Soy Milk

- an attributional Life Cycle Assessment examining the potential environmental impact of soy milk.
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1. Background

Regular milk contains significant amounts of saturated fat, protein and calcium. For millennia the milk from cows has been processed into other products and milk in all different shapes is very popular. Sweden is the second largest consumer of milk measured per capita.

Soy milk is a high protein, iron-rich milk-like product produced from soybeans. It resembles regular milk in appearance but is higher in protein and iron content and is cholesterol-free, low fat and low sodium [1]. Soy milk is a popular alternative to regular milk among lacto-intolerant, milk-allergic and vegans. It is, however, also associated with the deforestation of the world’s rainforests.

The Chinese have been cultivating soybeans for thousands of years and many believe that they also have been making soy milk for centuries. By the sixth century soybeans made their way to Japan and by the seventeenth century they came to Europe. During the American Civil War, soldiers used soybeans as a substitute for coffee beans and were thus making their own soy beverage. In the nineteenth century soy beverages also became available in Europe. In the 1970s the interest in soy milk soared and throughout the twentieth century soybeans are grown in 29 states in the U.S.A, where they are the second largest cash crop.

The world’s second largest producer of soybeans is Brazil and stood for over 25% of the world’s total production in 2007 [2]. This is from where many producers of soy milk choose to import their soybeans, one amongst them being Alpro, the producer chosen as a “reference” producer for this study.

2. Goal and scope definition

In this section, the goal and definition of the study, its functional unit and system boundaries are defined. Additionally, the assumptions and limitations of the study, as well as the impact categories and use of impact assessment methods are explained.

2.1. Goal of the study

Soy milk has been a popular drink for a long time, but has in Sweden been an increasingly popular substitute for regular milk in later years. At the same time one can see a dropping consumption of regular milk. Therefore, this attributional study has been conducted to analyze the potential environmental impact of soy milk and to pinpoint where in the life cycle of soy milk there is room for improvements, seen from an environmental point of view. The study is intended for the public as a source of information on how soy milk may affect natural resources. Additionally, the study roughly compares the results found in this study with results from external LCA studies on regular milk to provide some perspective on the impact results.
2.2. Functional unit

The functional unit is a quantified measure of the performance of the functional outputs of the product system. The functional unit for this study is one liter of drink, which is the regular amount of one package of regular milk or soy milk. The reason for the choice of one liter of drink, instead of one package is due to the differences in the packaging requirements of the two drinks.

2.3. System boundaries

Geographical boundaries

The study is based on regular milk consumption and daily shopping habits in Stockholm, Sweden. This has a huge impact on how heavily the transportation of the soybeans to the production plants affects the overall flows of the analysis and should be considered when reviewing the results. The production of the soy milk is said to be in Belgium (where Alpro produce their milk), which also affects the transportation issues.

Loop-back

Some percentage of waste bean fiber from the soy milk production, called okara, is used for production of animal food. This is not included in the calculations.

Time boundaries

Because of the short life-span of the product, and because the project group assumes that no difference in drinking habits would come of a longer durability (“use”), no boundaries in time are set. However, there might be a boundary in the validity of the facts and data acquired for the calculations. One example is the yield of today’s soybean crops, which, due to constantly improving technology is estimated to increase massively in the coming years [3]. With increasing yield values, the data might become too uncertain over time and the project group estimates the validity of the data to be no more than a maximum of 5 years.

Equipment boundaries

In order for the study not to become too extensive, production of equipment needed for raw material extraction and production of the soy milk was not taken into consideration.

2.4. Assumptions and limitations

A number of assumptions have been made, and some limitations exist in the study. These are presented in the following section.

Assumptions

Transportation

All transportation has been idealized into three major parts; from farm to coast in Brazil, from the Brazilian coast to the production site in Belgium and from production site to retailers in Stockholm, Sweden. These distances were very roughly measured using online distance calculation tools, and are therefore not accurate [4].

According to the United States Department of Agriculture, long distance transports of soybeans in Brazil are made both using large lorries as well as trains [5]. Within Brazil,
transport was therefore simplified to 50% by lorry and 50% by train (see section 3.2. for details on type of lorry and train). For transportation across the Atlantic Ocean, a transoceanic freight ship with a load capacity of approximately $133 \times 10^3$ tons of soybeans was used. Finally, transportation from Belgium to Sweden was made using a smaller lorry than in Brazil (for details on type se section 3.2.). All different vessels for transportation were assumed to be loaded with their respective maximum capacities.

Due to the extremely small distances compared to the inter-oceanic freights, transports between coast and production site were omitted and shopping of milk in Stockholm was assumed to be made on foot.

**Cultivation and production**

All soybeans used in this study are assumed to have come from Brazil, even though many soy milk manufacturers sometimes choose to mix beans from different countries. While Brazil is the second largest producer of soybeans today, there exists production in other countries, such as the USA, Belgium and China. The reason for the choice of Brazil in this study is, as earlier mentioned, the fact that the producer of the reference product (one liter of Alpro soy milk without any additions) for the study states that they use soybeans coming only from Brazil.

As described in section 3.2, there are a number of different processes included in the production of soy milk from soybeans. However, due to the difficulties in finding raw data for different processes, one single energy value was assigned to all processes combined. This value is based on data from one single producer of soy milk in India\(^1\). The energy is declared to have been produced from L.P.G (Liquefied Petroleum Gas). The value was then directly converted in the Life Cycle Assessment software SimaPro to a mix of electricity from different sources in Belgium + import, since no data was available from the producer regarding the type of energy used in the Belgian production facility [6]. The fact that only one total value was given results in difficulties in finding individual hotspots in the production process.

**Limitations**

**Waste management**

The waste management process for the life cycle of the soy milk is not complete; it contains only the waste process for the packaging of the soy milk. All milk is assumed to be consumed and no consideration has been made for potential energy costs due to leftover liquid (sewage load).

**Data for comparison**

To compare the impact category data acquired for the soy milk with data for regular milk, several external LCAs were examined. However, none of the studies matched impact categories with the different categories available in SimaPro. Additionally, data given in the external LCAs of regular milk were not very detailed (do not include explanations of processes) which means that some comparisons are difficult to make.

\(^1\) The producer wishes to remain anonymous
2.5. Impact categories and impact assessment methods

To have the possibility to compare the potential environmental impacts of both drinks an LCA on soy milk has been made and then compared to existing data from different LCA:s of regular milk. To be able to fairly compare the two drinks, the same impact categories which have been used in the study of regular milk have been used for the study of soy milk.

The following six impact categories were used in both studies*:

- Land use
- Fossil energy use (or energy use)
- Eutrophication
- Acidification
- Climate change
- Ozone layer depletion

3. Life cycle inventory analysis

In the following section, flowcharts for the life cycle process as well as the production process are presented. Figure 1 displays the process flow chart. Additionally, the data collection is explained.

3.1. Process flow chart

![Process flow chart of soy milk.](image)

Figure 1. Process flow chart of soy milk.
3.2. Production of soy milk

In this section, the manufacturing process for soy milk is explained and visualized in Figure 2.

Manufacturing process of soy milk

To create soy milk, the only ingredients necessary are soybeans and water. The whole manufacturing process for soy milk is shown in Figure 3. When the soybeans are harvested they are cleaned in a grain elevator or bin. The manufacturing process starts with de-hulling the beans. This is done by steaming the soybeans which makes them split in half. Then the hulls are removed with a vacuum pump. A specific enzyme must be invalidated by cooking in high pressure, water and high temperature, in order for the beans to be digestible for humans.

Now the soybeans are ready for the first grinder. The beans are roughly grinded and water is added. Then the beans are put through a fine grinder the further pulverize the beans. The product now consists of a hot slurry and to extract the tiny bits of beans that is still left in the slurry a centrifuge separate the soy milk from the bean fibers. The waste bean fiber, okara, is used for production of animal food.

The soy milk is then placed in large tanks and flavors, vitamins and sugars may be added in this step. The soy milk in this comparative LCA is being conducted on natural soy milk without any accessory food factor. The next step is to sterilize the soy milk. This is done with pressure and very hot temperatures within a vacuum. It is very important that this is done in an aseptic environment to make sure the soy milk is not introduced to any bacteria. All the following steps must be aseptic until packaging.

To prevent fat particles from separating the liquid is homogenized. After this the soy milk is cooled down to room temperature by passing close by cold plates. Now the soy milk is stored in aseptic tanks until packaged in cardboard packages [6].
3.3. Data collection

Data collection has been a major difficulty for this study, as most manufacturers of soy milk have not been able to share their production data with the project group. Many manufacturers from several different countries have been contacted but only one manufacturer (from India) replied, giving the project group the total energy consumption for the manufacturing process seen in Figure 3. The data has been converted from energy from combustion of L.P.G (Liquefied Petroleum Gas) into the corresponding amount of MJ of electricity mix (Belgium + import). From this data, assumptions have been made concerning the energy data for the manufacturing in Belgium, where Alpro declare that they have their soy milk production.

The data taken from SimaPro 7 is shown in Table 1. Some data from SimaPro has been modified to fit the data from the manufacturer from India. The modified processes are shown as italic in Table 1.
Table 1. Data and databases used in this study. Modified processes are in italic.

<table>
<thead>
<tr>
<th>Assembly</th>
<th>Material/process</th>
<th>Amount*</th>
<th>Database</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soy milk manufacturing</td>
<td>Electricity mix B + Import S</td>
<td>0,34 MJ (1)</td>
<td>ETH-ESU 96 System process</td>
</tr>
<tr>
<td>Soy milk manufacturing – Soybeans</td>
<td>Soybeans, at farm/BR U LCA 04</td>
<td>0,154 kg (2)</td>
<td>Ecoinvent system process</td>
</tr>
<tr>
<td></td>
<td>Truck 40t ETH S</td>
<td>0,196 tkm (3)</td>
<td>ETH-ESU 96 System process</td>
</tr>
<tr>
<td></td>
<td>Infra freight train S</td>
<td>1,956 tkm (4)</td>
<td>ETH-ESU 96 System process</td>
</tr>
<tr>
<td></td>
<td>Transport, transoceanic freight ship/OCE S</td>
<td>1,230 tkm (5)</td>
<td>Ecoinvent system process</td>
</tr>
<tr>
<td>Soy milk manufacturing – Water for milk</td>
<td>Tap water, at user/CH S</td>
<td>0,928 kg (6)</td>
<td>Ecoinvent system process</td>
</tr>
<tr>
<td>Packaging</td>
<td>Production of liquid packaging board containers, at plant/RER U LCA04</td>
<td>27 g (7)</td>
<td>Ecoinvent system process</td>
</tr>
<tr>
<td>“Use-phase” – Cooling for storage at home</td>
<td>Refrigerator, small, B</td>
<td>0,288 l*day (8)</td>
<td>LCA Food DK</td>
</tr>
<tr>
<td></td>
<td>Refrigerator, big, B</td>
<td>0,863 l*day (9)</td>
<td>LCA Food DK</td>
</tr>
<tr>
<td>“Use-phase” – Cooling for storage at retail</td>
<td>Retail (cooling counter, large store)</td>
<td>0,5 kg (10)</td>
<td>LCA Food DK</td>
</tr>
<tr>
<td>“Use-phase” – Transport to retail</td>
<td>Truck 28t ETH S</td>
<td>0,205 tkm (11)</td>
<td>ETH-ESU 96 System process</td>
</tr>
</tbody>
</table>

(1) Energy use for 1 liter of milk, according to production in India. Converted from energy from combustion of L.P.G (Liquefied Petroleum Gas) into the corresponding amount of MJ of electricity mix.
(2) The amount of soybeans needed for one liter of soy milk, according to the Indian production plant.
(3) Transportation from farm to coast in Brazil, for the equivalent amount of beans for a half liter of soy milk. Approximated that 50% of the beans, for one liter of soy milk, is conveyed by rail and 50% by truck.
(4) Transportation from farm to coast in Brazil, for the equivalent amount of beans for a half liter of soy milk. Approximated that 50% of the beans, for one liter of soy milk, is conveyed by rail and 50% by truck.
(5) Transportation from coast in Brazil to production in Belgium, for the equivalent amount of beans for one liter of soy milk.
(6) The amount of water to produce 1kg milk. 1 liter of soy milk is approximately the same as 1 kg soy milk.
(7) For one package, according to data from Tetra Pak. Total weight of package and individual material percentages modified.
(8) Based on the daily consumption for household with 1 person. [7]
(9) Based on the daily consumption for a family household with 3 persons. [7]
(10) A survey shows that approximately 50% of the retails store their soy milk cooled. Therefore it’s counted on a half package in cooling counter.
(11) Transportation from production in Belgium to retail in Stockholm, for one liter of soy milk.

* All transportation amounts were calculated by multiplying the weight for the amount of soybeans needed for one liter of drink with the transport distance in km
Table 2. Data and databases used in this study.

<table>
<thead>
<tr>
<th>Disposal scenario</th>
<th>Process/waste scenario</th>
<th>Amount*</th>
<th>Database</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging - Container</td>
<td>Transport, lorry 3.5-16t, fleet average/RER U</td>
<td>0.00135 tkm</td>
<td>Ecoinvent system process</td>
</tr>
<tr>
<td></td>
<td>Disposal, aluminum, 0% water, to</td>
<td>1.35 g</td>
<td>Ecoinvent system process</td>
</tr>
<tr>
<td></td>
<td>municipal incineration/CH S</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disposal, polyethylen, 0.4% water, to</td>
<td>6.75 g</td>
<td>Ecoinvent system process</td>
</tr>
<tr>
<td></td>
<td>municipal incineration/CH S</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disposal, packaging cardboard, 19.6% water,</td>
<td>5.67 g</td>
<td>Ecoinvent system process</td>
</tr>
<tr>
<td></td>
<td>to municipal incineration/CH S</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recycling, cardboard/RER S</td>
<td>13.23 g</td>
<td>Ecoinvent system process</td>
</tr>
<tr>
<td>Packaging – Lid</td>
<td>Transport, lorry 3.5-16t, fleet average/RER U</td>
<td>0.00015 tkm</td>
<td>Ecoinvent system process</td>
</tr>
<tr>
<td></td>
<td>Recycling PE/RER S</td>
<td>3 g</td>
<td>Ecoinvent system process</td>
</tr>
</tbody>
</table>

(1) Transportation from recycling station to municipal incineration or recycling.
(2) The amount of aluminium in one package, according to data from Tetra Pak. Approximated that 100% of the aluminium is incinerated.
(3) The amount of polyethylene in one package, according to data from Tetra Pak. Approximated that 100% of the polyethylene is incinerated.
(4) The amount of cardboard in one package, according to data from Tetra Pak. Approximated that 30% of the cardboard is incinerated. The ratio 30% incineration of cardboard comes from information on TetraPak’s homepage.
(5) The amount of cardboard in one package, according to data from Tetra Pak. Approximated that 70% of the cardboard is recycled. The ratio 70% recycling of cardboard comes from information on TetraPak’s homepage.
(6) Transportation from recycling station to municipal incineration or recycling.
(7) The approximated amount of polyethylene in one lid. Approximated that 100% of the polyethylene is recycled – this is because the lid is assumed to be taken off and recycled separately.

* All transportation amounts were calculated by multiplying the weight for the package and lid with the transport distance in km

4. Life cycle interpretations

This section presents the results as well as a discussion and the conclusions drawn from the study.

4.1. Results

Below, the results of the different impact assessments, as well as the summarized results are presented.

Land use

The cultivation of soybeans in Brazil was found in the Ecoinvent database. The land used for the amount soybeans needed (0.15 kg) for one liter of soy milk is 0.59 m². This is based upon a
land yielding 2 544 kg/ha. According to the USDA the state of Maranhao is cultivating soybeans on an area of 300 000 ha [8]. It produced 700 000 tons in 2002/03. This land yields 2 300 kg/ha which means that 0.65 m is needed to grow soybeans for one package of soy milk. As technology develops the management of soybean is improving. The Amazon region is estimated to have potential to crop 3 600 kg/ha. This indicates the efficiency will rise and less area will be needed to produce the same amount of soybeans. But as this efficiency is not yet reached, the land use according to Ecoinvent is considered to be a good estimation for this study.

According to Cederberg et al 2004 conventional milk needs 1.5 m/kg [9]. The area from the farm is the biggest contributor to the land usage, but land usage for cow feeds are taken into consideration.

Since soybeans grow closely on plants, one square meter of plants can produce many soybeans. For milk, one cow can produce 8 000-9 000 liters of milk per year. A cow does need a bigger area than a plant does, and therefore the results are not very surprising.

Although the effects from different pesticides might have an impact on the land quality, they were not taken into consideration. A non-LCA discussion regarding the social value of farmland versus soybean cultivation could be interesting in this context.

**Acidification**

According to the EPD 2007 database, the acidification from soy milk production is 1.92 g SO\textsubscript{2} equivalents, as shown in Figure 4. This mainly comes from the soy milk manufacturing phase, which stands for almost 73% of the total acidification. The production of the package stands for 10% while the use phase contributes with 17%. Within the soy milk manufacturing, the processes connected to the cultivation of the soybeans and the transports contribute most to the acidification.
The acidification for the regular milk production is 10 g SO$_2$-equivalents [10]. The largest overall contribution comes from emissions from the dairy farm, and ammonia is the element that accounts for the main part of the total acidification.

**Eutrophication**

The soy milk contributes to eutrophication with 1,15 g PO$_4$- equivalents which can be converted into g NO$_3$- equivalents by using the generic EP factors (1 PO$_4$ = 0,1 NO$_3$) [11]. The largest contributor of NO$_3$-equivalents from soy milk is the soybean manufacturing. More than 85% of the eutrophication impact comes from the manufacturing of soy milk according to Figure 5. The production of the package and the use phase together stand for the remaining 15%.

*Figure 4. Acidification for soy milk*
Ordinary milk contributes to the eutrophication with 39 g NO3- equivalents. At the dairy farm the eutrophication is affected by emissions and leaching. The conventional farm feed production is the largest contributor [12].

**Fossil Energy Use**

For soy milk, the total energy in the life cycle, according to SimaPro, is 3,37 MJ. The largest part of this energy, 49%, comes from the manufacturing including the transports, followed by 26% for the package and 25% for the use phase. This is seen in Figure 6.
For the total life cycle of one liter of regular milk, data from two different sources were used and a mean value was calculated. This was done due to the very diverse results in the sources. Svensk Mjölk state that the fossil energy use is 3.9 MJ. Cederberg, on the other hand, states that it is as low as 2.6 MJ. The mean value, 3.25 MJ, was used in the results for this report. Of the total energy use, the farm production stands for nearly 60%, the manufacturing of the packaging for 15%, the use, burning, disposal and recycling of the packaging as well as transports in between these instances for the remaining 25%.

**Climate change**

Climate change expressed in global warming potential for soy milk is 215 g CO$_2$-equivalents, see Figure 7. The largest contribution to climate change from soy milk is the energy used in soy milk manufacturing. It stands for 60% of the total 58% of global warming potential coming from the soy milk manufacturing processes. The use phase contributes with 24% and the production of the package stand for the remaining 18% and nearly 4% goes back in the system from the recycling of the package, see Figure 7.
Agricultural activities are known to add to the global warming. According to the IPCC agriculture is one of three main causes for the increase of green house gases [13]. The farm in this study emits 900 g CO$_2$-equivalents per liter milk it produces. For conventional milk the contribution to global warming comes from, in descending order: Methane, Nitrous oxide and Carbon dioxide. Methane emissions originate in fermentation and manure management. Nitrous oxide comes directly from manure and soil. The carbon dioxide is emitted by production and transports.
Stratospheric ozone depletion

The soymilk has its largest contribution to ozone layer depletion in the production of the package phase with 60% of the total of $3.2 \times 10^{-7}$ kg CFC$_{11}$. Figure 8 shows the network tree for the stratospheric ozone depletion caused by soy milk and Figure 9 displays how much each phase of the life cycle contributes. There is no hotspot in the package production since this step consists of several processes with no large contribution alone.

![Network tree for stratospheric ozone depletion caused by soy milk](Figure 8)

The ozone depletion caused by conventional milk is $5.12 \times 10^{-8}$ kg CFC$_{11}$ and 64% originates from the dairy were transports are the largest contribution. The transport between farms and dairies is responsible for a third of the total effect. 36% stratospheric ozone affect comes from the farm. At the farm fodder production is the main cause of the depletion.
Summarized results

Table 3. Summarized results according to impact category.

<table>
<thead>
<tr>
<th>Results</th>
<th>Unit</th>
<th>Soy milk</th>
<th>Ordinary milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land use</td>
<td>m²/l</td>
<td>0,59</td>
<td>1,5&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Acidification</td>
<td>g SO₂-eq/l</td>
<td>1,92</td>
<td>10&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Eutrophication</td>
<td>g NO₃-eq/l</td>
<td>0,115</td>
<td>39&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Climate change</td>
<td>g CO₂-eq/l</td>
<td>215</td>
<td>900&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Energy use</td>
<td>MJ</td>
<td>3,37</td>
<td>3,9&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ozone layer depletion</td>
<td>kg CFC₁₁/l</td>
<td>3,2 e⁻⁷</td>
<td>5,12 e⁻⁸&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>


<sup>c</sup>A. Hospido, M.T. Moreira, G. Feijoo, 2002, Simplified life cycle assessment of galician milk production

Figure 9. Bar graph showing the characterization of impact categories
4.2. Discussion and reflections

General discussion

One of the most important factors when considering the environmental impact of soy milk is the choice of country farming the soybeans; different countries might have very different farming routines, which in turn could lead to rather different results in the environmental impact assessment. As one can see in the characterization of the results, the farming and transportation has the largest overall environmental impact for nearly all impact categories, something which was expected. However, no impact assessment has been made with data from soy farming countries such as Belgium. This would be an interesting addition to this study, but has not been done, due to the limitations in time.

Something which is a source for discussion is the fact that the characterizations used for the different regular milk LCA:s are unknown. This could make a crucial difference in the results, and the project group believes that a more complete study of regular milk should be used as a reference for the comparison.

Finally, the issue of nutrition should be discussed. In this study, one liter of each drink was considered side by side. This is only accurate if the drinks are merely considered as thirst quenchers. However, if one takes the nutritional values of both drinks into account, one would have to drink nearly twice the amount of soy milk to get the same energy as from one liter of regular milk. Both drinks have similar fat and protein values, but to obtain the same amount of carbohydrates as one gets from milk, 50 times the amount of soy milk would have to be consumed, as stated in Appendix 1. Naturally, this would have a huge impact on data values if taken into account and might be interesting from a social point of view. For instance, what would happen if soy milk became so popular that it completely replaced regular milk? Would children get enough calcium and other vital minerals they need growing up?

Discussion of specific impact results

The project group argues that another important aspect to consider is the land use and the definition of the term “land use”. For soy milk, the land use mainly comes from the soy bean cultivation and the stubbed land that is a result of the cultivation. The meaning of stubbed land is deforestation of rainforests being transformed into soy plant fields, which by many people might be seen as a major environmental impact, compared to an open pasture with grazing cows. For regular milk, the land use mainly comes from the farming of the animals. According to the “Milk and the Environment” report from the Swedish Dairy Association, grazing animals are absolutely necessary for ensuring that the diversified landscape in Sweden does not disappear. Furthermore, the report states that several animals and plant need grazed land to survive. Thus, the project group feels that larger area needed for milk production seems reasonable. Moreover, the group reasons that there in the future should be some kind of key factor for measuring the social issues of land use in addition to the raw environmental impact.

The fact that the eutrophication is nearly 400 times bigger for regular milk than that for soy milk (as shown in Table 3) seems peculiar. Since both soybean farming and dairy farming are agricultural activities, these should at least have similar values to eutrophication. The large number could in part be due to the cultivation and growing of cow fodder. Thus, a hypothesis
is that the fertilizers and pesticides used for this are far greater in number than those used for the soy bean farming. This would have to be verified for a more accurate result.

Another slightly surprising result is the fact that regular milk produces roughly four times more acidification than soy milk production. The main contributor to acidification is often SO4 (from the combustion of oil and coal), which leads the project group to the hypothesis that there may be far less machines used for soy bean farming than for cow farming. In addition to the oil used for the machine fuel, some dairy farms could also be using oil for heating their facilities. A more thorough analysis of the procedures for the two different drinks might give more insight in the issue, but could not be conducted, due to limitations in time and resources.

The Climate change factor (global warming) is roughly three times larger for regular milk, something which the project group feels is slightly odd. Due to the large amounts of deforestation and the impact this has on the balance of carbon dioxides in the atmosphere, the project group expected the figure for soy milk to be bigger. Conversely, a large number of scientists claim that the emissions of methane (which has a high CO2-equivalent value) from the cows are a large contributing factor to rising carbon dioxide levels. This would be one explanation why the figures are higher for regular milk, but is not really a fully recognized fact, and other scientists argue the environmental impact of cows’ emissions. Another factor which could affect the climate change of regular milk is the cultivation of the fodder used to feed the cows.

Perhaps the most intriguing result is that of the fossil energy use. Here, much larger figures where expected for the soy milk, mainly due to the extremely long distance the soybeans travel to the production site and the retail stores. This leads the project group to believe that the assumptions and calculations for the different transportations might not be entirely reliable. However, as previously mentioned, the dairy farms might use a larger number of machines for the farm work as well as heating systems for the keeping of the cows. Also, regular milk needs to be cooled in all stages of its life cycle, something which might use a lot of fossil energy.

Regarding the ozone layer depletion, the only main difference in the packaging is the aluminium in the soy milk package. However, this factor is so small that might not even be worth optimizing.
5. Conclusions

To make any general conclusions regarding the environmental impact of regular milk versus soy milk is difficult, especially due to the scant data available for soy milk production and not very detailed process descriptions in the regular milk studies. However, two specific conclusions have been drawn by the project group:

- For both drinks it is true that the actual farming is a major factor in the environmental impact and could probably be optimized in some areas.

- Soy beans have a larger “direct” environmental impact, due to deforestation and transformation of land. Regular milk, in turn, has more long term impacts, such as climate change, acidification and eutrophication.

- Transports is a large contributor in all stages, but is something which could probably be optimized.

- Cooling of drinks is a significant contributor to environmental impact, but could be avoided for soy milk.
6. References


Appendices

Appendix 1 – nutritional values

<table>
<thead>
<tr>
<th>Nutritional value (100 g)</th>
<th>Regular Milk</th>
<th>Soy milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy value</td>
<td><strong>260 KJ, 60 kcal</strong></td>
<td><strong>147 KJ, 35 kcal</strong></td>
</tr>
<tr>
<td>Protein</td>
<td>3.3 g</td>
<td>3.7 g</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>5 g</td>
<td>0.1 g</td>
</tr>
<tr>
<td>Fat</td>
<td>3 g</td>
<td>2.2 g</td>
</tr>
</tbody>
</table>