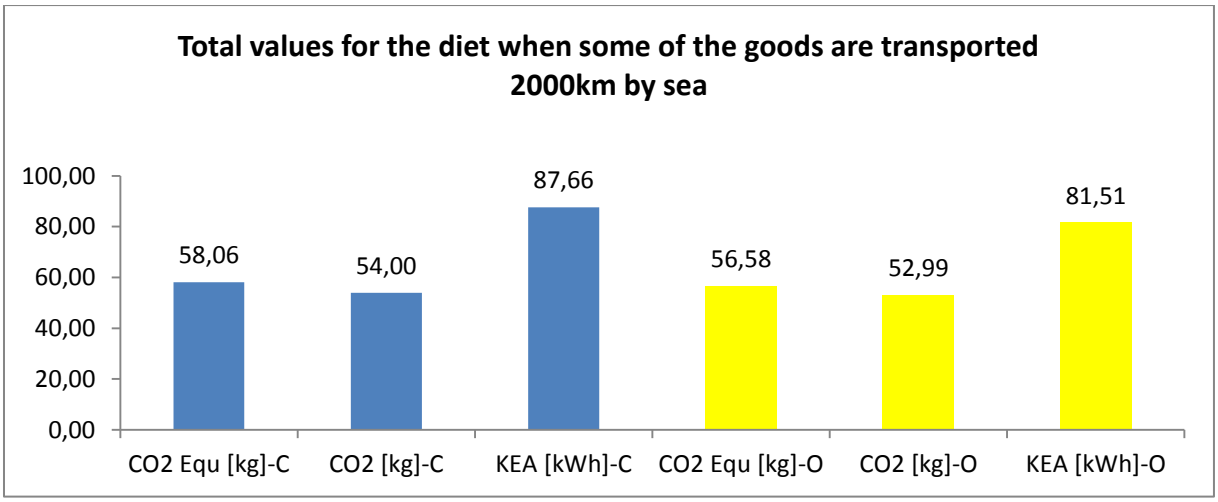
Graph 20: Total Values – Transport by Air (5000 km)



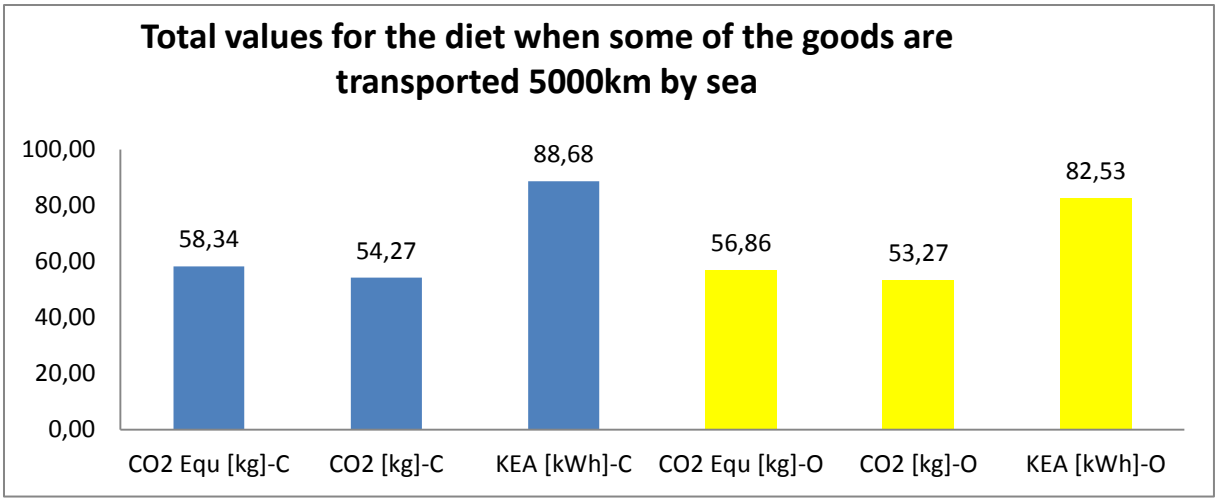
Graph 21: Total Values – Transport over Land (2000 km)



Graph 22: Total Values – Transport over Land (5000 km)



Graph 23: Total Values – Transport by Sea (2000 km)



Graph 24: Total Values – Transported by Sea (5000 km)

8.6 Survey

In order to see to what extent awareness of embodied energy and carbon footprints had penetrated the awareness of "ordinary" people, a brief survey was circulated the results of which will be discussed below. In no way should these results be viewed as representative of the population in general.

The majority of participants currently live in Austria. However, there were many people who live in other countries and so what the survey will show is that the conclusions drawn from the survey in no way only apply to Austria; however, in general the participants were residents within EU countries.

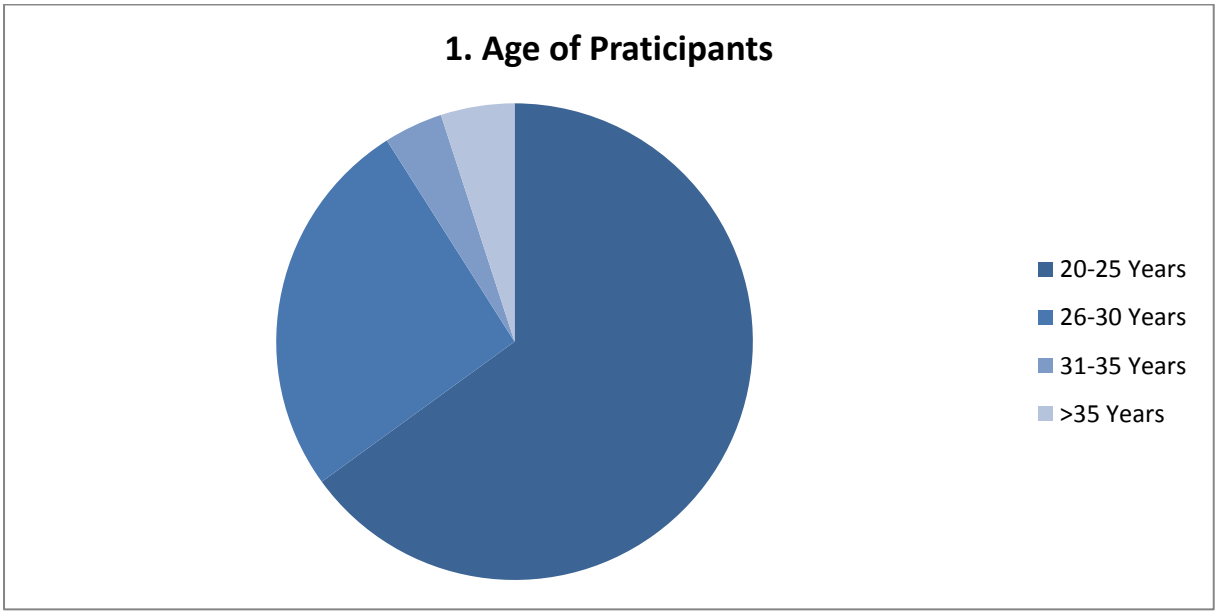
The majority of participants were aware of the differences between organically and conventionally produced foods. Most likely this is because of the organic food "hype" that has been growing in the past few years, as well as the extensive advertising campaigns launched by both the EU and supermarket chains to promote this. However, this awareness apparently does translate to altered consumer behaviour or at least heightened consumer awareness, and hence these campaigns can be deemed successful.

What is very interesting about these results is that though few people have heard of the term embodied energy, most are familiar with the term carbon footprint. It is because of this awareness that most people who completed the survey do pay attention to the place of origin

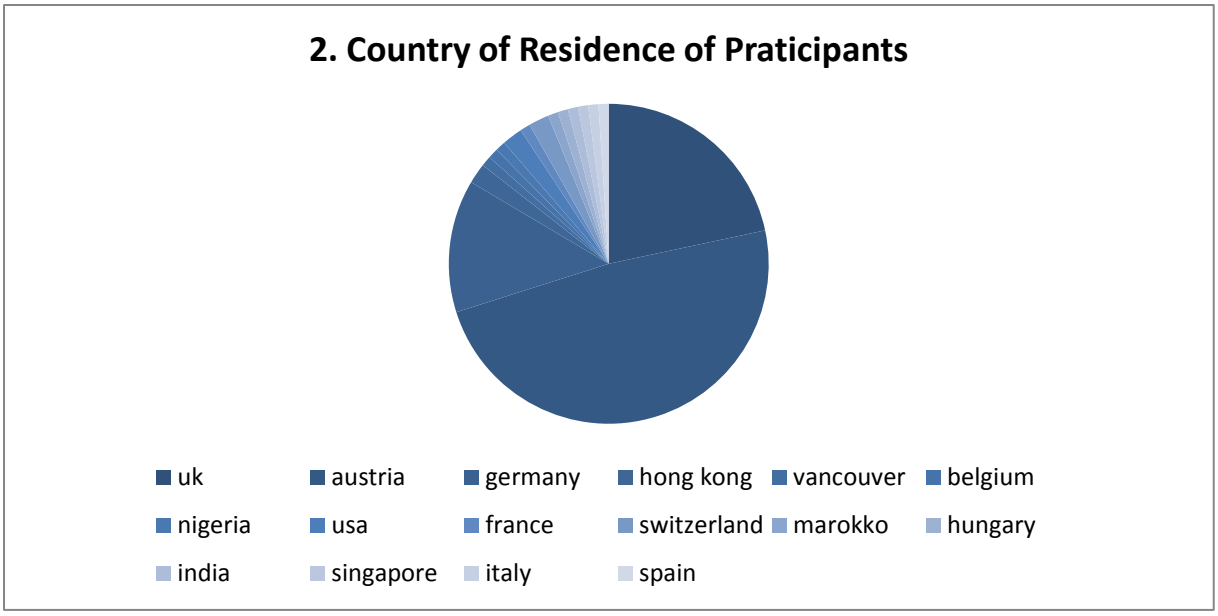
of their food and, where possible, will try to buy locally produced products or, when this is not an option, buy a good with the nearest place of origin. Furthermore, the majority of participants claim to have given some thought to how a good is transported and they are more than capable of ranking modes of transport (plane, lorry and freighter-ship) in terms of their perceived energy efficiency correctly. This is a testament to the extent to which general awareness of such matters has permeated the general consciousness, at least that of a group of young people (20-25 years old) who are interested in and able to afford to think about such things and not be hindered too much by monetary considerations.

While this is a rather superficial survey, merely designed to give a brief overview of the general state of awareness, the results are considerably more positive than had been anticipated. The fact that such widespread awareness already exists is a good base for an increased number of projects looking at firstly further raising awareness of the energy requirements of food transport and, more importantly, gathering public support for measures looking to reduce these values, as well as a trend towards more seasonal dietary habits.

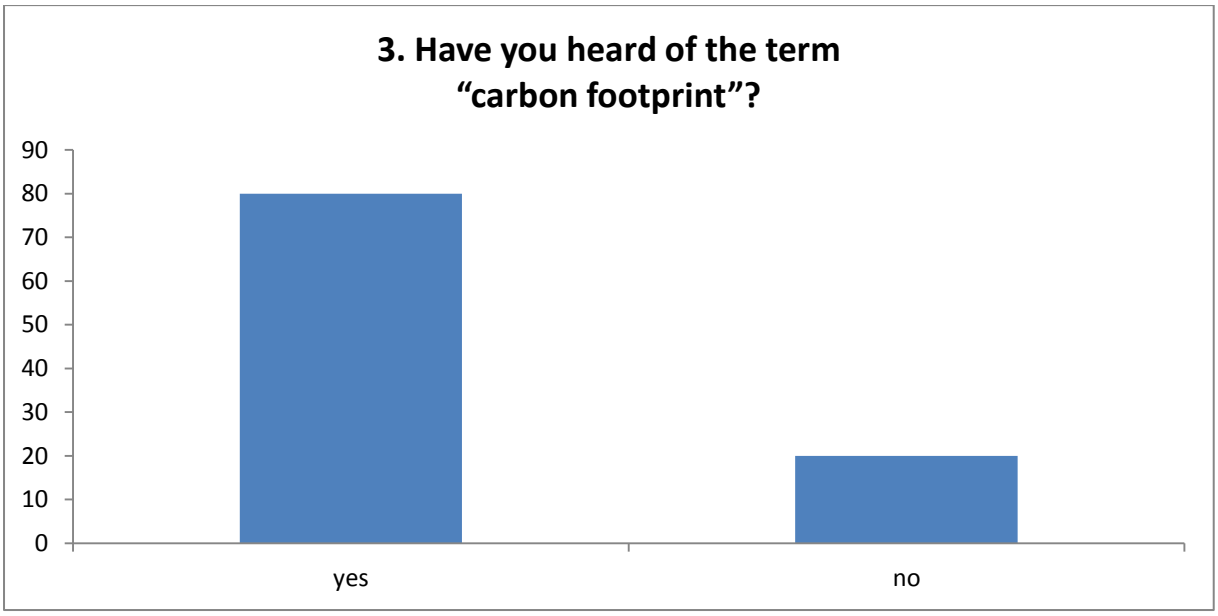
8.6.1 Results of Survey



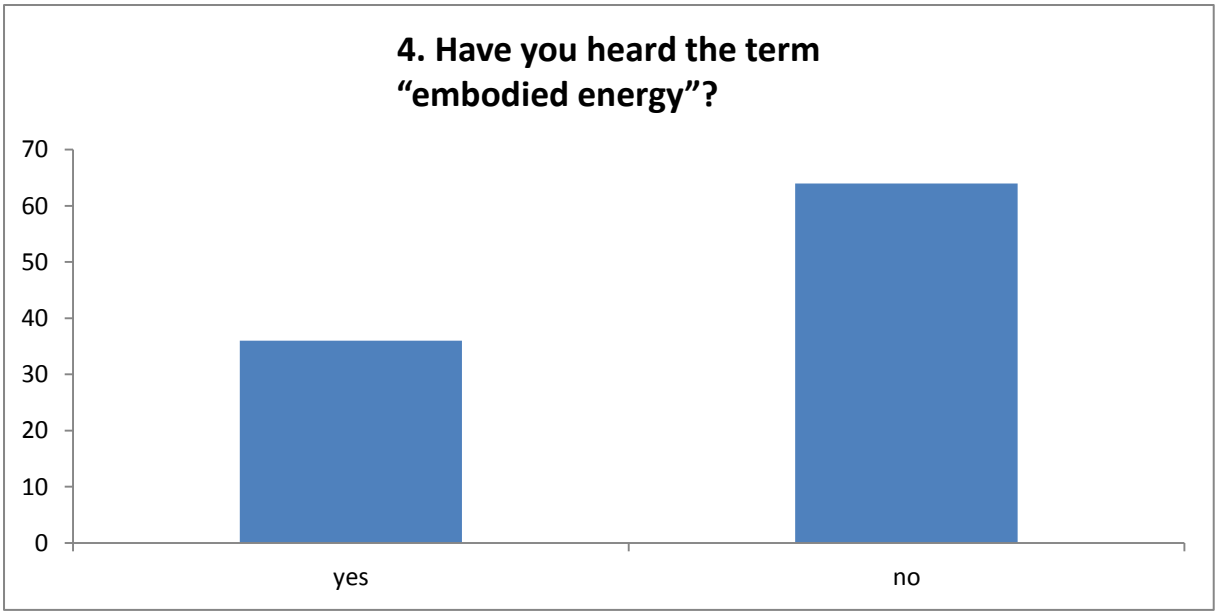
Graph 25: Survey Question 1 - Age of Participants



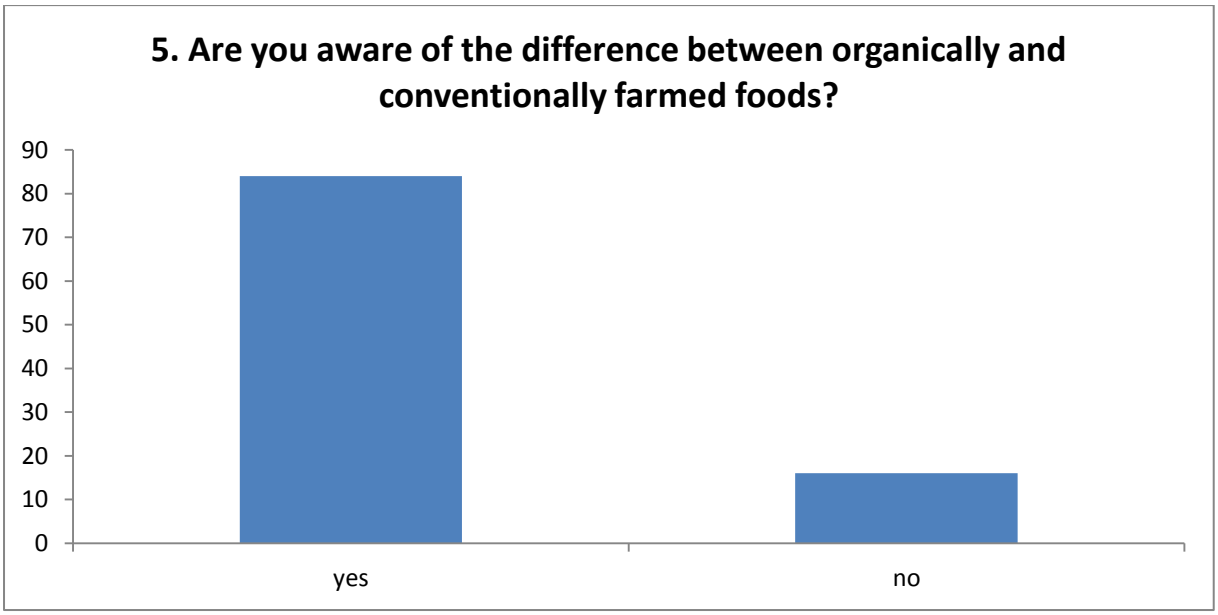
Graph 26: Survey Question 2 – Country of Residence of Participants



Graph 27: Survey Question 3 – Have you heard of the term "Carbon Footprint"?

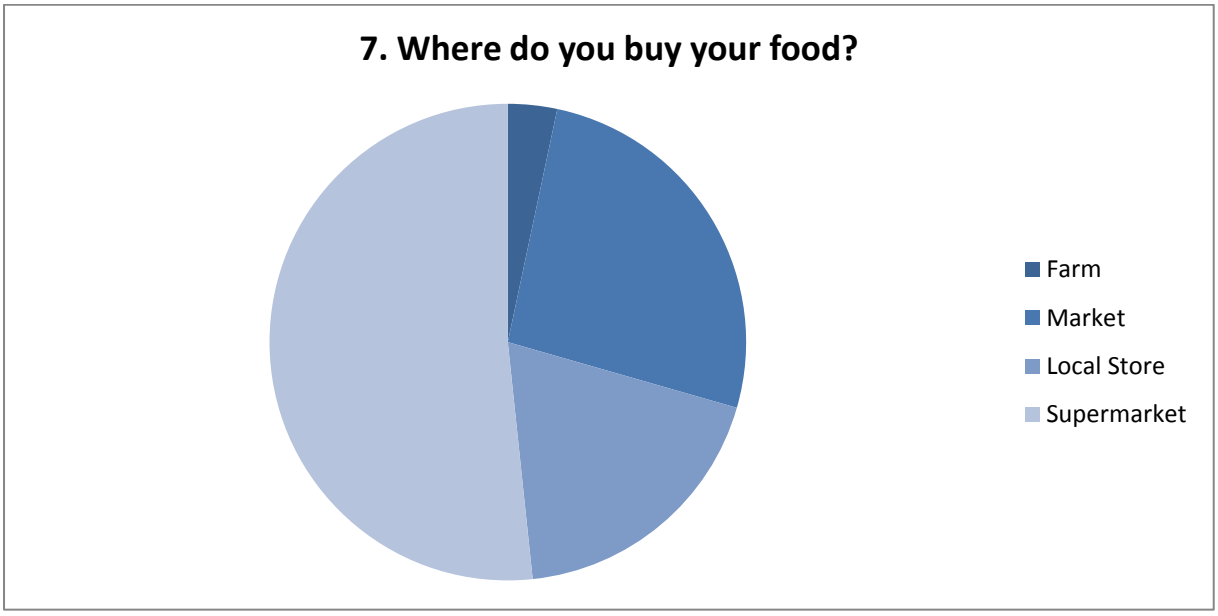


Graph 28: Survey Question 4 – Have you heard of the term "embodied energy"?

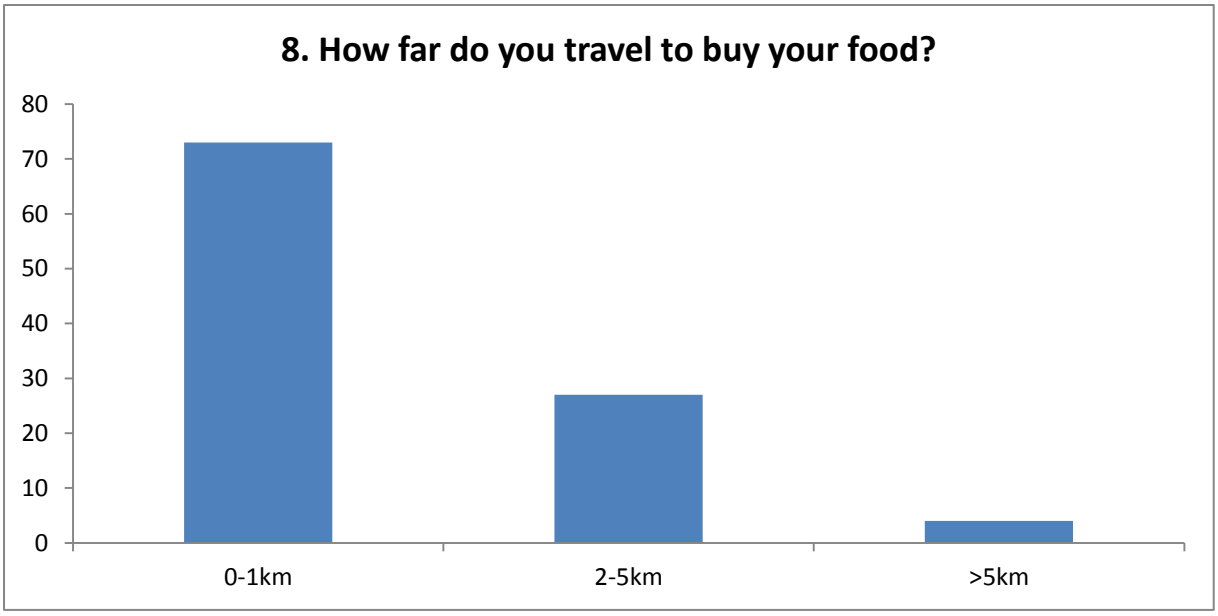


Graph 29: Survey Question 5 – Are you aware of the difference between organically and conventionally farmed foods?

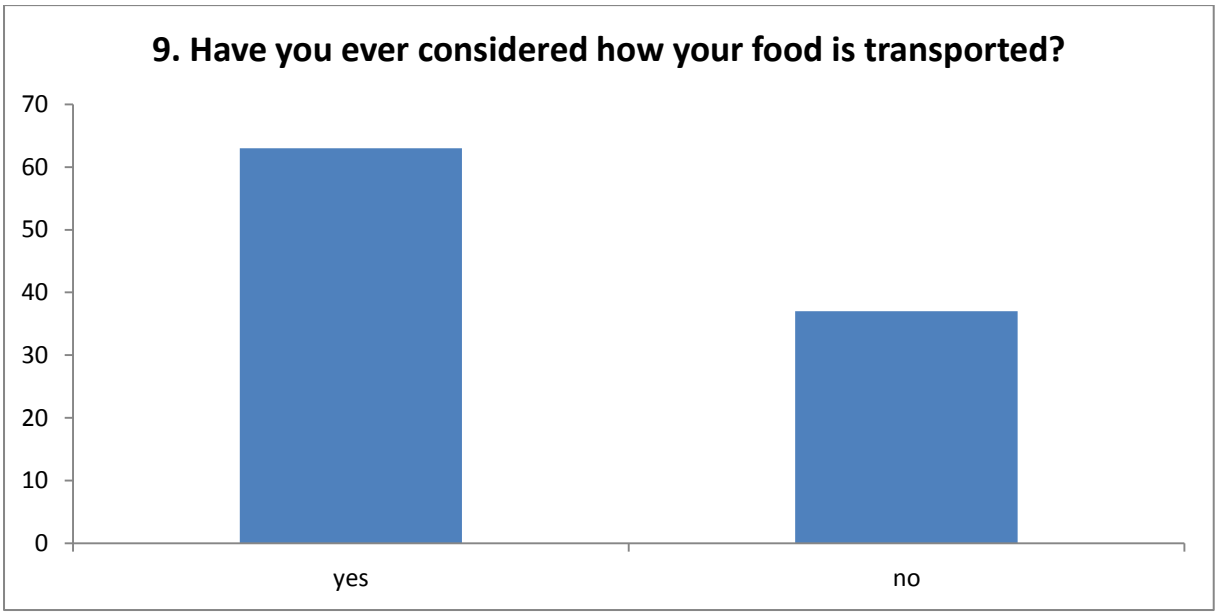
Graph 30: Survey Question 6 – When you shop, do you pay attention to the place of origin of your food?



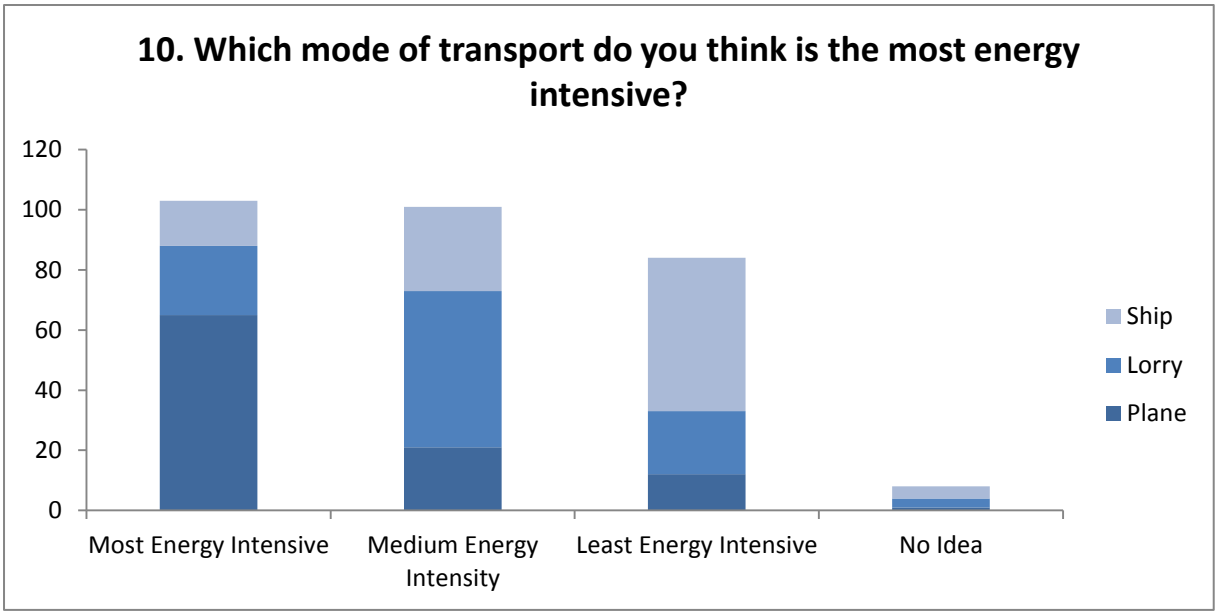
Graph 31: Survey Question 7 – Where do you buy your food?



Graph 32: Survey Question 8 – How far do you travel to buy your food?



Graph 33: Survey Question 9 – Have you ever considered how your food is transported?



Graph 34: Survey Question 10 – Which mode of transport do you think is most energy intensive?

9. Conclusion

As mentioned in the introduction any city, at any given point, merely has enough food to support its citizens for three days. Thus huge amounts of food are transported on a daily basis. Having looked at local production only and seen the staggering values for this scenario, the environmental impact of this can barely be imagined. However, this is something that should be considered, not only from the perspective of the interested consumer but also from the point of the company as the associated costs are huge and can only be expected to increase as fuel prices continue to rise.

Overview of Results:

The general trends of the results have been discussed in detail already. However, in conclusion, they will be outlined in general terms.

The carbon dioxide and carbon dioxide equivalent emissions, which is what is meant by the general term "carbon footprint", are already considerable when the good is not transported and increase in a proportional manner to the distance over which they are transported.

The cumulative energy input required for the making available of each good in a supermarket is also considerable. When this cumulative energy is broken down into its contributing parts along a process chain it can be seen that usually the highest consumption occurs at the point where the raw materials are transformed into the final good. This is not surprising as this is also usually the point at which the most waste products are incurred and so the efficiency ratios tend to be at their lowest.

In general there are minimal differences between goods which have been organically produced and those produced by conventional methods thus disproving the assumption that organically produced goods are more energy intensive and have lower efficiency ratios. This is counter-intuitive because this then raises the question of why not all food is produced organically, and leads to the conclusion that there are other factors influencing this that either have not been considered in the data or have not been considered in this paper.

Ways of Reducing the CO_2, CO_2e and CEI:

The energy going into even feeding just one four-headed family is huge and so are the associated emissions. Several things can be done to reduce this, and programmes have already started to educate citizens to this effect. The first step would be to only eat goods as they are in season. This will probably be the hardest to do as people have become used to all sorts of goods being available all year round. However this would lead to the highest reductions.

The second would be to, as far as possible, only eat locally sourced goods. There is a strong movement towards this already gathering momentum. This was clearly underlined by the results of the survey, with the majority of people already paying attention to the place of origin of most of their food, especially with regards to fresh products. There are two major advantages of this: firstly the reduction of the carbon footprint of food transport as the distances over which locally produced food is usually transported are minimal, not to say negligible in a lot of cases. The second would be the obvious benefits to the national economy of a country and the preservation of the way of life of farmers as well as the countryside in its current form, especially if organic production continues to be encouraged. This can reasonably be expected to be the case, as growing awareness of the importance of diet in the maintenance of a general sense of wellbeing spreads.

The third, and admittedly least practical, of the steps which can be taken to reduce the carbon footprint and embodied energy of food would be to de-centralise the supply of food. This would mean the re-introduction of small stores, butchers, bakeries etc. and a re-education of the population that sourcing food this way is preferable. However, as the number of households in which both providers are working is rising steadily and hence there is the perception that there is not enough time to buy each component of a diet in a separate place. Also considering the fact that the majority of food in Austria is supplied by one of three market-players, a great deal of resistance can be expected should such a plan be presented.

It is interesting that all of the ways of reducing the CO_2, CO_2e and CEI are essentially ways of providing for a family that were practiced in earlier times out of necessity. It has only been with the growing presence of supermarkets and the technical capabilities of providing almost all foods all year round that this has changed so dramatically. However, as more and more information becomes readily available about the environmental impact of the transport of goods there is a growing segment of society, mainly in developed countries, that are trying to adapt their lifestyles to reduce the carbon footprint of their consumption. While initially many consumers were put off by the higher prices of organically produced foods, this has begun to change. As people, especially in rich countries, have higher disposable incomes a rising portion of it is spent on food and especially foods perceived to be healthier. While it has been proven that organically produced foods are in no way healthier, i.e. they do not have higher nutritional values, they do represent a way of farming and production that is deemed preferable over that which is used when goods are conventionally produced.

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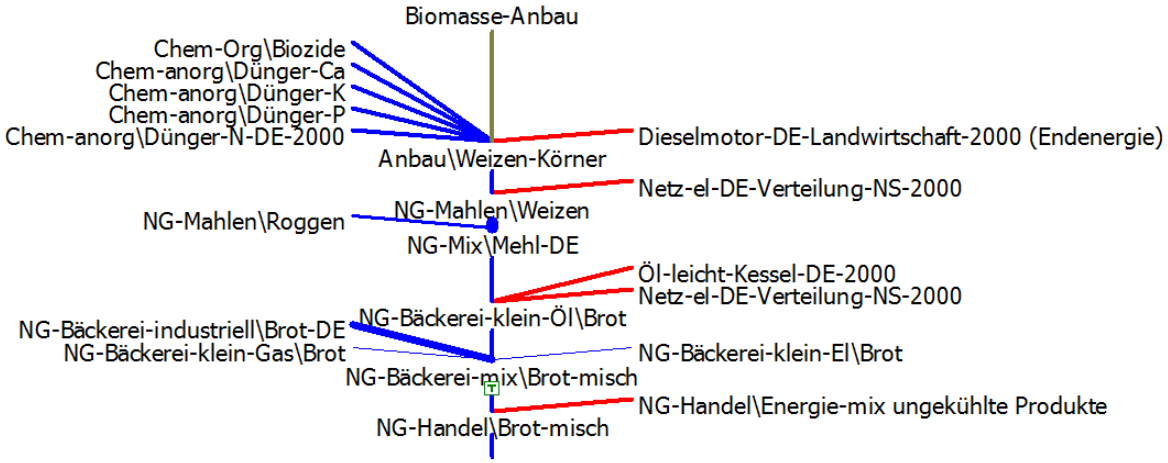
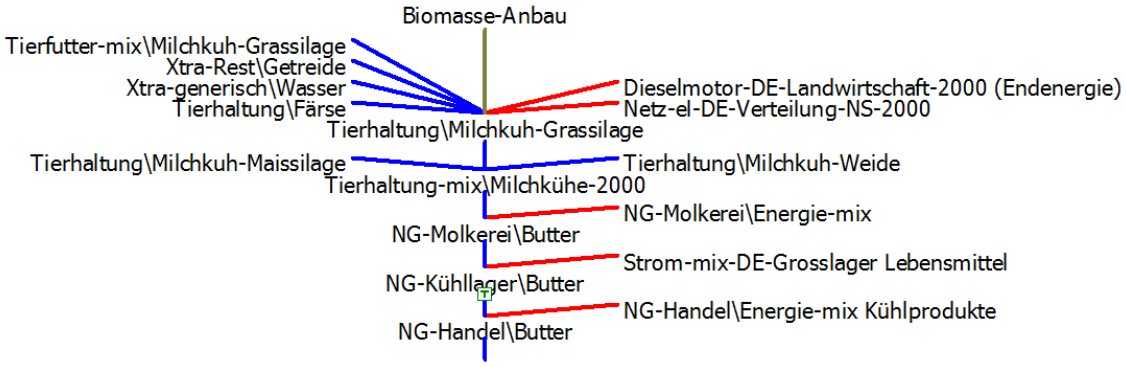
Appendix A: Process Chains for the Foods included in the Dietary Plan

Bread



BREAD	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
anbau\weizen-körner	7,69E-01	6,17E-01	97,50	98,50		
ng-mahlen\weizen	1,220198	1,028792	78,00	78,00	0,45	0,41
ng-mix\mehl-de	1,221789	9,90E-01	na	na	0,00	-0,04
ng-bäckerei-klein-öl\brot	2,03808	1,883329	150,00	150,00	0,82	0,89
ng-bäckerei-mix\brot-misch	2,317056	2,16E+00	na	na	0,28	0,28
ng-handel\brot-misch	2,350716	2,196479	100,00	100,00	0,03	0,03

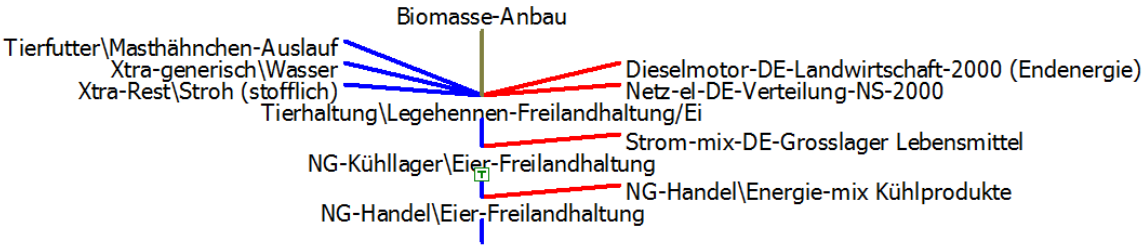
Butter



BUTTER	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
tierhaltung\milchkuh* "	7,97E-01	4,73E-01	100,00	100,00		
tierhaltung-mix\milchkühe-2000	9,01E-01	3,73E-01	na	na	0,10	-0,10
ng-molkerei\butter	18,32325	7,770754	5,00	5,00	17,42	7,40
ng-kühllager\butter	18,36432	7,810293	100,00	100,00	0,04	0,04
ng-handel\butter	18,59297	8,170756	100,00	100,00	0,23	0,36

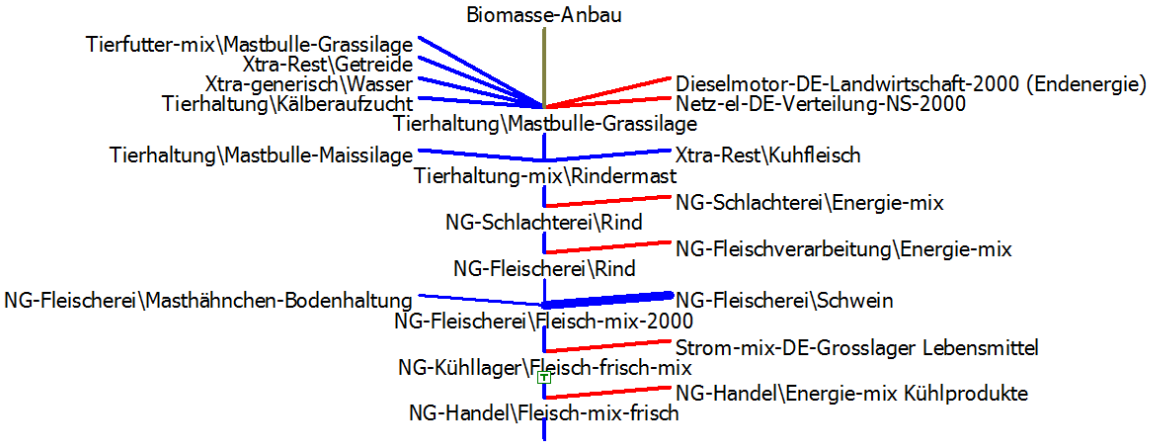
*-grassilage (conv.) / " –öko (org.)

Free-Range Eggs

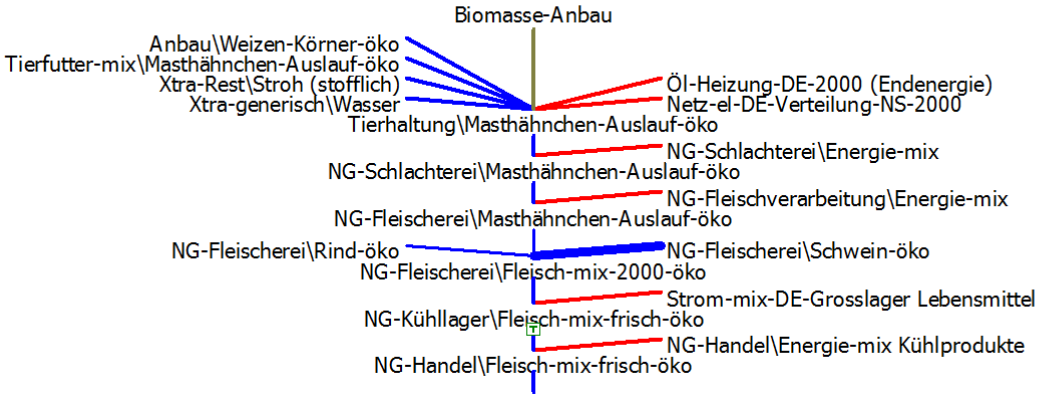


FREE-RANGE EGGS	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
tierhaltung\legehennen-freilandhaltung/ei	5,050364	3,006009	100,00	100,00		
ng-kühllager\eier-freilandhaltung	5,06597	3,021623	100,00	100,00	0,02	0,02
ng-handel\eier-freilandhaltung-00	5,42341	3,378206	100,00	100,00	0,36	0,36

Fresh Mixed Meat

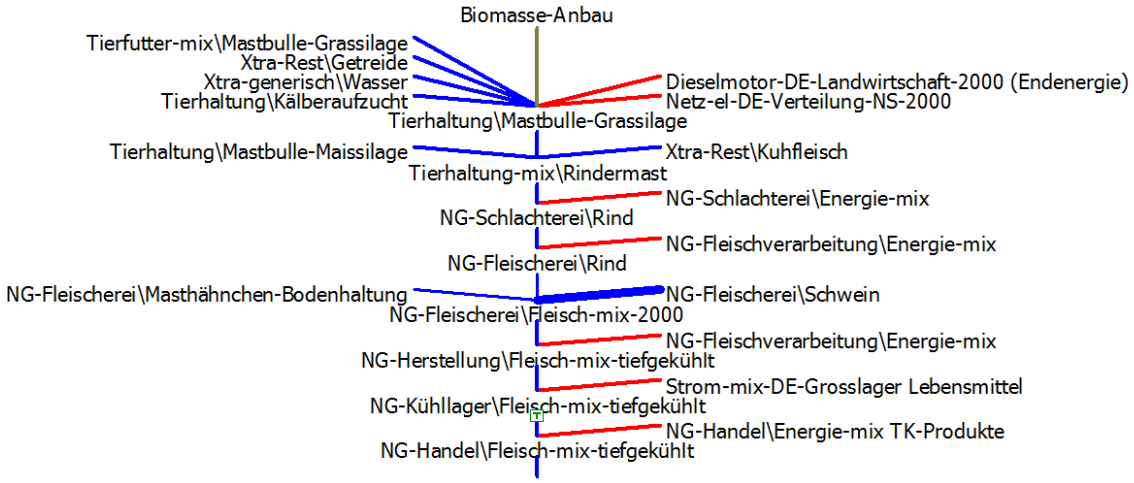


MEAT-FRESH-MIXED	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
tierhaltung\mastbulle-grassilage	4,565294		100,00			
tierhaltung-mix\rindermast	4,256454	3,607313	na	100,00	-0,31	3,61
ng-schlachterei\rind	9,360785	5,839155	50,00	70,00	5,10	2,23
ng-fleischerei\rind	14,34322	9,896927	67,00	59,00	4,98	4,06
ng-fleischerei\fleisch-mix-2000	9,931304	6,729836	na	na	-4,41	-3,17
ng-kühllager\fleisch-frisch-mix	9,947075	6,745589	100,00	100,00	0,02	0,02
ng-handel\fleisch-mix-frisch-00	10,30368	7,102176	100,00	100,00	0,36	0,36



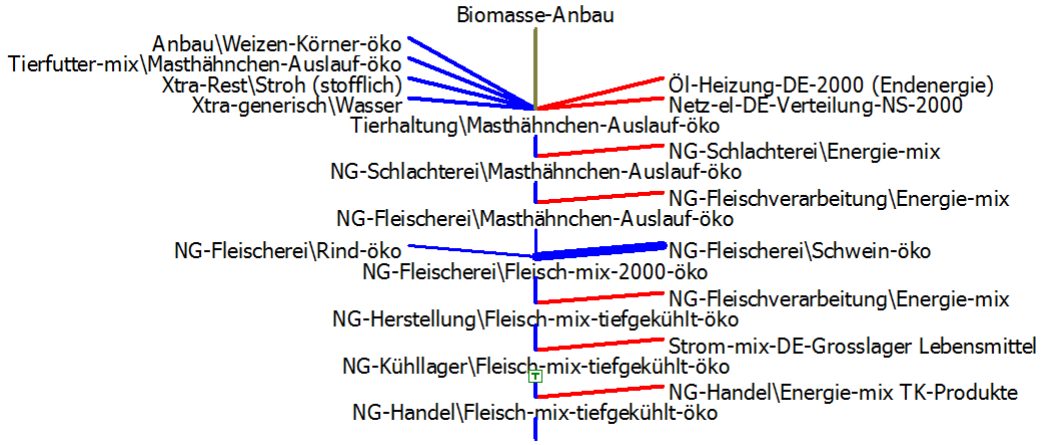
SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org	**MEAT-FRESH-MIXED**
4,565294		100,00				
4,256454	3,607313	na	100,00	-0,31		tierhaltung\masthänchen-auslauf-öko
9,360785	5,839155	50,00	70,00	5,10	2,23	ng-schlachterei\masthänchen-auslauf-öko
14,34322	9,896927	67,00	59,00	4,98	4,06	ng-fleischerei\masthänchen-auslauf-öko
9,931304	6,729836	na	na	-4,41	-3,17	ng-fleischerei\fleisch-mix-2000-öko
9,947075	6,745589	100,00	100,00	0,02	0,02	ng-kühllager\fleisch-mix-frisch-öko
10,30368	7,102176	100,00	100,00	0,36	0,36	ng-handel\fleisch-mix-frisch-öko-00

Frozen Mixed Meat



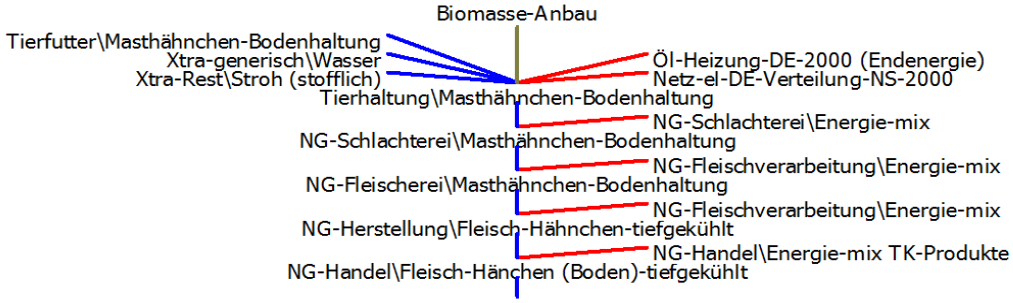
MEAT-MIXED-FROZEN	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
tierhaltung\mastbulle-grassilage	4,565294		100,00			
tierhaltung-mix\rindermast	4,256454	3,607313	na	100,00	-0,31	
ng-schlachterei\rind	9,360785	5,839155	50,00	70,00	5,10	2,23
ng-fleischerei\rind	14,34322	9,896927	67,00	59,00	4,98	4,06
ng-fleischerei\fleisch-mix-2000	9,931304	6,729836	na	na	-4,41	-3,17
ng-herstellung\fleisch-mix-tg	13,00345	9,807201	100,00	100,00	3,07	3,08
ng-kühllager\fleisch-mix-tg	13,18085	9,983612	100,00	100,00	0,18	0,18

ng-handel\fleisch-mix-tg-00	13,32113	10,12387	100,00	100,00	0,14	0,14



SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org	**MEAT-MIXED-FROZEN**
4,565294		100,00				
4,256454	3,607313	na	100,00	-0,31		tierhaltung\masthänchen-auslauf-öko
9,360785	5,839155	50,00	70,00	5,10	2,23	ng-schlachterei\masthänchen-auslauf-öko
14,34322	9,896927	67,00	59,00	4,98	4,06	ng-fleischerei\masthänchen-auslauf-öko
9,931304	6,729836	na	na	-4,41	-3,17	ng-fleischerei\fleisch-mix-2000-öko
13,00345	9,807201	100,00	100,00	3,07	3,08	ng-herstellung\fleisch-mix-tg-öko
13,18085	9,983612	100,00	100,00	0,18	0,18	ng-kühllager\fleisch-mix-tg-öko
13,32113	10,12387	100,00	100,00	0,14	0,14	ng-handel\fleisch-mix-tg-öko-00

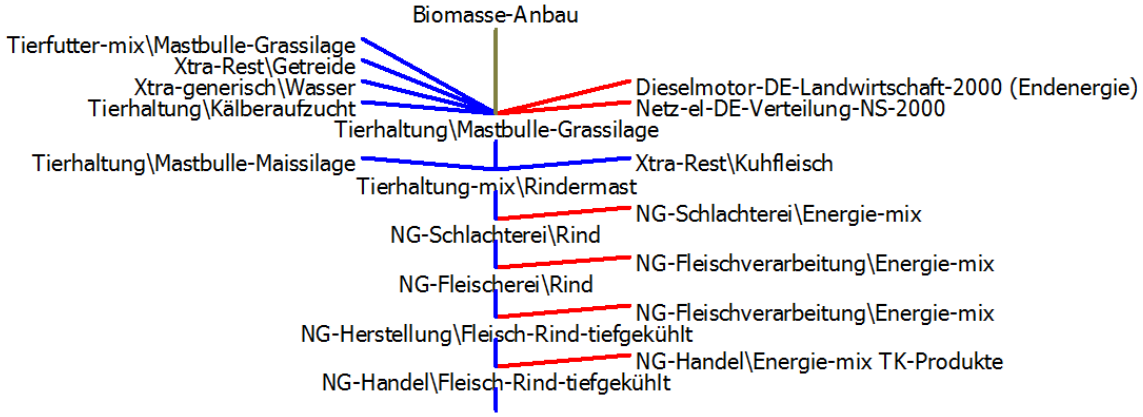
Frozen Chicken



CHICKEN	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
Tierhaltung\masthänchen*	4,475247	3,607313	100,00	100,00		
ng-schlachterei\masthänchen	7,07936	5,839155	70,00	70,00	2,60	2,23
ng-fleischerei\masthänchen	11,95578	9,896927	59,00	59,00	4,88	4,06
ng-herstellung\fleisch-hänchen-tg	15,06786	12,96824	100,00	100,00	3,11	3,07
ng-handel\fleisch-hänchen-tg	16,20485	14,10612	100,00	100,00	1,14	1,14

*-boden (conv.) / -auslauf (org.)

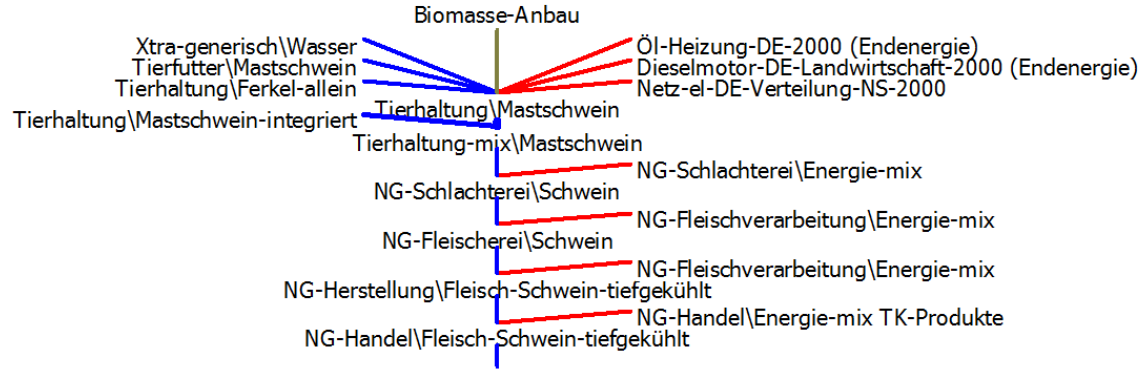
Frozen Beef



MEAT-BEEF-FROZEN	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
tierhaltung\ * "	4,665686	1,962108	100,00	100,00		
tierhaltung-mix\rindermast	4,345704	1,502402	na	na	-0,32	-0,46
ng-schlachterei\rind	9,609919	3,922756	50,00	50,00	5,26	2,42
ng-fleischerei\rind	14,34322	5,854916	67,00	67,00	4,73	1,93
ng-herstellung\fleisch-rind-tg	17,42062	8,92605	100,00	100,00	3,08	3,07
ng-handel\fleisch-rind-tg	18,55912	10,06633	100,00	100,00	1,14	1,14

*-mastbulle grassilage (conv.) / " –mastochse von milchkuh-öko (org.)

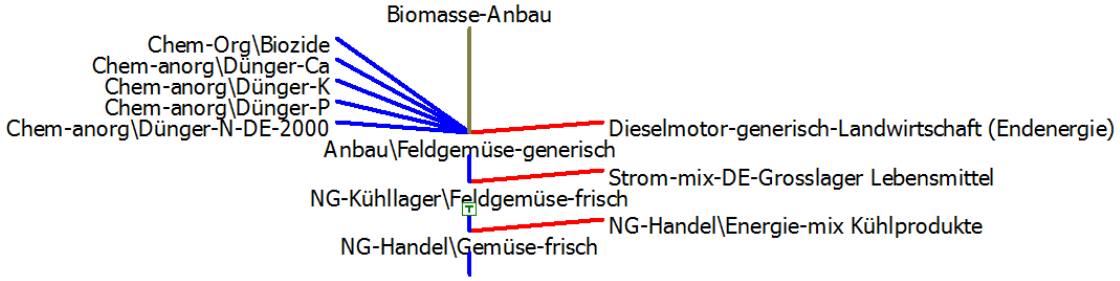
Frozen Pork



MEAT-PORK-FROZEN	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
tierhaltung\mastschwein	4,826879	3,228438	100,00	100,00		
tierhaltug-mix\mastschwein*	4,64369		na	na	-0,18	
ng-schlachterei\schwein	6,723062	4,952858	80,00	80,00	2,08	1,72
ng-fleischerei\schwein	8,403839	6,191097	80,00	80,00	1,68	1,24
ng-herstellung\fleisch-schwein-tg	11,48123	9,267738	100,00	100,00	3,08	3,08
ng-handel\fleisch-schwein-tg	12,62012	10,40499	100,00	100,00	1,14	1,14

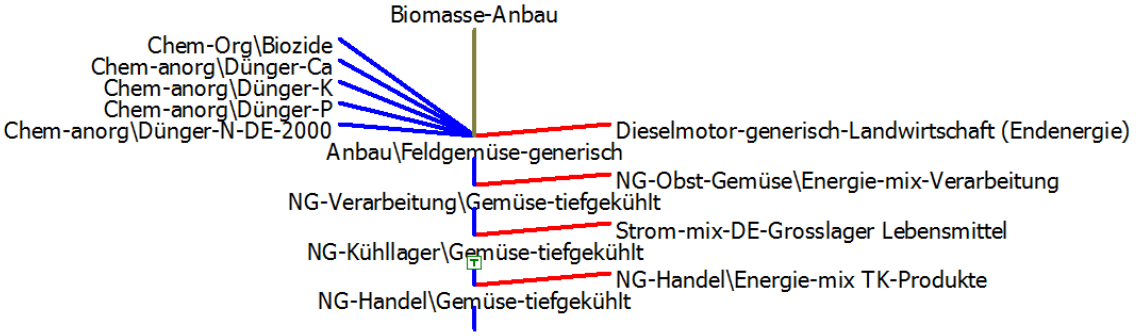
* not found in the organic process chain

Fresh Vegetables



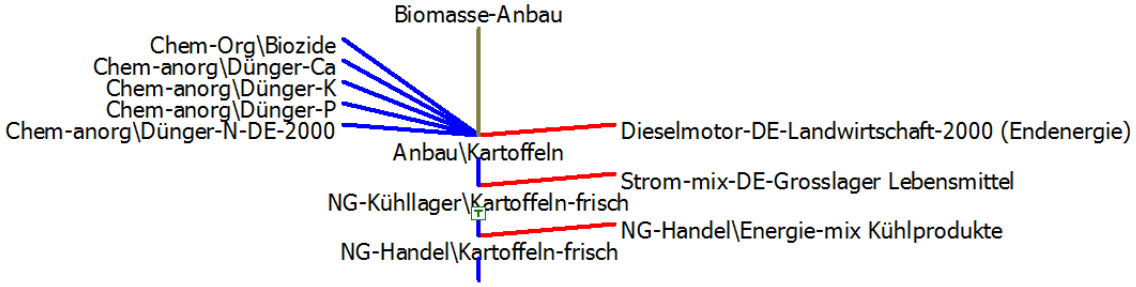
VEGETABLES-FRESH	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
anbau\feldgemüse-generisch	8,02E-02	5,49E-02	97,00	100,00		
ng-kühllager\feldgemüse-frisch	3,18E-01	2,92E-01	100,00	100,00	0,24	0,24
ng-handel\gemüse-frisch-00	4,97E-01	4,71E-01	100,00	100,00	0,18	0,18

Frozen Vegetables



VEGETABLES-FROZEN	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
anbau\feldgemüse-generisch	8,02E-02	5,49E-02	97,00	100,00		
ng-verarbeitung\gemüse-tg	8,32E-01	7,90E-01	62,00	62,00	0,75	0,73
ng-kühllager\gemüse-tg	1,363739	1,321914	100,00	100,00	0,53	0,53
ng-handel\gemüse-tg-00	1,503955	1,462184	100,00	100,00	0,14	0,14

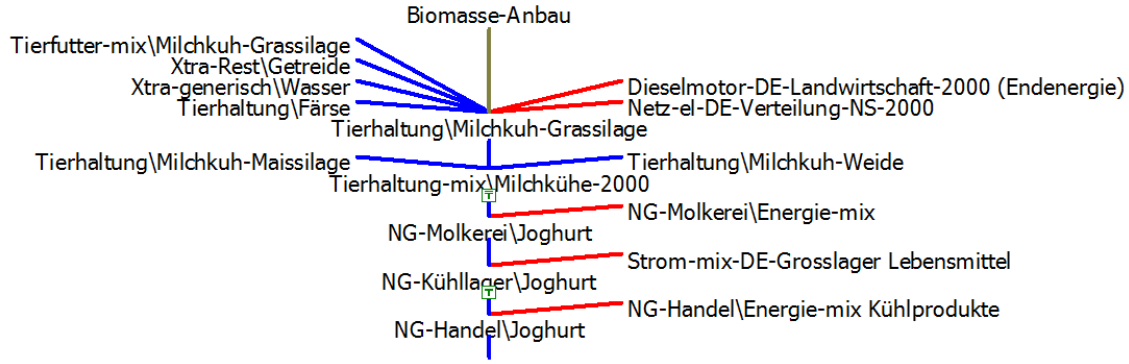
Fresh Potatoes



POTATOES-FRESH	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
anbau\kartoffeln	1,99E-01	1,17E-01	97,00	98,50		
ng-kühllager\kartoffeln-frisch	4,38E-01	3,55E-01	100,00	100,00	0,24	0,24

ng-handel\kartoffeln-frisch-00	6,15E-01	5,33E-01	100,00	100,00	0,18	0,18

Joghurt

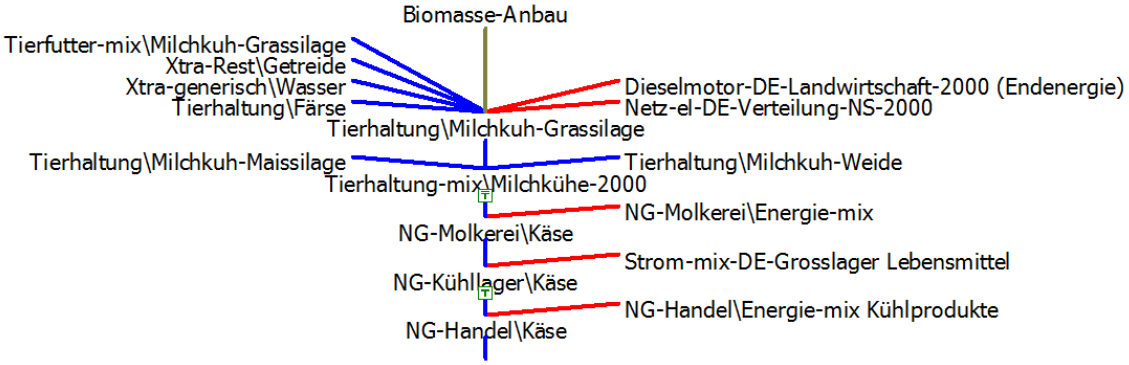


JOGHURT	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
tierhaltung\milchkuh* "	7,97E-01	4,73E-01	100,00	100,00		
tierhaltung-mix\milchkühe-2000	9,01E-01	3,73E-01	na	na	0,10	-0,10
ng-molkerei\joghurt	1,234038	7,81E-01	116,00	116,00	0,33	0,41
ng-kühllager\joghurt	1,249777	7,97E-01	100,00	100,00	0,02	0,02
ng-handel\joghurt	1,644593	1,19E+00	100,00	100,00	0,39	0,39

*-grassilage (conv.) / " –öko (org.)

Values for no Transport: 1,2571043 (conv.) / 729,86e-3 (org.)

Cheese

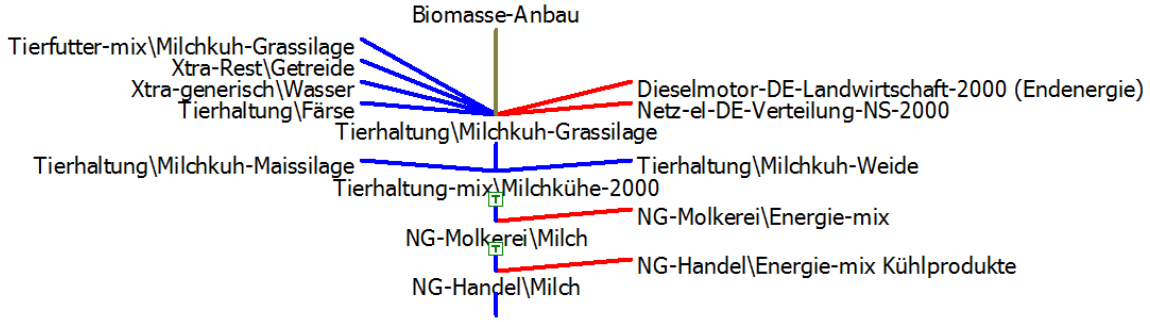


CHEESE	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
tierhaltung\milchkuh* "	7,97E-01	4,73E-01	100,00	100,00		
tierhaltung-mix\milchkühe-2000	9,01E-01	3,73E-01	na	na	0,10	-0,10
ng-molkerei\käse	7,728999	4,217154	15,00	15,00	6,83	3,84
ng-kühllager\käse	7,844011	4,332141	100,00	100,00	0,12	0,11
ng-handel\käse	8,606097	5,089805	100,00	100,00	0,76	0,76

*-grassilage (conv.) / " –öko (org.)

Values for no Transport: 1,2571043 (conv.) / 729,86e-3 (org.)

Milk

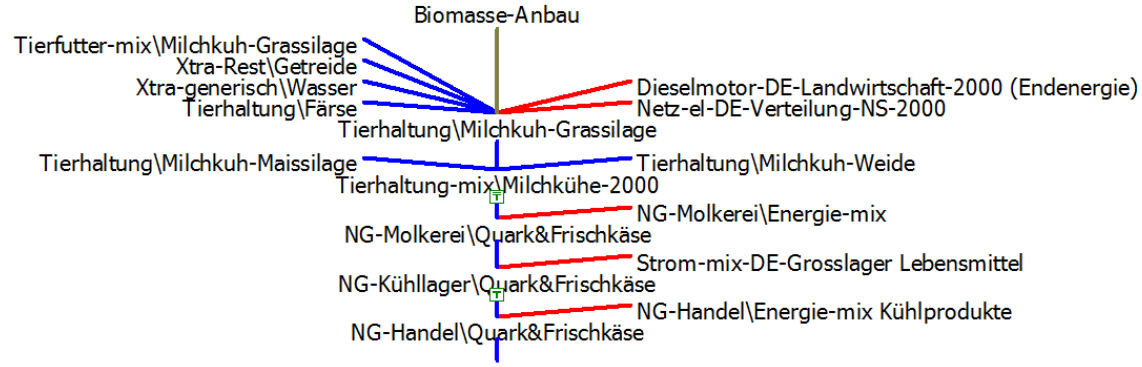


MILK	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
tierhaltung\milchkuh* "	7,97E-01	4,73E-01	100,00	100,00		
tierhaltung-mix\milchkühe-2000	9,01E-01	3,73E-01	na	na	0,10	-0,10
ng-molkerei\milch	7,83E-01	4,25E-01	147,00	147,00	-0,12	0,05
ng-handel\milch	1,176844	8,19E-01	100,00	100,00	0,39	0,39

*-grassilage (conv.) / " –öko (org.)

Values for no Transport: 1,2571043 (conv.) / 729,86e-3 (org.)

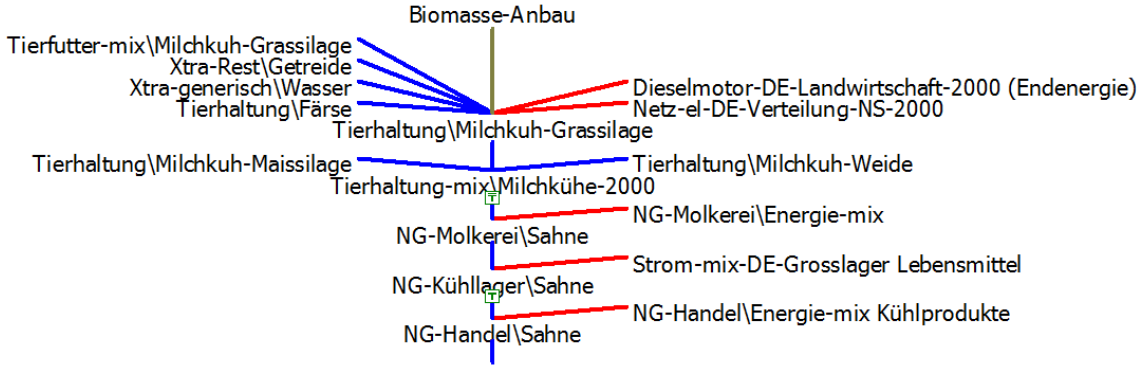
Curd and Fresh Cheese



FRESH CHEESE & CURD	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
tierhaltung\milchkuh* "	7,97E-01	4,73E-01	100,00	100,00		
tierhaltung-mix\milchkühe-2000	9,01E-01	3,73E-01	na	na	0,10	-0,10
ng-molkerei\quark&frischkäse	1,593723	8,07E-01	67,00	67,00	0,69	0,43
ng-kühllager\quark&frischkäse	1,634804	8,75E-01	100,00	100,00	0,04	0,07
ng-handel\quark&frischkäse	2,027041	1,242864	100,00	100,00	0,39	0,37

*-grassilage (conv.) / " –öko (org.)

Cream

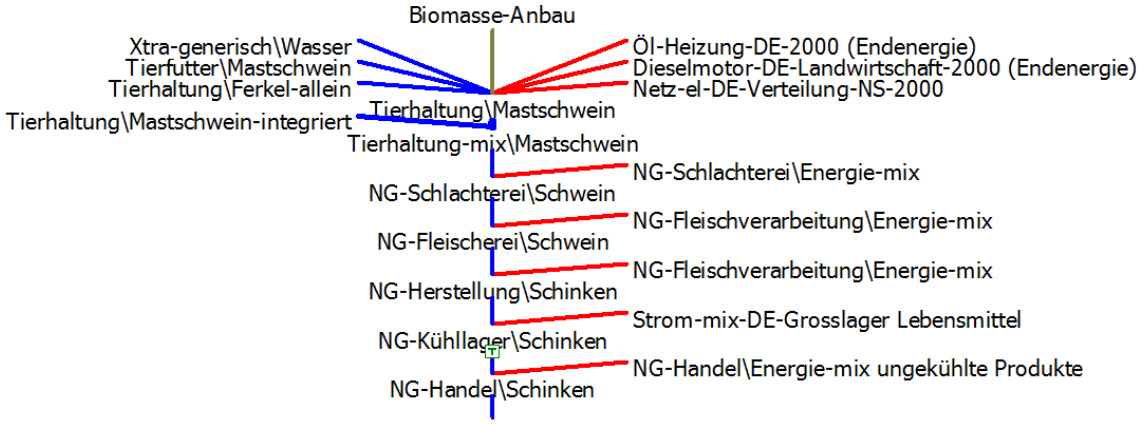


CREAM	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
tierhaltung\milchkuh* "	7,97E-01	4,73E-01	100,00	100,00		
tierhaltung-mix\milchkühe-2000	9,01E-01	3,73E-01	na	na	0,10	-0,10
ng-molkerei\sahne	6,198145	2,902007	16,00	16,00	5,30	2,53
ng-kühllager\sahne	6,239197	2,943061	100,00	100,00	0,04	0,04
ng-handel\sahne	6,632693	3,337694	100,00	100,00	0,39	0,39

*-grassilage (conv.) / " –öko (org.)

Values for no Transport: 1,2571043 (conv.) / 729,86e-3 (org.)

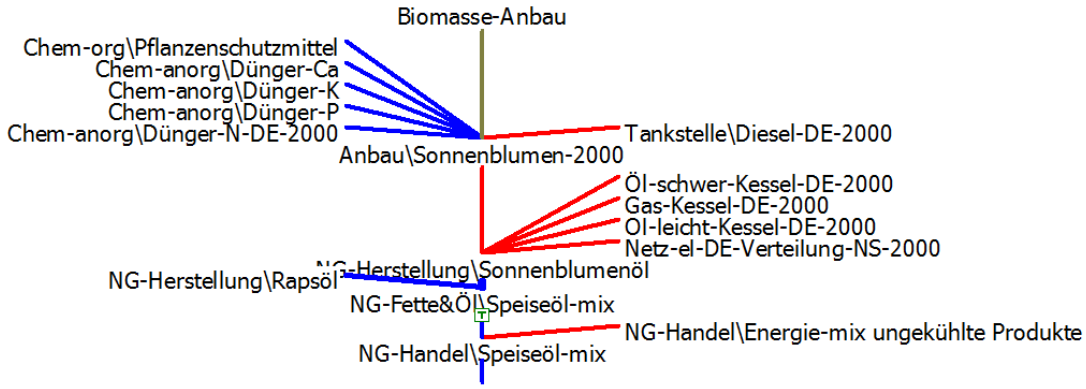
Ham incl. Gammon



HAM	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
tierhaltung\mastschwein	4,826879	3,228438	100,00	100,00		
tierhaltug-mix\mastschwein*	4,64369		na		-0,18	
ng-schlachterei\schwein	6,723062	4,952858	80,00	80,00	2,08	1,72
ng-fleischerei\schwein	8,403839	6,191097	80,00	80,00	1,68	1,24
ng-herstellung\schinken	12,41725	9,465637	75,00	75,00	4,01	3,27
ng-kühllager\schinken	12,45011	9,498493	100,00	100,00	0,03	0,03
ng-handel\schinken	13,03717	10,08493	100,00	100,00	0,59	0,59

* not found in the organic process chain

Cooking Oil

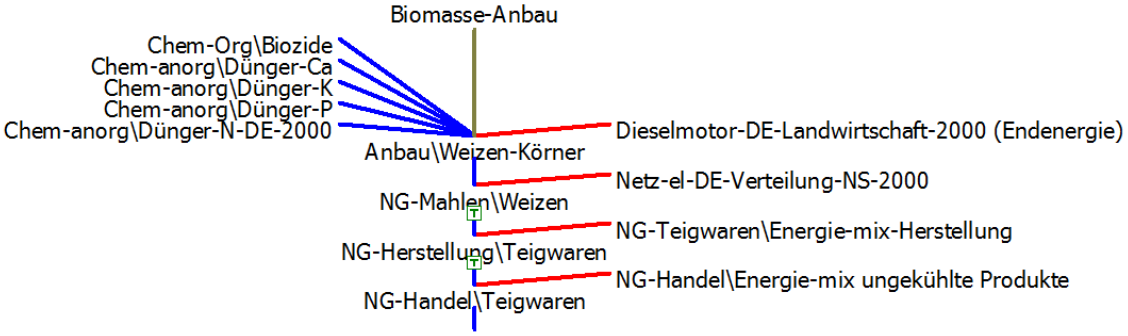


COOKING OIL	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
anbau\sonnenblumen-2000*	1,139823	1,160247	100,00	100,00		
ng-herstellung\sonnenblumenöl	9,35678	9,508685	40,00	40,00	8,22	8,35
ng-fette&öl\speiseöl-mix	9,453959	9,411316	na	na	0,10	-0,10
ng-handel\speiseöl-mix	10,03973	9,998058	100,00	100,00	0,59	0,59

* anbau\sonnenblumen-de-öko-2000

Values for no Transport: 9,9644204 (conv.) / 9,9216133 (org.)

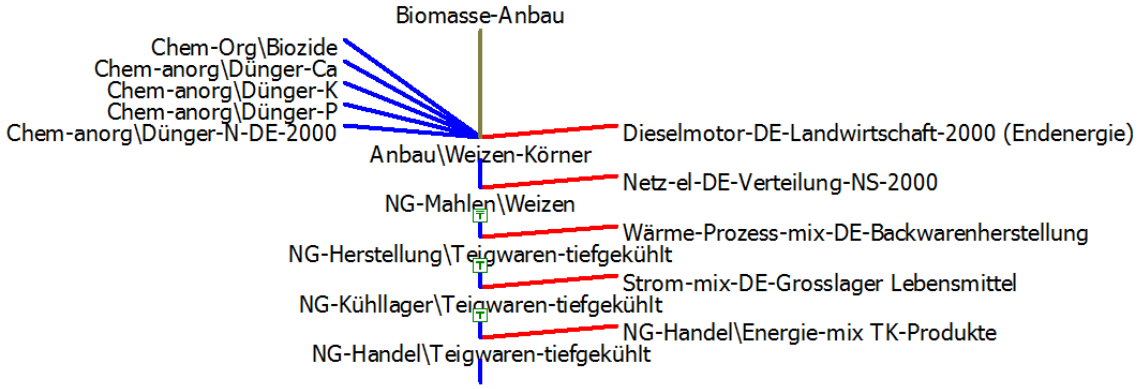
Pasta



PASTA	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
anbau\weizen-körner	7,69E-01	6,20E-01	97,50	95,20		
ng-mahlen\weizen	1,220198	1,028792	78,00	78,00	0,45	0,41
ng-herstellung\teigwaren	2,31211	2,123162	121,00	121,00	1,09	1,09
ng-handel\teigwaren	2,899184	2,709758	100,00	100,00	0,59	0,59

Values for no Transport: 1,7302951 (conv.) / 2,6335460 (org.)

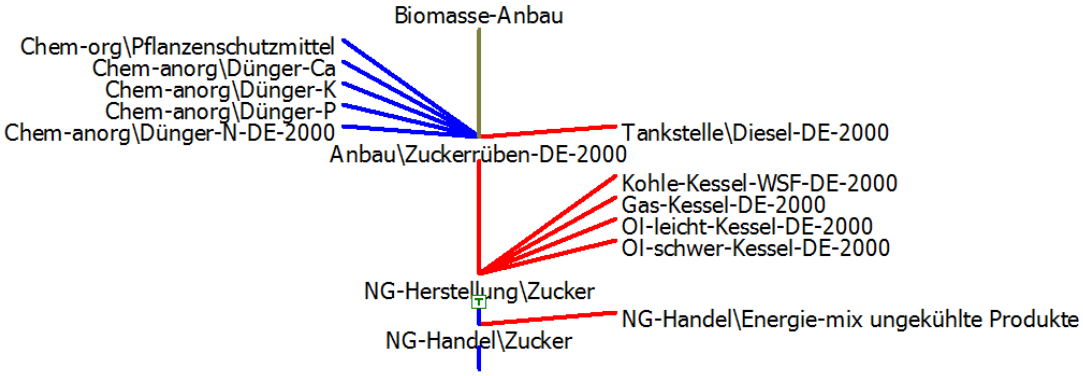
Frozen Pasta



PASTA-FROZEN	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
anbau\weizen-körner	7,69E-01	6,20E-01	97,50	95,20		
ng-mahlen\weizen	1,220198	1,028792	78,00	78,00	0,45	0,41
ng-herstellung\teigwaren-tg	1,502199	1,378498	154,00	154,00	0,28	0,35
ng-kühllager\teigwaren-tg	1,746259	1,622548	100,00	100,00	0,24	0,24
ng-handel\teigwaren-tg	1,963019	1,839385	100,00	100,00	0,22	0,22

Values for no Transport: 1,3604326 (conv.) / 1,1690445 (org.)

Sugar



SUGAR	SUM-KEA	SUM-KEA	NuGr % (nö)	NuGr % (ö)	Δ con	Δ org
anbau\zuckerrüben-de-2000	1,156983	7,11E-02	100,00	100,00		
ng-herstellung\zucker	7,81325	4,146101	14,70	14,70	6,66	4,07
ng-handel\zucker	8,400153	4,731559	100,00	100,00	0,59	0,59

Values for no Transport: 8,3238444 (conv.) / 4,6547384 (org.)

Appendix B: Survey

Survey

1) What is your age?
    - 20-25
    - 26-30
    - 31-35
    - >36
2) Where do you currently live?
3) Have you heard of the term “carbon footprint”? Yes / No
4) Have you heard the term “embodied energy”? Yes / No
5) Are you aware of the difference between organically and conventionally farmed foods? Yes / No
6) When you shop, do you pay attention to the place of origin of your food?
    - Bread Yes / No
    - Butter Yes / No
    - Eggs Yes / No
    - Frozen Chicken Yes / No
    - Fresh Meat Yes / No
    - Frozen Meat Yes / No
    - Fresh Vegetables Yes / No
    - Frozen Vegetables Yes / No
    - Joghurt Yes / No
    - Milk Yes / No
    - Pasta Yes / No
    - Sugar Yes / No
    - Cooking Oil Yes / No

7) Where do you buy your food?
    - Farm
    - Market
    - Local Store
    - Supermarkte
8) How far do you travel to buy your food?
    - 0-1km
    - 2-5km
    - >5km
9) Have you ever considered how your food is transported? Yes / No
10) Which mode of transport do you think is the most energy intensive? (1 most; 3 least)

	1	2	3	No idea
Plane				
Ship				
Lorry				