Life Cycle Assessment (LCA) of the Production of Home made and Industrial Bread in Sweden

Group No. 03

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Abstract
The purpose of this study is to compare the environmental effects associated with the production of white bread on two different scales: home and industrial bread production. Data from these two scales have been collected from various sources. The processes that have been examined include production and transportation. The quantification of the energy used and the potential contributions to global warming, ozone layer depletion, eutrophication, human toxicity and acidification have been evaluated.

It is realised that the home baking system shows a relatively higher energy requirement in baking as well as overall higher contribution to environmental impact in ozone layer depletion, eutrophication, human toxicity and acidification. The difference is however small.

1 Introduction

1.1 Background
Bread is perhaps the most important item in our diet; it has often been called the staff of life. Surveys have shown that bread provided us with more energy value, more protein, more iron, more nicotinic acid and more vitamin B1 than any other basic food. Bread comes to us in many interesting shapes and flavors. Nowadays, the sliced and wrapped loaf is the most popular loaf of all and for workers' lunches. (Bonham's Educational Pages, 2006). The trend in the industrialized world today is an increasing proportion of the food consumed to be prepared industrially. Food preparation takes two dimensions: Industrial and home made but the industrial appears to be gaining more strength. Like any other production process, bread production is associated with environmental impacts due to the demand of resources and due to emissions. The impacts, nevertheless, vary depending on the way bread is produced.

The use of energy in food production systems has been widely studied in the 1970s and the 1980s. Many difficulties exist in conducting Life Cycle Assessment (LCA) studies on foods because the production systems are large and complex (Anderssson et al, 1998). In Sweden there is much discussion of whether or not baking at home causes less environmental impact than in industrial bakeries and the subsequent distribution of bread for consumption. Although home baking has been common the trend is decreasing.

The systems that have been assessed in this study are: the production of inputs to cultivation of the wheat, milling, transportation, energy used and the baking process. This project has been carried out with the help of a small industrial bakery called Petite France, located in Stora Essingen, coupled with a home bread production, also located at Enskede Gård, both in Stockholm, Sweden. It was therefore possible to obtain some site specific inventory data for the study.

1.2 Goal and Scope Definition
Our main goal for the project is to compare the environmental effects of producing white bread on the two different scales- home versus industrial bakery. We also aim to provide information to the general public on which type of bread production has less environmental impact, to understand which of the processing stages account for the highest or lowest environmental effects and to evaluate how the environmental impacts can be reduced. In this study we limit ourselves to the bread being produced and consumed in Sweden.

1.3 Functional unit

The appropriate functional unit of the bread is defined as: 1 kilogram of bread ready for consumption at home. The scales compared are: the industrial bakery that uses a Svea Dahlen brand of oven and produces 100 baguettes at a time and home baking, that uses Electrolux brand of oven, baking for 6 loaves of bread at a time.

1.4 Research Questions

The study seeks to answer the following research questions:
1. What are the environmental impacts of bread production?
2. Which type of bread production (home or industrial) has less environmental impact?
3. What are the different materials used in these two methods of production?
4. What are the different methods of bread production?
5. What are the corresponding recommendations?

1.5 System Boundaries

Since the study is set to compare the different scales of bread production and there are no major differences between the ingredients for the two scales, certain processes have been excluded in order to get a clear boundary of the study. The major ones that have been excluded are:

1. Production of the capital goods such as machinery
2. The production of bread ingredients such as warm water
3. Cleaning of the ovens and the use of the cleaning agents

In the cultivation stage, the assimilation of carbon dioxide by the crop was not taken into consideration, neither was the leakage of gaseous emissions such as ammonia and nitrous oxide from the fields. The system boundaries for the industrial bakery are somewhat wider than the home baked bread. The reason is that data used for baking and milling includes packing of the loaves of bread and extra transportation.

1.6 Assumptions and Limitations

The major assumptions of this project are that:

1. The flour is produced in Sweden
2. There is no wastage at the flour milling factory
3. The environmental impact of drying and storage are negligible
4. The seeds, pesticides, machinery and fertilizers are held in the farm
5. There is no transportation between the home made bread and consumption
6. There is no packing of home made bread and so no waste is produced
7. Packing of the industrial bread produces insignificant waste
8. Transportations involved are assumed to be (i) harvest of the wheat to storage (ii) storage to milling (iii) milling to industrial bakery (iv) industrial bakery to retail (shops) (v) milling to shop in case of the home made bread. Means of transport from the shop to the house is assumed to be walking.

There have been time and data limitation for this project. The data used are not totally from the bakeries. A number of assumptions and calculations were made during the various stages of the project.

2 Methodology

2.1 Data Collection and impact assessment methods

The SimaPro 6.0 software was used to collect some inventory data and to choose the relevant impact categories for assessment. These are included in the impact assessment methods in the SimaPro software. The method which we have selected is more applicable for describing the chosen impact categories, the CML 2 baseline 2000. The selection of this is based on the principle of best available practice. It is recommended for simplified studies. The guide provides guidelines for inclusion of other methods and impact category indicators in case of detailed studies and extended studies. The method covers most of the impact categories that we wish to analyse. There has been exhaustive use of the available data in the database of the programme.

Any data that could not be obtained from the SimaPro 6.0 were obtained from Petit France industrial (commercial) Bakery, where we visited during our field work, in Stora Essingen, Stockholm. This was supplemented with data from our own first hand bread baking experience. We also got some data on yeast production from the research engineer of Jästbolaget AB (Jonas Rejholt) the yeast production company in Sweden. Data on the flour was however estimated.

According to our goal of the study the following impact categories were chosen: Global warming, Ozone layer depletion, Acidification, Eutrophication and Human toxicity.

2.2 The process Flow charts

Two process flow charts were designed- one for each scale of the bread production. A detailed description of the flow systems, assumptions made and the data used can be found in subtopics of life cycle of bread, assumptions made and data collection in the report. The processes involved in the flow charts are analysed mainly in terms of in the production and transportation. The flow charts are labelled as figures 2.1 and 2.2 below.

Figure 2.1 Flow chart for Life Cycle of Industrial bread

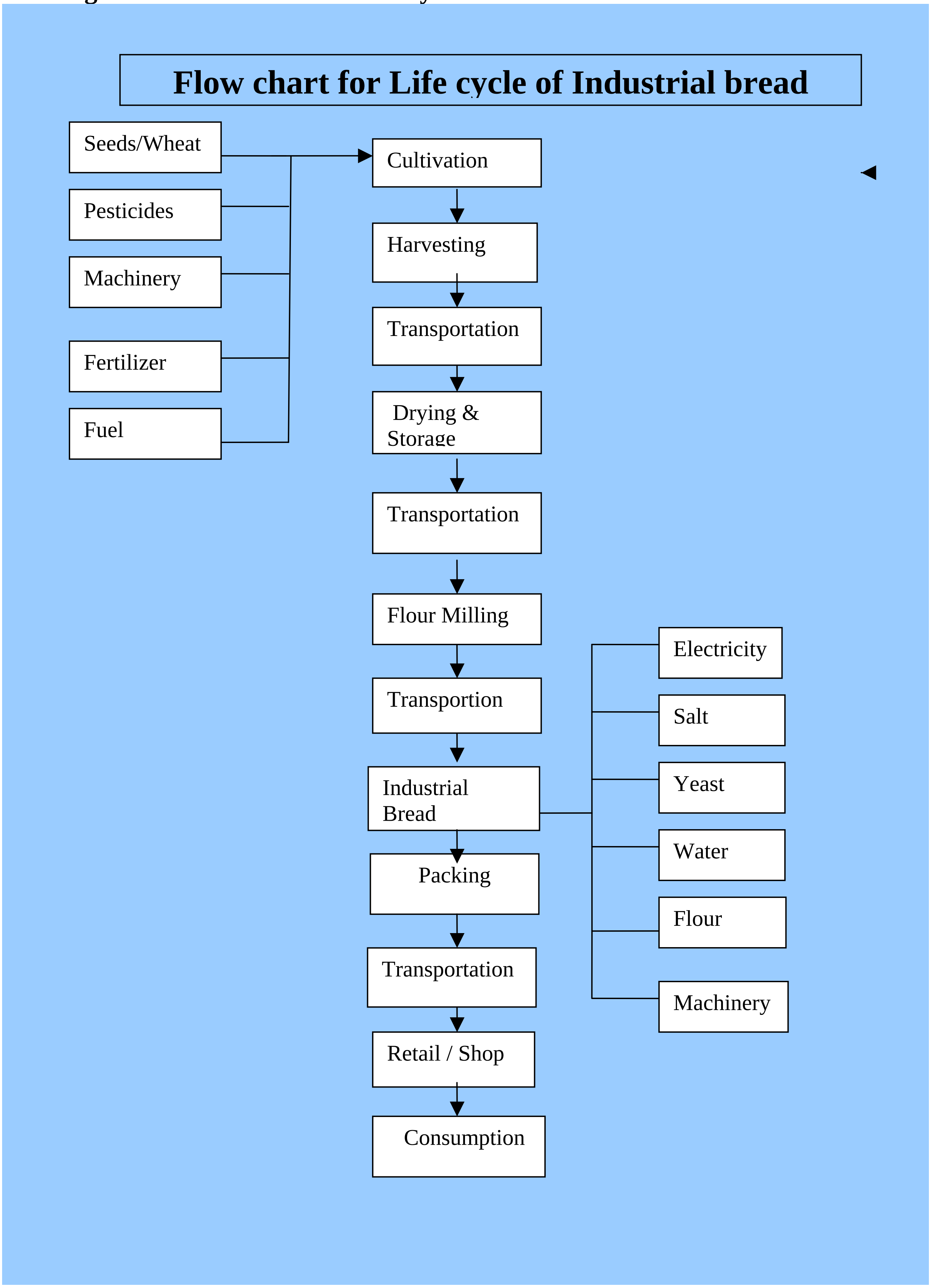
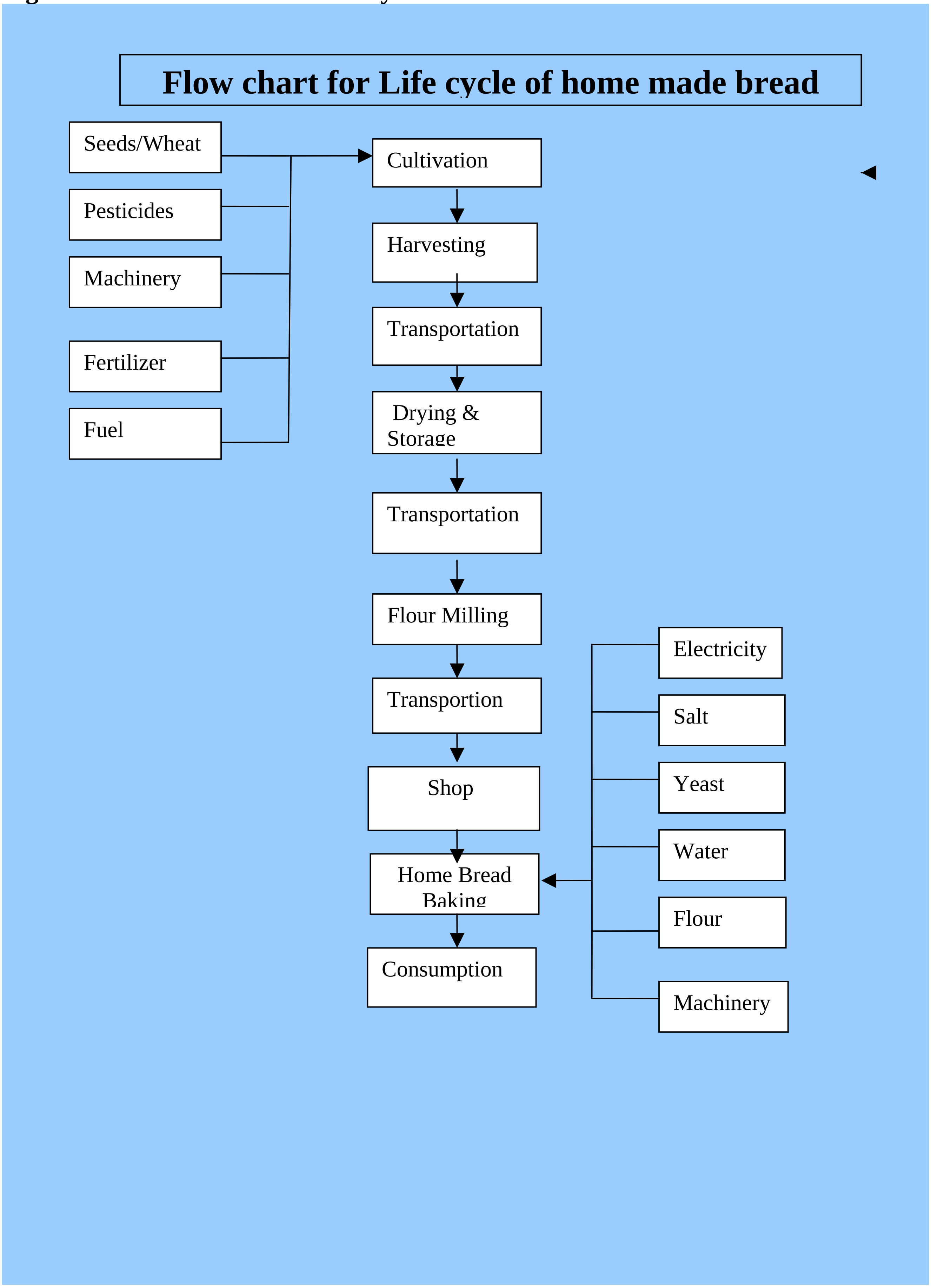


Figure 2. 2 Flow chart for Life Cycle of home made bread



2.3 Life Cycle of Bread

The entire life cycle of Bread starts from the farm where cultivation of the grain or wheat is needed for the flour. Other necessary inputs in the farm are machines, fertilizers, pesticides, fuel, water and energy. After harvesting the grain, it is dried, stored and later transported to the mill to be grinded. The grinding may involve some wet processes such as washing of grains and wet pre-grinding or pre- grinding and bolting. Finally the grains are grinded into the flour in the mill and later packaged for the next process.

For the industrial baking, the flour together with other ingredients such as yeast and salt are delivered to the bakery. There the ingredients are weighted out and mixed with water in a kneading machine to form the dough. The dough is prepared automatically by a machine and left for rising. The risen dough is then cut in to several pieces, shaped in to desired shapes and put into the baking oven at a specific regulated temperature. The baguettes are eventually baked after a certain time period.

The loaves of bread are made to cool and packed in either plastic or paper bags. They are (sometimes labelled) then distributed by the transportation system to the retailers/shops/customers who in turn sell them to the final consumers.

The industrial bread baking technology is modern with a high degree of automated machines. Wastewater generated during cleaning processes is diverted to municipal wastewater treatment. These wastewater and solid waste generation are not included in the system boundary because they are considered insignificant.

For home made bread, the ingredients for the bread are bought from a near by shop. The baking passes through the same major processes such as mixing, dividing and forming before the actual baking. However these major processes are done by hand. Proportional weighting of the various ingredients is estimated but results are always close to precision. In the end a kitchen oven type such as the Electrolux brand that can bake few loaves of bread is usually used for the actual baking.

As usual the loaves of bread may be left to cool for sometime and then be eaten immediately by the household or stored in the fridge for future consumption. Similar to the consideration in the industrial bakery, the water used in cleaning the cooking utensils and the oven are left out of the system boundary because they are in fact very negligible.

2.4 Inputs for actual bread baking

The inputs associated with the two scales of bread production to produce one kilogram of bread are shown in the table 2.1 below.

Table 2. 1: Inputs of Home and Industrial bread production

		Home made bread	Industrial bread
Inputs	Wheat flour	0,7 kg	0,7 kg
	water	0,6 l	0,6 l
	yeast	25 g	25 g
	salt	17 g	17 g
	electricity	2,0 kWh	1,5 kWh
Output	White bread	1,0 kg	1,0 kg

Electricity used: Electricity production mix NORDEL/NORDEL S
Source of documentation of electricity: Simapro 6.0 Database, Inventory

2.5 Processes involved in Industrial bread baking

In order to make this analysis we have visited a small industrial bakery called Petit France located in Stora Essingen in Stockholm. There are several steps to go through to bake the bread. The owner of the bakery has taken us through the actual baking process to produce two kilograms of baguette. This is explained below. The accompanying diagrams are listed in the appendices.

Recipe: The recipe is given as: 1.5 kilo of flour, 1 litre of water, 30 grams of salt and 30 grams of yeast

Mixing: This is the first process .The flour is mixed with the water, salt and the yeast. A blending machine also known as the spiral mixer (8kWh) does the blending for 15 low speed minutes, and later a high speed blending (at 12 kWh) for 3 more minutes .

Dividing: In this process the dough is introduced in a special dividing machine that gives the right weight to each piece of dough. The machine (at 5.5 kWh) works for 30 seconds to complete the process. The capacity of the machine is 7 kg and produces 20 baguettes (350 gm/piece).

Forming: The baguette moulder machine is very fast. During the forming stage, 350 gm of dough is processed during 7 seconds at 7 kilowatts of power.

Baking: This is the final process. After the dough pieces of baguettes are formed, they are left to rise for one hour at room temperature. When they are ready, they are introduced in to the oven for 35 minutes at 45 kWh. However 10 minutes extra must be added to warm up the oven. The capacity of the oven is 100 baguettes at a time. From 350 grams of dough, 250 grams of bread is obtained. The rest is evaporated.
The energy consumption at the various processes to bake one kilogram of bread is tabulated below.

Table 2.2 Energy consumption to bake 1 kilogram of bread at the Industrial bakery

Stages at the bakery	Kilowatts per hour(kWh)	Remarks
Mixing	0,037 kWh	Done by machine
Dividing	0,018 kWh	Done by machine
Forming	0,054 kWh	Done by machine
Baking	1,350 kWh	Done by machine
Total	1, 459 kWh	

Electricity used: Electricity production mix NORDEL/NORDEL S
Source of documentation of electricity: Simapro 6.0 Database, Inventory

2.6 Processes involved in Home Bread baking

There are different ways to bake bread at home but we chose a purposeful way in order to obtain data for our project. Although the process is similar to that of the industrial bread baking, the mixing, dividing and forming are all done by hand. The only time that a supply of external energy is used is during the actual baking process, which is the final stage.

Baking: At home, the baking is done by a normal kitchen stove that doubles also as an oven. A common oven in the home consumes between 2 and 3 kilowatts. The potential of our oven is 2, 65 kilowatts. After the baguettes are formed by hand, they are left to rise for about 1 hour at a room temperature. Later, when the pieces of dough are ready, the oven is switched on. 10 minutes waiting time is given to the oven to warm up after which the loaves of dough are put into the oven and baked for 35 minutes. The only energy consumption observed in the processes to bake one kilogram of bread is recorded in the table 2.3 below.

Table 2. 3 Energy Consumption to bake one kilogram of bread at the Home

Stages at the Home	Kilowatts per hour(kWh)	Remarks
Smashing of yeast	0,0 kWh	Done by hand
Mixing1 of yeast salt & water	0,0 kWh	Done by hand
Mixing 2 of flour & water content	0,0 kWh	Done by hand
Dividing the dough	0,0 kWh	Done by hand
Forming/rolling	0,0 kWh	Done by hand
Baking	2. 00 kWh	Done by machine

Electricity used: Electricity production mix NORDEL/NORDEL S
Source of documentation of electricity: Simapro 6.0 Database, Inventory

3 Results

3.1 Interpretation of the impacts

For each of the two systems studied, the potential contribution to global warming, ozone layer depletion, Human toxicity, acidification and eutrophication are characterized. The results are presented below in histograms and in tables.

Figure 3.1 Characterisation results of the Impact assessment for industrial bread

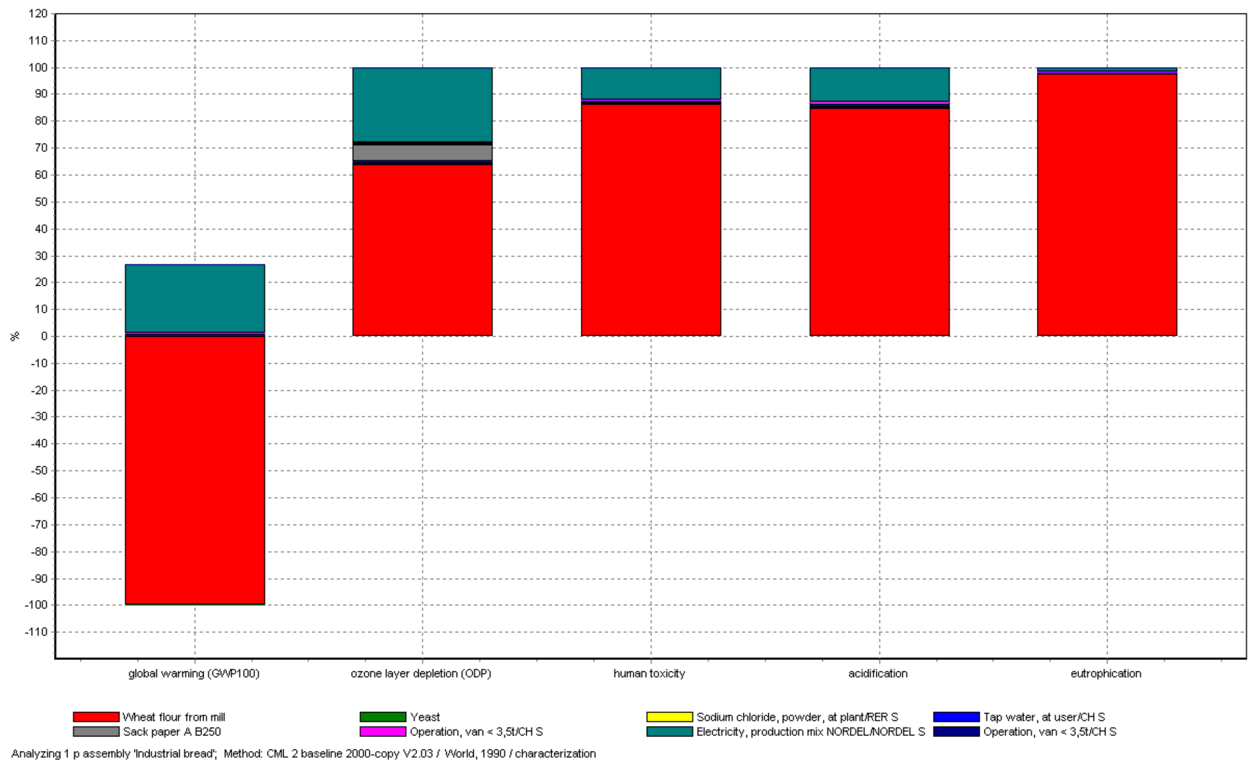


Table 3.1 Impact contribution of inputs to the various impact categories in Industrial bread

	Global warming	**Ozone layer depletion**	**Human toxicity**	**Acidification**	**Eutrophication**
Unit/ Indicator	kg CO_2-equivalents	kg CFC-11equivalents	kg 1,4-DB-equivalents	kg SO_2-equivalents	kg PO4-equivalents
Total	-0,56	4,14E-8	0,374	0,00498	0,00421
Wheat flour from mill	-0,762	2,64E-8	0,323	0,00423	0,00411
Yeast	-0,00139	3,9E-10	0,0018	3,08E-5	1,62E-5
Sodium Chloride	0,00284	1,64E-10	0,00317	1,45E-5	2,35E-6
Tap water	9,74E-5	5,87E-12	4,37E-5	3,64E-7	3,9E-8
Sack paper	0,00532	2,54E-9	0,00055	5,81E-5	1,02E-5
Operation, van >3.5t/CHS	0,00156	2,17E-10	0,00027	4,73E-6	7,64E-7
Elec., prod. mix NORDEL/NORDEL S	0,193	1,16E-8	0,0457	0,000641	7E-5
Operation, van >3.5t/CHS	0,000234	3,26E-11	4,05E-5	7,1E-7	1,15E-7

Source of documentation: Simapro 6.0 Database, analysis

3.1.1 Global warming

Global warming refers to the gradual increase of the temperature of the earth's lower atmosphere as a result of the increase in greenhouse gases. The main cause is emission of carbon dioxide (CO_2) from the exhausts of vehicles and production plants. In our study, it is realised that the carbon dioxide (CO_2) and yeast have negative values in both the industrial and home made bread productions. These are shown in the histogram figures 3.1 and 3.2.

From table 3.1 (for industrial bread), resultant global warming value observed for industrial bread production is -0.56 (in kg CO_2-equivalents). This negative number for global warming is caused by the uptake of carbon from the atmosphere when wheat and sugar beets grow. These are indicated in the table where wheat flour from mill and sugar beets (for production of yeast) contributed -0,762 and -0, 00139 respectively. Other indicators that produced significant amount of carbon dioxide for global warming are Electricity production mix NORDEL/NORDEL S (0,193) and production of tap water (9,74E-5).

Similar to the principle observed in the industrial bread production, the home made bread also has a negative global warming effect as depicted in histogram figure 3.2 . However the total effect to the global warming is -0,501 with the contributions from wheat flour from mill and sugar beets (for production of yeast). Others that contribute to the global warming can be seen from the histogram and the table 3.2.

3.1.2 Ozone layer depletion

Ozone depletion is caused by high levels of chlorine and bromine compounds in the stratosphere. The origins of these compounds are chlorofluorocarbons (CFC). As a result of depletion of the ozone layer more ultra violet radiation comes to earth and causes damage to living organisms such as skin cancer in humans.

In industrial bread production, the dominant indicators causing ozone layer depletion are transportation of wheat flour from mill, electricity production mix NORDEL/NORDEL S and sack paper A B250 as shown in the figure 3.1 and the table 3.1. The main gas responsible for the ozone layer depletion is the chlorofluorocarbons (in kg CFC equivalents). The total is 4, 14E-8 whiles contributions from the main indicators in their dominance order are: wheat flour from mill (2, 64E-8), electricity production mix NORDEL/NORDEL S (1, 16E-8) and sack paper A B250 (2, 54E-9). The impact of others is insignificant from the histogram.

For the home made bread, the total impact is 4, 27E-8. Two main indicators can be seen in figure 3.2 as causing ozone layer depletion. These are wheat flour from mill and electricity production mix NORDEL/NORDEL S with their respective values as 2, 64E-8 and 1, 55E-8 as written in table 3.2. Sack paper is completely absent from this scale as it is not needed in the production of home made bread.

3.1.3 Human toxicity

Human toxicity refers to chemical, physical or biological substances that may cause harmful effects to the human system. They are expressed as 1,4-dichlorobenzene (DB) equivalents/ kg emission.

The total human toxicity effect in industrial bread is 0,374 (in kg 1,4-DB-equivalents). Inferring from figure 3.1, the main contributors to this effect are transportation of wheat flour from mill with a value of 0,323 and electricity production mix NORDEL/NORDEL S with 0, 0457.

The same trend of impact is observed in the home made bread. This is evidenced in figure 3.2. From table 3.2 the value for the entire impact is 0,389 (in kg 1,4-DB-equivalents), and the key indicators are transportation of wheat flour from mill and electricity production mix NORDEL/NORDEL S. All other indicators have highly negligible impacts.

3.1.4 Acidification

Acidification is caused by acid depositions which originate from anthropogenic emissions of three main pollutants: sulphur dioxide (SO2), nitrogen oxides (NOx), and ammonia (NH3). These acid depositions have a negative impact on water, forests, and soil. Fossil fuel combustion for energy production and transport is very active in causing acidification.

Sulphur dioxide (SO2) is the chief pollutant documented in the CML 2 baseline 2000 method and is therefore used in the acidification impact category. Transportation of wheat flour from mill and electricity production mix NORDEL/NORDEL S are again viewed to be the main causes of acidification

The overall effect of acidification for the industrial bread is 0, 00498 (in kg SO_2-equivalents).Wheat flour from mill with a value of 0, 00423 and electricity production mix NORDEL/NORDEL S with 0,000641. The impacts of others are not well-felt.

Concerning the home made bread, the total effect of acidification is 0, 00514 (in kg SO_2-equivalents). It is again realised that transportation of wheat flour from mill and electricity production mix NORDEL/NORDEL S are very influential in the total impact. Wheat flour from mill accounts for 0, 00423 and electricity production mix NORDEL/NORDEL S records 0,000854. Other indicators still have less recognisable effects.

3.1.5 Eutrophication

Eutrophication refers to the excessiveness of nutrients that cause plants growth. The most important of these can be found in the elements like phosphorus and nitrogen. In CML 2 baseline 2000 method the main agent is PO4.

In the production of both industrial bread and home made bread, figures 3.1 and 3.2 reveal that the main cause of eutriphication is transport of wheat flour from mill. Whiles industrial bread has an overall impact to eutriphication as 0, 00421 (in kg PO4-equivalents), the home made bread accounts for 0, 00422 (in kg PO4-equivalents). Yeast, Tap water and operation van have completely negligible values.

Figure 3.2 Characterisation results of the Impact assessment for home made bread

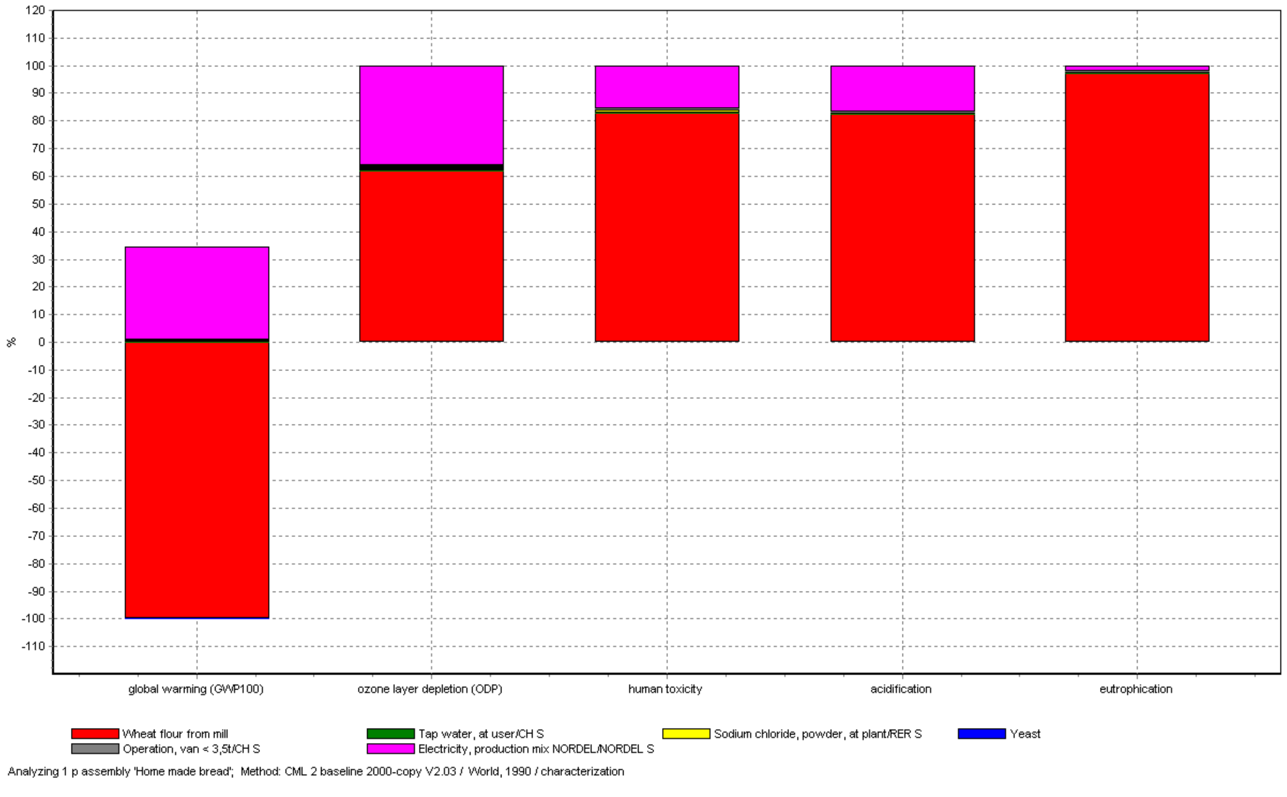


Table 3.2 Impact contribution of inputs to the various impact categories in Home made bread

	Global warming	**Ozone layer depletion**	**Human toxicity**	**Acidification**	**Eutrophication**
Input/ Indicator	kg CO_2-equivalents	kg CFC-11equivalents	kg 1,4-DB-equivalents	kg SO_2-equivalents	kg PO4-equivalents
Total	-0,501	4,27E-8	0,389	0,00514	0,00422
Wheat flour from mill	-0,762	2,64E-8	0,323	0,00423	0,00411
Yeast	-0,00139	3,9E-10	0,0018	3,08E-5	1,62E-5
Sodium Chloride	0,00284	1,64E-10	0,00317	1,45E-5	2,35E-6
Tap water	9,74E-5	5,87E-12	4,37E-5	3,64E-7	3,9E-8
Sack paper	-	-	-	-	-
Operation, van >3.5t/CHS	0,00156	2,17E-10	0,00027	4,73E-6	7,64E-7
Elec., prod. mix NORDEL/NORDEL S	0,258	1,55E-8	0,0609	0,000854	9,33E-5
Operation, van >3.5t/CHS	-	-	-	-	-

Source of documentation: Simapro 6.0 Database, analysis

3.2 Network Analysis

Referring to the networks of both the industrial and home made bread production; it is evident that various contributions are made to the environmental impacts. Whiles some are negative others are positive. From figures 3.3 and 3.4, all the processes that give negative percentages are those that have the potential to cause increase in global warming. The networks however show a net reduction of global warming which is scaled to 100 %, with the main cause being growth of wheat grains and sugar beets.

Figure 3.3 Network analysis of the Industrial bread (12 visible nodes out of 16)

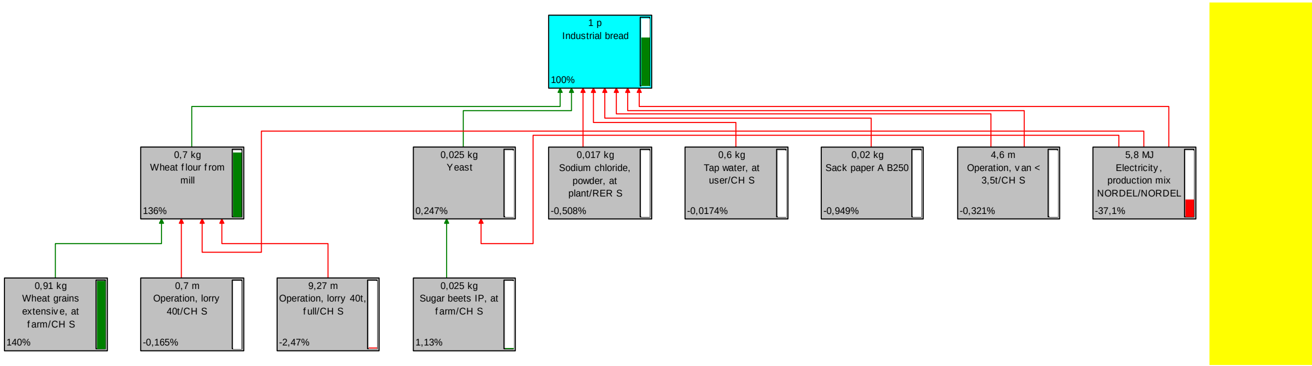
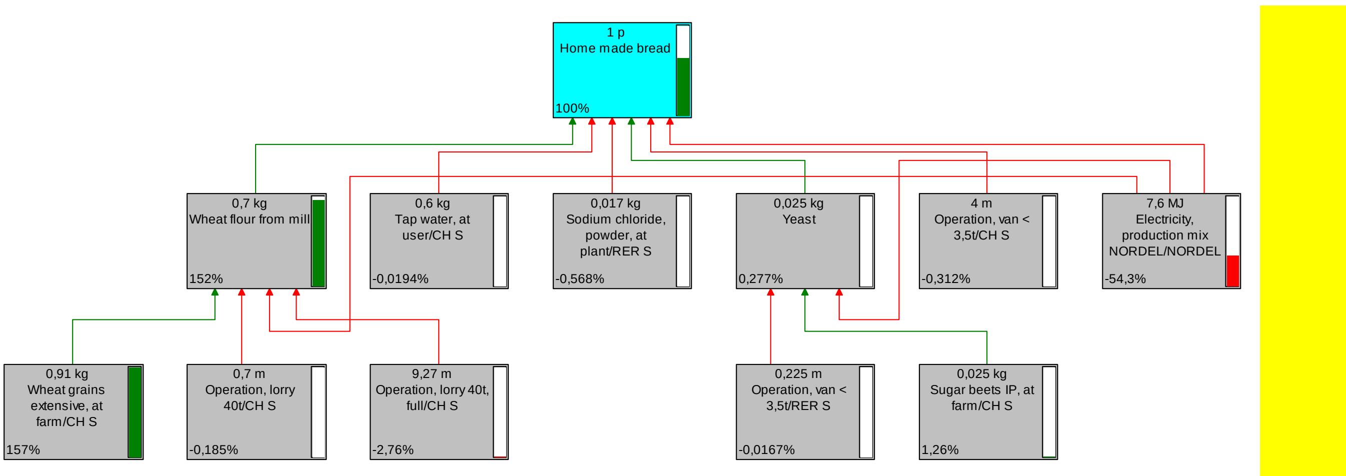
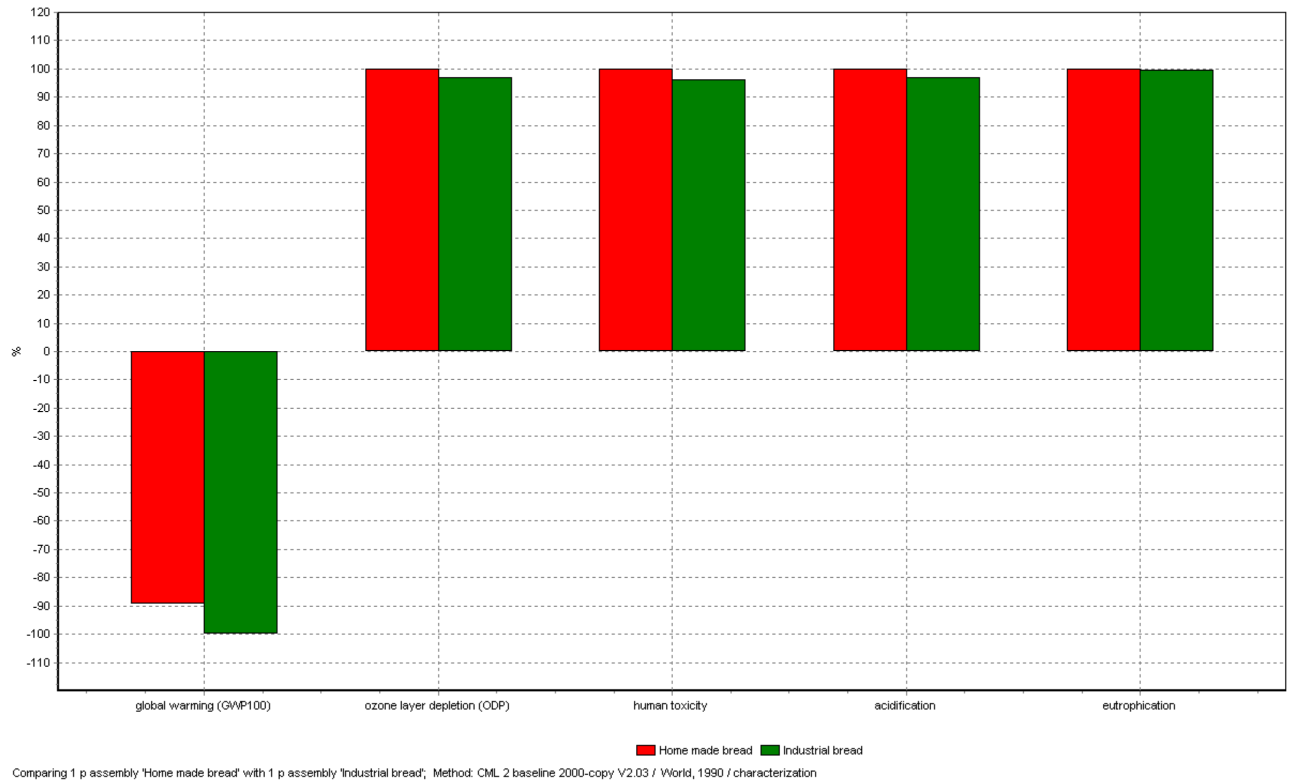


Figure 3.4 Network analysis of the Home made bread (12 visible nodes out of 15)



4 Discussion

Figure 4.1 Comparison of the production networks



4.1 Impact Assessment

It is noted from the evaluation of the 5 impact categories that only two indicators (wheat flour from mill and electricity production mix NORDEL/NORDEL S) stand tall among the rest in having consistent and significant effect on the impact categories. The effects of yeast, sodium Chloride, tap water, sack paper and operation van are either minimal or completely absent in the two scales.

As we further examine to determine which type of the production system- industrial or home baking has more environmental impact, the results presented above indicate that home made bread production system has slightly more environmental impact than industrial bread production. Comparing the impact categories in figure 4.1, the contribution of home made to environmental impact is a little over that of industrial bread in terms of ozone layer depletion, human toxicity and acidification. The two scales are almost at the level in terms of eutrophication.

About global warming impact category, there is an uptake of carbon dioxide from the atmosphere when wheat and sugar beets are grown. This is shown in figure 4.1. The phenomenon is serving as carbon sinks in both the industrial and the home made bread productions. The fact however is that these two carbon sinks will ultimately release the carbon back in to the atmosphere when human wastes are degraded, especially after consumption. Nevertheless this aspect of the carbon emission is outside our system boundary and is not included in our model.

Judging from figure 4.1, carbon dioxide intake in industrial bread production is more than that of home made bread. This goes to explain the reality of a slower rate of global warming process in the industrial bread production than home made bread production.

Table 4.1 Comparison of impact assessment of the Home & industrial bread

Impact category	**Causal Unit**	**Home made bread**	**Industrial Bread**
Global warming	kg CO_2-equivalents	-0,501	-0,56
Ozone layer depletion	Kg CFC-11equivalents	4,27E-8	4,14E-8
Human toxicity	kg 1,4-DB-equivalents	0,389	0,374
Acidification	kg SO_2-equivalents	0,00514	0,00498
Eutrophication	kg PO4-equivalents	0,00122	0,00421

Source of documentation: Simapro 6.0 Database, analysis

As can be observed from above (table 4.1), impact categories: Ozone layer depletion, Human toxicity, Acidification and Eutrophication have positive values in both scales of production. In industrial bread production Ozone layer depletion accounts for 4,14E-8 in Kg CFC-11equivalents, Human toxicity records 0,374 in kg 1,4-DB-equivalents, Acidification contributed 0,00498 in kg SO_2-equivalents and Eutrophication added 0,00421 in kg PO4-equivalents to the environmental effect. In the home made bread, the respective values for the same impact categories in that order are: 4, 27E-8, 0,389, 0, 00514 and 0, 00122. Negative values are recorded in the case of global warming for the two scales of bread production, with -0, 56 and -0,501 (in kg CO_2-equivalents) going for industrial and home made bread productions respectively. The documentation in the table 4.1 has shown that impacts of home made bread outweigh that of industrial bread production.

Although home made bread seems to have a higher environmental impact than Industrial bread production on the impact categories examined, it can be observed that the difference or the magnitude is very small and this is depicted by figure 4.1 above. This small difference/margin comes from the fact that the production process is the same for the two scales but the difference lies in the transportation of wheat flour from mill and electricity production mix NORDEL/NORDEL S, during the production process. Energy and transport use are therefore critical parameters in these two systems of production.

Tables 2.2 and 2.3 give the energy needed to bake one kilogram of both industrial and home made bread. From these tables it can be seen that energy consumption of 1, 459 kWh is needed to bake one kilogram of industrial bread. Although the home baking does not depend on energy for smashing and mixing of yeast, salt and water, dividing the dough and forming or rolling, as much as 2,000 kWh of energy is needed to bake one kilogram of home made bread. This is more than what is needed for the industrial bread and what is accounting for this difference include important parameters such as the quantity of loaves of bread baked at a time and the duration the oven is used. In the industrial baking process, the quantity of loaves of bread baked at a time at the same temperature is quite large compared to the home baking process where a small number is baked at a time.

Transport is also a major factor which accounts for the environmental loads caused by the transportation of the flour from mill and the distribution of the bread to retailers in the case of industrial bread production. The transportation is carried out by lorries and haulers which travel long distances and therefore consume energy and cause emissions. This effect is well pronounced in all the impact categories except global warming where growth of wheat and sugar beets have absorbed carbon dioxide from the atmosphere to take care of the transportation of the one kilogram of bread considered, resulting in a negative net emission in both scales of bread production.

5 Conclusion and Recommendation

As we have noticed, the differences between industrial baking and home baking are quite small. The main differences are the transportation of wheat flour from mill and electricity production mix NORDEL/NORDEL S used during the production process. The energy for the home made bread is higher than that of industrial bread production whilst the transportation for the industrial bread production is also higher than that of the home made bread.

We can then remark that the evaluation of the process is going to be decisive when selecting the resources and the process itself. For instance when choosing which kind of flour is going to be considered or which kind of oven to use. However on the aggregate the results show that home made bread has more environmental impact than industrial bread production.

Another variable to consider in the environmental impact in bread production is the packaging. The paper or bags that are used in purchasing the bread has an impact that must be considered by the consumers.

The production of bread at home seems to be a bit less sustainable than the industrial production. This is due the economies of scale in baking bread in large quantities. Even though the production of industrial bread use more machines in the different stages in the process, the allocation of this energy is more efficient than in baking at home. A more efficient use of the oven at home can make the baking at home more sustainable. This can be arrived by baking larger quantities of bread at home.

As a general recommendation to the end consumers of bread it can be said that local flour should be chosen rather than imported flour or coming from far away. Also the packaging should be avoided and preferably own bags should be carried to the shop when purchasing bread to avoid unnecessary packaging.

References

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2. Anderson, K., Ohlsson, T. & Pär Olsson (1993). *Life Cycle Assessment (LCA) of Food products and production systems, Part 2: LCA & Foods,Annual report*, School of Environmental Science Chalmers University of Technology, Gothenburg
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6. Simapro 6.0 Database, Inventory & analysis

Appendices

Appendix 1
Baguettes: output (loaves of bread) from the actual baking

Appendix 2
Spiral Mixer: (blending machine) that blends flour, water, salt and yeast in to dough

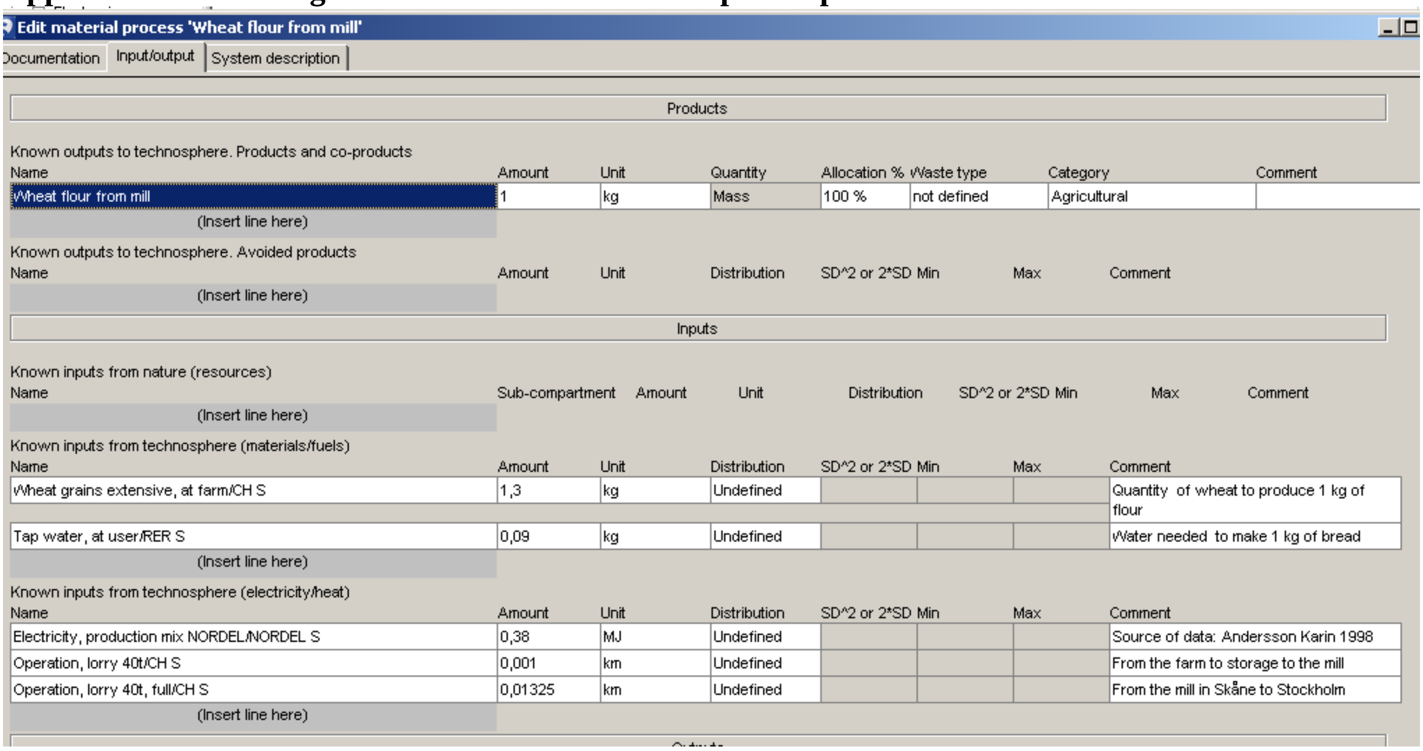
Appendix 3
Dough Divider: machine that divides and gives the right weight to each piece of dough.

Appendix 4
Baguette Moulder: machine that moulds or shapes the baguettes during the forming stage

Appendix 5
The Oven: the machine that does the actual baking of bread

Appendix 6
Kitchen stove & oven: (Electrolux brand)- this machine is usually used for the home bread

Appendix 7: Processing of Wheat flour from mill- Input/output table



Edit material process 'Wheat flour from mill'

Documentation | Input/output | System description

Products

Known outputs to technosphere. Products and co-products

Name	Amount	Unit	Quantity	Allocation %	Waste type	Category	Comment
Wheat flour from mill	1	kg	Mass	100 %	not defined	Agricultural	
(Insert line here)							

Known outputs to technosphere. Avoided products

Name	Amount	Unit	Distribution	SD^2 or 2*SD	Min	Max	Comment
(Insert line here)							

Inputs

Known inputs from nature (resources)

Name	Sub-compartment	Amount	Unit	Distribution	SD^2 or 2*SD	Min	Max	Comment
(Insert line here)								

Known inputs from technosphere (materials/fuels)

Name	Amount	Unit	Distribution	SD^2 or 2*SD	Min	Max	Comment
Wheat grains extensive, at farm/CH S	1,3	kg	Undefined				Quantity of wheat to produce 1 kg of flour
Tap water, at user/RER S	0,09	kg	Undefined				Water needed to make 1 kg of bread
(Insert line here)							

Known inputs from technosphere (electricity/heat)

Name	Amount	Unit	Distribution	SD^2 or 2*SD	Min	Max	Comment
Electricity, production mix NORDEL/NORDEL S	0,38	MJ	Undefined				Source of data: Andersson Karin 1998
Operation, lorry 40t/CH S	0,001	km	Undefined				From the farm to storage to the mill
Operation, lorry 40t, full/CH S	0,01325	km	Undefined				From the mill in Skåne to Stockholm
(Insert line here)							

Appendix 8: Processing of Yeast – input/output table

Material process 'Yeast'

Documentation | Input/output | System description

Products

Known outputs to technosphere. Products and co-products

Name	Amount	Unit	Quantity	Allocation %	Waste type	Category	Comment
Yeast	1	kg	Mass	100 %	not defined	Chemicals\Others	

Known outputs to technosphere. Avoided products

Name	Amount	Unit	Distribution	SD^2 or 2*SD	Min	Max	Comment

Inputs

Known inputs from nature (resources)

Name	Sub-compartment	Amount	Unit	Distribution	SD^2 or 2*SD	Min	Max	Comment

Known inputs from technosphere (materials/fuels)

Name	Amount	Unit	Distribution	SD^2 or 2*SD	Min	Max	Comment
Operation, van < 3,5t/RER S	0,009	km	Undefined				from factory to the shop
Sugar beets IP, at farm/CH S	1	kg	Undefined				
Tap water, at user/RER S	0,2	kg	Undefined				
Electricity, production mix NORDEL/NORDEL S	1	MJ	Undefined				

Appendix 9: Assembly of materials for industrial bread

Name: Industrial bread

Image:

Comment: Assembly of materials for Industrial bread at Stora Essingen

Materials/Assemblies	Amount	Unit	Distribution	SD^2 or 2*SD	Min	Max	Comment
Wheat flour from mill	0,7	kg	Undefined				Quantity of flour that is used in baking 1 kg of bread at the industrial bakery
Yeast	25	g	Undefined				Quantity of yeast that is used in baking 1 kg of bread at the industrial bakery
Sodium chloride, powder, at plant/RER S	17	g	Undefined				Quantity of salt that is used in baking 1 kg of bread at the industrial bakery
Tap water, at user/CH S	0,6	kg	Undefined				Quantity of water that is used in baking 1 kg of bread at the industrial bakery
Sack paper A B250	20	g	Undefined				Weight of Papers for wrapping the baked bread at the industrial bakery
(Insert line here)							

Processes	Amount	Unit	Distribution	SD^2 or 2*SD	Min	Max	Comment
Operation, van < 3,5t/CH S	0,004	km	Undefined				Distance travelled by operation van to convey inputs from mill to industrial bakery at Stora Enssigen
Electricity, production mix NORDEL/NORDEL S	1,5	kWh	Undefined				Energy used to bake 1 kg of bread at the industrial bakery in Stora Essingen
Operation, van < 3,5t/CH S	0,0006	km	Undefined				Distance travelled by operation van from bakery to shops to distribute bread
(Insert line here)							

Appendix 10: Assembly of materials for home made bread

Name: Home made bread

Image:

Comment: Assembly of materials for home made bread

Materials/Assemblies	Amount	Unit	Distribution	SD^2 or 2*SD	Min	Max	Comment
Wheat flour from mill	0,7	kg	Undefined				Quantity of flour that is used in baking 1 kg of bread at home
Tap water, at user/CH S	0,6	kg	Undefined				Quantity of water that is used in baking 1 kg of bread at home
Sodium chloride, powder, at plant/RER S	17	g	Undefined				Quantity of salt that is used in baking 1 kg of bread at home
Yeast	25	g	Undefined				Quantity of yeast that is used in baking 1 kg of bread at home
(Insert line here)							

Processes	Amount	Unit	Distribution	SD^2 or 2*SD	Min	Max	Comment
Operation, van < 3,5t/CH S	0,004	km	Undefined				Distance travelled by operation van to convey inputs from mill to shop in Stockholm
Electricity, production mix NORDEL/NORDEL S	2	kWh	Undefined				Energy used to bake 1 kg of bread at home
(Insert line here)							