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Developing a Regional Closed-loop Economy: a Case Study of a Bakery in Zürich

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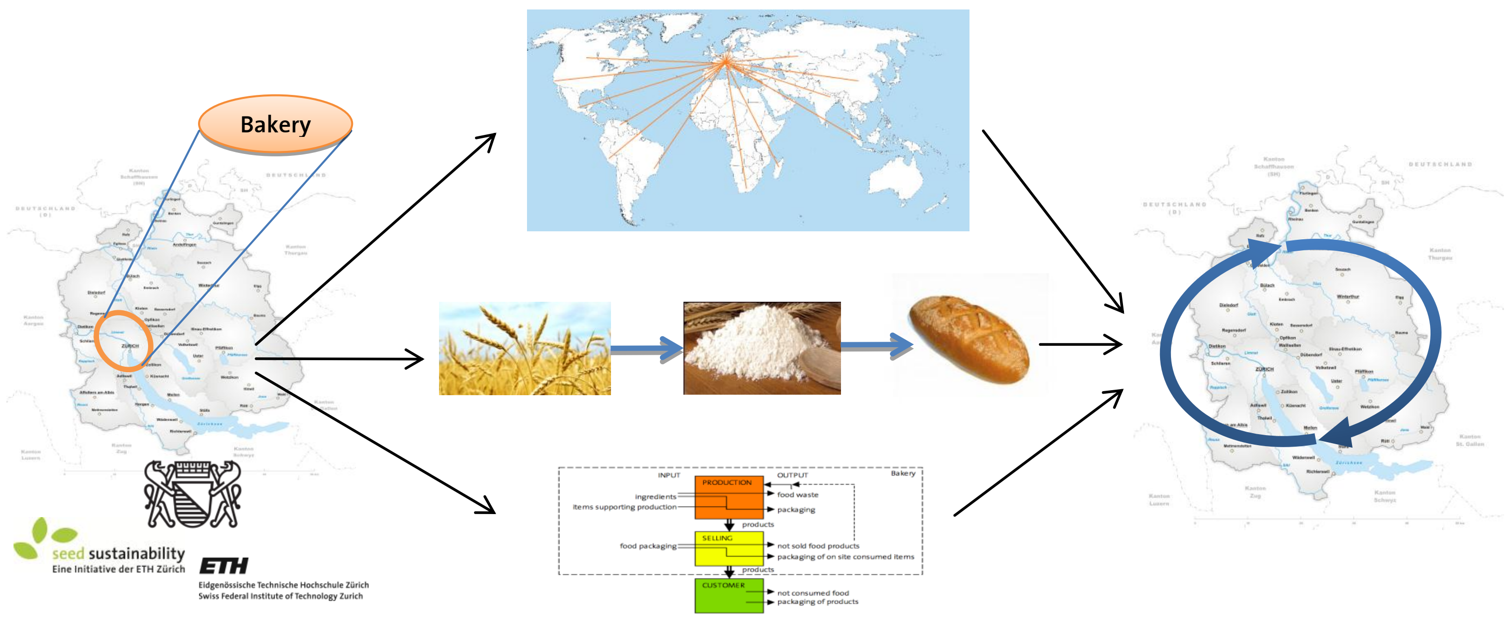

IED – Institute for Environmental Decisions
NSSI – Natural and Social Science Interface

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Abstract

People consume two times more resources on a global scale than what nature is able to regenerate. The present material management therefore is far from being sustainable. In order to establish a sustainable material management (SMM) it is estimated that the worldwide material flow would have to be reduced by 40-60%. Hence it is necessary to shift from the present economy based on linear material flows to a so called closed-loop economy enabling a cascading use of materials and high quality recycling.

The city of Zürich endorsed a postulate to research the potential of small to medium sized enterprises (SMEs) for actively supporting the development of a regional closed-loop economy. For this reason the goal of the thesis is to identify actions the city and enterprises can take to support regional and circular material flows. Hence a case-study based analysis is performed on a bakery. The analysis of the case study consists of three methods. First a material flow analysis (MFA) on purchase food products is performed to characterize incoming goods in relation to weight, price and origin. The results of the MFA are then compared to 3 alternative procurement patterns. Secondly a life cycle assessment (LCA) is conducted on bread produced by the bakery. The current situation is compared to 9 alternative options. The third method consists of a qualitative analysis of the enterprise by-products management.

The results from the MFA illustrate that ¾ of the presently purchased food is domestic. In comparison to the current purchase pattern, alternative patterns show a maximal cost saving of 10%, for the low-cost alternative (LA), and a maximal cost increase of 30% for the completely organic alternative (OA). Consequences of applying the LA are increase of imports from Europe (EU) and decrease of domestically based expenditure. The OA increases both EU and Swiss expenditure. Secondly, the outcomes of the LCA showed that the total environmental impact (TEI) of 1kg bread baked with IP-Suisse flour is 3'486 UBP (17 MJ, 747 g CO_2-eq.). The main contributions come from cultivation (80.5%) and baking (14.1%). Other factors, as transport, are of secondary importance. In comparison to the currently produced bread, U.S. imported flour increases TEI by 55-63% and flour from Swiss organic cultivation by 36%. A decrease of impact ranging between 2-14% is observed for baking with electricity from renewable energy, wheat imported from Germany, increased oven efficiency and shorter local transport. Thirdly, by-products management showed potential for reducing waste production at the source. Furthermore unsold food which is still palatable can be offered to charity associations, while uneatable food could potentially be processed in future municipal fermentation plants within the city.

The results recommend that the bakery retains present purchase patterns but evaluates possibilities of purchasing electricity from renewable energy and increasing oven efficiency. Because the results show that local food does not necessarily imply better environmental performance, life cycle based indicators need to be developed offering transparent information to customers (and enterprises). The city could support SMEs in taking active roles within the development of a closed-loop economy by setting financial incentives, involving public institutions, and building information networks. SMEs are key players within the development of a closed-loop economy, as they can give change impulses to other actors, i.e. larger business, institutions, education. In addition SMEs may profit from new market shares created by developing reverse logistics and cascading material use.

Keywords

Sustainable Material Flows, regional closed-loop economy, circular flow, LCA, MFA, SMEs, Bakery, Bread

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Abbreviations

DMC: Domestic Material Consumption

ETHZ: Eidgenössiche Technische Hochschule Zürich, Swiss Institute of Technology Zürich

HES: Human-Environment Systems

IP: Integrated Production

LCA: Lice Cycle Assessment

MFA: Material Flow Analysis

NSSI: Natural and Social Science Interface

SMEs: Small to Medium Size Enterprises

SMM: Sustainable Material Management

UGZ: Umwelt- und Gesundheitschutz Zürich, Environmental and Health Protection agency

A. INTRODUCTION

1. Background information

Materials matter

I was eating a cereal bar, when at some moment I started reading the ingredients on the packaging. A single cereal bar contained 20 ingredients, at least 5 of which were imported from tropical climates. I ate the cereal bar in 2 minutes and started to think how long did it take for the ingredients to arrive to my mouth. Several European countries and 5 perfect holiday destinations just to reach the production country of Austria, and next they were transported to Switzerland, from wholesale to the retailer where I bought the bar. Suddenly the world behind the consumption of a regular good started to take on a new dimension. How much energy and materials were used to produce a good that I consumed in 2 minutes? Is the world so rich in resources to enable a cereal bar to make a world trip?

The fact is that the world is not able to renew the amount of resources consumed at the present consumption rate. In Switzerland for example people use more than 3 times the amount of resources that can be restored (GFN, 2010). Three trends of the present material flow management show how the system is not sustainable. First materials flow in a linear way from extraction, production and consumption into waste treatment facilities. In the U.S. 99.8% of all materials used are trashed, while only 0.02% flow back into the system through recycling and composting (Lovins, 2005). The second concern relates to the amount and quality of materials consumed nowadays: the domestic material consumption (DMC) per capita of the EU-12 increased by 50% between 1992 and 2008 (EEA, 2010) and the growing amount of elements used in each product component causes toxicity issues at disposal and hinders gaining back materials (Johnson, Harper, Lifset, & Graedel, 2007). Additionally the expected worldwide demand for products will rise because of population growth and expansion of western consumerism lifestyle in countries with large populations (Constantinos, Sørensen, Larsen, & Alexopoulou, 2010). The last trend involves market globalization and its related amount of transportation. The volume of end-goods imported to in Switzerland grew by 50% between 1990 and 2006 (Schmid & Kägi, 2008). Further, while the total volume of transported goods did not increase, the number of trips and their length did so, leading to an increase of 76% of the transport performance of goods[1] between 1980 and 2004 (Spielmann, Bauer, Dones, & Tuchschmid, 2007). From these facts it becomes evident that by considering the limits of natural resources the present material flow management is not viable in the long term. The European Environmental Agency estimated that for reaching sustainability in the long-term a reduction of global materials flows of 40-60% is needed (EEA, 2010).

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[1] measured in tons-kilometers per year

Swiss and regional political context

Initiatives striving for sustainable development became apparent worldwide during last years, reaching the political level. In Switzerland several steps were done forward during the last years. In 1997 the first strategy for "Sustainable Development in Switzerland" was issued and followed by new versions till the last of 2008-2011 (ARE, 2008). Targets, as the reduction of CO2 emissions stated in the CO2 Act, and Sustainability indicators (Monet) allowing to track progress were developed (FSO, 2010), giving the base for concrete measures as increasing energy efficiency of buildings and promoting renewable energies. Large differences exist between the approaches taken from the national directives on a regional level (ARE, 2011).

In November 2008 the population of Zürich approved a popular initiative promoting the 2000-Watt-Society Vision and the reduction of CO2 emissions to 1 ton. Through this initiative the city became the first in Switzerland to endorse such ambitious objectives in the legislative frame. The implementation strategy adopted by the city to reach the goals, focuses on decreasing energy use and CO2 emissions, and promoting renewable energies. Several steps have already been taken in the reduction of energy consumption in the building domain that increase energy efficiency, like the initiative taken by the construction section of the city, which incorporated Minergie (Swiss standard sustainable building) Standards to all building projects (Hänggi, Volland, Gessler, & Püntner, 2011). Additionally the "Öko-Kompass" program, a new initiative in its kind, focusing on reducing environmental impacts of small- to medium sized enterprises (SMEs) (see definition in BOX 2), started its activities. The "Öko-Kompass" service of the city offers to SMEs access to mediation, consulting and public relations on environmental protection actions, proven optimization tools (environmental management etc.) and different political support programs at the cantonal and national level.

Close to the endorsement of the popular initiative, the city signed a postulate aiming to complement the "Öko-Kompass" measures focusing on enterprise internal energy and resources use, with initiatives taking into account the potential of saving energy and materials through collaborations between several enterprises, by building short supply chains and develop a regional closed-loop economy. Thus the municipal council required the city council:

> "to investigate how he can, in relation to "Öko-Kompass", start and sustain pilot projects supporting the development of a regional closed-loop economy and supply chains with short transportation pathways.", 07.01.2009 (Nagel & Heinrich, 2009).

The interest of the Environmental and Health Protection agency (Umwelt- und Gesundheitschutz (UGZ)) in charge for answering the postulate, to research the role of SMEs in fostering a close-loop economy, led to start a collaboration with the Swiss Institute of Technology Zürich (ETHZ). Seed Sustainability[2] mediated the research interest of the UGZ by finding an appropriate partner able to supervise a master thesis on the subject and a student. Thus through the supervision of the Natural and Social Science Interface (NSSI) section of the Environmental Department of ETHZ and the interest of UGZ, developed the concepts of the present praxis oriented thesis.

[2] Seed Sustainability is an initiative of ETHZ aiming to connect academia with practice through applied research of bachelor, master and doctorate thesis.

2. Research frame

Objective and guiding questions

The introduced background arises questions, as how could the present material flow management be modified to allow for a use of resources that is not dependent on depletion of natural stocks? How would a sustainable material management (SMM) look like and how would it shape our future? The objective of the present thesis is derived from these general questions. Its aim is to gain an understanding on the present materials flows within a specific context to identify potentials for improvement. The perspective of different actors shaping material flows is addressed, by researching tailored opportunities for action. Thus from the thesis an introduction to existing SMM approaches can be gained, with particular regard to those focusing on closing material flow loops, analyzing material flow of a particular case and developing strategies for fostering SMM. Within the query of the city of Zürich the thesis also aims at supporting the UGZ in answering the postulate, by focusing the scope of research to the city of Zürich and on to the role of SMEs. With respect to the objective of the thesis two overarching guiding questions were formulated with four case specific guiding questions.

Overarching guiding questions:

1. What is the potential of SME to i) develop a closed-loop economy and i) foster supply chains with short transportation pathways in the city of Zürich?
2. Which political instruments can support SMEs in exploiting their potential for developing a closed-loop economy and foster short supply chains?

Case specific guiding questions:

1. How are procured materials and produced waste characterized in relation to costs of alternatives supporting a regional closed-loop economy?
2. Do alternative procurement and waste treatment options exist and how are they characterized in relation to economic and geography parameters?
3. How are environmental impacts characterized in relation to the geographic origin of materials?
4. Which political instruments can support the most environmentally sustainable option?

Methodological choices

The city of Zürich established a query – how can a closed-loop economy be fostered - and the focus was on SMEs. Thus the research first focused on SMM approaches, particularly in relation to sustaining a closed-loop economy in a regional context. Next analyze and apply the gained knowledge in the context of the city of Zürich in regards to a specific enterprise. The attention was narrowed down from SMEs to a specific branch and then to an enterprise to generate a crisp view on its material flows and its relations to surrounding systems and specific actors. A comprehensive study was done on an enterprise, which included material flow analysis (MFA) of purchased goods in relation to price and origin, a life cycle assessment (LCA) of a core product to integrate environmental impacts, and a qualitative analysis of by-products management options.

3. Thesis road map

A short summary of the thesis content is given with the objective of depicting the common thread and logical connection between chapters (see Figure 1). The paper gives first an introduction to the theoretical background (B.), next comes the case study (C.), the discussion (D.) and finally the conclusion (E.).

B. Theoretical background

The theoretical background section (B.) is divided in chapters. The first introduces the theoretical background of material management (B.1) by giving an overview on the reasons making the present material flow not sustainable (B.1.1). Next the origins of the present configurations of materials flows are illustrated by the key events of human history that modified the relation humans have with materials and nature (B. 1.2). The last point of the chapter illustrates how a sustainable material management could look like (B.1.3). In the second part of the background section different approaches for implementing SMM are depicted (B.2). As the SMM vision is inspired by the idea of developing closed-loop material flows, the first chapter focuses on the concept of a closed-loop economy (B.2.1). Following this, individual implementation approaches surrounding SMM, being also part of the broader closed-loop economy concept, are presented (B.2.2.). The implementation strategies of material flows for single products, are related to the concept of regional closed-loops in the next chapter (B.2.3.). The implementation approach section finishes with an overview of current initiatives fostering closed loop material flows (B.2.4).

C. Case study

The next section on the case study (C.) contains the core of the thesis. The section is divided in three parts, firstly introducing the case study framework (C.1), next the methodological approach (C.2) and then the results of the performed analysis (C.3).

In the chapter on the case study framework, the procedure applied for selecting the case study partner (C.1.1) is presented. The selection is based on choosing a branch that has potential for act within a closed-loop economy, is well represented in the city of Zürich and for which a single case can give representative outcomes for the whole branch. The next part of the section describes the bakery collaborating for the case study (C. 1.2). A particularity of this section is the description of the enterprise history by using the human-environment systems (HES) framework.

In the next section of the case study the methods are described which were applied for inquiring into the case (C.2). The first is a material flow analysis reporting the characteristics of all food products purchased by the bakery in relation to weight, price and origin (C.2.1). In addition to the analysis of the present situation, the most relevant 18 products were selected and used for building 3 alternative purchase patterns. This was done to give an overview on the possible alternatives the bakery has to influencing the surrounding economy through its purchase priorities. In the next chapter the methodology used for the LCA of bread is described (C.2.2). The analysis shows 8 scenarios built on different alternatives. These include variation of wheat cultivation (organic, IP, extensive), wheat countries of origin (Switzerland, Germany and U.S.), alternative transportation means (truck, train, freight boat) for wheat import and two options being part of the decision range of the enterprise (oven efficiency, centralized production). Finally after illustrating the methodology used for a bread LCA, the procedure applied for inquiring into alternatives for by-products treatment is addressed (C.2.3).

In the subsequent section of the case study (C.) are depict the results of the methodologies explained in the chapter C.2.2 are depicted. Thus first the results of MFA (C.3.1) are outlined, and then those of bread LCA (C.3.2). Finally the results of by-product management approaches (C.3.3) end the chapter.

D. Discussion

The relevance of the case study outcomes for the overarching guiding question is illustrated in the discussion section (D.). The discussion is divided in three chapters. The first compiles the results of the three methods with respect to the guiding question (D.1), starting from the case specific questions (D.1.1) and addressing next the general guiding questions (D.1.2). In the next chapter methodological considerations depict strengths and weaknesses of the applied methodology (D.2). Finally in the action orientation chapter (D.3) approaches for the city and the bakery are proposed (D.3.1), including an outlook for further research (D.3.2).

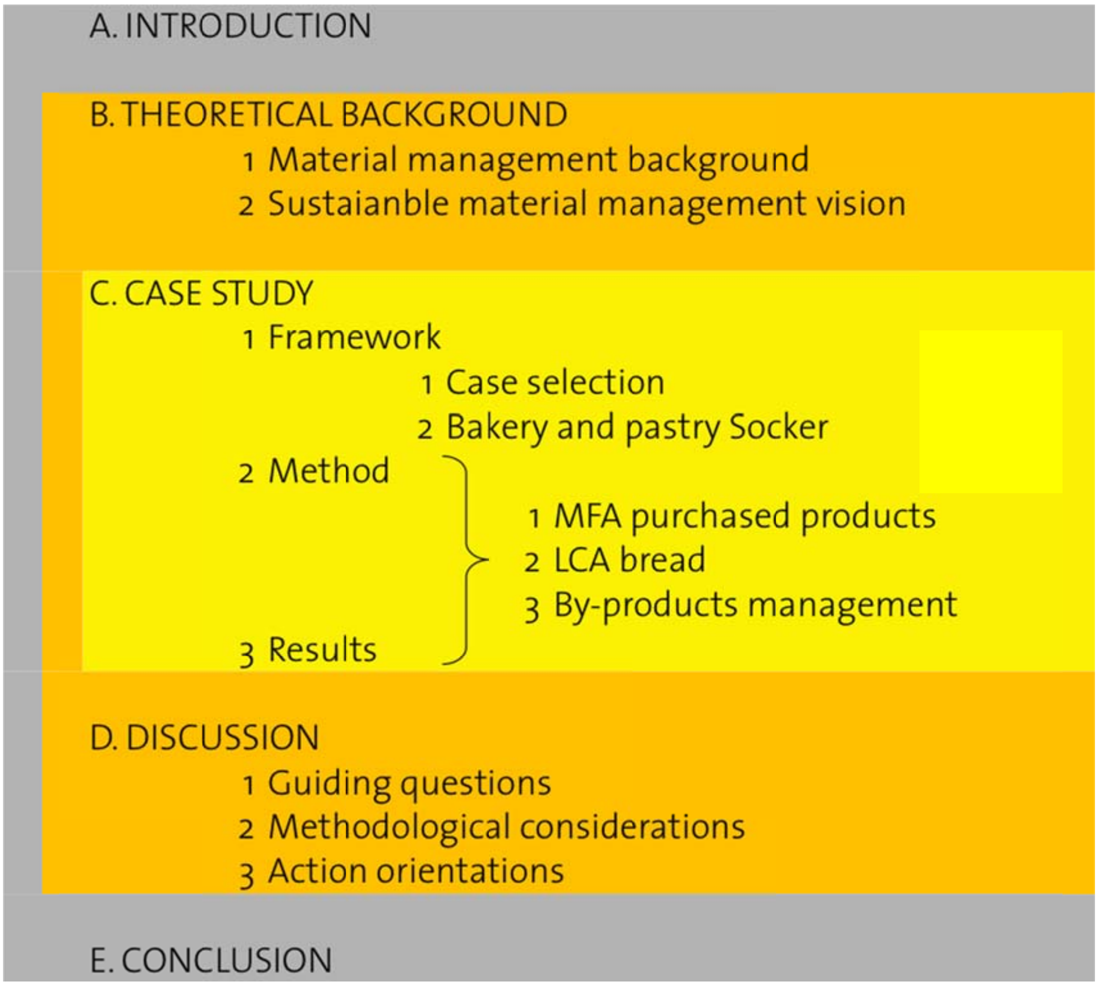


Figure 1: Thesis structure

B. THEORETICAL BACKGROUND

1. Research background

In this section, we discuss the background that led to the formulation of the research question of the present paper. First, an overview of the present environmental challenges and their complexity will show the need of changing the way human activities exploit their own habitat. Subsequently, three economical paradoxes of the present mainstream economy demonstrate the need of challenging the assumptions on which the present society is built. Questioning the sustainability of a system involves understanding where the present attitudes towards nature and material use come from. To this end, an introduction of the historical background, and the main steps that radically changed the relationship between human societies and the natural environment is presented.

1.1. Environmental limits and economical paradoxes

Human activity is deeply and irreversibly interfering with natural ecosystems to an extent that never happened before (Kates & Parris, 2003; Lubchenco, 1998). The environment has limits, but currently, these are not respected by mankind. The average global footprint is 50% higher than the capacity of the planet of renewing used resources and even higher when considering only industrialized countries, which consume up to 4.5 times more resources than available (GFN, 2010). This means that today, people live on the earth as if it would be one third larger and more fruitful than it actually is. Two kinds of pressure affect natural limits. On the one hand, the depletion of non-renewable resources, e.g. fossil fuels and metals, and the overuse of renewable natural resources like forestry and fishery. On the other hand, increasing pressure is exerted on environmental sinks through the emission of substances into the atmosphere, watersheds and soil that are disrupting global biogeochemical cycles (Klee & Graedel, 2004). These pressures have different origins and impacts, which increases the complexity of the challenges faced. Three combinations can be found: some challenges have a global origin and impact, as climate change; others are caused by global demand, but have effects only on a local level, as local water pollution due to ore mining; finally some are entirely local, as water overuse and eutrophication cause by intensive agricultural practice (GreenAlliance, 2005b). In addition to the type of challenges and the levels the environmental impacts occur, two more factors will increase the stress on natural resources, and thus the urgency for finding new ways to embark upon. The global population is growing exponentially, and the western consumerist lifestyle is expanding to countries with large populations as China, India and Brazil (TSB, 2009). These factors show that understanding the origin of the encroachment of natural limits and the development of new strategies that enable people to live well today and in the future are urgently needed.

The problems caused by the over use of the natural capacity of the planet are strongly related to the present economic system that is based on the satisfaction of material needs (TSB, 2009). (EEA, 2010)Three main characteristics attempt to explain the economic failure in relation to environmental sustainability. The first paradox relates to the fact that the present economic system is based on a circular flow of income and outputs, which is sustained by a linear flow of resources. The economy is based on a circular flow in the sense that business pays salaries, which are spent for consumer goods, being produced by business that pays salaries and invests in producing goods. The problem is that the produced goods are based on a linear system that makes materials flow from extraction, to production, use and disposal. Hence, as the planet is a closed material system, in the long term it is not possible to keep alimenting a circular flow with a linear one (EEA, 2010). The second problematic point of the present economy is that environmental costs are not included in goods and service prices. This hampers the causality connection between monetary costs and environmental externalities, which in the end are paid by society rather than by consumers or producers causing them. In the case of transportation, for instance, costs of personal mobility do not include the negative impacts of climate change caused by CO_2 emissions. The third key economic characteristic is the focus on short-term investment and use of discount rates. The economic system is accentuating short-term perspectives that allow and support the development of systems that do not account for the depletion of natural resources. These systems often make arise natural resources sharing situation with the "tragedy of the commons" characteristics, leading to increasing environmental pressure (GreenAlliance, 2005b). These three assumptions of the present economy indicate that a deeper understanding and change at the system level are needed since a sustainable system cannot be based on weak assumptions.

1.2. Historical background

Human history is signed by an increasing grade of intervention with the environment, coupled with a changing perception of nature. The agricultural and industrial revolutions are the two key steps that signed the largest changes in the way humans use materials. The changes of lifestyle were coupled with a transformation of the perception of nature from a living organism to the mechanical worldview that dominates western society since 300 years. This worldview modification is at the base of psychological and social pre-conditions that allowed the development of the current society (Winter & Koger, 2010). An overview of the evolution of the material flow typology, perception of nature and energy use is given in Table 1.

The development of human beings with the present physiology dates back to 200.000 years ago. Thus, the homo sapiens is a young species compared to the first living organisms that appeared 3.8 billions years ago. These living organisms have gone a long path, during which they developed winning strategies for survival despite changing environmental conditions. In comparison to these, human beings are still in their fledgling stage, even though there are marking differences to other species. The highly developed brain and erect position allowed humans to develop mental functionalities and use tools, giving access to possibilities going beyond those of all other living organisms. Communities established themselves all over the world, taking advantage from what they found in the environment to survive (Wikipedia, 2011). In the beginning, humans survived by hunting and gathering. Their influence on the environment was similar to that of any other animal. They lived in a close relationship with nature, as they directly experienced changes in weather and availability of resources. At this time the environment was perceived as a living organism, as a mother providing food and shelter, but also threatening existence thought violent events (Sterr & Liesegang, 2003; Winter & Koger, 2010).

The agricultural revolution, which took place 10.000-7.000 years ago, was the first break that changed the way humans interacted and perceived nature. By understanding some

BOX 1 - Definitions

Ecosphere: the area encompassing all world's ecosystems, governed by biotic and mineralogical rules.

Technosphere: a subsystem of the ecosphere encompassing all material flows created by human activities since the industrial revolution (Liesegang 1992).

or technosphere can be understood as a subsystem of the ecosphere encompassing all human activities. The limits between the two systems are defined by the modification of natural elements by human action, thus a mineral enters the technosphere, as soon basic mechanisms on how nature functions, for the first time they gained the possibility of controlling it. They moved from observing a seed becoming a plant, towards putting the seed in the soil and taking care of it until the moment when its fruits would be ripe. Since this very moment, humans were not any more dependent from what they found in nature to survive, but actively modified the environment and started ruling it. The control of nature was also linked to taking responsibilities, like caring for the crop they planted and their animals. From being nomadic, people became sedentary. This new lifestyle led to an increase of use and modification of materials. A house had to be built, tools where needed for planting and harvesting crops, and only a small part of the cultivated plants could be used as food. All these activities made show up material that started to accumulate, but as it was mainly organic matter it didn't pose a real problem. During the evolution of living beings, thousands of microorganisms specializing their activities, and all together developed the ability of decomposing any substance used by other living organisms. Thus any human waste could be brought back to natural flows (PHASE 1 of Figure 3). The sedentary lifestyle and the improvement of the agricultural techniques served as the basis for the development of the first civilizations (Benyus, 2002; Sterr & Liesegang, 2003; Winter & Koger, 2010).

The industrial revolution made the next break through the historical relation of humans with the environment. In the middle ages, nature was seen as an obscure power that needed to be dominated. In the industrial revolution the domination was affirmed and nature became a pool of resource available for exploitation. People moved to cities where their relation with the natural environment wasn't anymore based on everyday experience, as they started to mainly work indoor i.e. in factories. Life in the urban environment was coupled with the establishment of new kinds of needs. For instance, working away from home made new forms of food necessary, e.g. canned food, as well as of a new culture based on consumption of goods (clothes, furniture, etc.). The establishment of a consumerism society and the growing population made the demand for materials and products grow exponentially. Thus, the construction of a linear material flow system, based on labor mechanization, started an increasing hunger for energy and dependency from fossil fuels (Sterr & Liesegang, 2003; Winter & Koger, 2010).

The new needs of the developing system drove technological innovation. Mechanical engineering allowed using amounts of power that had never been available to humans before. The access to new materials and the possibilities of modifying them led to important chemical innovations. The first chemically synthesized substances opened the door for a new way of modifying the world, by creating new substances that had never existed before. All these developments massively increased the extent to which humans extracted resources and produced value less by-products that started accumulating in the technosphere.

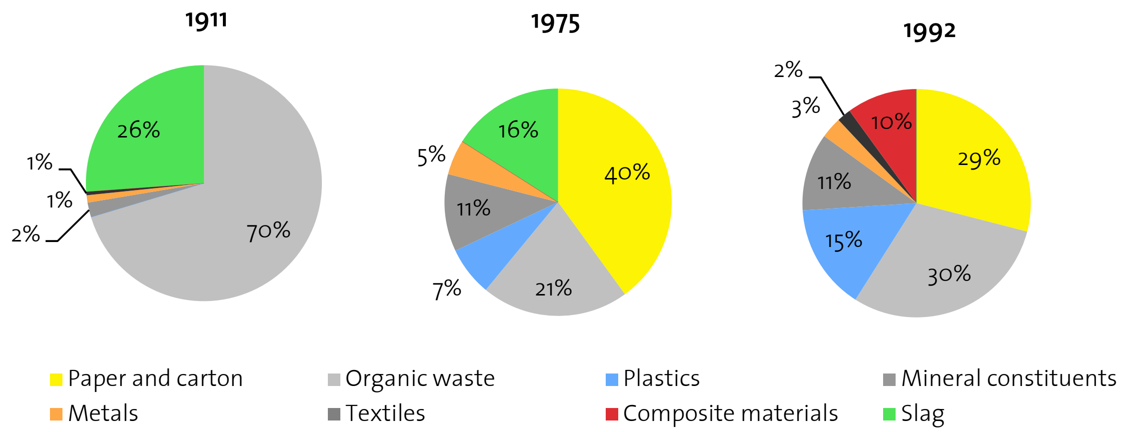


Figure 2: Swiss waste compositing showing increasing heterogeneity of materials (BUWAL)

During 3.5 billion years, Nature used a reduced set of elements, e.g. 20 amino acids, to built every cell, while during the last 200 years mankind created 4 million new synthetic substances that started to accumulate and leach into the environment, disrupting the functions of ecosystems and natural cycles (see Figure 3 PHASE 2 and material composition of waste Figure 2). Thus the most crucial change was linked to the quality of the materials circulating in the environment (Sterr & Liesegang, 2003; Winter & Koger, 2010).

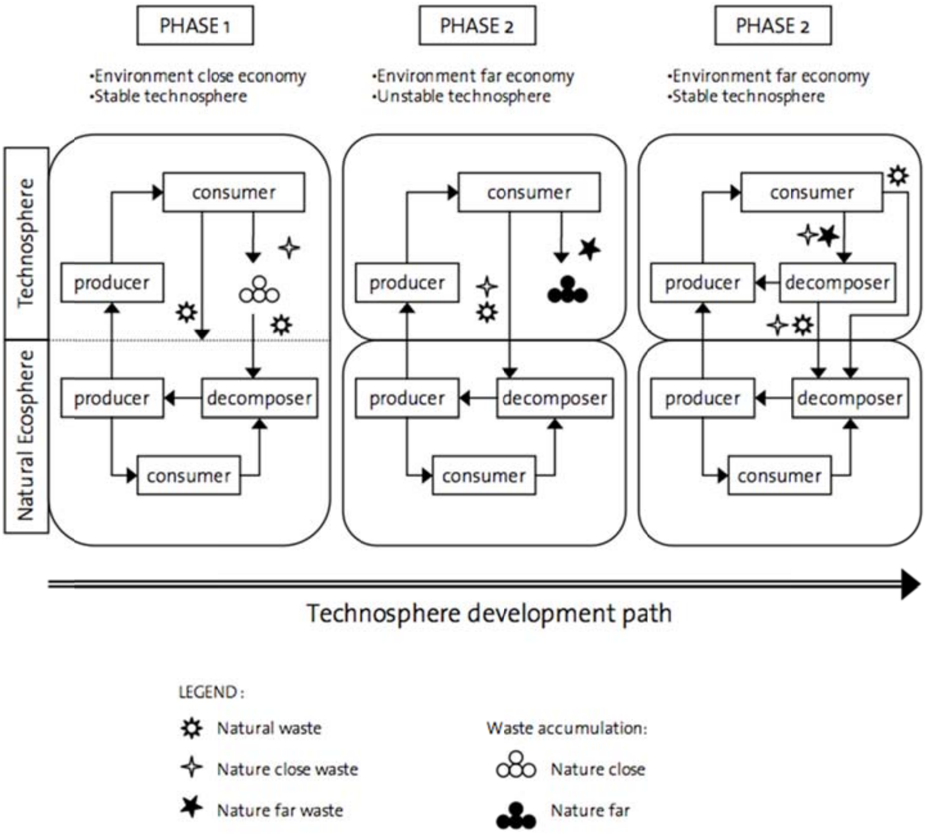


Figure 3: Technosphere developement path (Sterr, 1999; Sterr & Liesegang, 2003)

Sterr presents a summarized model for describing the evolution of material flows during human history taking into account possibilities for developing SMM. Human historical evolution is represented in the three steps of Figure 3. Natural ecosystems are built from relations between organisms that have three types of functions: producers, consumers and decomposers. During PHASE 1 human economy was close to the environment. Even if people used products from the ecosphere as food, clothing and for shelter, the modification of the materials was limited. Natural material exchange processes driven by decomposers were possible, and the materials used by humans could flow back in the ecosphere. The system was stable since used materials could refill the stocks of the ecosphere. In this phase there was no clear distinction between ecosphere and technosphere. PHASE 2 started with the industrial revolution and the production of chemically synthesized substances. The division between natural ecosphere and technosphere started when humans developed the ability of isolating some material flows from the ecosphere decomposer activity. In this way, the technosphere became a system with only production and consumption activities, which led to accumulation of materials. At present, economic activities are in this phase. PHASE 3 depicts a desirable evolution of the material flow towards a nature economy that is stable, as materials do not accumulate in the technosphere, but can either be reabsorbed by the ecosphere or circulate in the technosphere (Sterr & Liesegang, 2003).

This historical introduction shows how the main problems of the present material flows are related to the fact that materials accumulate in the technosphere (see Definition BOX 1), without renovating stocks of the ecosphere. In addition, the speed of the flow –and thus the amount of materials being displaced (Scholz, 2011) - and the chemical composition of the materials created by human activities –which cannot easily be biodegraded– increase the instability of the system. Finally the question arises how society could switch from the present material flow (PHASE 2) to one that could be supported by nature in the long term. Sterr proposes the transition to PHASE 3 illustrated in Figure 3. In this proposed system, waste doesn't accumulate in the technosphere even if human activities are nature far. Instead, it can either be transformed into substances that are directly reused in the technosphere or safely degraded by natural decomposers. This vision shows an approach closing the open loop of the present material flows (Sterr & Liesegang, 2003)..

Table 1: Summary of historical key changes in energy consumption, material management and perception of nature (Sterr & Liesegang, 2003; Weisz, 2007; Winter & Koger, 2010)

	Energy used per capita 3.5 GJ physiological minimum	**Material Flow**	**View of Nature**	**View of the relation between humans and nature**
100'000-90'000 years ago Hunting and gathering society	10-20 GJ (over 3-6 times the physiological minimum)	Integrated in nature	• living organism • spiritual • kinship	integrated
10'000-1500 a.C. Agricultural revolution	60-80 GJ (over 20 times the physiological minimum)	First emissions, but only of materials known by the environment that can be completly degraded.	• first control • strong link in everyday life	
1500-1800 a.C. Enlightenment		increasing population & amount of emissions	• unanimated physical element driven by laws • domination	first separation
1800-now Industrial revolution	210-450 GJ (over 100 times the physiological minimum)	a lot of inputs / output chemical revolution	• machine • metaphor exploitation • progress	over separation

2. Sustainable material management vision and implementation

2.1. Sustainable material management vision

How could a sustainable material management look like? This section shows some examples of approaches that were inspired by the closed-loop system on which nature is based. The main objective is to show sources of inspiration for the implementation of a closed-loop economy. In the beginning, Industrial Ecology (IE) with its principles will be introduced. Subsequently, we present the cradle-to-cradle approach, which has the advantage of formulating a closed-loop economy with positive terms.

The first research and activity field promoting an economy based on closed material flows is industrial ecology (IE). The article of Frosch and Gallopoulos "Strategies for Manufacturing" (1989) marked the beginning of the dynamic evolution of this discipline that today is well established in the international community (Frosch & Gallopoulos, 1989; Isenmann & Hauff, 2007; Nzihou & Lifset, 2010). IE is a:

> "[...] systematic approach that has the goal of moving from a linear to a closed-loop system in all realms of human production and consumption, by shifting closer to an ecological model in its dynamics..." (Lowe & Evans, 1995) pp.47

From a biological ecology perspective, IE can also be defined as:

> "[...] the study of technological organisms, their use of resources, their potential environmental impacts, and the ways in which their interactions with the natural world could be restructured to enable global sustainability." (Graedel & Allenby, 2003) pp. 49

Industrial ecology is based on the natural ecosystem metaphor. The main features of ecosystems taken as models for industrial systems are the capacities of an ecosystem to:

- recycle every material used
- use cascading energy
- have only solar energy as incoming flow of the system

In a broader sense the metaphor provides a model of a sustainable system (Korhonen, 2000b). Korhonen proposes extending the metaphor with three additional features of ecosystems: diversity, locality and gradual change. These characteristics allow to extent the IE metaphor to a regional context (Korhonen, 2000b). The most famous examples where IE was applied in practice is the industrial park of Kalundborg in Denmark (Ehrenfeld & Gertler, 1997), but several other examples exist of self-organizing or top-down shaped industrial symbiosis (Chertow, 2007).

Industrial Ecology sets a vision for the development of sustainable industrial systems by taking a systematic approach focusing on relations between industries rather than looking at them as isolated entities. The strength of the approach is the change of the perception of nature, from the extraction and the use of resources to seeing Nature as a model, from which everyone can learn. Several other currents a part of IE, started to apply the principle of "learning from nature" during the last decades. Green Chemistry, Eco-Design, Biomimicry, Biothinking are only some of those examples (Anastas & American Chemical Society, 1996; Benyus, 2002; Giudice, Rosa, & Risitano, 2006; Sim Van der & Stuart, 2007).

William McDonough and Michael Braungart propose a particular framework for fostering a circular material flow management. In the cradle-to-cradle vision materials are either "biological nutrients" or "technical nutrients" (Figure 4). By means of a positive list of the chemicals a certain product contains, products are designed for either being safely re-absorbed by the environment, through biodegradation, or being easily disassembled and recycled within a high quality recycling process. This approach includes the life-cycle thinking and closed-loop principles of IE, but differs regarding the implementation. Cradle-to-cradle is not focused on increasing efficiency, reducing energy consumption and material use; but rather on using energy and materials effectively. The cherry tree is taken as an example, of "nature's industry" that works with solar power, constantly adapts to circumstances, produces 10.000 blossoms even though only a few will give life to a new tree. The cherry tree nourishes its environment, hosts other species and produces zero waste. It is not efficient, but effective (Mc Donough & Braungart, 1998). Hence, the approach of cradle-to-cradle is not about diminishing the emissions of industries. It rather deals with changing the goal of these industries as to become installations that produce in a way that is not endangering the natural environment and human health, but supporting it (McDonough & Braungart, 2002). The cradle-to-cradle approach is the antithesis of the end-of-pipe environmental management.

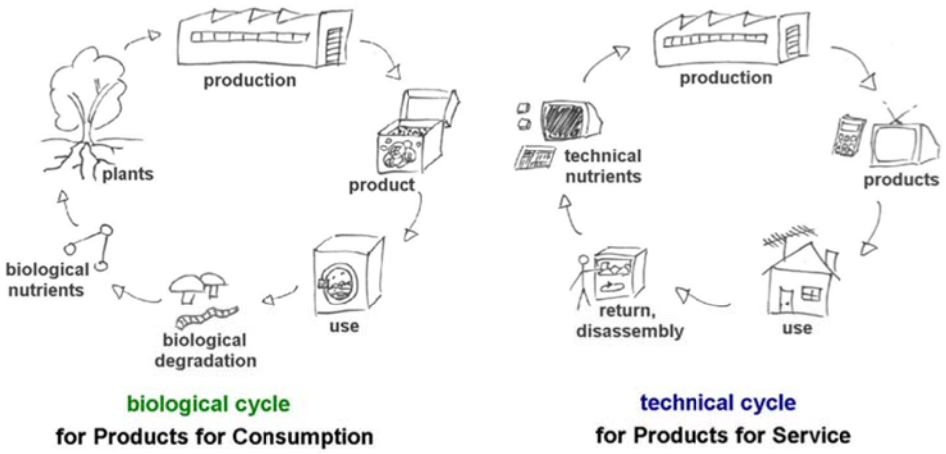


Figure 4: Cradle to cradle approach dividing material flows in biological and technical cycles (Braungart, 2009)

2.2. Including thermodynamic principles in the closed-loop vision

A sensitive topic of the approaches supporting closed-loop economy is the increasing entropy of materials during its life cycle. The first rule of thermodynamics states that the energy and material content of a closed system is constant, while the second claims that energy and material tend to transform themselves towards the maximum degree of disorder (Sterr & Liesegang, 2003). Entropy measures the amount of thermal energy of a system that can be converted into mechanical work (Dictionary, 2005). The Earth can be considered an open energy system, as solar energy constantly irradiates the planet, but a closed material system. According to the second rule or entropy, the degree of disorder in the natural system should constantly increase. However, equilibria of natural cycles show how material can circulate in the environment between different entropy levels. Schneider and Key demonstrated that natural ecosystems are able to transform the incoming solar energy into heat that is dissipated in the environment. The incoming energy allows the ecosystem to mature, while the amount of energy that is transformed into heat is a proxy for the ecosystem development level in terms of the amount of organisms in each trophic level and complexity of food network (Schneider & Kay). This research shows how the limits of a closed material flow are not given by the law of thermodynamics, but rather by the need of an unlimited primary energy source and the ability of materials to cycle back into elements within human lifetime spans.

Entropy is a property of energy and materials of which nature takes advantage, as it offers the possibility for species to diversify at different energy levels. From a broader view producers carry out the first step by transforming incoming radiation into chemical energy. After this the entropy of energy starts to increase. By each trophic level, energy dissipates by a factor of 10 to the point when decomposers sequentially use the last available energy and finally close the material flow by releasing the starting components into the environment. In this way nature uses energy as a cascade, in which each organism profits of a certain stage by coupling material transformation with the dissipation of energy that is available. The concept of cascading resource use can also be adopted in the technosphere in order to allow for the maximum expansion of the lifetime of the materials use phase (Korhonen, 2000a; van Berkel, Willems, & Lafleur, 1997). Combining the cradle-to-cradle approach with the cascade model would allow to shape material flows for which entropy would not have to be considered as an obstacle. This is due to the fact that the dissipating materials would be biodegradable and the incoming energy renewable. If a shoe sole were produced with a material that could be biodegraded, for instance, its wear and tear and dispersion into the environment would contribute to the fertility of the soil (McDonough & Braungart, 2002). Hence, a vision for a sustainable material management would balance environmental impacts and resource security by shaping new material flows (TSB, 2009).

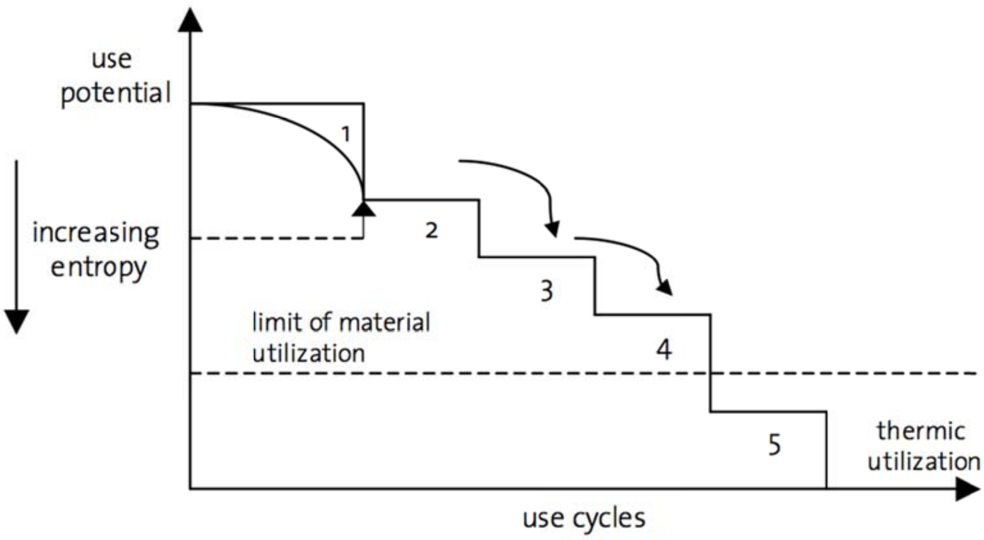


Figure 5: Cascading model of material use (Rinschede & Wehkingund, 1995)

2.3. Implementation approaches

2.3.1. Closed-loop economy

The closed-loop economy approach can be derived from the vision and inspiration given by nature, as it is an exemplar closed-loop material flow. “Closing the loop” in the context of human activities is about avoiding dispersive losses of non-biodegradable materials and applying strategies to material flows that, by modifying the present design of products, use and waste management, enable an exhaustive cascading use of materials, their reuse, remanufacturing and recycling (TSB, 2009). In a broad sense “closing the loop” is as well understood as “diverting products from landfills” (Lifset, 2001) or developing material flows based on recycling of household and industrial wastes, sharing by-products and the inclusion of geographical proximity in the supply chains (Nzihou & Lifset, 2010). Frequently, a closed-loop approach is linked to waste management and recycling. However, this approach describes rather a system view of material flows encompassing all stages from design to reverse logistics. This is because it is mainly during the design phase that the ability to take part in a closed-loop system is defined (Sterr & Liesegang, 2003). In a general sense a closed-loop economy is:

"[...]an economy with the goal of minimizing material and energy flows along a circular flow allowing a new use of materials..." (Nathani, 2003) (p.10).

An ideal closed-loop economy has several benefits but also limitations. Trade-offs of the system are for example obtaining high quality recycled products, balancing total environmental impacts, users mental limits for adopting new product/modes of use and setting an efficient reverse logistic system (Steven, 2004). First, costs (monetary and environmental) of reverse logistics need to be lower than costs of resource extraction. In addition, the enterprise is required to perceive a need for dealing with problems related to the addition of uncertainties related to scraps amounts, quality and composition (Dyckhoff, 2004; Steven, 2004). Apart from these specific problems; real challenges occur on a system level since only limited knowledge on the transition of wider systems is available. The present material flow situation is not sharply understood due to the complexity and global character of the production, distribution and disposal networks. The outlines of the target, which is a closed-loop economy, are not clearly defined either, nor are the path and its impediments known yet. This situation can be described as an ill-defined problem (Scholz & Tietje, 2002) that needs to be addressed by the use of methods which allow to integrate different types of knowledge and stakeholder perspectives.

Even if several challenges and unknowns persist on the path towards a closed-loop economy, numerous relevant benefits within the sustainability discourse can be identified. First, the pressure caused by the rapid, unsustainable depletion of renewable resources and the non-renewable extraction can be released. Subsequently, the energy demand, the amount of dumped waste and released toxic substances would decrease. On the economic side, the system change offers opportunities to businesses for new types of competitiveness and innovation (GreenAlliance, 2005b; Steven, 2004).

2.3.2. Sustainable Material Management Implementation Approaches

Several approaches on sustainable material management exist and are implemented by different stakeholders. Figure 6 illustrates a management approach that takes as the overarching goal of SMM the development of a closed-loop economy based on integrated systems. Proactive approaches can be found at different levels of "maturity". The levels are moving from an "eco-efficient" and "eco-effective" economy to a "sufficient economy". The figure can also be read in relation to a time scale that moves from the present state-of-the-art of material management on the left, to the future situation on the right. The picture also represents individual, isolated proactive approaches moving towards integrated systems that are set in a new frame enabling an SMM (Bienge, Jones, Geyesen, & Rossy, 2010).

The single approaches illustrated in Figure 6 can be summarized into approaches aiming to increase energy and material efficiency through the life-cycle of products, and those that focus on the circular flow, long-term perspective and safety of products (GreenAlliance, 2005a). The first approach aims at increasing the efficiency of material management by keeping the present extraction, manufacturing and disposal systems, but by reducing the energy and material use through more efficient technologies and processes. In a next step, the focus can be put on the product, by substituting certain materials with different ones that have lower environmental impacts, by reducing the amount of materials used in the product (dematerialization) or by increasing the longevity of the materials (Ploetz, Reuscher, & Zweck, 2009; TSB, 2009). The second approach focuses on the effectiveness of products, which does not exclude interventions to increase efficiency, but rather is a matter of the internal priorities of an enterprise i.e. the adoption of new business models. The effectiveness of a product increases by applying eco-design principles, which include all life-cycle stages (i.e., it doesn't stop at the use phase) of products already during their design. Datchefski defines three principles for sustainable design:

- cyclic – products are made for circulating in the biological or technical cycle,
- solar – solar energy is the only source of energy for the production and consumption of products,
- safe – all releases into air, water and soil are non-toxic (Datschefski, 2010; GreenAlliance, 2005b).

The approach can be a good inspiration for designers, although compliance with all requirements is not practicable yet. What can be added to these design principles as a criterion for evaluating products sustainable design is its ability of to take part in a material cascade that increase the total life time use of the material and makes the whole network more efficient.

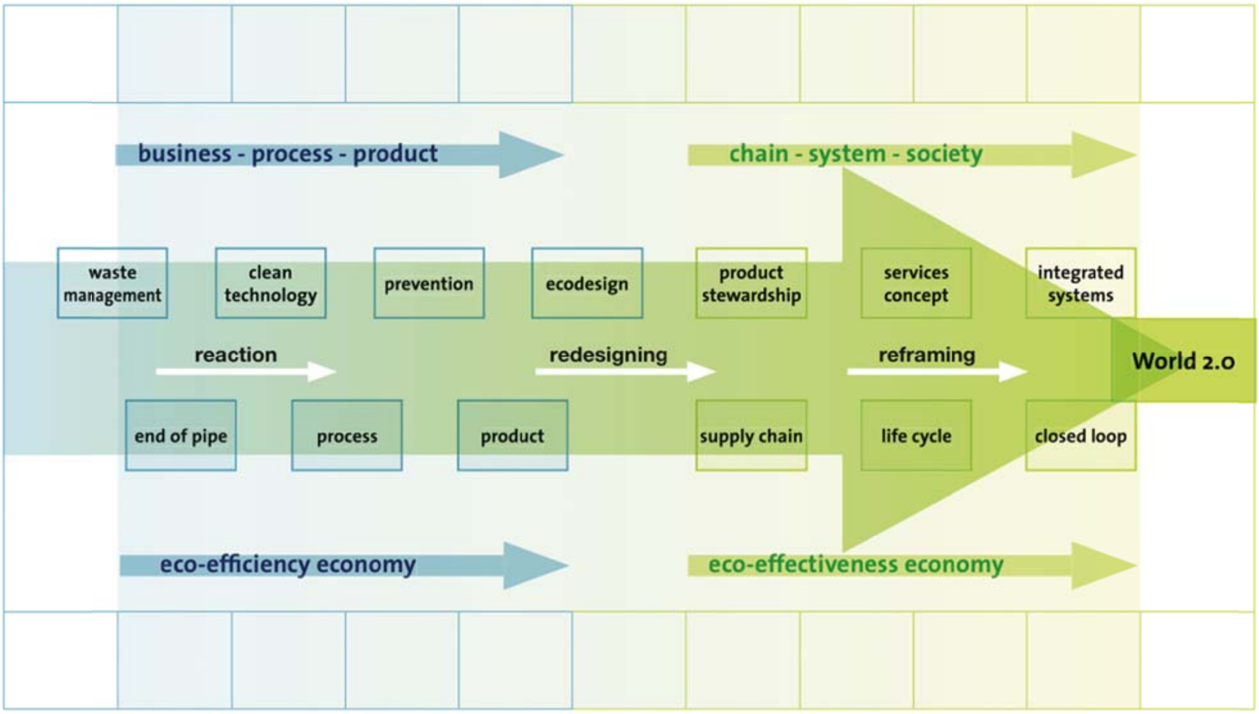


Figure 6: Sustainable Material Management Framework (Bienge, et al., 2010)

Another approach increasing the effectiveness of a product is reframing the modality of its use, by defining a system in which services instead of materials are sold. This is already happening in several sectors (renting and sharing of products as cars, photocopying machines…), but could become more widespread still. Home and office furniture for instance could be rented for a determinate time frame instead of being owned, after which the company would take it back to replace it with new models. The company would gain new materials to build furniture and the owner would have to keep the same furniture 20 years and have to pay taxes for the produced waste. In this way the company would keep being the owner of the products, while the customer would pay for the service provided by the products. The advantage of this approach is also that it enables decoupling the economy from material consumption (EEA, 2010; Ploetz, et al., 2009).

In Figure 7 Figure, we present a quantitative example of the present material flows of the United States of America from resources extraction to waste accumulation prepared by the Don Seville and Rocky Mountain Institute. The figure shows that up to 93% of waste are produced during the manufacturing process, and in total, up to 99.98% of materials are disposed of even before reaching the use phase. These numbers give a new dimension to sustainable material flow management: the potential of saving resources extraction through recycling is convincing. The following Figure 8 illustrates the perspective of a system driven by natural capital conservation and regeneration. This approach is based on modifying the present system four steps that aim to increase resource efficiency in a comprehensive and radical way. The paradigm modifications are to:

1. change design to eliminate waste and toxicity
2. recapture resources after manufacturing and use
3. implement a system rewarding efforts done at each intervention point
4. reinvest in natural capital

The final goal of the approach is to foster a new revolution that increases the resource productivity. The vision is to replace the principle of the industrial revolution, that is, scarce people and abundant nature, with those of the present World, that is, abundant people and scarce nature, by shifting from the focus on increasing labor productivity to that of rising resource productivity.

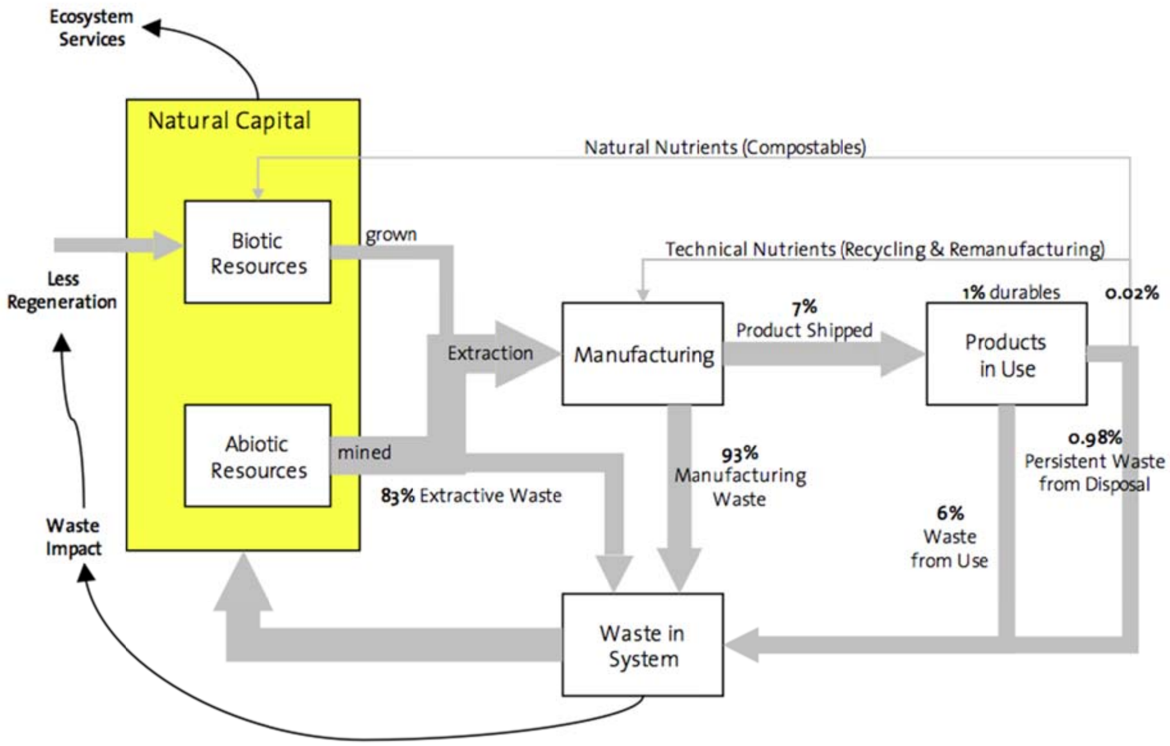


Figure 7: Present material flows oft he U.S. (Lovins, 2005)

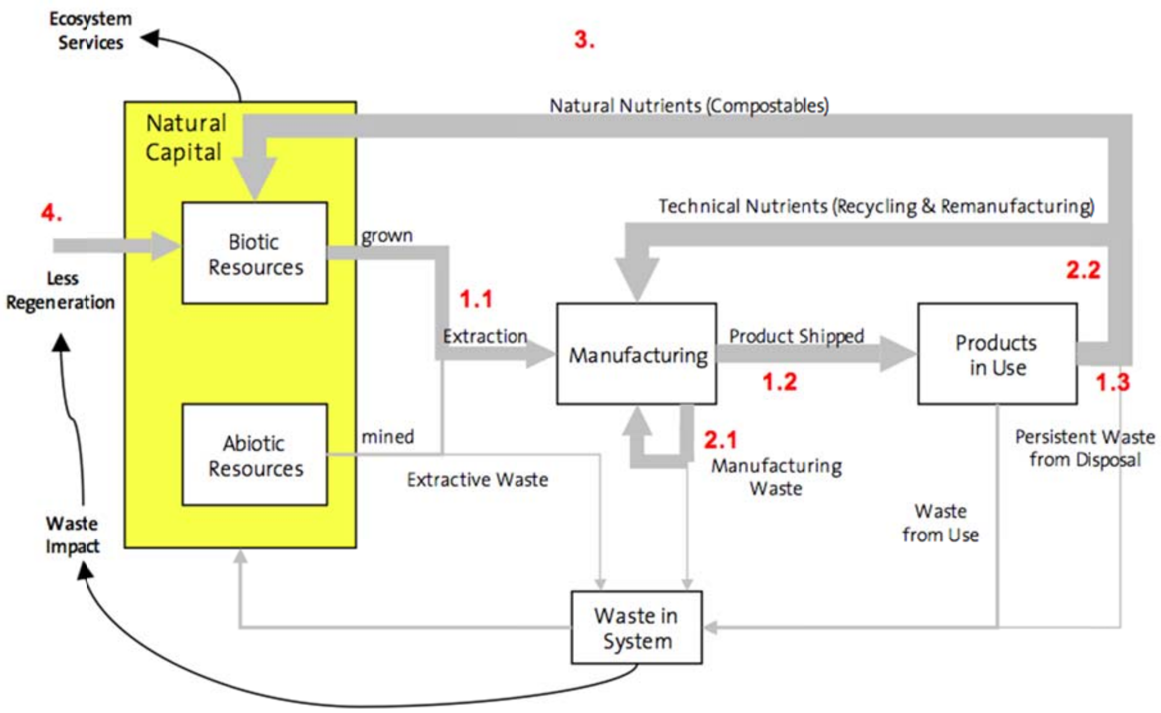


Figure 8: Example showing system driven by natural capital conservation and regeneration (Lovins, 2005)

2.3.3. *Regional closed-loop economy*

The concept of closed-loop economy is often applied to the management of single material flows or products, that is, through eco-design development of recyclable products. The regional closed-loop economy is a different approach since it takes into account the spatial dimension, which adds one more degree of complexity to the system. A regional closed-loop economy can be regarded in relation to the geographical boundaries of a region, constituting a political and administrative entity, or in relation to the functional activities performed, which shape the economic structure. The administrative and economical systems often don't share the same geographical boundaries. In the case of the economic system, these boundaries can hardly be defined in a distinct way. Figure 9 shows an economical activity region as a system of multidimensional relations. This representation helps to understand material flows in relation to specific systems that influence them. For instance, an enterprise producing an item is linked to other enterprises by its supply chain on the same system level, but it is also linked to the political level, which sets regulation and compliance standards. Furthermore, the enterprise is linked to its customers who directly define the demand for item that the enterprise supplies. The real site surface gives the spatial dimension showing links between different levels in relation to the location (Sterr & Liesegang, 2003).

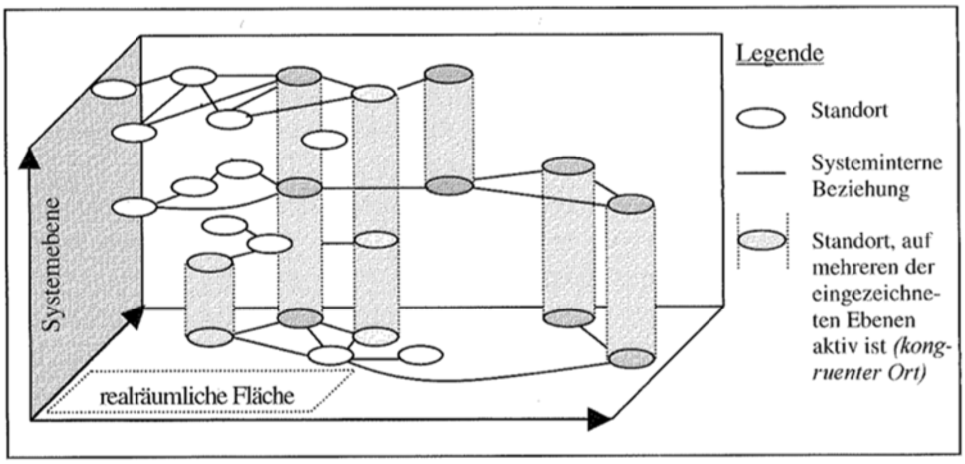


Figure 9: Regional economy as a multidimensional relationship area pp. 205 (Sterr, 2000; Sterr & Liesegang, 2003)

The interesting part of dealing with a regional closed-loop economy is that the "size" of the "loop" is considered as relevant. Closed-loop material flows are viable only within a specific area, beyond which the costs of closing the loop are higher than the benefits. The maximum distance depends on the costs of transport and on the total environmental impacts of a product life cycle. Using regional resources avoids emissions from long-distance transport and dislocation of direct environmental impacts, which are the very source of problems going along with overconsumption. For instance, the impact of chopping down a forest at one's doorstep is closer to personal reality than clearing a tropical forest somewhere far away. In addition to this, the global market suffers from lack of transparency and minimal standards ensuring environmental protection and fair-trade. Thus, arguments for promoting a regional closed-loop economy are not only environmental, but also economical, since the development of a regional addition of value ensures high employment rates and offers opportunities for creating new job markets within the reverse supply chain (Sterr & Liesegang, 2003; Steven, 2004).

2.3.4. *Regional Initiative linked to closed-loop economy*

Initiatives supporting a closed-loop economy, or generally SMM, can be found on the global to the local level. Industrial ecology strongly supports the creation of industrial closed-loop material flows between large enterprises sharing the same industrial area, which can be considered as "local industrial closed-loop economies". The aforementioned case of Kalundborg (section 1.3. Sustainable Material Management approaches) may serve as an example here (Ehrenfeld & Gertler, 1997; Erkman, 1997; Sterr & Liesegang, 2003). Examples that focus on industrial activities but take a regional economic perspective exist in Austria, for example in the Obersteiermark region (Sterr & Liesegang, 2003). For this region, the potential of developing an industrial regional material exchange network was analyzed by the University of Graz. The researchers first conducted a wide input/output material flow analysis of the region, which allowed for identifying the material flows and possible exchanges between industries. Several hindering factors for the implementation of the exchanges could also be determined empirically. These included time, quality, and site specific and legislative related aspects (Sterr & Liesegang, 2003).

Beyond the approaches that exclusively focus on industries, several initiatives generally attempted to promote SMM. On the global level, the most powerful tool is legislation. From a top-down perspective the legislative framework shapes the way the world looks like. Regulations set the limits within which economic activities can be performed. The integrated product policy (IPP) and the regulation, registration and authorization of chemicals (REACH) regulation EC 1907/2006 are two examples of EU regulations that are strongly influencing the environmental burden of companies from a prevention and eco-design point of view. The objective of the IPP is to strengthen product-related environmental policies by applying the principle of "the polluter pays" to taxations allowing internalizing environmental costs of products and promote eco-design. REACH is a huge change in the chemical regulation: for the first time only products that have previously proved to be safe for health and the environment can enter the market (EU, 2011) REACH works on the "producer responsibility principle" and even though it has been criticized for its administrative inefficiency (MPR, 2008) and costs and for hampering innovation, it implies a radical change of the legal responsibility level.

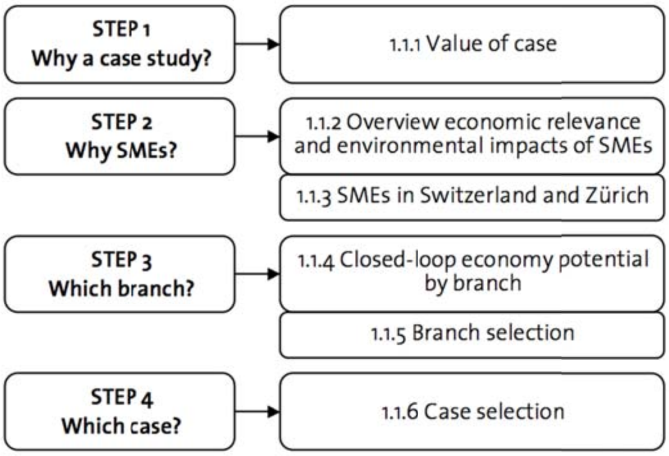
On the national level each country has it's own sustainability strategy. With regards to the promotion of a close-loop economy, Germany has been the first country that adopted a closed-loop and waste management regulation (the "Kreislaufwirtschaft-/Abfallgesetz" in 1994), which redefined the concept of waste. The regulation also clarified terms and priorities between avoiding the production of waste, reusing, recycling and disposal. Its main innovation is the idea to only consider materials that have not found any other path for use as waste (Sterr & Liesegang, 2003).

Further initiatives also exist on the inter-regional and regional level. The Interreg IV is a EU program sustaining the interregional cooperation by improving the effectiveness of regional policy instruments. The program aims to support regional sustainable development through action in different areas, which include natural and technological risks, climate change, water management, waste prevention and management. Examples of these programs are the "North Sea Programme 2007-2013" or the "interreg IV Alpenrhein, Bodensee, Hochrhein". The closed-loop economy is not in the center of the projects taking place within this framework, but efficient sustainable material flows and waste management initiatives are supported. This frame shows how regional initiatives have the power to expand, since tools already exist for sharing knowledge and positive experiences. On a regional level, the region of Limburg in the Netherlands can be cited, where several initiatives promoting the implementation of a closed-loop economy inspired by the cradle-to-cradle principles are taking place. Venlo, forming part of the region, aims to become the "first cradle-to-cradle region of the world" (REFE web Venlo). Two key initiatives, the development of Greenport Venlo, where agriculture, industry, transportation and logistics will be integrated, and the preparation of the Floriade international horticulture fair 2012, are fields were the cradle-to-cradle principles are applied on a regional level (sustainablecities, 2009).

C. CASE STUDY

1. Case selection

In the following section the procedure that led to the selecting of a bakery as case study partner is illustrated (See Figure 1). The selection is based on answering four questions that justify: the use of a case study approach in the present context, the focus on SME, the selection of the branch and of the case. The rationales are explained by introducing economic, environmental and conceptual data related to specific questions.



1.1.1. The value of a case study

Two methods could be used to analyze a complex system like material flows of SME in a specific region: input/output regional material flow analysis and a case study approach. Input/output analysis of material flows is a method commonly used on a national level, since it allows monitoring quantitatively all flows entering and leaving a system. The disadvantage of applying the method on a region is that there are no physical boundaries delimiting the area, as the border does at the national level. The collection of data requires defining artificial boundaries and an accounting system has to be set up, as presently only isolated and incomplete data can be collected. For example, looking at the amount of waste produced in the city of Zürich can be easily collected from the municipal waste management company (ERZ). However no specific data for SME can be derived, as some of the waste is thrown away in specific industrial containers and some in the municipal collection bag used also by households. The lack of available data makes this method impractical within the frame of a master thesis. In contrast a case study approach has the advantage of being more suitable for a study of the present range. Data can be gathered from the enterprise and additional information can be gained by direct contacts. Additionally the results of the analysis are relevant for the case partner, which is not always the case when a system analysis is based on aggregated statistical values. From the methodological point of view a case study offers the possibility of learning about the system from the case. This is possible because the integral analysis of the enterprise, taking into account most of the aspects related to its activities, clarifies the relations of the enterprise with the surrounding actors at different levels. The comprehension of the enterprise subsystem allows for the understanding of the mechanisms and relations between different actors thus learning about the whole system.

BOX 2 - Definition SMEs

Small to medium sized enterprises (SMEs) have less than 250 employees, an annual turnover below 50 Mio. euro or a total annual balance of 43 Mio euro.

Small enterprises are defined as having less than 50 employees and an annual turnover below 10 Mio.

Micro enterprises are defined as having less than 10 employees and an annual turnover below 2 Mio. euro. (BFS. 2011)

1.1.2. Environmental impact of SMEs

SMEs are a key sector with regard to environmental emissions (Constantinos, et al., 2010), even though it is difficult to quantify the impacts because of lack of data at the national level (Hillary, 2004). A common estimation of the environmental impact of SMEs is that they account for 70% of industrial pollution (Hillary, 1995, 2004). A recent report from the EU specifies that the environmental impact of SMEs in the EU is 64% of the industrial share of environmental impact (Constantinos, et al., 2010).The share of SMEs in the EU and in Switzerland is very close (Table 2), thus the environmental impact of Swiss SMEs are probably in the same range as in the EU. Additionally industries and services account for 35% of the total energy consumed in the country (BFE, 2010). Since energy use is closely related to environmental impacts, the relevance of the activities of SMEs in Switzerland becomes evident. Despite the relevant contribution to environmental impacts of SMEs the focus of policies and regulations is often on large industries, because they produce punctually significant amount of emissions. During the last few years external pressures, in the form of legislation, public opinion, and cost saving opportunities, pushed large industries to reduce their emissions in the EU (Constantinos, et al., 2010), but no improvement is reported for SMEs. Thus it is important to consider SMEs in the environmental debate, as they are a central player of national economies and the environmental footprint.

Looking into more detail, the features of SMEs are that not only are their activities very heterogeneous, but also their type of the environmental impact. The environmental impact of a single SME depends on the size of the company (micro, small or medium enterprise (see definition BOX 2), branch of activity, product and level of technological innovation. For example some sectors have a large total impact, but very low impact per company, such as the wholesale and real estate sector, while in other sectors the main difference between the intensity of environmental impact per company depends mainly on the size of the enterprise.

Table 2: Data on European and Swiss SMEs

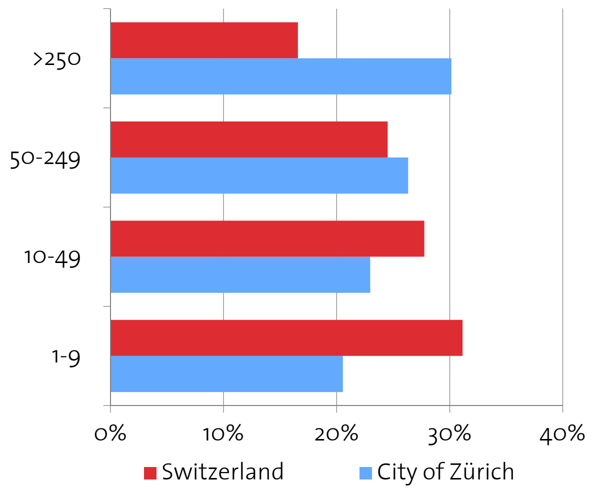
KMUs	Europe	Switzerland
Amount of companies	99.8%	99.6%
Employed people	130 Mio	2.1 Mio
Turnover	58%	-
Share industrial environmental impact	64%	-

This is for instance the case of mining, pulp and paper industry, recycling, fabricated products and water transport; where environmental problems are encountered with smaller enterprises rather than with large ones. In addition to all these factors the choice of different environmental indicators can lead to various outcomes. For these reasons the discussion on environmental impacts of SMEs cannot be generalized, but needs to take into account the variations of different groups (Constantinos, et al., 2010).

1.1.3. SMEs in Switzerland and Zürich

The City of Zürich is a central player of the Swiss financial market; it hosts research and development centers, traditional machine industries, and the offices of several international corporations (Regwerty, 2009). 91.5% of people work in the tertiary sector (SSZ, 2008). Even though the City has a higher amount of large enterprises than the Swiss average (see Figure 11 Left), the role of the 25'000 SMEs in the City is important. SMEs provide more than 2/3 of the city jobs. Considering that the number of employees of a SME is a proxy to estimate its environmental impact (Constantinos, et al., 2010), involving SMEs in environmental programs becomes essential for allowing the city to reach the objectives of the 2000-Watt-Society. Figure 11 on the right shows the amount of companies by size and Figure 12 illustrates the distribution of employees of those 14 sectors that provide 65% of work places in the City of Zürich (SMEs and larger companies).

The activities of SMEs in Zürich are divided in 44 different branches. Looking at the companies having between 10-250 employees accounts for 79% of the work places of SMEs, ten sectors represent 75% of the companies (see Figure 13). Within the most abundant sectors the most material and energy intensive are construction, and restaurants and accommodation. Additionally wholesale, and retailers and repair of used items directly deal with the exchange of goods. Therefore they have a higher environmental impact, due to transportation and storage of goods, than a company focused on office services. The health branch also abundantly consumes items and energy to provide its services.



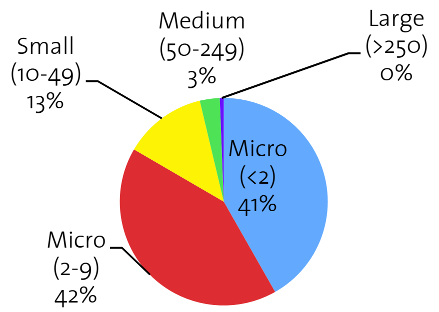


Figure 11: Left: Comparison of employed by company size in Zürich and Swiss average. Right: Working places in Zürich by company size.

Figure 12: Employed by sector in Zürich

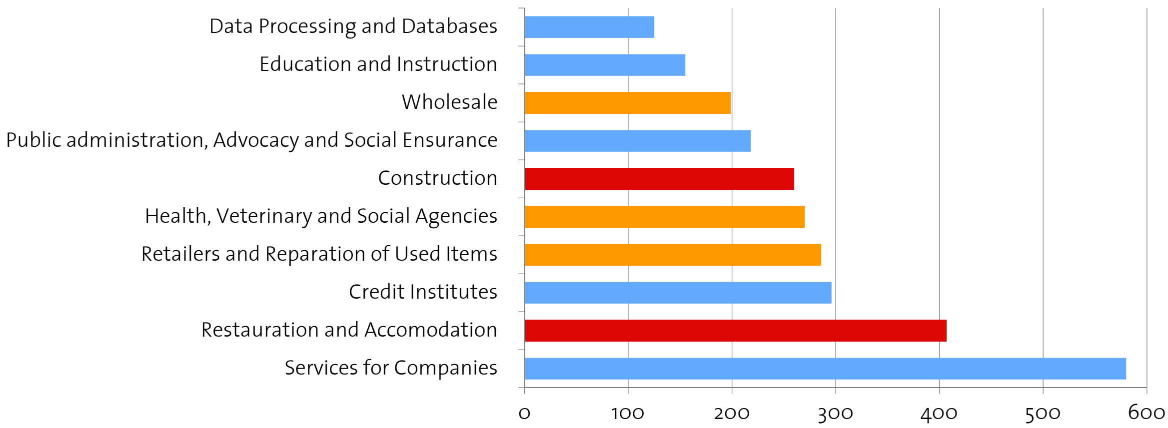


Figure 13: Amount of SME per sector in the City of Zürich. Colors of the graph are related to the intensity of material flows and environmental impacts. Red is high intensity, orange medium and blue minimal.

1.1.4. *Closed loop economy potential by sector*

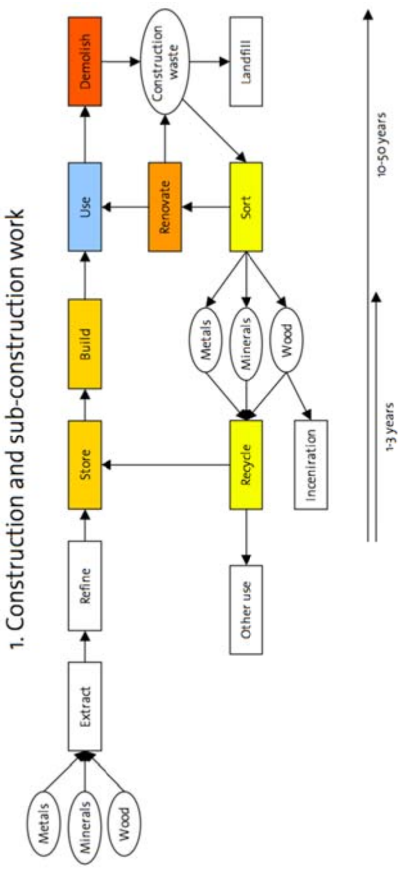
The five above cited sectors (construction, restaurants and accommodation, wholesale, retailers and reparation of used items, and health services) were chosen and a qualitative analysis was done to show the existing options for the sectors to foster a closed loop economy. The role of SME in the involved decision-making process can be analyzed through this simplified system approach. Red, orange and yellow colors are used to highlight the stages in which SME are already involved or could further be an active part of the chain to close the loop. This could be done thorough collaboration of different small to medium companies; each one specialized in one task, or by a large company with specialized sectors. Both solutions have advantages and disadvantages. SME are more flexible and adaptive, and able to find innovative ways to close the loop if the opportunity to make gains is clear. However in the present political and economic system the monetary flows are not set in a way to promote activities leading to closing the material flow loop. Larger companies are more efficient and are able to better coordinate the different steps of the process. Thus difficulties exist to shift from the present business model to a closed loop material flow, as this needs effort from the product design to the practical implementation. As well, this involves planning the transition and overcoming uncertainties related to the take-back system, for example.

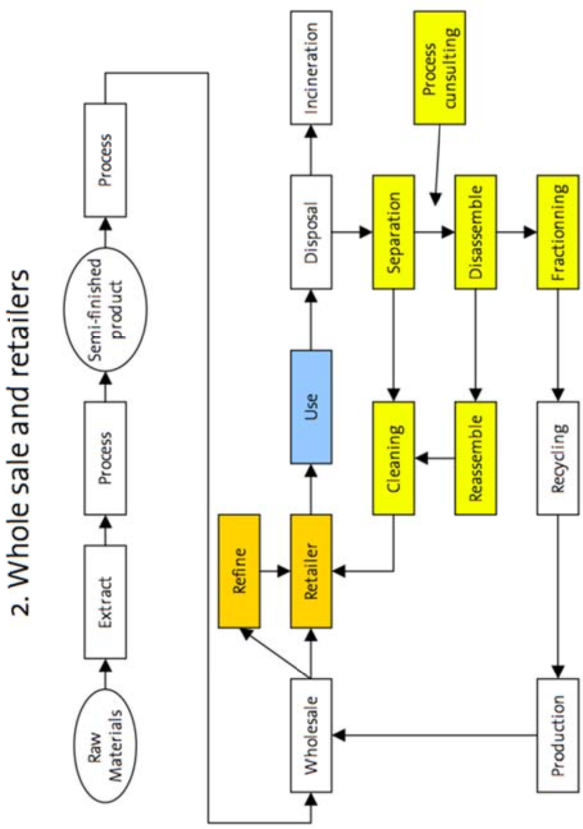
1.1.5. *Selection of Enterprise for the Case*

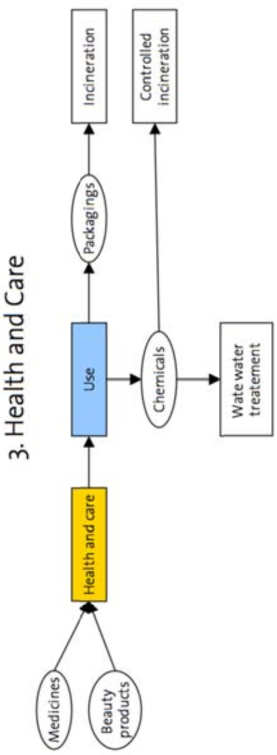
The sector and enterprise of the case study was selected within the five branches presented above in Figure 14. All the five branches are relevant with regard to economic volume and intensity of specific environmental impacts. To choose the most appropriate option within them attention was paid to possibility of gaining raw materials from the region and of setting a system able to "close the loop" of material flows. As the majority of SMEs are not directly producing products, but mainly handling purchased materials to provide services, the possibility of influencing the system in the sense of reducing or reusing by-products from a SME perspective is often limited. A SME cannot change the way a large enterprise designs a specific good, it can just choose to buy it or not. In some fields however SMEs still have the possibility of choosing between different products in relation to quality and origin, being able to promote products that fit well in a closed loop economy. In the next paragraphs are illustrated the rationales behind the final choice of the gastronomy branch.

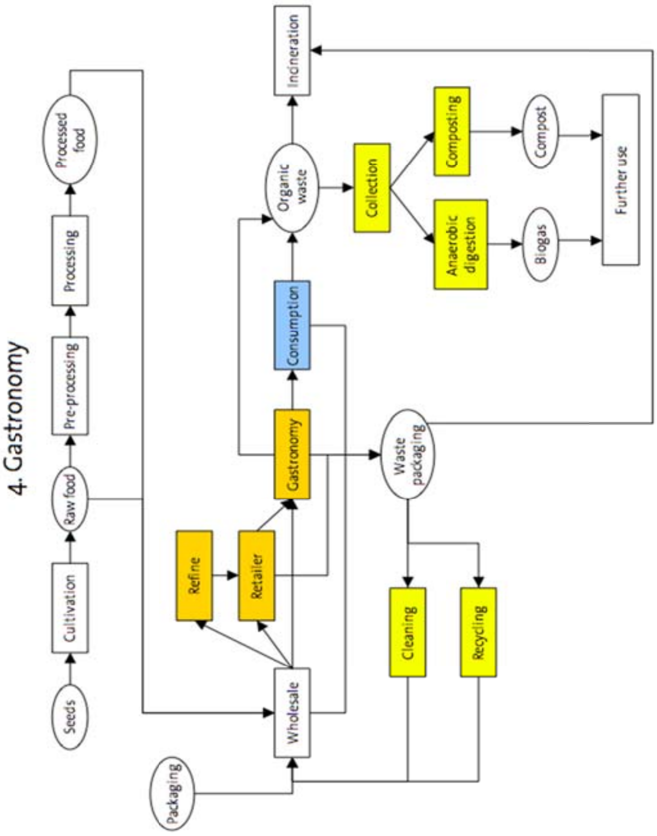
Health branches deal with large amount of products that have to be treated as special waste, because of their high content of chemical substances. Even though the amount of waste produced per year in Switzerland is not very high - 0.6% of the special waste collected (BAFU, 2009)- the improvement potential is large because of the quantity of one-time use products. The main difficulty of developing a closed-loop material management strategy for SMEs from the health branch comes from the fact that the branch is very differentiated. A dentist, a family doctor and a physiotherapist are all considered under the same category, however doing a case study on one of them would not lead to results relevant for the whole sector. Additionally the dependency from large corporations for the purchase of drugs and inspection utensils cannot be avoided from the action of single SMEs as there are strict regulations for hygienic standards.

Retailer and whole sale are very important in terms of amount of employees, however the environmental impact per enterprise is very low (Constantinos, et al., 2010), as there is no production or direct use of materials involved in their activities. They play a central role in the efficiency of the global supply chain of goods consumed in the everyday life, but have a limited decision-making range, as they are in the middle of a chain of actors. For instance a shop cannot sell locally produced clothes, if the local production cannot supply a wide demand and have competitive price, so often local tailored clothes remain an exclusive niche product. The role of retailers and wholesale, seen as intermediary between production and customers is


1. Construction and sub-construction work
Metals
Minerals
Wood
Extract
Refine
Store
Build
Use
Demolish
Construction waste
Landfill
Renovate
Sort
Metals
Minerals
Wood
Recycle
Incenration
Other use
1-3 years
10-50 years


2. Whole sale and retailers
Raw Materials
Extract
Process
Semi-finished product
Process
Wholesale
Refine
Retailer
Use
Disposal
Incineration
Process cunsulting
Separation
Disassemble
Fractionning
Cleaning
Reassemble
Recycling
Production


3. Health and Care
Medicines
Beauty products
Health and care
Use
Packagings
Incineration
Chemicals
Controlled incineration
Wate water treatement


4. Gastronomy
Seeds
Cultivation
Raw food
Pre-processing
Processing
Processed food
Packaging
Wholesale
Refine
Retailer
Gastronomy
Consumption
Organic waste
Incineration
Waste packaging
Cleaning
Recycling
Collection
Anaerobic digestion
Composting
Biogas
Compost
Further use

essential for the development of a closed loop economy, as a selling point can easily become also a take-back and sorting centre, becoming an intermediary for both directions of the loop.

The building sector has a huge environmental impact. It shapes the landscape for centuries, uses chemical substances that can be harmful for the health and the environment – e.g. asbestos, etc. – and requires enormous amounts of energy for the building material production. Construction waste accounts for 72% of the waste produced in Switzerland (BAFU, 2009). Several materials used in the building sector are not renewable, such as metals, and most of them can be reused or recycled easily if the deconstruction phase has been included in the building design. Some forward steps have been made in the sector, though mainly on the energy efficiency side rather than on an integrated concept of material use (Ortiz, Castells, & Sonnemann, 2009). Taking SMEs perspective in the building sector, the main constraint comes from the fact that the life cycle of a building ranges from 20 years to centuries. This causes several difficulties: an enterprise working in construction has no incentive to use different technologies to facilitate the deconstruction as it will not be involved in the end of the building life cycle. Today an enterprise working in deconstruction cannot obtain high quality products, as building were built with hybrid materials not planned for recycle and reuse. The building sector is a good example for a sector in which the political level has to take the responsibility for a closing the loop through generations. However it is of limited interest for the actual case study.

Gastronomy in contrast to the building sector deals with materials that have a very short life span: most food products are grown and consumed within 1-2 years. Eventually the plastic packaging, in which food is often sold, are made for lasting during centuries, but the organic matter is made for circulating in the natural system leaving no trash behind. The sector dealing with food is relevant within SMEs and independently from the specific nature of the activities – restaurant, take-away, bakery, etc. – some of the outcomes of a specific case can be generalized for the whole category. Food can be grown regionally or imported from overseas, giving the possibility for a SME to choose between sustaining the regional, national or international economy. The cultivation can follow different standards, ranging from extensive to organic practice. The pathways, for treating by-products produced during cooking or refining processes, so how the possibility of choosing between one-time use or reusable packaging, are also mostly the same for the whole sector. Additionally by food products the relation to the origin is relevant for customers. The implications for customers of the origin of electronic goods or clothes are very different than that for food products. Discussions on preference between regionally grown versus imported food products, and organic versus extensive cultivation are very topical within the public debate.

1.1.6. Case selection

There are several types of SMEs providing food services. Table 3 shows the quantity of enterprises present in Zürich. Companies dealing with food restaurants stand out because of their abundance. However for a customer choosing a restaurant, the origin of the food plays a secondary role, compared to the menu, atmosphere and location. A product having a strong relation with its origin is bread. It is traditionally the basic food on each table. Within bakeries there are not as many possibilities of differentiation as restaurants have, therefore the ability of providing information on the origin and quality of the products can readily clarify which proactive actions for the

Table 3: Amount of gastronomy enterprises in Zürich

Amount	Entreprise
1540	Restaurant
178	Take Away
162	Catering
124	Bakery
107	Bakery, pastry shop
107	Wine-trade
56	Choclate and pastry shops
52	Bucher
8	Cheese specialities

environmental can make a difference. Additionally bakeries have a relatively stable food assortment year after year, enabling results which are representative for longer time periods. Thus doing a case study on a bakery seemed to be a good option.

A bakery of Zürich agreed on being the partner enterprise for the case study of the present thesis. The enterprise is a well-established family led bakery of Zürich. It serves more than 10'000 customers each day, has over 100 employees and an annual turnover above 10M Swiss francs. Since the beginning of the XX century fresh bread and other sweet and salty specialties have been served to customers. Today the bakery has several branches in central locations of the city.

2. Method

2.1. Material flow analysis of purchase products

The analysis of the implications of the present and alternative procurement pattern of the bakery consisted in doing first a material flow analysis (MFA) on purchased products and next elaborating three alternative purchase options. Consequently the theoretical background of the methods and the procedure followed during the research process.

2.1.1. Theoretical description of material flow analysis

Material flow analysis (MFA) is a quantitative method accounting for material and energy flows of a system with defined spatial and temporal boundaries. The systematic method quantifies input, size of stock and output flows by applying the principle of mass conservation (Reisinger, et al., 2009). This follows an iterative four steps procedure (Baccini & Bader, 1996; Brunner & Rechberger, 2004):

1. System Definition:	Identification of materials, processes and one or more compounds.
2. Data measurement or gathering:	Description of materials flows and concentrations.
3. Calculation of material flows:	Supported by computing systems or specialized software.
4. Schematic representation and interpretation of results:	Important sources and sinks of materials are identified, as well as theoretical possibilities for modification of flows through change of material, process technology and concentration of substances.

MFA is used in relation with sustainable development, to indicate the evolution of the link between economic growth and material consumption. It allows defining impacts of resource use and its spatial distribution. The European Union has adopted MFA as a base for defining some sustainable development indicators (Foundation, 2003). Applied on a national or regional level MFA illustrates visible flows of imported materials, thus the environmental impacts related to the extraction and processing during early product life cycle stages. Beyond the use of MFA on a political level, the method can be used for developing cleaner production by characterizing flows on specific phases of the production (Reisinger, et al., 2009).

To supplement the MFA alternative purchase options were elaborated. The adopted procedure goes in the direction of methods used for building alternative scenarios (e.g. formative scenario analysis (FSA), etc.). The main differences are that data of alternative options are based on the present situation and not projected in future states, thus the alternative options show possible procurement configurations in the present state but don't include factors influencing future modification of the parameters.

2.1.2. *Practical procedure*

The procedure for the analysis of material purchased by the bakery started by defining system boundaries, then clarifying the analysis scope and setting the methods for gathering data. Next came the process applied for analysis of the present situation and building alternative purchase pattern.

System boundaries and data gathering

In the present study, MFA is used to analyze the input and output material flows of a bakery with the objective of quantifying material and economic streams in relation to the origin of raw materials (see Figure 15). The system boundaries are defined by:

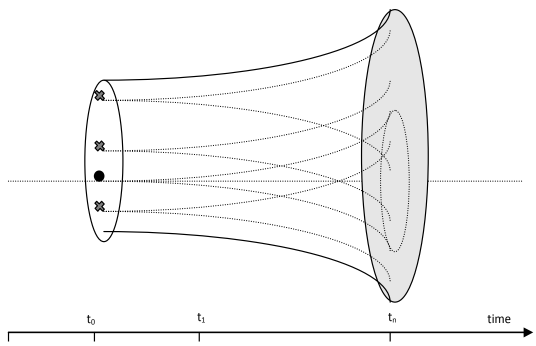
"*The total food products purchase by the bakery during the year 2010*."

The bakery is considered as an enterprise, thus products were considered independently from their place of delivery. The temporal reference is one year to acquire a comprehensive data set that includes seasonal and festival day variations. The incoming assortment analyzed is limited to food products that are processed by the bakery. Therefore sold drinks and chocolate snacks are excluded, as well as cleaning products and packaging. This choice is based on the fact that it is mostly impossible to determine the origin of all components of processed products having large numbers of ingredients. Additionally in the case of branded drinks and chocolate snacks the bakery has a limited range of alternatives, as the choice of different products implies a change of product brand which may decrease the customer demand. However, because drinks represent a significant fraction of the weight of purchased products, this flow will be displayed in the analysis of the present situation, but not modeled.

The partnership with the bakery allowed for gathering data for the MFA. The bakery asked its supplier for accounts on all the purchased products during the year 2010, containing data on total product weight, cost, and origin. After receiving the data a screening and classification procedure was done. When the origin of a set of products was not known, a selection of the most relevant products in terms of weight and price was done. Data on these products were requested directly by suppliers. After completing the data of all the purchased products the analysis of the present situation was carried out. The bakery also furnished data on the amounts of waste collected in industrial bins from the production, and in the branches. However data on the amount of waste produced in the other branches was not available. A description of the typology of produced waste was given by the enterprise.

BOX 3 - Method for alternative purchase pattern selection and Scenarios

A scientifically built scenario is a coherent and consistent picture or model of a future state of a system. Scenarios are based on possibility, therefore they are not predictions of the future, but rather showing possible alternatives of a system (Scholz & Tietje, 2002). As the elaboration of the product set is not based on the future states of the system, but rather shows a picture of an alternative state of the system in the present moment, it cannot be considered as a proper scenario. However, the alternatives can support the prospective decision-making process by showing the range which the system could take and influencing its evolution.



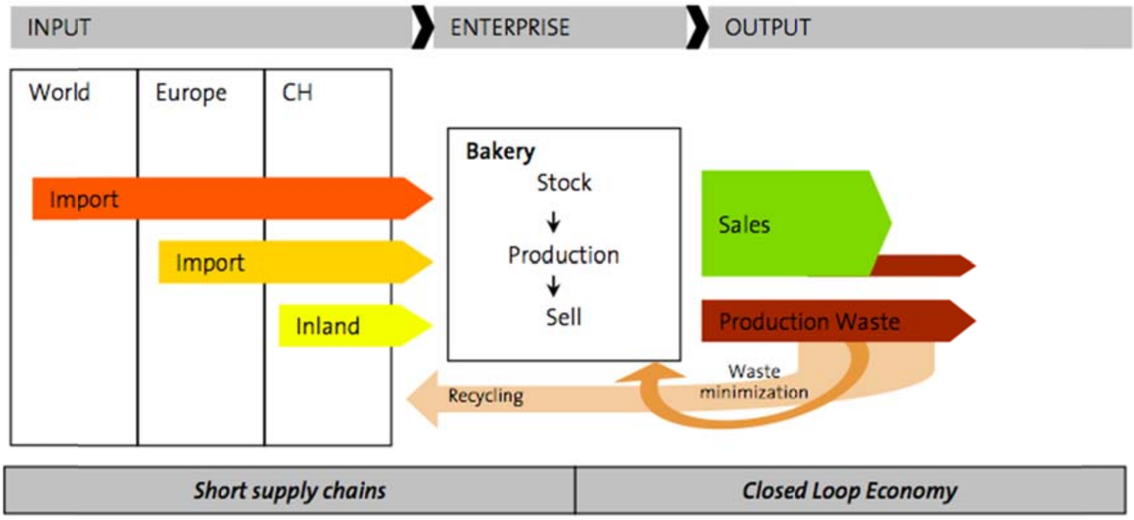


Figure 15: Simplified material flows of the bakery. On the left side are shown the system boundaries of the MFA of purchase products.

Analysis of present situation

Each product purchased by the bakery was classified with three variables: weight, price and origin. The weight represents the total amount of products purchased during one year and is expressed in kg. Products with original units not in weight (liters, number of eggs, etc.) were converted into kg. The price represents the total purchase cost of the products the bakery bought, but not the selling cost. From several suppliers the costs are adapted to the amount of purchased products. The origin was defined under the three categories *Swiss*, *Europe* or *World* depending on the major component of each product. Origin was not representing the manufacturing site, but the country in which the main production steps are performed, e.g. agricultural cultivation of wheat in the U.S. for bread production. Products origin was considered to be *Europe* if the main ingredient was grown in countries of the European Union 25+. If products were grown in neither Switzerland nor European countries they were considered under the category *World*. A distinction between regional Swiss products and Swiss products was not done as, a part of two regional suppliers that are as well producers (eggs, vegetables), on the product description there is no information about the production region (e.g. Swiss milk, yogurts, meat, etc.). The origin of products was considered because it gives information on the distance products traveled, however it cannot be considered as a proxy for environmental impacts, as more specific methods such as LCA have to be used to define them.

In addition to the presented variables, to gain an overview, products were classified in 13 groups, which are illustrated in Table 4. The analysis of the present situation displays the relation of the three variables for each product group.

Table 4: List of product groups used in the material flow classification

Product group	Products examples	Notes
Bakery products	Baking powder, wheat starch, flour mixes, oat flake, müsli, pasta, rise, etc.	Not sweet products being further processed
Eggs	Egg, pealed egg, liquid egg, egg white, etc.	Products having eggs as main component
Fat and Oil	Butter, margarine, cooking fat, oil, etc.	
Meat	Ham, poultry, meat loaf, salami, etc.	
Fruits	Plum, apricot, banana, orange, strawberries, apple, pear, etc.	Fresh and canned fruits
Vegetables	Salad, tomatoes, cucumber, canned corn, spinach, onion, etc.	Fresh and canned vegetables
Spices and aromas	Salt, pepper, herbs, aroma, etc.	
Flour	White flour, half-white flour, whole meal flour, rye flour, etc.	Only not yet mixed flour
Dairy products	Milk, yogurt, cheese, cream, etc.	Any milk derivate
Nuts and seeds	Almond, walnut, hazelnut, sunflower seed, linseed, sesame seed, etc.	
Sweet products	Marzipan, jam, chocolate, chestnut puree, sweet mixes for cakes, etc.	Mixed products having a sweet component
Sugar	Crystal sugar, cane sugar, powder sugar, vanilla sugar, etc.	
Other	Fish, salad dressing, coffee, tea, alcohol for pastry, food pigments, etc.	All products not fitting in the above categories

Construction of alternative procurement patterns

After analyzing the present situation a set of products representing the highest share as possible, in terms of weight and costs, was selected from the whole assortment. First the most relevant product groups were selected through a multi criteria evaluation, which was done by assigning points to each criterion in relation to its relevance. The criteria and threshold levels are shown in Table 5. Selecting products having a large fraction in terms of weight and price was assumed to be relevant, as well as the number of different products per product group. The amount of products was relevant in relation to the possibilities of representing the whole product group with a reduced set of products. For this reason a high number of different products were considered as a negative factor, while a small amount as a positive one. The last criterion applied was the possibility of choosing between alternative options of a product category. For instance if a product cannot be produced in Switzerland because of climatic conditions (e.g. bananas, coffee, cacao) it doesn't have alternatives apart from changing the assortment of the bakery. In relation to this it can be noted that questioning the product range of the bakery was not part of the thesis, as the principle "the customer is the king" of the bakery is respected. Finally the multi-criteria selection led to results by summing up the points of the four criteria. The resulting ranking led to selecting six product groups.

For each selected product group between one and four products were selected by means of a graphical representation of weight against price. Through this procedure an amount of products covering more than 80% of the product group weight and price were considered.

Table 5: Criteria and threshold values of product groups selection

Points	Weight (kg)	Price (chf)	Amount of products	Amount of alternative options
3	more than 150'000	more than 300'000	0-15 products	Regional, Swiss, Europe and Worldwide production possible
2	150'000-100'000	300'000-200'000	15-25	Swiss, Europe and Worlwide production possible
1	100'000-50'000	200'000-100'000	25-35	Restricted selection of possible alternatives
0	less than 50'000	less than 100'000	more than 35	Production possible only in one area

After having selected the set of key products, alternative products were researched by contacting present suppliers, as well as other ones. During the research, specific prices for gastronomy and larger buyers had to be requested from the suppliers. For some products it was not possible to find an alternative and for others assumptions on the gastronomy price were done, because the supplier had only the right to communicate them to customers.

The elaboration of alternatives was based on several purchase priority sets, or philosophies, which differed in relation to product price, quality, label and origin. From the analysis of the actual product assortment the present purchase prioritization of the bakery could be derived. From this baseline different approaches were considered:

- *Present:*
  "Buy high quality, as far as possible from the region, but with a competitive price."
- *Low-cost Alternative:*
  "Buy as cheap as possible, eventually with a lower quality and independently from the origin of products."
- *Organic Alternative:*
  "Buy organic products, as far as possible from the region and independently from the price."
- *Partially Organic Alternative:*
  "Buy good quality, regional and organic when economically viable."

The choice of the low-cost alternative relates to the assumption that economic forces mainly drive enterprises, thus the maximization of its own profit through minimization of expenditure. The organic alternative was taken, as the organic food market of Switzerland has strongly increased during the last few years (Bio-Suisse, 2011a), showing that consumer sensitivity is increasing and opening possibilities for SMEs to address a new target group. In addition to the organic alternatives a third one was built by combining the present situation of the bakery with the organic purchase scenario. To select a set of organic products being economically viable, only organic alternatives having a price that was not above 50% the present price of the products purchased by the bakery were considered.

Finally the modeled price and origin of the three alternatives were compared to the present situation of the bakery to gain a multi-perspective view on the possible purchase options and the impacts they can have on a regional and international level.

2.2. Life cycle assessment of bread

In the following section the LCA methodology is first introduced and then the procedure applied during the performed LCA on bread. This entails a description of the functional unit, system boundaries, data sources and applied impact category methods.

2.2.1. *Introduction to the methodology*

Life Cycle Assessment (LCA) methodology was developed with the objective of having a comprehensive and standardized method for analyzing environmental impacts of products and services. As the name says LCA applies a *life cycle* approach that takes into account energy and resources used, thus it compiles the emissions deriving from material extraction, production, use and disposal (Hendrickson, Lave, & Matthews, 2006; Hillary, 2004). The first activities on LCA started in the 1970s after the publication of the book "Limits of Growth" (Meadows, Meadows, Randers, & Behrens, 1972), which drew attention to the externalities caused by resource use, and the oil crisis, which brought the world's focus on energy (Baumann & Tillman, 2004). LCA pioneers started to apply the method around the world, and in 1997 the first international standard (ISO 14040 1997) was issued. Defining a common methodology was an essential step enabling the use of the method on a wider scale. The four main steps of the developed procedure are illustrated in the LCA framework of Figure 16 and described below:
Because LCA takes a system analysis approach, it is a worthy tool to support decision-making process.

1. **Goal and scope definition:** In relation to the objective of the analysis a functional unit is chosen and the scope is defined by setting system boundaries.
2. **Inventory analysis:** Representation of all inputs and outputs flows of each process on a flow chart, collection of quantitative data on each flow and calculation of the environmental loads of the system in relation to the functional unit.
3. **Life cycle impact assessment (LCIA):** It includes impact category definition; classification of results of the life cycle inventory in relation to their respective impact category; characterization of the extent of the environmental impact per category; normalization of the extent of the environmental impacts in relation to regional emissions; and weighting of normalized results to different impact categories.
4. **Interpretation and presentation of results:** Conclusions and recommendations in relation with the LCA goal are formulated by identifying significant issues and evaluating confidence in the results.

Developing solutions then take into account the whole system, avoiding the displacement of externalities between different stages of life cycle and environmental compartments (Andersson & Ohlsson, 1999).
Several LCA were done on bread during the last 30 years, focusing on different aspects. The earliest studies looked at energy used at different stages (Andersson & Ohlsson, 1999; Grönroos, Seppälä, Voutilainen, Seuri, & Koikkalainen, 2006; Leach, 1976), some compared organic with conventional cultivation (Grönroos, et al., 2006; Weidema, Pedersen, & Drivsholm, 1995), local and industrial baking process (Andersson & Ohlsson, 1999), the effect of transportation (s. Sundkvist, Jansson, & Larsson, 2001) or several contemporary aspects (Braschkat, Patyk, Quirin, & Reinhardt, 2003; Reinhardt, Gärtner, Münch, & Häfele, 2009). Not only does the focus of the studies vary but also the system boundaries, data sources and impact assessment categories used. Differentiation is as well related to the evolution of the LCA methodology and available database in the last 20 years, which became more complete and accurate.

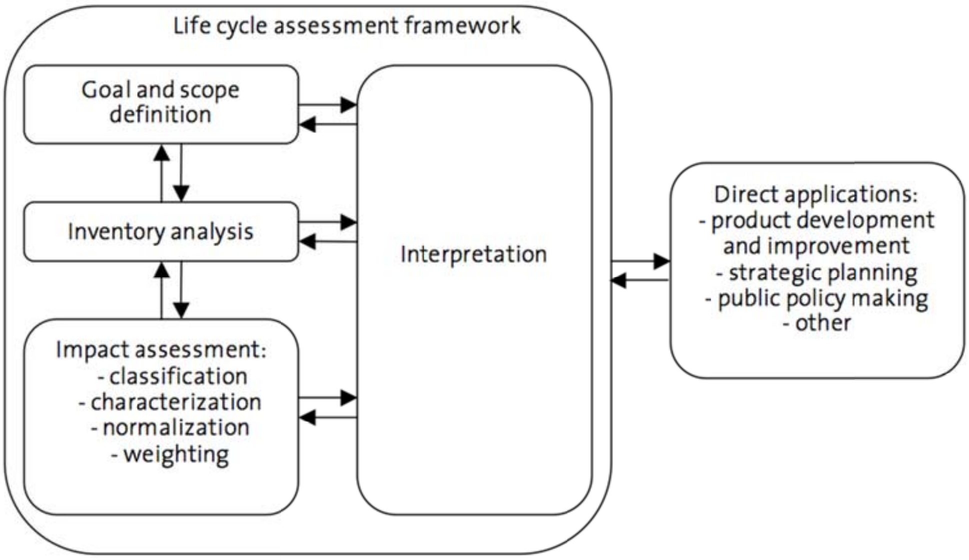


Figure 16: Life Cycle assessment framework from ISO 14041 1998 (Hendrickson, et al., 2006; ISO14041, 1998)

2.2.2. *Procedure of bread LCA*

Functional unit and investigated system

The functional unit of the present LCA is "1kg of white wheat bread". This unit is used by most of the bread LCA studies allowing the comparison of transformation units and results. The reference product purchased by the enterprise is white wheat bread type 550 from IP-Suisse cultivation. All the steps from cultivation to bakery selling branches are included. The system boundaries are shown in Figure 17. Only the processes and inputs included in the calculations are shown.

Within cultivation all material inputs are included, as well as fertilizer, herbicides, seeds, and impacts from the field labor with and without machinery. The milling process includes electricity used for milling, lighting, machinery maintenance, and for the rooms used by employees. Other energy sources than electricity are not used in the mill, i.e. fossil fuels. Impacts deriving from infrastructure and machinery are not included (Hediger, 2011). During the milling process bran that is used as animal fodder is produced as a by-product. An allocation of the environmental impacts is done by substitution of silage maize fodder. Baking processes include only electricity used for mechanical dough preparation and baking. Transportation includes vehicle manufacture, maintenance, operation and disposal, as well as road construction, maintenance and disposal (Spielmann, et al., 2007). The bread is produced in the bakery production center 30 km from the city center, transported to the core shop and from there distributed to four selling branches. The analysis stops at the entry to the selling branches; thus electricity used in the shops and bread packaging are not included.

In the performed LCA several alternatives to the presently used IP-Suisse wheat were analyzed. First, the impact of different wheat grain production were considered, by comparing extensive and organic cultivation to integrated production (IP). Next the impact of wheat origin was examined by considering import of grains cultivated conventionally in Germany, in the Saxony-Anhalt region, and extensively in the US in Kansas. For each alternative two different transportation modes where considered. Finally, three options show the impact of different choice that can be taken by the bakery in regard to the purchase of certified electricity from renewable sources, the efficiency of the oven and the possibility of producing bread locally (not 30 km from the city center). An overview of the analyzed options is given in Figure 18.

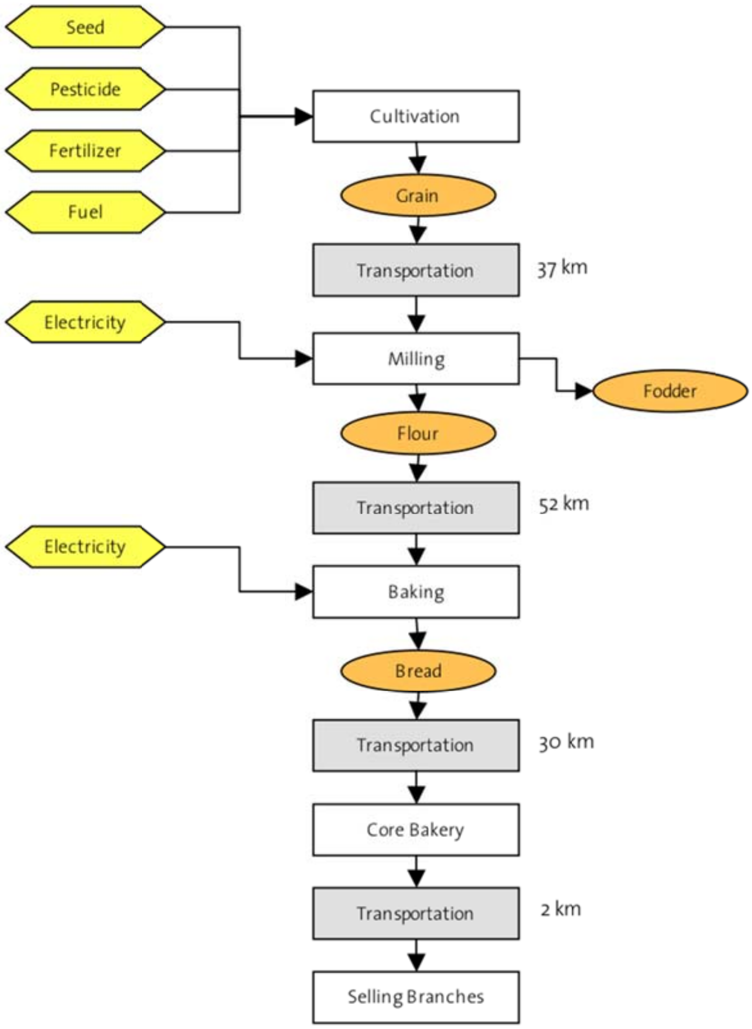


Figure 17: Simplified system boundaries of analyzed bread life cycle. Yellow fields stand for inputs, white boxes for processes, grey boxes for transportation and orange ovals for products and by-products.

Data sources and impact assessment categories

The main data source used for processes is ecoinvent v2.01 database. From this database data on cultivation, by-products, electricity and transportation were taken. The bakery provided data on the amounts electricity used for dough preparation and baking, conversion units from wheat to bread, transportation distances and used vehicles. The mill, providing flour to the bakery, furnished data on energy used for milling, conversion units from grain to wheat, by-product production and use, transportation from regional grain collection centers to the mill and from the mill to the bakery (Lehmann, 2011). Data for the efficient oven scenario were taken from an oven on sale in Germany (Tugkan, 2009). The scenario based on grain produced in the USA assumes that the wheat is produced in Kansas, as it is the largest wheat producing state of the country (USDA-NASS, 2005).

Four different impact categories were used: Ecological Scarcity 2006, EDIP2003, Global Warming Potential and Energy Demand. Ecological Scarcity 2006 (UBP) is a comprehensive method developed in Switzerland. It integrates impacts on all natural compartments from various resources used. Its particularity is that the weightings are dependent on the Swiss political agenda. However in the present study no weightings were used. EDIP2003 is also an exhaustive method characterized by its possibility to do spatially differentiated analysis. In the present study the method was used to compare impact categories with the ecological scarcity method and gain values of global warming potential for 100 years (GWP100), which are expressed in kgCO2 equivalents/person/year. The characterization factors used are taken from the IPCC consensus report (Althaus, Bauer, Doka, & Dones, 2010). Energy Demand corresponds to the amount of primary non-renewable energy used. It is taken from the Cumulative Energy Demand Impact Category of ecoinvent database, but includes only the impacts from fossil and nuclear energy use. The method is used as a means of comparison with analysis, which were focused on energy use.

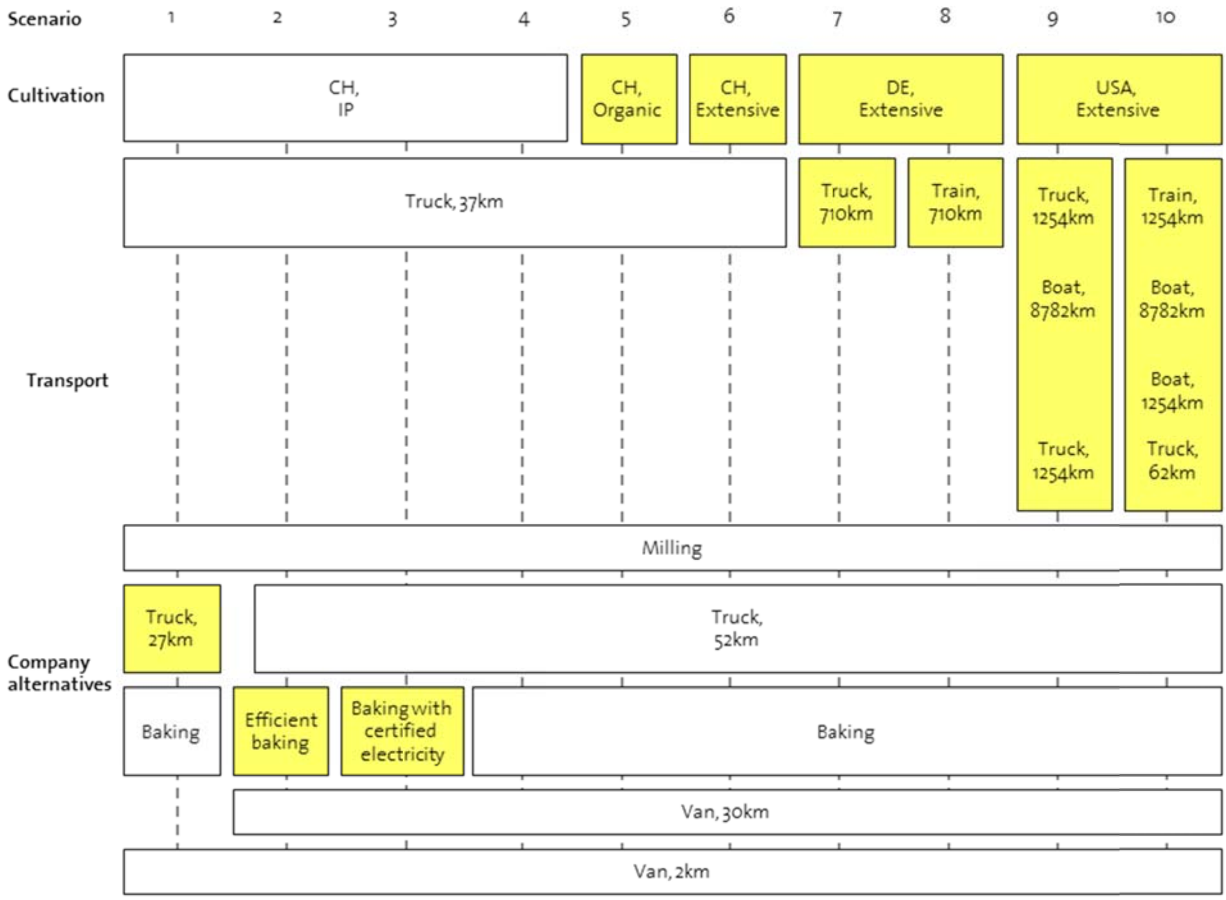


Figure 18: Schematic representation of the 9 Scenarios analysed. CH stands for Switzerland, DE for Germany, IP for integrated production.

2.3. By-products management

The procedure applied for the qualitative description of the by-products management options includes three steps. First material flows entering and exiting the bakery are analyzed to identify sources of by-products, next comes a description of the by-products typology and finally existing treatment options for the two main types of identified by-products are illustrated. Thus in the method section the boundaries of the analyzed system are presented and in the result section the outcomes for the other two steps.

2.3.1. System boundaries

The system boundaries of the analysis of by-product management are represented in Figure 19. In the following paragraphs comes a description specifying the single material flows. The bakery is purchasing ingredients for producing bakery and pastry products, as well as materials to use during the production (eg. vegetables and fruits or scraps from preparation process (e.g. from cutting shapes, mistakes, etc.). In the case bakery the production of scraps is already optimized, as every valuable food mixture excess is reused in other products, additionally there are no large quantities of vegetable or fruit scraps as products are partially elaborated by the supplier (e.g. pealing apples, halving prunes and apricots, etc.). Thus only a minimal quantity of organic by-products appears during production in the enterprise. The main stream of materials thrown away during production comes from packaging of ingredients and items used for helping production. Products are packed in the bakery branch when they are sold to customers. Bread is packed in paper bags and other items (as Ice-cream, Birchermüsli, salads, etc.) in plastic containers. Additionally by take-away products plastic forks, spoons or knives, napkins and plastic bags are provided. Not elaborated products such as beverages and chocolate snacks are also packed in plastic. When customers have the possibility of consuming on site some of these packaging are disposed directly in the bakery. As the bakery guaranties fresh products every day, at the end of the day in every branch an amount of high quality unsold items are left over. Finally when products are sold to customers they dispose of the packaging and may not consume the entire product.

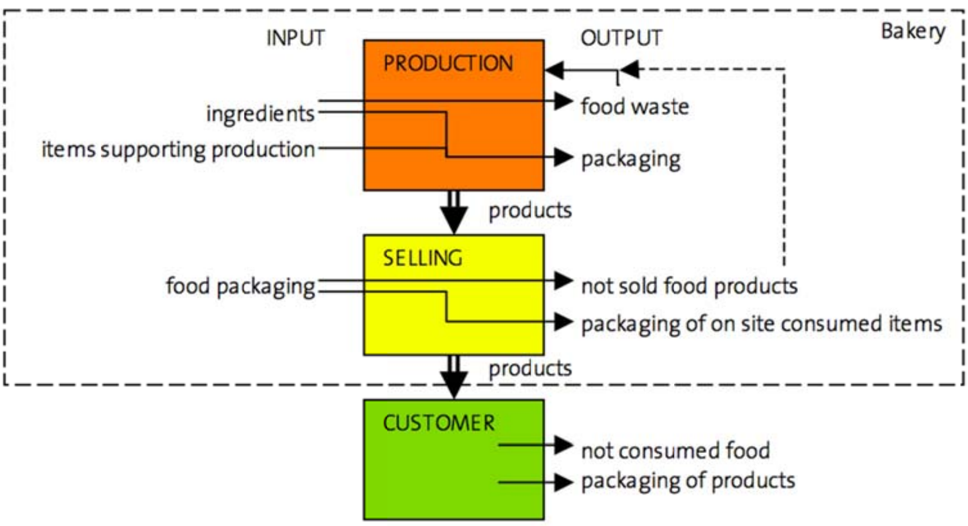


Figure 19: System boundaries of by-product management system showing entering and exiting material flows.

3. Results

3.1. MFA of purchase products

The results of the MFA begin by describing the present material flow of the enterprise. Next, comes the construction of alternative purchase patterns. This starts with the result of the selection of a restricted set of products and ends with the description of the alternative purchase pattern implications on enterprise costs and the origin of products.

3.1.1. Present Material Flow

The data set on which the MFA was performed contains 530 products, which correspond to 70 tons of supplied goods and 2.5 million Swiss Francs (CHF). An overview is given on the origin of different product groups by weight and price in Figure 20 and Figure 21. The initial data set of MFA contained 760 products, from which chocolate snacks and drinks were excluded. Chocolate snacks don't represent an important share of the entire product assortment, opposite to that of drinks representing 12% of the total weight of the purchase goods. More than 50% of drinks are manufactured in Europe therefore they should be taken into account in a study looking in detail at the supply chain network of an enterprise.

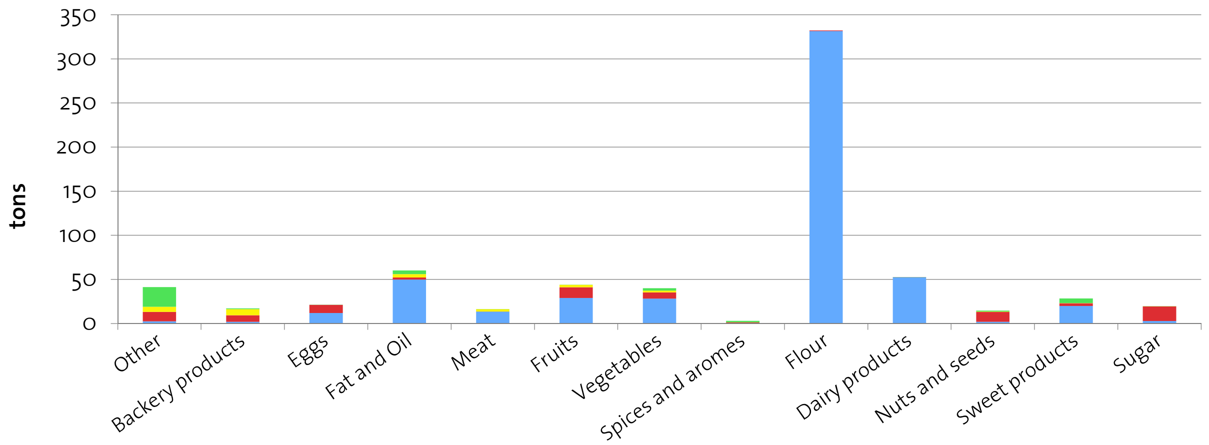


Figure 20: Weight per product group

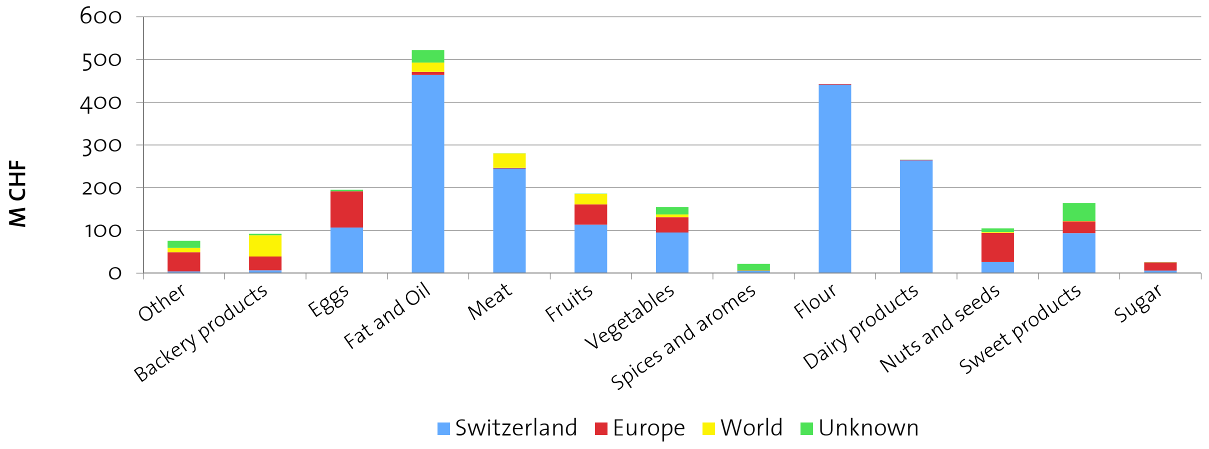


Figure 21: Price per product group

Most the products come from Switzerland (see Table 6). Looking at the weight of different product groups, flour drastically stands out even if it is not carrying the highest expenses. The second most represented products with respect to weight are dairy products, fat, and oil, which correspond to the main ingredients used in bread products. Looking beyond to the price of different groups, fat and oil constitute the highest expenses, as the material is very concentrated.

Table 6: Total share of purchased products by origin in relation to weight and price

Origin	Weight	Price
CH	79%	74%
EU	12%	15%
World	4%	6%
Unknown	6%	5%

Figure 22 show shares of products up to their origin by weight and price. In most of the product groups there is a linear relation between weight and price of products in a defined country. However several cases show that prices in Europe are generally lower than in Switzerland. This can be seen in the case of sugar, for example, where less than 20% of the weight is purchased in Switzerland, but more than 20% is spent.

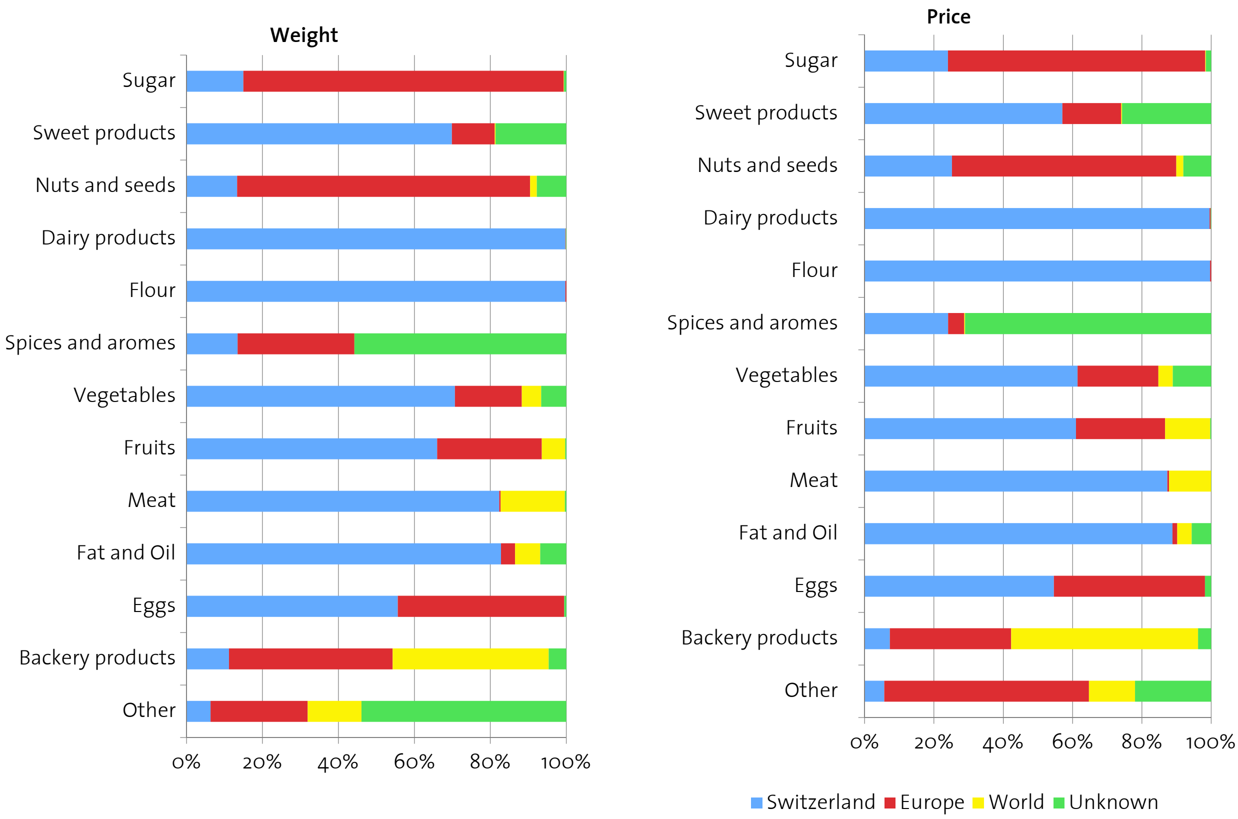


Figure 22: Weight (left) and price (right) share per product group

Figure 23 shows the relation between the share of purchased weight and the amount of money spent per product group. This highlights how some products are not dominant in terms of weight, but in term of costs – like the purchase of meat, fat and oil; while other products dominate the purchased weight, which implies higher amounts of materials that have to be transported to the enterprise, but not the cost (i.e. flour, sweet products and sugar). While defining alternative options both aspects have to be taken into account to determine the significance of a choice from the perspective of the bakery.

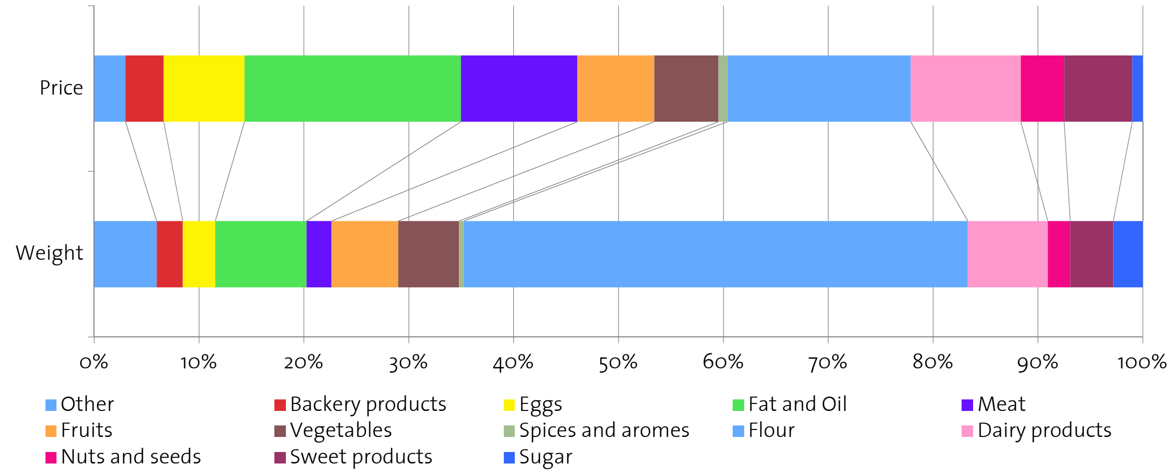


Figure 23: Price and weight share per product group

3.1.2. Alternative procurement pattern

Choice of alternative products

To build alternative purchase patterns, the entire assortment of 530 products was reduced to 18 products representing more than 50% of the total weight and price (see Table 8). The selection was done through a stepwise procedure. First the most representative products were determined by using a multi criteria matrix (Table 7). The 6 groups with the highest scores were selected for the next process (eggs, fat & oil, meat, flour, sugar).

Table 7: Multi-criteria scores for choosing significant products groups.

	Weight	Price	Amount of Products	Alternative Options	Scores
Other	0	0	0	0	0
Backery products	0	0	0	1	1
Eggs	0	1	2	2	**5**
Fat and Oil	1	3	0	1	**5**
Meat	0	2	0	3	**5**
Fruits	0	1	0	1	2
Vegetables	0	1	0	2	3
Spices and aromes	0	0	0	0	0
Flour	3	3	2	3	**11**
Dairy products	1	2	0	3	6
Nuts and seeds	0	0	1	1	2
Sweet products	0	1	0	2	3
Sugar	0	0	3	2	**5**

Next the profile of each selected product group was analyzed with respect to weight and price of single products (Figure 24). From each group between 1 and 4 products were selected, allowing to cover between 75-85% of the weights, and between 60-90% of the price of the product groups (Table 8). Most of the products are from Switzerland.

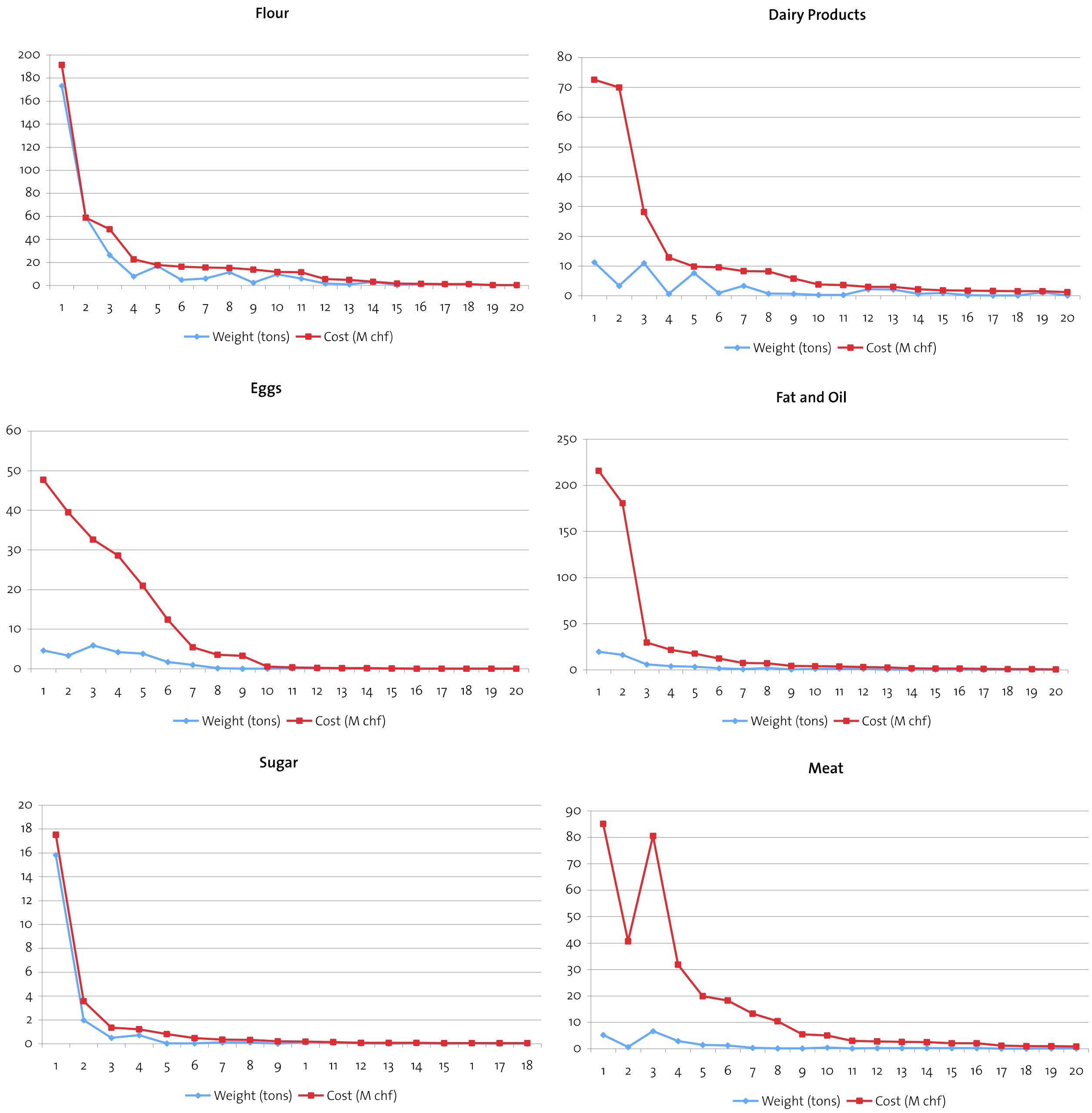


Figure 24: Weigh and price of single products of selected product groups

Table 8: Selected products weight, price and share in relation to the total amount of purchased products

Product Group	% Selected Weight	% Selected Price	Product	Origin	Weight	Price	% Selected Weight	% Selected Price
Flour	75%	60%	White flour	CH	173'128	191'343	52%	43%
			Wholewheat flour	CH	59'559	58'747	18%	13%
			Half white flour	CH	16'711	17'662	5%	4%
Fat and Oil	85%	90%	Butter	CH	35'700	396'066	59%	76%
			Margarine	World	13'400	68'731	22%	13%
			Oil	World	1'860	7'214	3%	1%
Meat	86%	82%	Ham	CH	77'656	123'221	46%	43%
			Meat Loaf	CH	2'892	31'808	17%	11%
			Chicken	CH	2'775	33'960	16%	12%
			Dried Grisons Beef Meat	CH	608	40'640	4%	14%
Eggs	99%	76%	Liquid eggs	CH	9'720	53'460	39%	27%
			Eggs	CH	5'578	53'069	22%	27%
			Eggs white	EU	5'938	40'936	24%	21%
Dairy Products	69%	71%	Cream	CH	11'245	72'523	23%	28%
			Yogurt	CH	14'340	36'343	29%	14%
			Cheese	CH	3'360	69'907	7%	27%
			Milk	CH	7'650	9'790	15%	4%
Sugar	81%	68%	White Sugar	EU	15'825	17'513	81%	68%

Alternative purchases options

For each of the 18 selected products, alternatives were analyzed. Differences between the selected options exist in relation to price, supplier, origin, quality and presence of a label.

The present products purchased by the firm encompass four products with labels (IP-Suisse flours and fair-trade sugar), the low-cost alternative has no products with labels, the organic option is composed only of certified organic products (Knospe, Bio Suisse, Bio EU), and the partially organic alternative includes the present purchased products plus 8 organic products (all flour, dairy products and eggs).

The price difference per unit purchased product, between the present assortment and two alternatives - low-cost and organic purchase -, is shown in Figure 25. It can be noted that the organic alternative has prices that are by far higher than those of the cheap option. A partial overestimation of the organic prices is due to the fact that these products are rarely sold to gastronomy and therefore don't always have a discount for large purchases (price could decrease by around 10%) and are not easily found In the product line.

Relating price per unit with amounts of purchased products gives an overview on the alternative total cost, which shows sensitivity of products from the enterprise perspective. The results displayed in Figure 26 show that the present purchase pattern is very close to the economic optimum of the low cost alternative. The completely organic alternative would imply an increase of price of 1/3, which is not economically viable. The partial increase of organic products option would constitute an increase In total costs of 10%, the same share of savings the enterprise would have by choosing the low-cost alternative.

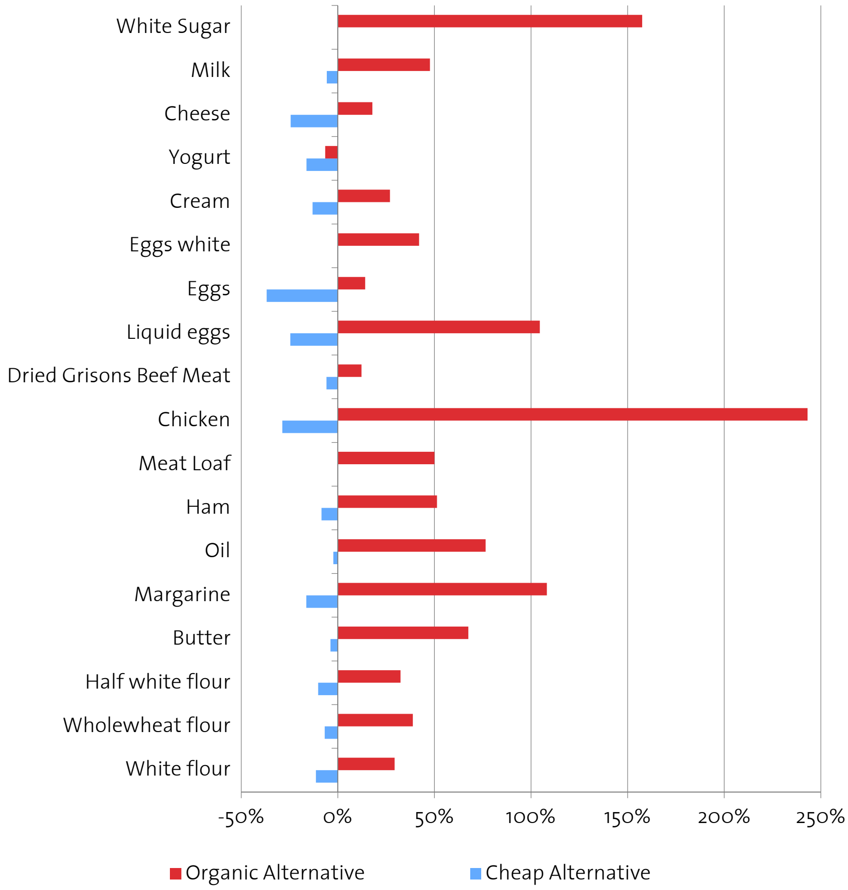


Figure 25: Price difference of alternative purchase pattern compared to the presently purchase products

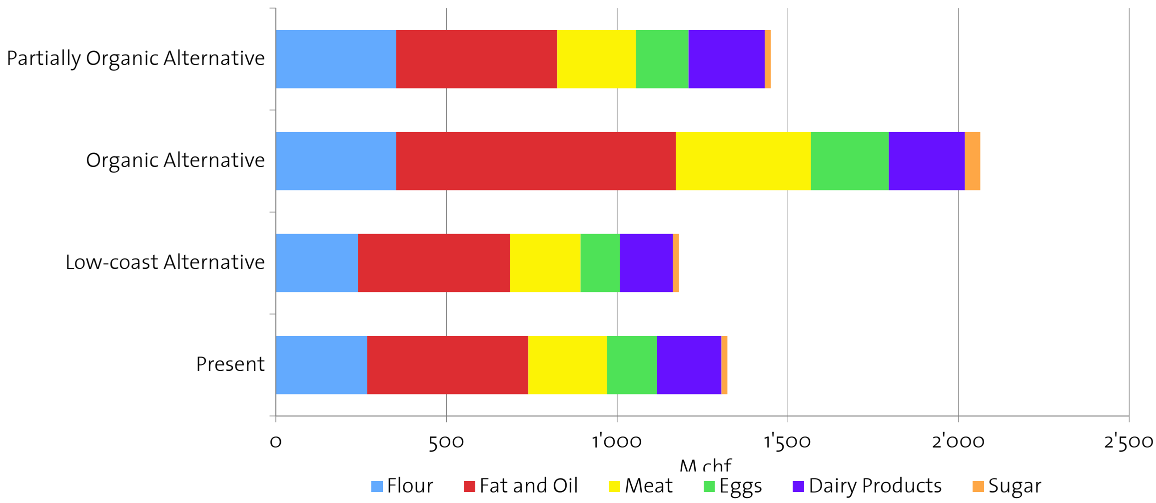


Figure 26: Present and alternative purchase patterns total cost

The origin of the products of the alternative purchase patterns does not differ drastically from the present situation (Figure 27). This can be explained by nothing that the alternative products are only the products already available by the major supplier assortment. Even if the prices from products produced abroad could be found, the transportation and import taxes could not be estimated to gain a realistic total price. The share of products imported from Europe is higher in the low-cost alternative, while the Swiss share of products is higher in the organic alternative. This is due to not importing eggs and sugar from Europe. The share of organic products imported from Europe is not decreasing, as products that were before imported from the world, like oil and margarine, shifted now to originate in Europe. Looking at the cumulative transport distance of the four options It can be seen that in the low-cost alternative the imports from Europe increase from 6% of to 10% of total weight, while the imports from the World stay the same. Thus there is an increase in the total transport of goods. The organic option reduced imports from the World from 4% to zero, while the imported weight from Europe does not change in a significant way. Thus the organic alternative reduced total distance of transported goods in a more important way. The partially organic alternative did not modify the distance travelled by purchased goods.

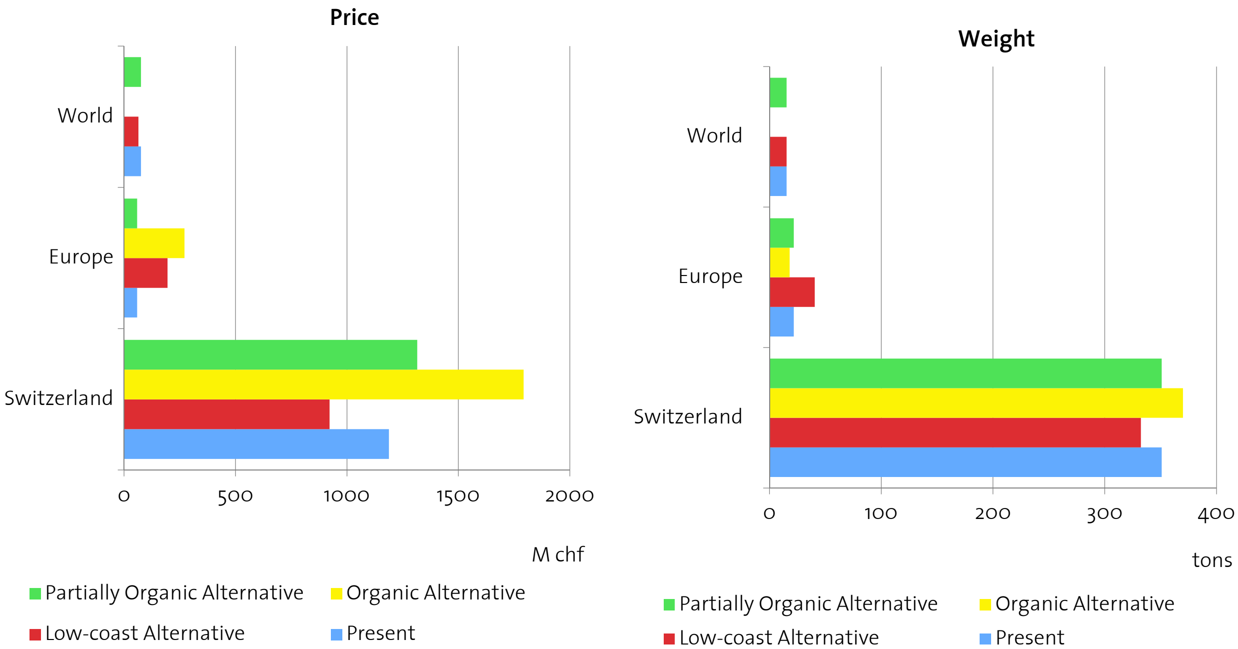


Figure 27: Origin of alternative purchase patterns products in relation to price and weight

3.2. Life cycle assessment of bread and review of food LCAs

The present chapter is divided into three sections. First the environmental impacts of the presently produced bread are presented. Additionally the link of the results with the choice of LCIA method is highlighted. In the second section the outcomes of alternative options, in relation to cultivation and origin are illustrated. In the third one the outcomes of a review on LCA studies on food products depicts the specificity of the environmental impacts of different foods in relation to their origin.

3.2.1. Present situation

Conversion factors

Life Cycle Assessment of white bread produced by the bakery was conducted by using the conversion factors of Table 9. These factors were gathered through discussions with the bakery and mill owners. The units show the steps of the production process: first the grain is milled into flour producing bran as a by-product. To prepare the dough, water and yeast are added to the flour, which increases the weight. Finally during the leaven process the chemical reaction done by the yeast releases carbon dioxide, which increases the volume but decreases the weight of the bread. The conversion factors used are close to thus applied by a Danish LCA conducted on bread (0.875kg grains and 0.7kg wheat for 1kg bread) (Braschkat, et al., 2003).

Table 9: Conversion factors of bread production processes

Process stage	Product	After	Reference unit	
			1kg grain	**1 kg bread**
p1	grain	Cultivation	1.00	0.90
p2	wheat	Milling	0.80	0.72
p2	fodder	Milling	0.20	0.18
p3	dought	Dough preparation	1.33	1.20
p4	bread	Baking	1.11	1.00

The production of bran fodder as a by-product during the milling process was allocated through a substitution of silage maize. To convert the amounts of fodder the “netto-energy-lactation (NEL)” value was used. Maize silage has a NEL value of 6.6 MJ and Wheat Bran of 5.9MJ (LfL, 2011). Therefore 1kg of Maize Silage can be substituted by 0.9kg of Wheat Bran as animal fodder.

In LCAs impacts deriving from transportation are calculated by multiplying weight of functional unit per traveled distance (tons*km). In the calculation of the present LCA, the following travel distances and means of transport were used (see Table 10). The Swiss fleet average was taken as a standard reference for trucks and vans. In the case of the regional Grain Storage centre and the bakery selling branches a weighted average was done taking into consideration the amount of products traveling a single distance.

Table 10: Transportation reference units

Nr.	From	To	Mean of transport	Load (tons)	km
t1	Regional Grain Storage	Mill	truck > 28 t	26	37
t2	Mill	Bakery production site	truck 28-20 t	10	51.5
t3	Bakery production site	Core bakery	van < 3.5 t	1.7 - 2	29.5
t4	Core bakery	Selling branches	van < 3.5 t	0.6	1.9

Results for the present bread production

The results of the LCA done on the white bread sold in the branches of the bakery are shown in Figure 28. The bread is made with IP-Swiss grains, ground into white flour type 550 by a local mill. The electricity used in milling, dough preparation and baking, corresponds to the Swiss average consumer supply mix. This is composed by 41.3% nuclear, 35.7% water, 18.6% unknown, 2% waste, 1.9% fossil and 0.4% other renewable energy (Schaffner, 2009). The influence of using certified electricity from renewable sources is shown in one of the alternative options.

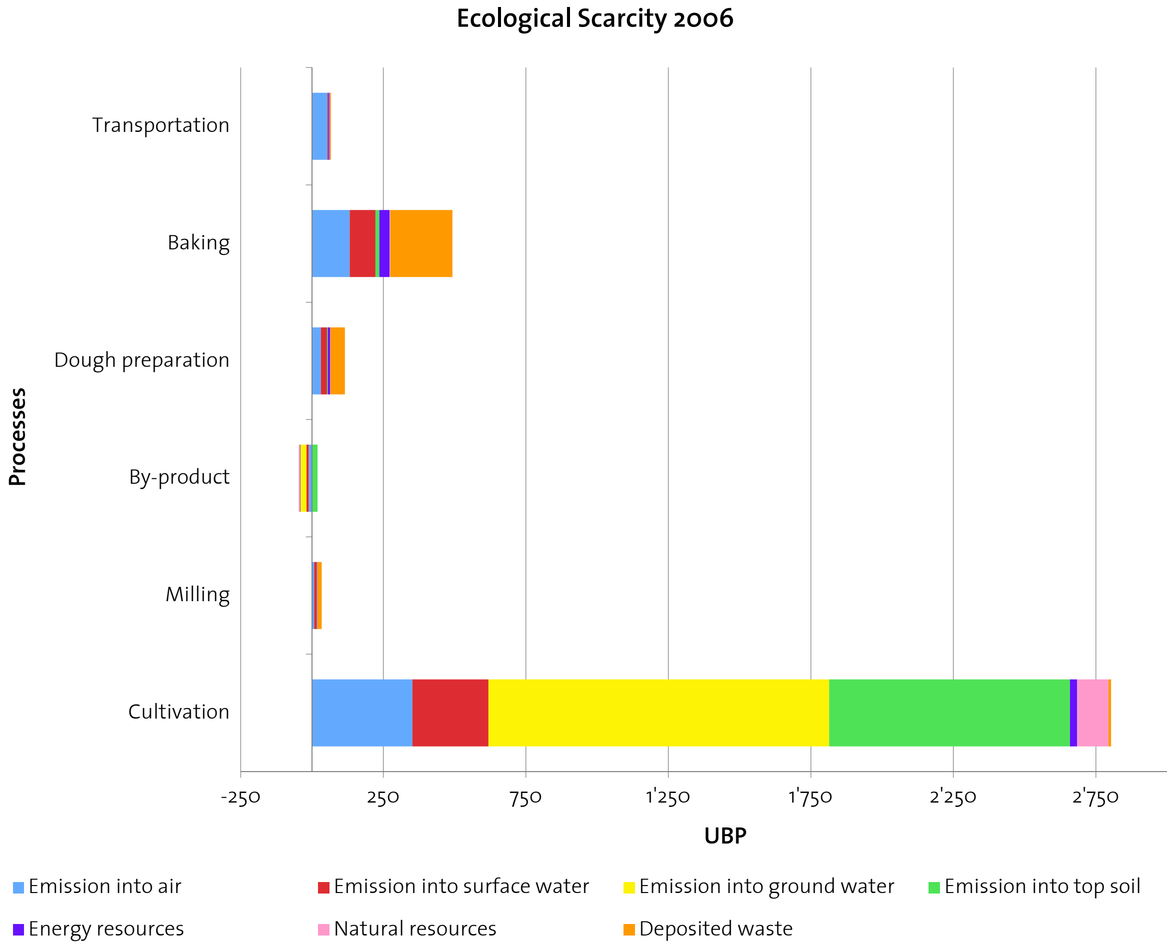


Figure 28: Total environmental impacts of 1kg bread produced with Swiss IP flour by the bakery

In Figure 28 it can be observed that cultivation is by far the most relevant process (2'804 UBP). Baking is the next most important process, although significantly less than cultivation (492 UBP). Transportation, dough preparation and milling have a marginal contribution. The impactful activities during cultivation include labor in the field and on the farm, including resources used for infrastructure and all inputs to the fields, such as fertilizers and herbicides. The resulting impacts come from emissions into ground water and topsoil due to leaching of fertilizers and deposition of heavy metals. The air emissions mainly come from the field due to the wheat growth phase. In the baking process only impacts due to electricity consumption are accounted. The main sources of deposited waste in aboveground and underground landfills (for radioactive and hazardous wastes), are by-products from infrastructure building and waste from energy production, while air emissions are caused by direct emissions from fossil fuel and emissions for infrastructure building.

For analyzing the results of the LCA several impact categories were used depending on the indicator results since each can be very different. In Figure 29 the percentages of total impact for each process for different impact categories are shown. Ecological Scarcity 2006, EDIP2003 and Eco-Indicator 99 are aggregated indicators that take into account the total environmental impact, by weighting and normalizing emissions of substances in specific impact categories. Energy Demand is not a comprehensive method as it does not take into account most of the environmental emissions caused by cultivation. Nevertheless, Energy Demand is useful to compare results of different LCA and to compare the use of non-renewable energies. The global warming potential is an indicator focusing on the greenhouse effect of the process, thus on climate change, but not taking into account effects of air emissions in the troposphere implicating health issues. Comparing the processes shown in Figure 29, it can be noted how Ecological Scarcity and Eco-Indicator 99 generate for higher impacts from agriculture. This is due to giving more importance to water and soil emissions than the EDIP 2003 method, which weights air emission as more important. Energy Demand is dominated by the impacts of the energy used during the baking phase.

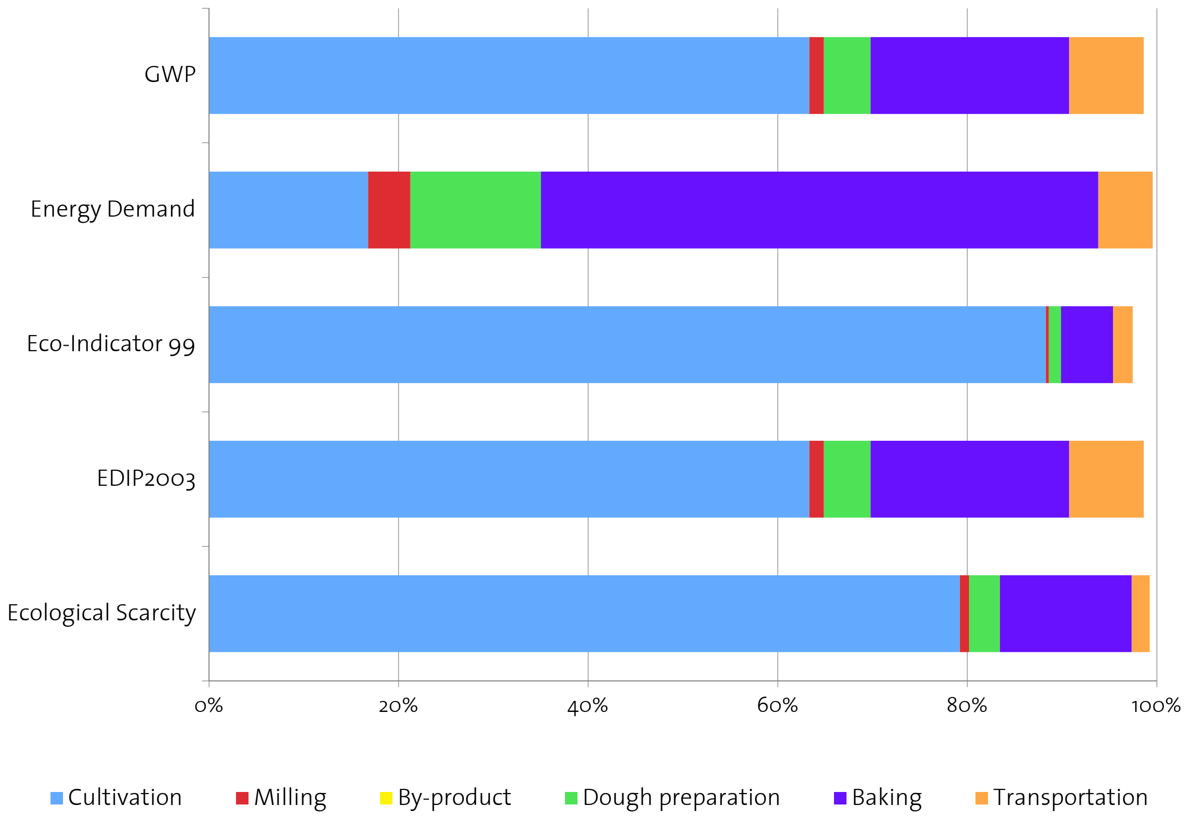


Figure 29: Relative environmental impacts of bread production processes by impact categories

3.2.2. *Alternative options*

Comparison of environmental impacts of different cultivations

In Switzerland it is possible to purchase flour with three different environmental standards: organic, IP and extensive. In the definition BOX 4 explanations about the different requirements for the "Bio" and "IP-Suisse" labels are presented. The results of the analysis are shown in Figure 30 and Figure 31.

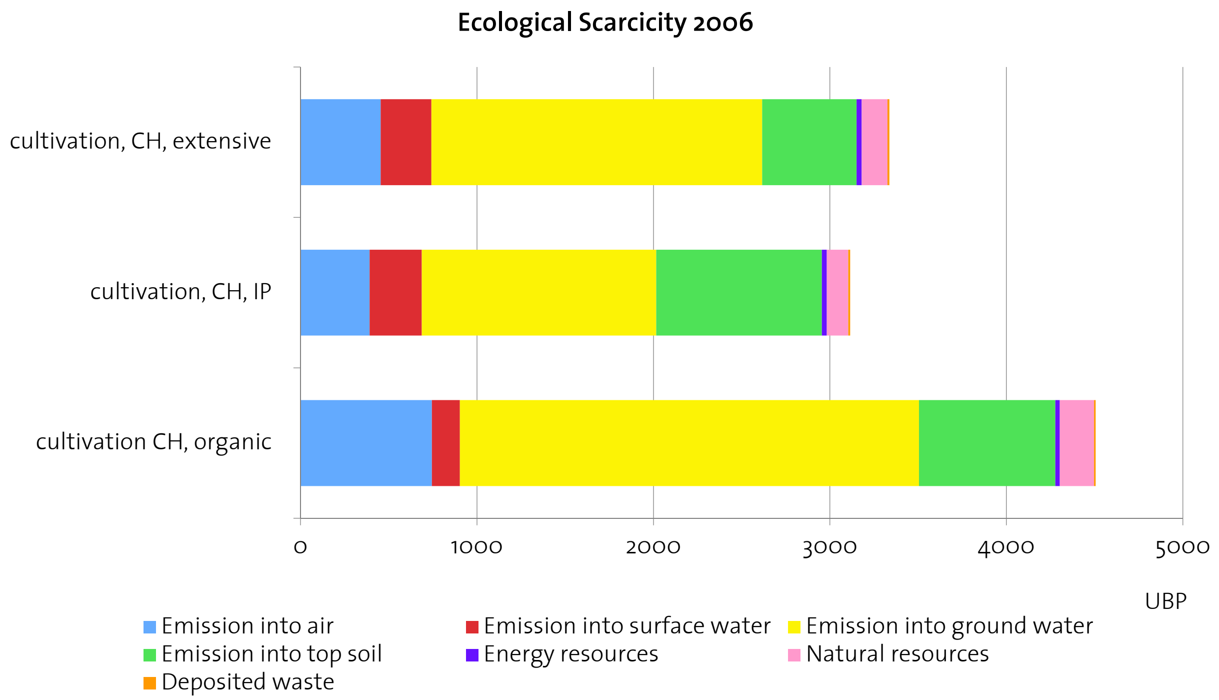


Figure 30: Comparison of Swiss organic, IP and extensive wheat cultivation

The results of Figure 30 show that IP has the lowest impacts, followed by extensive and organic cultivation. This result is surprising, as according to public opinion organic is not only related with healthy, but also with environmental friendly food production. The emissions making the main difference between organic and IP cultivation are the groundwater emissions. Groundwater plays an important role, as it provides 80% of Swiss drinking water (BUWAL, 2003). The high emissions are due to different types and quantity of fertilizers used. Organic cultivation avoids adding chemical fertilizers and herbicides on the land, however natural fertilizers, such as manure coming from pigs or cattle, are used. To have the same fertilizing power the organic cultivation needs to add higher amounts of manure resulting in twice as high nitrate emissions in the groundwater as compared to IP cultivation. Nitrates constitute a problem in regions with agriculture practice as the legal concentration limit is often exceeded and sometimes even the drinking water concentration limit is not respected (Frischknecht, Roland, & Niels, 2009). The effect of chemical fertilizers in extensive and IP cultivation is seen in the surface water emissions that are twice as high as the organic ones, but still not part of the major emissions. Emissions to air and natural resource use are the next major contributors to the high impacts of organic cultivation, as all of them have 60% more UBP than IP cultivation. These results are mainly due to the fact that organic cultivation has a lower yield on average than IP or extensive cultivation. Therefore the amounts of inputs per unit outcome are larger.

In Figure 31 the results of the single impact categories of ecological scarcity 2006 with global warming potential and energy demand are compared. For both of them organic cultivation ends up with less UBP points. For both this is due to the fact that no energy needs to be use to produce fertilizers and the mechanical treatments are less intensive.

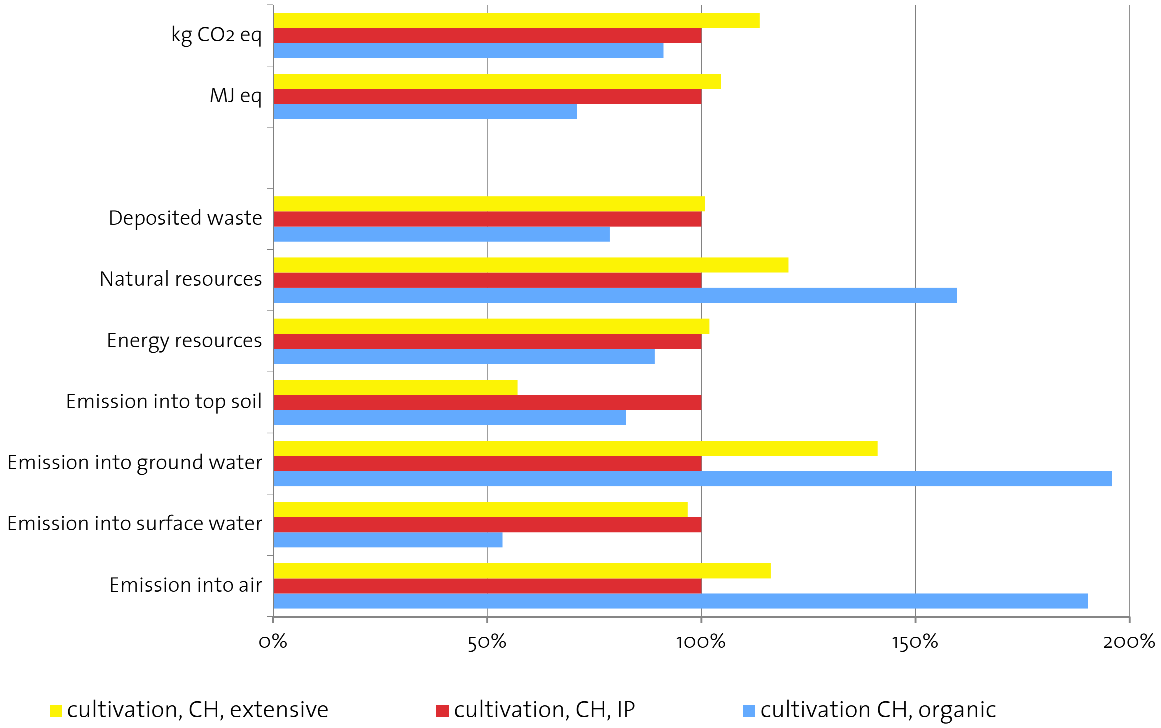


Figure 31: Global warming potential (GWP), energy demand and ecological scarcity of different cultivations

BOX 4 - Definition of cultivation practices

Conventional Agriculture: the "certificate of ecological performance" (Ökologische Leistungsnachweis (ÖLN)) is the standard Swiss cultivation practice. It is the minimal standard for Swiss farmers to receive subsides. The directive ensures fulfillment of national requirements that aim to promote environmentally improved cultivation by limiting the use of fertilizers and pesticides. Objectives are the maintenance of biodiversity, soil fertility, reduction of fertilizer and herbicide use and respectful animal husbandry.

IP-Suisse: farmers practicing IP-Suisse cultivation are a stage above conventional agriculture. In addition to the ÖLN standards they completely avoid using growth regulators, fungicides and insecticides. However herbicides are allowed.

Organic cultivation: the organic cultivation (BIO) is the strictest environmentally friendly cultivation practice. In opposition to the ÖLN production the use of chemical-synthetic fertilizers and pesticides is totally forbidden. Weeds are regulated through alternative methods such as mechanical and manual treatment. Organic farming is more labor intensive than conventional ones and can have lower yields (Bio-Suisse, 2011b; IP-SUISSE, 2005; SBI, 2011).

Influence of transportation on environmental impacts

Looking to the environmental impacts coming from transportation, several impact categories show similar results (see Figure 32), thus its choice is not decisive for the resulting ranking. To analyze the impacts of transportation, emissions of wheat cultivated in Switzerland (CH), Germany (DE) and United States (US) were compared. Additionally in the German and US case two transportation means for the path from cultivation site to mill, were analyzed. These were truck and train for Germany, and the combinations of truck-transoceanic boat-truck and diesel train-transoceanic boat-sweet water boat and truck for the US.

Furthermore, as the analyzed bakery has the production site outside the city center of Zürich, an option called "CH, short transport", in which the flour is transported directly from the mill to the city center, was added to show the influence of the decisions made on a local level. In Table 11 an overview is presented of the transportation distances and locations.

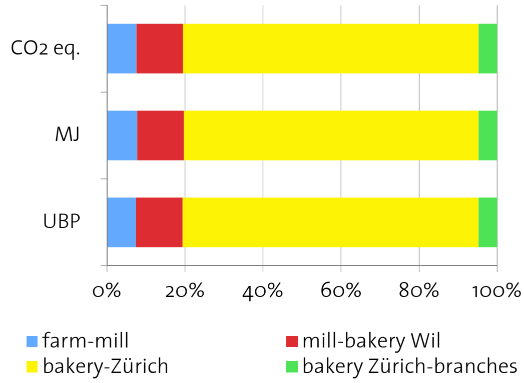


Figure 32: Relative contribution from transportation of different LCIA methods

The results of the transportation impacts (see Figure 33) show how import of goods from overseas has the largest environmental impact, followed by import from Europe. It can be noted how the choice of transportation means largely influences the results. Transport by truck is the least environmentally friendly option, as in both US and DE cases the option has the worst results. Another point of interest is the fact that emissions from transoceanic freight transport are 25% smaller than truck transports in Europe for shorter distances. The short transport option of the alternative where the production site is in the city shows a large potential for improvement within the local transportation network, as the transport emissions are reduced by 82%. However the choice between local products and import has overall a far larger total impact, as emission from transportation of imported goods can be ten times higher than locally produced ones.

Table 11: Mean of transport and distances per transportations stage

Alternatives	for	from	to	Mean of transport	km
Short tranportation	t2 and t3	Mill	Core bakery in Zürich	truck 28-20 tons	26.6
DE, truck	t1	Magdeburg (Anglo-Saxony)	Mill	truck > 28 tons	710.3
DE, train	t1	Magdeburg (Anglo-Saxony)	Mill	freight rail EU	710.3
US, truck	t1	Arkansas City (Kansas)	New Orleans Port	truck > 28 tons	1253.7
		New Orleans Port	Rotterdam, Niederland	transoceanic freight ship	8782.1
		Rotterdam, Niederland	Mill	truck > 28 tons	737
US, train&boat	t1	Arkansas City (Kansas)	New Orleans Port	freight rail diesel, US	1253.7
		New Orleans Port	Rotterdam, Niederland	transoceanic freight ship	8782.1
		Rotterdam, Niederland	Basel	freight ship	675.4
		Basel	Mill	truck > 28 tons	61.6

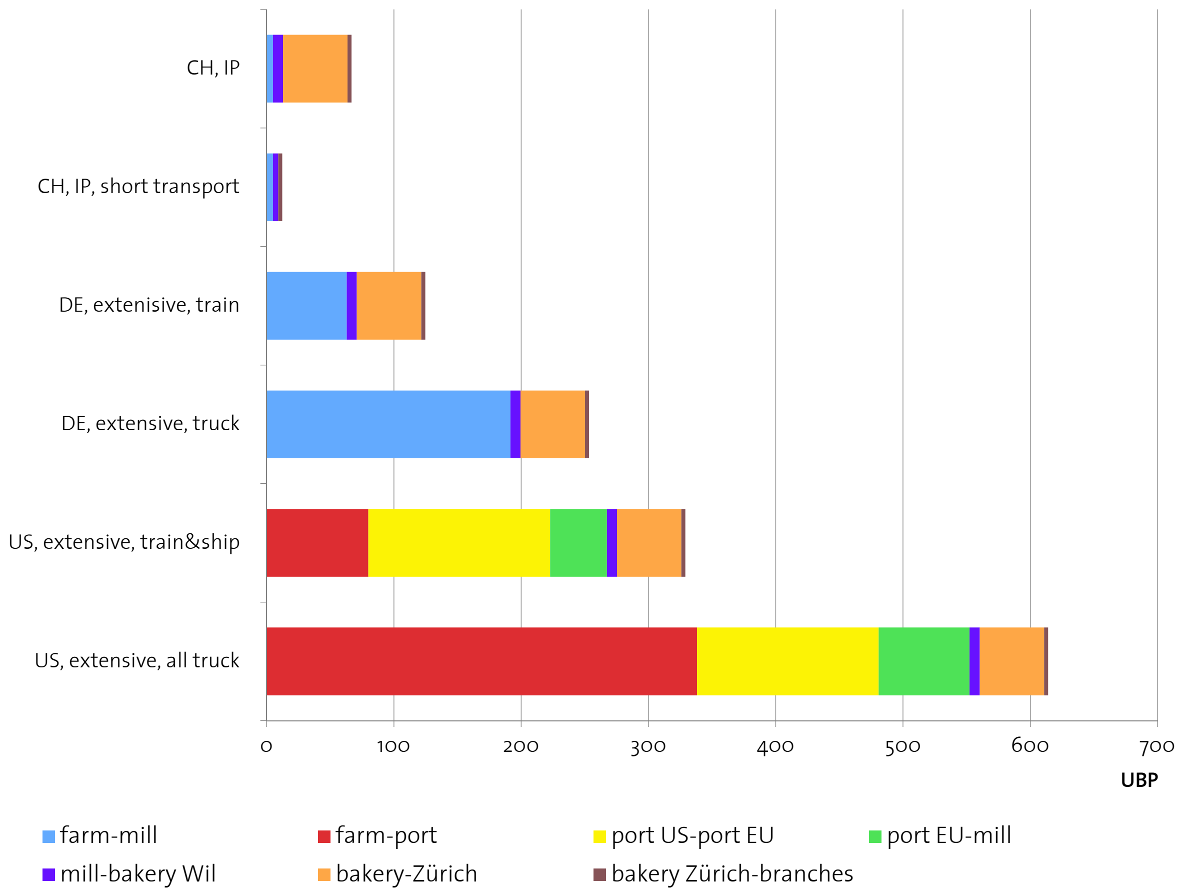


Figure 33: Transportation environmental impacts of 1 kg bread with ecological scarcity method 2006

Influence of increasing baking efficiency and the use of certified electricity

The results of the total environmental impact of the presently produced bread (Figure 28) illustrate how the baking process, after cultivation, is the second most relevant stage within the production of bread. For this reason two options aiming at reducing emissions related to baking are analyzed: first the potential deriving from improving oven efficiency and secondly the use of certified electricity produced from renewable energy.

The present oven efficiency is compared to a more recent oven having a higher efficiency (electric oven, 3m2 backing area, 78 bread 500gr., 16kW-27kW, 380/400 3Ph, 50Hz) (Tugkan, 2009). The increase of efficiency halves the emission of the oven from the present situation; however in respect to the total impact the improvement is of 10% for the ecological scarcity impact category and 30% for the Energy Demand.

In Switzerland most of the electricity providers offer "electricity products" with different shares of renewable energy. The Association for environmentally sound energy (VUE) developed the naturemade label, which ensures the use of energy from renewable sources (naturemade basic) and an ecological energy production (naturemade star) (naturemade, 2011). The purchase of certified electricity is possible for any company based in the canton of Zürich, even though the purchase of certified electricity implies an increase of costs. To show the environmental impacts of purchasing certified electricity from renewable sources, calculations were done by applying certified electricity in the dough preparation and baking Zürich was taken. This electricity is produced 80% from hydropower, 18% from biogas and 2% from solar energy.

Figure 37 illustrates the outcomes of the calculations. Using energy from renewable sources reduces the environmental impact of dough preparation and baking by 4.4 times (from 608 UBP to 137 UBP). The total environmental impact of bread production is reduced by 15% (from 3485 UBP to 3014), while the energy demand of bread production is reduced by 2/3 (from 17 MJ to 5 MJ).

From this results can be seen that the environmental performance of the energy use within the bakery can drastically be improved. Emission in the environment can be reduced most effectively by purchasing certified energy from renewable sources. In the case a new oven is purchased by the bakery it is important to pay attention to its efficiency, as it leads to energy and cost savings.

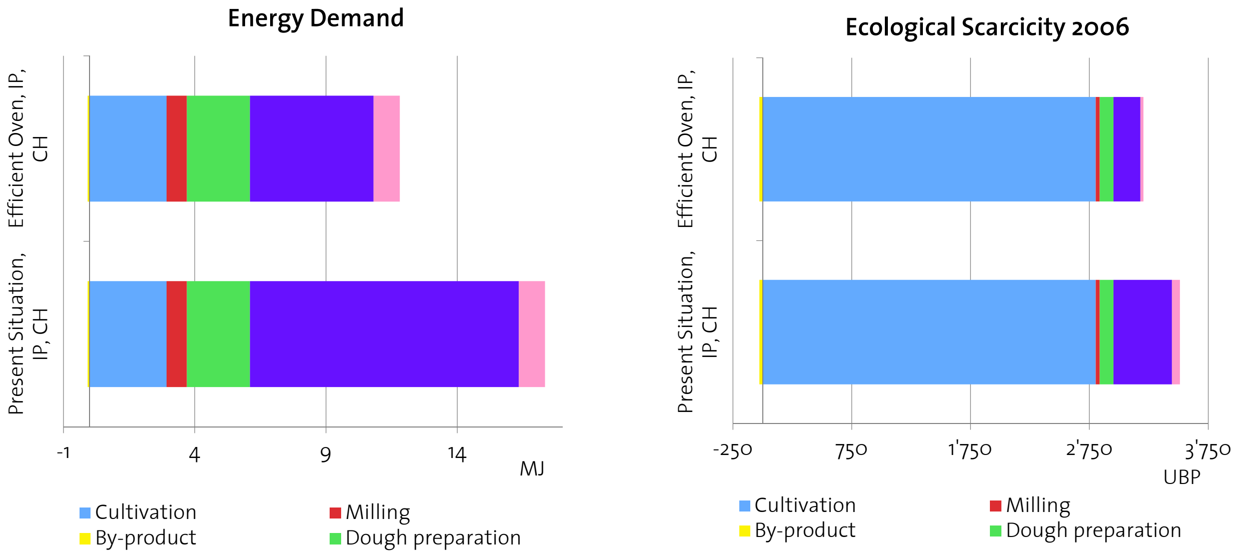


Figure 34: Comparison of energy demand and ecological scarcity for different baking efficiency

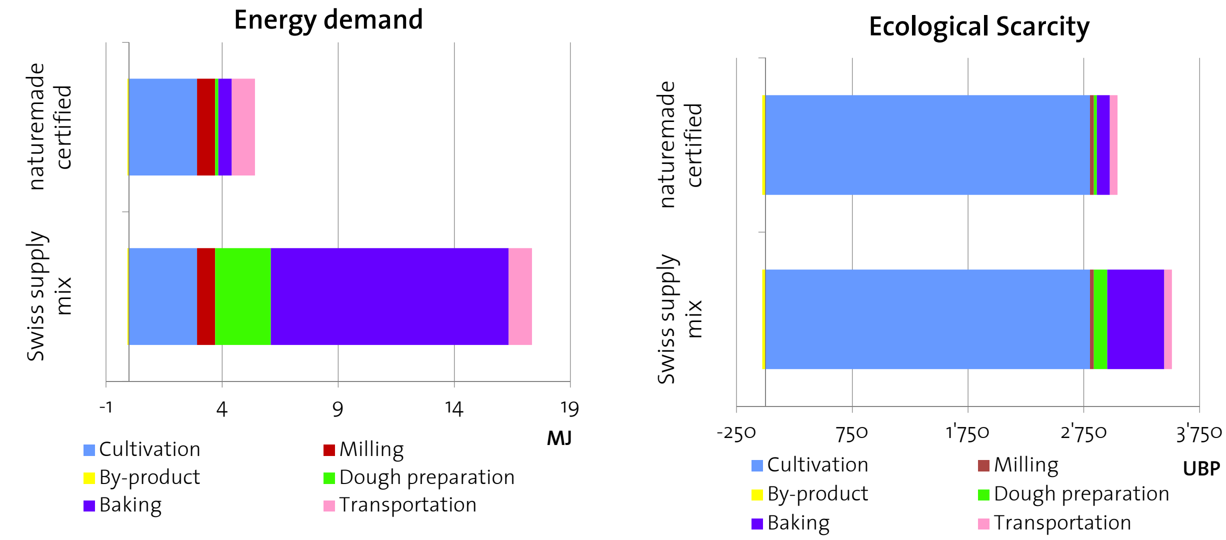


Figure 35: Comparison of energy demand and ecological scarcity for certified electricity and average Swiss supply

Overview of total impact of all analyzed alternatives

Figure 36 shows the total impacts of all the options analyzed above. In all options the main impact comes from cultivation. The variations are due to different sorts and amounts of fertilizer used in each country. The main environmental impact of US cultivation comes from emissions to surface water (64% of total US cultivation impact), while those from German cultivation are characterized by very low surface and groundwater emissions compared to CH results (10% and 19% of total DE cultivation impact), but high topsoil emissions (51% of total DE cultivation impact). It also has to be noted that the ecological scarcity characterization factors are based on the Swiss political goals of the environmental policy. This means that the pollution level of a specific substance is measured in relation to its critical flows determined by policy, thus substances not having legal limits nor target values for a specific natural compartment, as heavy metals in ground water, are not considered (Althaus, et al., 2010; Frischknecht, et al., 2009).

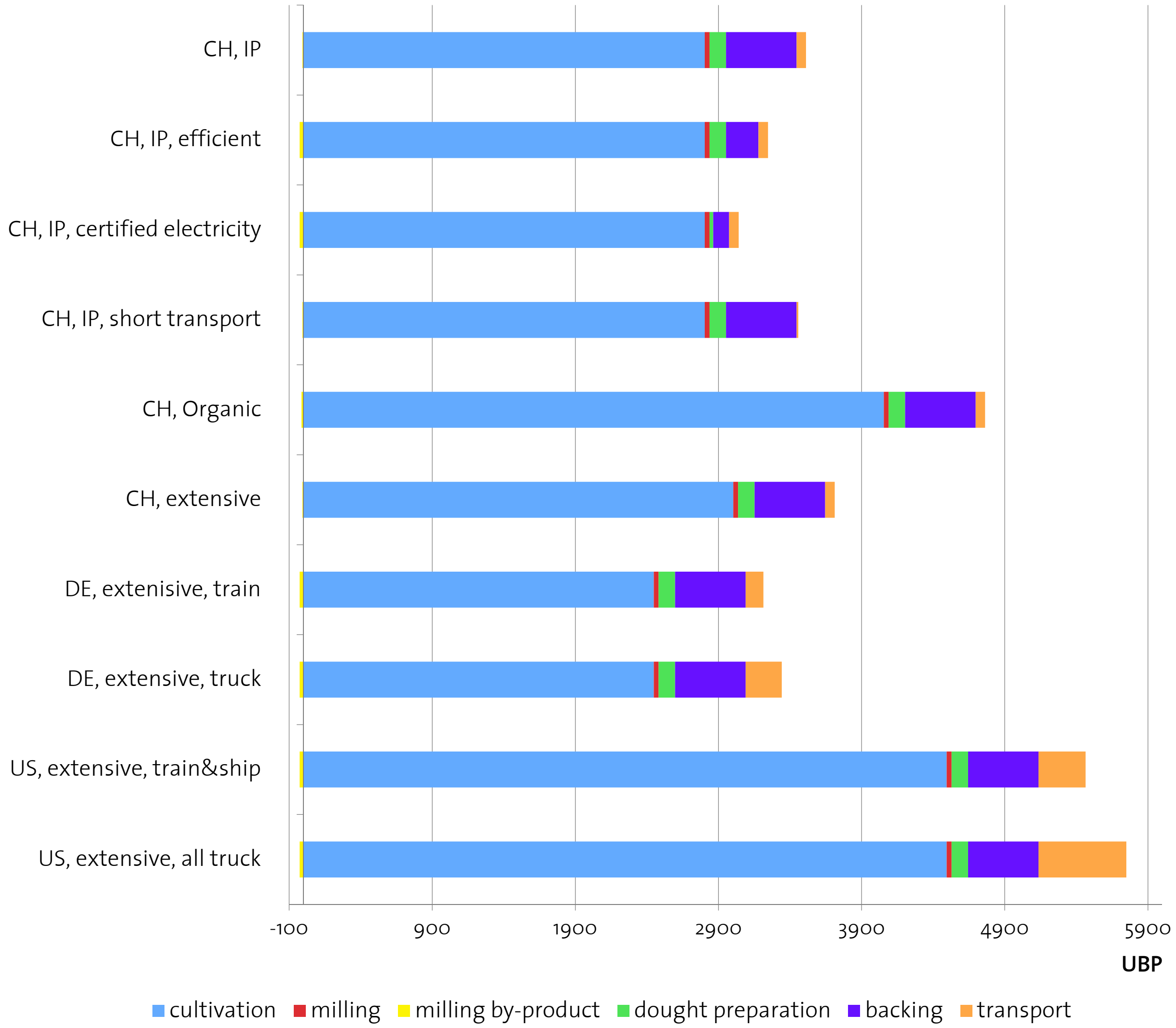


Figure 36: Overview on total environmental impact of 1 kg bread for all alternatives

3.2.3. *Origin related environmental impacts of selected products*

Is local food better than products that traveled long distances to reach our dishes? Advocates of the "local food is best" sustain their thesis by claiming that local food needs less transport, reduces CO2 emissions, increases food safety, guarantees high quality of products and sustains local economy. However, only few scientific researches confirmed these arguments yet (Edwards-Jones, et al., 2008). For these reason in this chapter will be given an overview of literature analyzing the environmental impacts of local and imported products. The main method used by the reviewed literature is life cycle assessment, which allows gaining insides on the impacts of different stages of the life cycle of products, so how on the affected natural compartment (see 2.2.1 Introduction to LCA methodology, C. CASE STUDY). The literature research entails products used in the construction of alternative purchase pattern, as they are most relevant for the case study. The influence of product's origin to the environmental impact will be given first on meat, milk and generally livestock products. Next products that can easily be imported from oversea, as sugar and oil will be treated. Than the review focus on vegetables and fruits, followed by bread. Finally a conclusion on the outcomes of the different cases in relation to the "local food is best" assumption will be given.

Beef meat

A report done by the energy and environment research institute of Heidelberg provides a collection of LCA focusing on the impact of regionally grown products. In the case of beef meat, regional grown cattle is compared with meat imported from Argentina. Two factors distinguish the productions: animal feed, cattle becomes forage in Germany and does open air grazing in Argentina, and presence of by-products, Milk is produced in German cattle farming, but not in Argentina where the function of the mother cow is exclusively breeding. The results of the LCA show that imported beef meat produces 15% more green house gas than regional beef, but uses 2/3 less fossil energy during the whole life cycle. The higher global warming potential (GWP) is due to allocation of emission from the mother cow to the cattle in Argentina, while the drastically lower values of energy consumption is due to the energy use for feeding stuff production in Germany. Breeding is the stage where most of the energy is used, while transportation plays a secondary role and has no impact on the final ranking, even though imported beef traveled 12'600 km (Reinhardt, et al., 2009).

Milk

Looking to the production of Milk, LCA studies comparing organic and non-organic milk came to the conclusion that organic fodder cultivation for cows applies fewer pesticides, but requires more land. By keeping conventional agriculture, potential for improving the efficiency of the system is found at several stages (Roy, et al., 2008). Cultivation of fodder and direct methane emissions from cows are the main greenhouse gases (GHGs) emission stages, however they have a less important role looking to fossil energy consumption. Packaging and transportation are the main sources of variation with regard to energy use of different milks. Regional production (20-50km) can reduce energy consumption up to 40% compared to inter-regional transportation (450-1050km), showing that in this case transportation plays a decisive role (Reinhardt, et al., 2009)

In the case of milk production, but also other systems having several by-products, can be seen that definition of system boundaries is a crucial step. For example in the beef meat study, German emissions from the mother cow are partially allocated to milk production (Reinhardt, et al., 2009). In the case LCAs done on milk production the production of meat, from milk cow calves is seen as by-product (Roy, et al., 2008). Difficulties deriving from assigning environmental emissions to singles products can be addressed by enlarging system boundaries (Roy, et al., 2008).

Livestock products

The majority of livestock products emissions come from cultivation and breeding stages (de Vries & de Boer, 2010). This means that independently from the origin of the products, the factor that influences most the environmental impacts caused is the choice between products differing in cultivation and breeding length and type. Thus comparing several livestock products the choice between type of meat, eggs and milk is determinant. For example, in respect to land use, GWP and energy consumption, livestock products can be ranked from higher impact to lower. The functional unit choice influences the results. In relation to kg of product, the highest impact comes from meat production, first beef, next pork and chicken. Milk and eggs have lower impacts (Roy, et al., 2008). Comparing impacts in relation to amount of produced proteins, beef is still the less environmentally efficient, while there are no consistent differences between pork, chicken, eggs and milk production (de Vries & de Boer, 2010). Thus comparing GHGs emissions from production of 100 kcal can be noted that vegetarian products cause between 300 and 40 times less emissions (Kirby, Bogdanovic, Heberlein, Simonett, & Stuhlberger, 2009). As food products account for 31% of EU GHGs emissions, the choice of products type shows a large potential for saving emission (Tukker, et al., 2006).

Oil and sugar

There are some food products that can be produced oversea or inland, be using different types of plants. LCA is an ideal tool for comparing this kind of products, as the definition of a common functional unit allows to compare impacts of products despite different origins and cultivation processes. Two example of these kind of products will be given.

A first example is oil, which can be produced from rapeseed or palms. Because of the support of bio-diesel from the EU as mean for saving CO_2 emission, large attention has been driven toward comparison of environmental emissions from inland and imported oil production. For instance a study showed that because palm oil generates more oil per hectare, its import causes fewer emissions than indigenous rapeseed production (in Ireland) (Thamsiriroj & Murphy, 2009). Unfortunately these results cannot be completed by an LCA focusing on oil production for food use, as no recent researches were found.

A second example can be taken from the sugar. A study showed that sugar import from Paraguay or Colombia can causes 20% less GWP, while the difference between imported products cultivated conventionally and the inland production is minimal by applying the Ecological Scarcity Method, which takes into account environmental impacts on all natural compartments.

Differences can be found between conventional and organic cultivation, in these case also the Ecological Scarcity Method showed values being 1/3 lower for imported organic sugar (Kägi & Wettstein, 2008). A second study, as well comparing inland production and import of sugar, showed that inland sugar cane sugar produced les emissions. The different results can be explained through the different allocation method used: in the first case credits were given through the economic value of by-products and in the second emissions avoided from the use of by-products as substitute for other products were considered. Like the case of livestock products, the choice of system boundaries and used method is decisive, rather than the pure land of origin of the products.

Vegetables and fruits

Vegetables and fruits are a category of products having tided relations between environmental impacts and origin. Generally environmental impacts of the category increase with the route length, however some examples show how other factors as season, cultivation and storage can be decisive. In the case of tomatoes its environmental impact depends on cultivation method, variety, location, packaging and distribution system. It was for instance shown how tomatoes imported in Sweden from Israel produced less GHG emissions than local tomatoes grown in a greenhouse heated with fossil fuels (Roy, et al., 2008; Tukker, et al., 2006). The impact of origin on green salad cultivation was considered by a study, which showed the importance of the cultivation method and season. In winter green salad imported from Spain caused lower GHG emissions than greenhouse grown salad grown locally, but green salad grown in summer inland produced drastically fewer emissions (Reinhardt, et al., 2009). The high relevance of transportation comes form the fact that open-air salad cultivation is not labor intensive. The case of apples showed that it is best buying seasonal and regional apples. When apples are bought beyond season, and they are stored in a cooled place the import from oversea and the energy used for storage compensate each other (Reinhardt, et al., 2009). From these studies can be seen that the importance of transportation and seasonality are crucial factors determining environmental impacts of fruits and vegetables.

Table 12: Overview on characteristics influencing environmental impacts of food products

Product	Most relevant stage		Relevance of transportation	Other factors	References
	energy	GWP			
Beef meat	breeding	methane from fattening bulls and breeding	low	by-product allocation	(Reinhardt, et al., 2009).
Milk	agriculture, packaging	agriculture and methane from cow	medium (energy), low (GWP)	by-product allocation	(Reinhardt, et al., 2009)
Livestock products	agriculture, breeding, direct methane emissions	agriculture, breeding, direct methane emissions	low	by-product allocation	(Kirby, et al., 2009).
Oil	cultivation	cultivation	medium		(Thamsiriroj & Murphy, 2009)
Sugar	cultivation, production, transportation	cultivation, production, transportation	medium		(Kägi & Wettstein, 2008).
Tomatoes	heating, transport	heating, transport	important	season	(Roy, et al., 2008).
Salad	heating, transport	heating, transport	important	season	(Reinhardt, et al., 2009).
Apple	cultivation, storage and transport	cultivation, storage and transport	important	season	(Reinhardt, et al., 2009).
Bread	backing, cultivation	backing, cultivation	low	individual shopping transpotation	(Reinhardt, et al., 2009).

Bread

Bread is the main product of the case study partner, thus a detailed LCA on the bread produced by the bakery is done and presented in the next section. Hereby only a short introduction to environmental impacts from bread production will be given. Several studies show that organic bread production necessitates a larger area, but has the advantage of applying less pesticides. The cultivation is the most relevant stage producing GHG emissions and causing eutrophication due to leakage of nitrogen compounds. The most energy intensive step of bread production is the backing process (Roy, et al., 2008). Comparisons of local small-scale bread production with centralized industrial production showed that industrial production is more efficient with regard to energy production in two cases (Reinhardt, et al., 2009; s. Sundkvist, et al., 2001) and to GHG emissions in one case (Reinhardt, et al., 2009). The main reason for the lower ranking of local bakeries is the inefficiency of the baking and milling process (Reinhardt, et al., 2009; s. Sundkvist, et al., 2001). Thus by improving process efficiency, local bakeries could outweigh the additional emission industrial bakeries have due to long transportation and have the best ranking. An additional key factor is the transportation mean used by customer to go shopping, if a car is taken for buying exclusively bread, the emissions from the individual transportation overcomes the emission form the whole life cycle steps, showing the importance of promoting mobility with public transportation (Reinhardt, et al., 2009).

Literature review conclusion

Finally a position can be taken on the question wheatear local food is better than imported products. The considered studies (see overview Table 12) showed that there is not only one answer to the question. Each food product is different and depending on the constellation of the production system, specific stages have to be considered depending on their improvement potential. The key outcomes of the literature overview are:

- The largest amelioration of livestock products is rather in the product choice than in prioritizing local products, apart from the case of milk, where transportation over 400km becomes more important than environmental friendly packaging or other measures.
- In the case of oil and sugar import results depend on used allocation method. A priori inland and import could both have similar environmental impacts, showing the importance of also considering social aspects.
- In the case of vegetables comes out that priority should be given to avoiding greenhouse cultivation and import from abroad, which implies prioritizing seasonal and regional products.
- The case of bread production is strongly linked to the efficiency of the baking process in addition to mode of cultivation. It can be concluded that local food is not always the best, as environmental, social and ethical aspects have to be considered (Edwards-Jones, et al., 2008).

In addition to the single product issues, for developing sustainable food systems attention should be given to tightening feedback loops. Strengthen feedback loops means improving communication, difficult task in complex and globally food system, and allow having transparent feedbacks on ecological impacts of production systems (A. Sundkvist, Milestad, & Jansson, 2005).

3.3. By-products management

A description of the material flows entering and exiting the bakery is given first, follows a description of the waste typology and the disposal options existing in the city of Zürich for each type of material.

3.3.1. Waste typology

There are two main types of by-products: food and packaging. Food by-products can be divided in food scraps (food leftovers not adapted for human consumption), not sold food (high quality, ready for consumption in short time frame products) and not consumed food (sold products, that were not consumed by customers). Packaging waste can be divided in recyclable and not-recyclable materials. In Zürich materials as PET plastic bottles, metals, aluminum, glass, old oil, paper and carton are separately collected and are recycled, even though each material has individual pathways. The waste treatment company (ERZ) collects paper and carton door by door for free, while products like glass, metals, aluminum and old oil have to be brought to collection points by individuals. Waste that is not part of the above-cited categories is collected as municipal waste (ERZ, 2010). Swiss waste legislation includes the application of the "polluter pays" principle (BUWAL, 2001), thus in several cities plastic bags for waste collection are specifically marked and have an elevated prices to incentive waste reduction and recycling (110L bag costs 5.70 CHF).

3.3.2. Strategies for packaging

Looking to the material flows and type of produced waste several strategies to avoid waste production or to recycle them can be found. The responsibility of the firm entails waste obtained from production and selling, even though from a broader perspective, their decisions influence the waste of customers, and can influence the amount of packaging used by suppliers.

Several approaches can be taken in relation to the production of packaging waste. Starting from the production to the customer following strategies can be adopted:

- purchase products with less packaging (flour as 25kg bags, or bulk), reusable or recyclable packaging.
- replace one-time use items for production process by exchanging the provided service with multi-use items, i.e. replace plastic film for cooling of pastry through reusable ones.
- diminish the amount of packaging used per product sold by finding alternative solution to one-time use packaging (sell textile take away bags, reusable take away fork-spoon-knife kit, textile napkins, etc.) or by increasing the efficiency of present solutions (use one carton bag for several items instead of packing each piece in single bags, add plastic bags, napkins and services only when requested, add a cost for take away plastic bag, etc.).

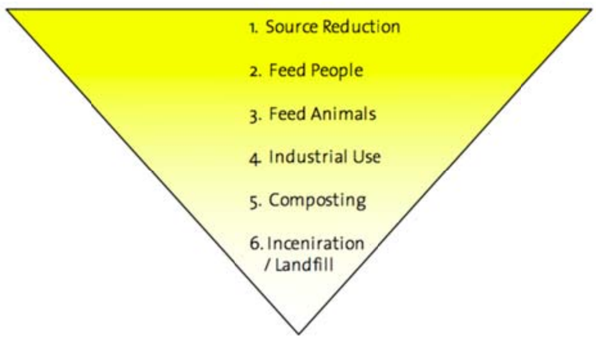
On the other hand measures can be taken to dispose existing waste packaging effectively. These can include:

- recycling of all recyclable products collected by the city (metals, aluminum, glass, old oil, paper and carton) and other organizations (PET-bottles, aluminum drinking cans)
- have a clear information policy toward co-workers (list with recycling golden rules for employees, etc.) and customers

3.3.3. *Strategies for food*

Undesired food products are the second type of by-product. The organic matter depending on the disposal options, can be divided either in animal derivates (food containing meat, eggs, ...) and vegetarian derivates (no meat and eggs) or in dry and creamy mixtures. Theoretically several options exist for treating organic waste, thus legislation, disposal cost and practical feasibility influence the final choice. In the following section will first be given an overview on the choices of food by-product treatment and their priority ranking, next some key numbers of Swiss food by-product production and use and finally the findings will be applied to the case study enterprise perspective.

The Environmental Protection Agency of the US, has issued a priority chart for the disposal of food products (Figure 37) (EPA, 2006). The strategy starts with reducing volumes of waste generate, donate food to charitable organizations as shelters and soup kitchens, use food scraps as fed for animals as pigs, use food industrially to convert oil in fuel or digest food scraps to produce biogas, produce compost and as final option leave organic material in the municipal treatment facilities. This fix hierarchy approach can be taken as a guideline, however the best disposal solution depends on specific local circumstances. For instance thermal treatment with energy exhaustion in a near facility can be better than transporting a waste to a far-away fermentation facility.



oducts

From an environmental point of view this classification makes sense, as it allows to increase the efficiency of the supplied food, by reducing scraps, next substitute the production of new products by finding new users (people or animals), use energy and materials present through industrial use or put back into the environment the nourishment by composting. Also incineration option allows gain back some energy present in the materials.

Looking more in detail to the waste treatment policy of Switzerland, particularly of Zürich, and the present economic conditions, choosing the best way to treat food waste becomes complicated. In Table 13 are shown the possibilities for the different options presented in Figure 37.

A large discussion is going on since years in the city of Zürich about the collection of organic waste from households and gastronomy. In 2006 a research done by ERZ showed that by comparing the present collection system to three options (collection of organic waste with greenery from gardens; collecting of organic waste only from gastronomy; one collecting waste form households separately) a separate collection was not rentable either from an economic perspective, nor from CO2 savings and amount of produced energy (ERZ, 2006). These results were discussed by several experts, explaining how central were the choice of system boundaries and research question (Bartha-Pichler, 2006). Later on a pilot project was done on a small scale, the project received a positive evaluation influencing the decision of starting collection of organic waste from households. Nowadays no separate collection of organic waste is offered by the city. Thus even if independently managed local composting facilities are supported through provision of information by the city, the majority of the household organic waste is treated in thermal plants. Finally in March 2010, the city of Zürich announced the plan for building a biogas plant treating gardening and food waste collected from households and gastronomy and the foundation of a new firm managing the biogas production (Biogas Zürich Ag). Thus a new option will be given to the enterprise soon.

Around 300’000 tons of food scraps are collected in Switzerland from households and gastronomy every year (Schleiss & Engeli, 2005). There are no accounting of the total amount of waste produced, thus as the average share of organic matter in household waste is 27%, the potential products that could be used amount to 1’000’000 tons (BiomassEnergie, 2009). Presently 72% of the collected organic waste is used as pig feed and 5% as fermentation substrate (Schleiss & Engeli, 2005). This numbers will change strongly after the prohibition, starting in July 2011 (Stoll, 2011), of feeding pigs with food scraps. The regulation will lead farmer to import amounts of feeds that correspond to 47’800 tons of bruised soy, 151’800t barely and some diet complementary substances (Zimmerli, 2011). A comparison of different ways to treat gastronomy food showed that from an environmental, social and economical perspective after animal feed, fermentation is the most suited option in the present context (Schleiss & Engeli, 2005). This position is also supported by the Swiss agency for waste, water, energy and air (AWEL), which promotes production of biogas as best alternative to feeding because it allows both an energetic use, through production of electricity, heat and fuel, but also a material use, as the output of fermentation can be transformed in high quality compost, which is distributed on the land and closes the material flow loop (Schleiss & Engeli, 2005). The use of biogas is expected to rise in the future. The main factors influencing its spread are the availability of biomass – the theoretical potential is large-, a supportive political framework, technology innovation and evolution of energy and food prices (Wirth & Markard, 2010).

Looking to the options available to the enterprise it is recommended to promote a cascade use of the food residues. As seen above minimal amounts are left over during the production process, but by the selling, due to daily variation of clients demand and the high quality requirement of the firm, ready to consume products as bread and pastries need to be disposed. The above hierarchy of decision can be followed, prioritizing human consumption for high quality food product. As the option of animal feed will be restricted since 2011, and fermentation is not yet an available option, the possibilities of starting self-managed composting can be exanimate by the enterprise. This option would include costs for composting management and initial infrastructure, but would allow gain from selling compost materials and have a flexible collection system, as the enterprise could manage it independently. Additionally composting allows closing the organic material flow loop. The last option is disposal in regular municipal waste, which is treated thermally, thus allow a energetic reuse. Within this frame the enterprise can find its best option.

Table 13: Overview of food by-products disposal options in Zürich

Options	Category	Legislative framework CH	Possibilities in Zürich
Human feed	Enterprise personnel	Allowed, compliance with hygen and health protection regulation needed.	Intern
	Charity		Schweizer Tafel (Schweizer-Tafel, 2009)
Animal feed	Pigs	Switzerland allows the use of food scraps for animal fed, while it the EU it is forbidden since 2006. Within bilateral agreement with the EU Switzerland reviewed the animal fed regulation. Since July 2011 it will be forbidden giving food scraps to animals (Scherer, 2009; Schweizerbauer, 2011; Stoll, 2011). The restriction is valuable only to food scraps containing meat residues (Zimmerli, 2011), however today there is no separation of food leftovers, thus all food scraps used as animal fed will be forbidden.	An example of prices given by a food recycling specialist preparing the pig feed mix is 15 chf for a container of 120L (0.125 chf/L)(Gasser, 2009)
Industrial use	Fermentation plants producing biogas	Switzerland strongly supports the development of renewable energy from biomass. Subsidies can be requested for building biogas plants allowing using food scraps for biogas production that can be used as heating, electricity production and as fuel.	Since 2012 the city will collect food scrap to be used in a biogas plant owned by the new founded company Biogas Zürich AG (ERZ, 2011b).
Composting	External company	There are no national incentives, as only materials, but not energy can be recovered.	
	Self-managed		the city supports self-organized composting (ERZ, 2011a)
Inceniration	Züri Sack	Any waste that cannot be recovered has to be incinerated. Incineration plants mostly recover the produced energy as heating for household (BAFU, 2011).	Disposed waste to municiapal solid waste treatement in bags costs in average 0.35 chf/kg
	Industrial Waste Collection Bins		Collecting waste in industrial containers cost 0.20chf/kg + tranposrtation costs. The city recommend small firms to rather use disposal bags, as it results cheaper for the firms (ERZ, 2010).

D. DISCUSSION

1. Discussion of the guiding question

In the introduction a general guiding question and four case specific questions were defined. In this section the results presented in the previous chapter will be discussed starting from the case specific questions and concluding with the overarching question addressing all SMEs. For each sub-question, we firstly present the outcomes on the purchased materials - inputs -, and secondly, we address the outcomes of the by-product management - outputs.

1.1. Case study results

1.1.1. How are the procured materials and produced by-products characterized in relation to economic and geography parameters?

INPUT: The majority of purchased products come from Switzerland (79% by weight and 74% by price), followed by products purchased in Europe and a minority from further away. The relation between price and weight of products determines their sensitivity within the total cost. For instance some products have elevated prices per unit weight (meat and fat & oil) and other have low prices per unit weight, but large amounts are purchased by the enterprise (flour and dairy products). In relation to this, it can be noted that the products which are purchased inland tend to represent large shares of weight (flour, butter, dairy products). In contrast to this, products that are more labor intensive during cultivation or processing, but either cannot be produced or have high domestic prices, are imported (nuts & seeds, refined bakery products, sweet products, canned fruits and vegetables). Exceptions to this trend are meat, –which even though it has a high cost per unit of weight is purchased domestically due to consumer sensitivity–, eggs – that have comparable costs inland and in Europe, but are half imported–, and sugar, which is mainly imported even though it has a low price per unit weight.

In general it can be observed that transportation costs of European and Swiss products are negligible with respect to the economic value of the products, a fact which is more strongly related to a specific country's economic policy. Swiss agricultural policy, for instance, protects national farmers by limiting imports of food products with contingents and import taxes (SBV, 2009). Transportation costs of products imported from non-European countries become more significant. In this case there is a trade-off between transport cost and lower production prices due to (i) different agriculture practice, i.e. extensive wheat, or palm oil monocultures; (ii) different social frame, i.e. lower salaries in developing countries; (iii) and/or national policies, i.e. less severe environmental regulations for the use of pesticides (Cheryl Baldwin, 2009).

OUTPUT: The produced by-products have negative to neutral economic values, as the enterprise has to pay for the municipal waste disposal (1.70 CHF/35L bag or 9 CHF collection + 0.20CHF/kg) and the collection of recycling materials, without PET bottles (86.40 CHF per collection)(ERZ, 2010). The economic value is negative for the collection of organic waste that is disposed as municipal waste in the city. Thus there is an incentive for decreasing the production of waste, but not for an environmentally sound disposal of organic by-products.

1.1.2. *Do options for the alternative procurement and by-products treatment exist, and how are they characterized in relation to economical and geographical parameters?*

INPUT: The case study results of the alternative purchase patterns revealed a variety of different options. The three analyzed alternatives showed the possibility of reducing costs up to 10% by decreasing the quality and the amount of domestic products, or increasing costs up to 30% by focusing on organic and locally produced food. The case study enterprise is taken as a benchmark, showing that despite the company's high quality inland purchase pattern their costs are close to the economically optimal option. In relation to product origin can be seen that in the low-cost alternative inland products expenditure diminished by 12%, in comparison to the total expenditure of the present purchase pattern. Further in the organic alternative the share or inland expenditure increased by 9% compared to the present one. In the low-cost alternative the share of products imported from the world is identical to the present share of products purchased from the World, while it diminishes by 5% in the organic option (which privileges short-distance transportation), as products are rather imported from Europe than from further away.

OUTPUT: Alternatives for the management of by-products produced by the enterprise exist. Measures can either focus on diminishing the amounts of packaging materials used and organic by-products i.e. not sold fresh food products, or on finding ecologically and socially sound reuse and recycling pathways. In the case of packaging, attention should be paid first to preferring goods with little packaging, second to avoiding the use of single-use items for the bakery and pastry internal production and third to promoting alternative packaging while selling products. In the case of food by-products it can be focused on reuse of comestible goods - for human consumption, enterprise internally or by supporting charity organizations redistributing food. Food that cannot be consumed by humans should serve as input material for fermentation (material and energy recover) plants first, next composting (material recover) or incineration (energy)plants (Bartha-Pichler, 2006; EPA, 2006; Schleiss & Engeli, 2005).

1.1.3. *How are environmental impacts characterized in relation to the geographic origin of the materials?*

INPUT: Two methods were used for inquiring the environmental impacts of food products: first, a literature research was carried out providing an overview on the key factors that influence the environmental impacts of selected product groups and subsequently, an LCA, specifically tailored to the bread production of the enterprise, gave results for the analyzed case. The results demonstrate that food purchased regionally doesn't need to have lower environmental impacts than imported products. Transportation is one of several factors influencing the environmental impacts of a product. In food products, though, the cultivation phase turned out to be the most relevant in the majority of the cases. In most cases, organic cultivation required more land for the production of the same amount of goods than conventional cultivation. Other decisive factors were the influence of seasonality and related production patterns, like the use of greenhouses, and the production process efficiency, as in the baking process of bread. It can be concluded that the geographical origin is relevant in relation to the environmental impacts of food production, as it allows to diminish transport distance and to clearly track production ways. This enables tightening communication feedback loops. However, the total environmental impact of a certain food product significantly depends on additional factors, such as cultivation type and production process.

1.1.4. *Which political instruments can support the most environmentally sustainable options?*

INPUT: According to the above results, the most environmentally friendly option for purchasing food depends on several factors. Hence, adequate political instruments to support good practice should, on the one hand, improve information transparency (life cycle labeling, make origin specification compulsory on packaging also for gastronomy, offer information session, …), and on the other hand internalize the environmental costs of the products moving in the economic system. The internalization of environmental costs could be supported by prohibiting actions supporting not environmental friendly cultivation options. For instance, to limit the use of greenhouses and import of not seasonal food products, which the literature review demonstrated to be not favorable for the environmental, an adequate tax system could be set imports or whole sale retailers. In the case of livestock products, costs could be internalized by differentiating prices of different type of products in relation to their environmental impacts (beef and shrimps would cost twice as much than pork and chicken).

OUTPUT: With respect to the by-product management, policy could support the most environmentally sound options by increasing prices of single-use products (e.g. packaging of take away food) and render recycling easier and less costly. In the case of food disposal, two initiatives could be promoted. First, in the case of unsold edible products, charity initiatives (i.e. Schweizertafel) redistributing food could be supported. Second, in the case of organic by-products, incentives could be created by coupling the collection of organic products with discounts on the collection of other recyclable products that are gathered from the firm individually by the municipal waste management company. In such a system a discount of 10 CHF could be given for the collection of glass and metals, if organic waste is provided as well. This system would not only give a value to the organic by-products, but promote the collection of other recyclable materials.

1.2. General guiding question

After having gained insights into the case specific questions, the discussion can focus on supporting closed-loop economy development in a wider sense. According to the actors´preference, different types of activities can be envisaged, thus before focusing on SMEs in general, the perspective of bakeries and SMEs dealing with food products will be taken.

1.2.1. *What is the potential of SMEs i) to foster supply chains with short transportation ways and ii) to develop a closed loop economy in the city of Zürich?*

Bakeries and gastronomy branch

i) Short supply chains

The potential of bakeries –and gastronomy SMEs in general– to support the development of short transportation ways mainly concern purchase patterns for the ingredients of their products. The selection of Swiss and regional products can reduce the transportation distance. The case study showed that grain purchased from abroad can increase the environmental impact of up to 9 times in comparison to grain cultivated in Switzerland. The potential of improving the regional supply chain network also exists. In our case study, less transportation between the production site and the selling branches could reduce the present impacts to one fifth. These results show how important effective urban planning is on a regional level. The manufacturing of food products close to their selling point avoids regular transport of ready to consume products with inefficient transportation means. An example for reflection can be taken from the recent case of Swiss Mill, which in February 2011 was allowed to enlarge its wheat silo in the centre of Zürich to 120m through a voting approved by the city habitants (TagesAnzeiger, 2010, 2011). The argument of decreasing logistics by having a central mill production site, is not consistent with the city urban planning which supports production outside the city. In the case study bakery, for instance, wheat purchased from the Swissmill silo would have to be transported 20 km to the production site and 20 km back to Zurich to the selling branches.

ii) Closed-loop economy

Regarding their potential of fostering a closed-loop economy, SMEs dealing with food products have the possibility to redirect their food by-products in the organic nutrients cycle. Within the city of Zurich, it is not easy yet to redirect organic waste in a circular flow. Considering that enterprises don't have large storage capacities, but regularly produce large amounts of food scraps, their potential benefits of participating in a collection system of organic waste are numerous. From the municipality side, the involvement of numerous SMEs would allow to reduce the costs of reverse logistics because of the densification of collection networks. Looking to the amount of non-recyclable by-products, SMEs have little alternative choice. Packaging of ingredients used for the food production cannot be eliminated, but different options do exist for the choice of packaging of their own products. The main constraint there comes from the expectations of the customers, which take-away food consumption strongly increased during last years. Innovative approaches consist in offering take away food in reusable take-back boxes, or selling bread in reusable cloth bags. The positive impacts of these strategies would go beyond a marketing campaign showing the good example by applying concrete actions.

SMEs

On a wider scale, as discussed during the case selection section, it is not possible to give general statements in relation to the environmental impacts that would be valuable for all SME branches. Nevertheless, considering the common features of all SME, for instance the size of the enterprise and the relatively low direct environmental impact per unit, can be seen that tailored tools need to be developed to include SMEs in fostering change.

i) Short supply chains

SMEs can contribute to short supply chains by adopting procurement patterns that take geographical distance into consideration and by specializing in regional activities (see strategies of SMEs *ii) closed-loop economy* below).

ii) Closed-loop economy

SMEs can be involved in two main ways in fostering a closed-loop economy: they can *improve business as usual* or *catch business opportunities* offered by creating reverse logistics. In the first case, the role of an SME would mainly consist in modifying purchase patterns, to sustain products able to "cycle" within a closed-loop economy, and thus firms engaged in producing products that can follow a cascade of product use would be preferred. A carpenter, for instance, could engage in producing furniture covered with paints that allow to later be burnt without producing toxic emissions, and allowing for disassembly. In this way the furniture could be disposed of safely and new models could be built by changing the arrangement of the parts. In addition, these enterprises would apply effective by-products management strategies acting in giving material forward in its cascading use. The second type of SME could identify within closed-loop economy new niches for specialized business. Depending on their starting point enterprises could act at different levels of the supply chain. Wholesale and retailers could add take back services to their current activities, acting as intermediary between the supply and the reverse logistics. Other firms could follow a new business model: instead of focusing on selling goods they could sell the service of the good for a specific time, ensuring a backward flow of material. For instance instead of buying a television and having to through it away after 2 years, people could exchange it with another one (Belz, 1998; Mc Donough & Braungart, 1998). Thus items still working would not be thrown away and there would be an incentive for the firm to repair products. The same kind of system is already implemented for photocopy machines, office furniture, household machines, office plants, etc. Finally enterprises could see in the present waste production possibilities for creating new activities by acting in the reverse logistic system. Opportunities exist in developing systems for collection, revision, cleaning, repair, disassembly, fractioning, reprocess and re-sell of materials (Sommer-Dittrich, 2010; Steven, 2004). Thus the main precondition for building such a system is a legislative framework supporting a cascading use of materials.

1.2.2. Which political initiatives can support SME to exploit their potential of fostering short supply chains and develop a closed-loop economy?

A good way to include SMEs in fostering the development of a regional closed-loop economy is creating an incentive for companies to take active roles. In general motivation can come from cost saving possibilities, compliance with regulations, improvement of image or business opportunities (Steven, 2004). Thereby, particularities of SMEs as the reduced capacity of dealing with administrative burden and limited possibilities for specialization in environmental issues have to be taken into account (Gadenne, Kennedy, & McKeiver, 2009; Gombault & Versteege, 1999; Hillary, 2004). Thus to complement the activities of öko-kompass, providing a free environmental management consulting for SMEs (Billeter, Lellig, & Marchesi, 2010), the city can act on different levels. First, by setting an adequate legislative framework, and next acting on three axes which address economic incentives, public procurement and information networks.

Legislative framework: First of all, a closed-loop economy needs to be possible, thus the legislative framework should enable and promote material exchanges in the sense that regulations should not block actions aiming to recycle and reuse materials. Second, the city can promote firms engaging in closing the loop by making business of enterprises that engage in reverse logistics viable. The waste regulation, for instance, could specify criteria for safe and high quality reuse and recycling, hence supporting producers that do not use toxic components or treatments, i.e. paints. Regulation could impede reuse and recycling, by defining very general criteria, i.e. prohibiting burning any wood product that has been used before in facilities other than municipal ones.

Economic incentives: On the first axis, there is the development of economic incentives. These are essential, as the present system steadily incentivizes the consumption of low quality imported products through low prices and aggressive advertisement, leaving no market opportunities for businesses engaging in collecting and repairing products, which are time intensive and thus rather expensive, but not material and energy intensive. If businesses promoting a different type of service provision want to be supported from the city, either the overall price system would need to change, by giving a different value to materials. Else, selective means to make the enterprise viable have to be set. Looking to the price system, it can be observed that on the city level it is not possible to directly modify prices of purchase goods since we are part of a global market. However, as the city is the main actor on the waste treatment side, it is possible to set incentives. These could aim at reducing the quantities of waste produced or changing the quality of by-products ending up in waste treatment plants, in the sense of sustaining cascade use of products. Setting a take-back system charging more, products that cannot enter a cascade material use, could do this. This would include the development of criteria that define the possibilities of reuse. For example in the cascade use of wood products, a label could specify whether surfaces were painted with chemicals that allow a safe reuse – or not. By applying such measures, recycling and collection points managed by the city could not only be the endpoints of materials as it is the case nowadays, but become pools for exchanging materials. Thus, firms specialized in reverse logistics of specific material streams could become partners taking back specific materials.

Public procurement: The second axe of action focuses on public procurement. This is a powerful measure for promoting firms that sustain alternative ways to produce and reuse materials, as it increases their income stability and security. In addition, the city gains the possibility of improving its image and to set a good example, motivating other firms to engage in a closed loop economy. The city of Zurich already showed a good example by sustaining the purchase of organic cotton for police T-shirts (EUCommission, 2008), but it could engage in further areas. Taking office furniture as an example, the company Herman Miller already applies a take-back system, which allows for dismounting and reusing each part of office chairs. The company works on service provision: it rents out furniture for a specific time, taking it back when it needs to be changed. Several possibilities already exist in this sector (carpets, textiles...), and new ones could be developed by sustaining companies working for developing a closed-loop economy (food sector, organization of events...).

Information network: The third axe consists of improving the information about used and produced products and by-products. This is a precondition allowing to inquire the potential for setting specific take back systems and showing possibilities for exchanging materials. As the amount of by-products produced per enterprise is normally not very large, a collection of information on all sources of a specific good and the quantities produced would show the potential for a new enterprise to engage in treating it. In the case of food by-products produced in the gastronomy, for example, clear information would allow for an efficient collection management and show the potential and economic viability of a business opportunity for producing biogas. Thus, building an information network on materials treated by SMEs could easily be supported by an internet platform on which enterprises could list the type and amounts of by-products produced and then sell them by auctioning. Auctions could work as well on the other side. A food by-product processing agency, for example, could offer to collect all the food waste of an area, if a minimal amount of partners participate. This would enhance the possibility of building locally efficient collection systems of specific materials (RecycleMatch, 2011).

2. Methodological considerations

In this section, a methodological consideration will be conducted, addressing first the combination of the single methods and subsequently each of them separately.

2.1. Combination of MFA, LCA and qualitative analysis

In this study, a case study approach combining MFA, LCA and a qualitative analysis of by-product waste management was taken. This procedure has both strengths and weaknesses. The combination of different methods on a specific case has the strength of offering a sharp view showing the role of the enterprise within different systems. The MFA of purchased food products showed the existing links between produced goods and their origin, hence providing a first model of the food supply chain network and its complexity. Thus, the MFA highlighted the role of the enterprise choices within the global supply chain system. In a next step, an LCA of bread allowed to gain insights into the environmental impact of the main product of the case study enterprise, displaying options for action within a framework setting that takes into account the whole life cycle of bread. This made it possible to track the role of the enterprise on the level of a product system in a more detailed way. The last method applied for defining by-products management strategies is qualitative and descriptive. This approach complements the other two methods, as it focuses on summarizing several possible options within the regional context by taking into accounts changes of the political framework conditions and priorities of the city waste management. This method provided insights into the legislative and social context characterizing the regional system, which the enterprise is part of. The combination of the three methods allowed gaining an understanding of the system needed to deal with trade-offs that result from the minimization of transport and overall environmental impacts.

Focusing on the weaknesses of the used method, these are mainly linked to the nature of case studies. Findings are precise, but case specific, thus are only partially relevant for the whole gastronomy branch and for SMEs in general. Thus, for being able to recommend concrete actions, an MFA should be accomplished on a regional level, accounting not only for material flows of SMEs, but also of larger enterprises and households. Extending the analysis to larger enterprises and households would allow for identifying the potential for combining the material streams of different actors. In this sense, SMEs could play a key role, as they can be regarded as being between the two groups (some SMEs provide services for larger businesses or households). Finally the main strength of the method consists in combining the standpoint of the enterprise within the global supply chain network, the supply chain and the environmental impacts of a specific material flow, and the regional level.

2.2. MFA and alternative purchase pattern

2.2.1. Origin of products

The collaboration between the case study enterprise and its suppliers was very fruitful, as they made data sheet on yearly purchased products accessible. However, data sheet of some suppliers had to be completed, as data regarding the origin of products were not complete. Data sheets were completed by first selecting the most relevant missing information on origin, in relation to products weight and price, and next contacting suppliers of suppliers. The procedure enabled reducing products with unknown origin to 5.6% of total weight and 5.4% of total price. The fact that an important amount of origin information was missing by suppliers selling processed products shows how information on origin decreases with the amount of production steps involved. Thus, throughout the food supply chain, there is still a significant potential for improving the information transfer to customers.

Regarding the product origin, it can be observed that most of the products come from Switzerland (see Table 6 pp.52).This is partially explained by the Swiss agricultural protection policy, sustaining Swiss farmers through direct subsidies, boundary protection and market tools (SBV, 2009) Each year the country fixes an import quota (Zollkontingent) in relation to the yields of the year to limit the imports of several foodstuffs. There are quotas for most of the domestic products, but they are particularly strict for example for bread wheat grain (BLW, 2011) or for the import of dairy products, where the organization Burra has a monopoly (FOAG, 2009). The state influences the amount and price of imported not elaborated products. Consequently, the suppliers of the enterprise have as well a limited range of products in their assortment. Therefore only in the case of some products, like eggs, vegetables and fruits, which are purchased from regional producers, it can be seen that the choice is part of the strategy of the enterprise, while for other products this cannot be confirmed due to the limited options.

2.2.2. *Alternative products*

A difficulty raised by constructing alternative purchase pattern. As organic products are rarely purchased by gastronomy, information on suppliers, their products and prices need to be researched carefully. Sometimes prices were available only for retailers. Because of this, some of the prices of the organic alternative of the purchase patterns are probably overestimated by 10% of the used price, nevertheless this is not influencing the results of the organic alternative significantly, since the prices of the products are between 10% and 225% higher than the presently purchased products, while the low-cost option difference ranges between a 40% and 1% lower price.

Additionally, it can be noted that the amount of imported products is limited, because alternative products were researched within real suppliers of the region, which have an assortment with mainly selling Swiss product. Even if the price of same products could be found from abroad, it was not possible to estimate transportation and administrative costs defining the real cost the enterprise would have to pay for these products. Therefore, in order to avoid options that included an excessive amount of assumptions, this selection method was excluded.

With regard to the amount of product modeled and their relevance for the whole purchased assortment, it can be noted that the choice allowed modeling the main ingredients of the products produced by the bakery. However, the selection is only partially representative for already processed products that are just sold in the branches of the bakery and for products used for refining main production (product categories: sweet products, spices & aromas, bakery products and other). These product groups have a larger amount of different products in respect to the modeled categories (flour, eggs, fat & oil, dairy products, meat and sugar) and a small share of total weight.

2.2.3. *Approximations and uncertainty*

In the MFA the geographical origin of products was approximated to the three categories Switzerland, Europe and World. This is clearly a rough estimation of the distance a certain foodstuff has traveled. “Europe” stands both for food coming from Germany close to the Swiss border and from southern Spain, while “World” includes imports from Israel and places as far as Australia. However, for the focus of the present thesis this grade of precision was sufficient with respect to the goal of describing the assortment of the food origin of a bakery. The grade of precision is also justified by the fact that an accurate evaluation of environmental impacts of a representative product followed the MFA. The inclusion of regional products as fourth origin category would have been an option, given the fact that the bakery purchases a portion of several products from the region (flour, eggs, vegetables). However, with respect to the total distance, imported products do differentiating on the Swiss level becomes irrelevant.

In the MFA and construction of alternative purchase patterns, no uncertainty analysis was carried out, mainly due to the limited time frame of this study. To increase the reliability of the used data, it would be very useful to perform a supplementary screening of the original data set, the reported origins and functional units. In addition, a wider screening for alternative products allowing to compare intermediate options would show the sensitivity of the prices of single products (if five options of a product are available, get information on the range of variation).

2.3. Bread LCA

2.3.1. System boundaries

The system boundaries of the performed LCA were set in a ways that did not take into account environmental impacts deriving from energy and infrastructure used in stores and for other processes beyond dough preparation and baking. Packaging and transportation to the consumer's home were not taken into account either. Including this data in the assessment would have allowed for identifying further options for action.

2.3.2. Sensitivity analysis

No sensitivity analysis was performed on the LCA, even though these would have been useful for example to identify the geographical scope from which emissions of transportation become significant in relation to the total impact. Sensitivity could also have accurately showed the influence of transport means used for specific stages.

2.3.3. Comparison with other studies

Several LCAs have been conducted in the past, even though the majority of them are not very recent. The total primary energy demand per kg of bread varies between 6.2 -16 MJ(Andersson & Ohlsson, 1999; Braschkat, et al., 2003; Grönroos, et al., 2006), and total primary non-fossil and nuclear energy was founded to be 7MJ by (Reinhardt, et al., 2009). With regard to results about the global warming potential of the production of bread, past studies found values between 500-900 g CO_2 eq. (agriculture, food processing, transportation) (Andersson & Ohlsson, 1999), 400-1200 g CO_2 eq. (Reinhardt, et al., 2009) and 250-650 g CO_2 eq. (Braschkat, et al., 2003)

The results found in the present study are not in line with previous studies, since the total primary energy found in the thesis varies between 32-42 MJ/kg bread and 16-26 MJ/kg total for primary non-fossil and nuclear power. The global warming potentials found in the present study are between 700-1200 g CO_2 eq. depending on the analyzed alternative. The main stages causing the variation in the results are due to high emissions in cultivation and baking.

The difference of the results cannot be explained by different system boundaries as some studies account for the same boundaries as the present study (from cultivation to retailer) (Grönroos, et al., 2006; s. Sundkvist, et al., 2001), but most of them take into account inputs and outputs of larger systems, which included packaging and transportation of bread to home (Braschkat, et al., 2003; Reinhardt, et al., 2009) and also waste disposal of packaging (Andersson & Ohlsson, 1999).

The significant difference observed in the results can be explained by the use of different types of databases and versions. During the past 10 years, the ecoinvent LCA database was expanded and enlarged and complemented by studies giving accurate values taking into account all the actions performed to produce a specific good. Today, the databases about wheat grain production include energy used and emissions coming from grain production and storage, fertilizer production and application, sawing, tillage, till drying of wheat grains in the region.

The ecoinvent database of wheat production used for the actual study was compared in detail to the database used by the Danish LCA (Braschkat, et al., 2003). A large distinction between the two methods can already be found in the input data: the ecoinvent database is by far more precise. Only considering the resources and material/fuels used, it contains 41 materials / process, compared to 5 of the LCAFood database. By comparing the values of the LCAfood inputs of fertilizers, it can be seen that the range of inputs is similar to that of the ecoinvent inputs – it is only slightly higher. The energy inputs stemming from processes and transportation cannot be compared because of the different classifications and units used. Nevertheless, from the comparison it can be concluded that there is a large difference in accuracy of databases, which explains the higher emissions resulting from the use of the ecoinvent database. When considering the fast advancement achieved in completing the databases (ecoinvent wheat data were update in 2009, while the wheat data of the LCAfood database in 2003), there is also a bias due to the fact that most of the studies to which the bread LCA was compared were done in the beginning of the century.

E. CONCLUSION

1. Research aim and process

Aim

The research in this thesis aims at identifying ways to foster a closed-loop economy in the city of Zürich, focusing particularly on SMEs. This involves understanding the present situation of material flows besides depicting how a system based on sustainable material flows could look like. Thus the analysis of an actual SME promises to point out specific actions for approaching an economy based on closed-loop material flows.

Steps of the research process

The research process applied in this thesis consists of performing a case study involving a bakery. During the process three methods were applied to gain a comprehensive view of its material flows.

First a MFA on procured goods was done to represent the relation between weight, price and geographical origin of all purchased food products. A selection of 18 products, representing more than 50% of the total purchased weight and price, was used to construct three alternative purchase patterns based on real products available within the Swiss market. These patterns represent different priorities an enterprise might focus on, such as price, organic cultivation or origin of the procured products. The goal was to demonstrate various implications of alternative purchase patterns on the enterprise and its economical, ecological and social environment.

Secondly a LCA was performed on the bakery's bread to show the environmental impacts of their key product in comparison to alternative options. Thus the present bread, baked with IP-Suisse flour, was compared to bread potentially baked with organic and extensive Swiss wheat grain. Further alternatives consisted of importing wheat grain from Germany and the U.S. taking different means of transportation into account. Other options also incorporate the increase of bread baking efficiency, the use of certified electricity produced from renewable energy and the simplification of the local transportation logistics. Additionally a literature review of LCA studies showed the environmental consequences of the selected products used in the MFA in relation to their origin. This revealed insights on the particularity of each food group.

The last method applied during the case study was a qualitative analysis of how by-products - mainly waste - are handled. Different treatment options and their environmental suitability were compared to the options available within the local context. Thus priorities between different options for disposal were identified.

2. Key outcomes

The applied methods lead to the following key outcomes.

MFA of purchased products

¾ of the presently purchased goods come from Switzerland, thus the enterprise already strongly sustains local agriculture and other food processing SMEs. Selecting 3% of the complete assortment of purchased products accounts for more then 50% of their weight and price. This demonstrates how the rather pragmatic approach used in this thesis leads to representative results.

The alternative purchase patterns showed a maximal cost saving potential of 10%. This is achieved by prioritizing minimal cost over high product quality and origin preferences (low-cost alternative (LA)). Purchasing exclusively organic products, preferably from Switzerland (organic alternative (OA)), revealed a maximum cost increase of 30%. In both alternatives the expenditures in Europe increased, by 12% in the LA and 9% in the OA. In the LA displacement the increase of expenditures is derived from reducing Swiss purchases, while in the OA it mainly comes from shifting 6% of global expenditures to within Europe. In relation to a product's origin, alternative purchase patterns differ less strongly looking at the imported weight than the increase of abroad expenditure. Finally the alternative purchase patterns showed how different purchase approaches, not only influences the local economy, but have repercussions on a wider scale in promoting low-coast production and fostering organic cultivation.

Origin related environmental impacts of food

The most important aspect resulting from the LCA performed on the bakery's bread and the literature review of several food LCAs, is that purchasing local food does not necessarily represent the most environmental friendly option. Local food has advantages going beyond environmental factors, as decreasing transportation, sustaining local economy and facilitating transparency along the supply chain. However looking at the total environmental impact of alternative options it is not always the best choice. This conclusion is partially true for the LCA performed on bread, which showed how considering the environmental impacts of food products several factors are decisive. By using the ecological scarcity method 2006 to compare the presently produced bread with alternative options, it was showed that wheat grains imported from the U.S. increase environmental impact by 55-63% due to transportation, while Swiss organic cultivation have a 36% increase due to groundwater leaching of nitrates. Other options showed a potential for reducing the impact of bread production by up to 14% by using certified electricity in the baking process, 9%-5% by importing conventionally produced wheat from Germany, 8% by increasing the efficiency of the oven and 2% by increasing the efficiency of the local transportation. These results indicate that the origin of wheat grains and the type of cultivation are the most decisive factors influencing the total environmental impacts of producing bread.

By-product management

Another key outcome represents the potential of improving the by-product management. Considering non-organic materials, a reduction of production and packaging materials is possible, even though with regard to the total environmental impact it is not the most crucial factor. In the case of organic food, a unexploited potential are products which have not been sold. One possible solution is to give the products to existing charity organizations. This option is favorable from an environmental as well as a social perspective. In the future separation of organic waste for biogas plants managed by the city will be available. In general, the analysis of available disposal options in the city of Zürich shows that a well-established recycling and disposal system already exists. Thus presently the system quickly hits its limits with regard to the promotion of a cascading use of products, because recycling is centered on specific streams of materials, but mostly ignores complex products and recycling of products parts. Difficulties with regard to the recycling of these products are related to material heterogeneity and costs of reverse logistic transport and recycling. These challenges can be addressed on one hand by modify the design of complex products, enabling easy disassembling and avoiding heterogeneous compositions leading to down-cycling, and on the other hand by enlarging and developing the present recycling framework.

General Outcome

The case study showed that an enterprise comparable with the chosen bakery indeed have a potential for fostering a regional closed-loop economy, especially as the actions taken by this type of enterprise have repercussions on the local and international economy. The enterprise can influence the total environmental impacts of their products, by being aware of what and where the impacts are produced and act consequentially. Thus by choosing specific origins and cultivations, purchasing electricity from renewable sources and increasing process efficiency the enterprise can play an important role within the larger system.

3. Recommendations

Proposal for action sustaining the development of a closed-loop economy and reduction of environmental impacts can be derived for the bakery, representing the gastronomy branch of SME, the city and for the research community.

Bakery and SMEs in the gastronomy sector:

- **Purchase pattern:** Keep purchasing mostly Swiss products rather imports from overseas, for bread keep the IP-Suisse flour standard, focus on seasonal products for fruits and vegetables.
- **Production:** Engage in purchasing certified electricity from renewable energy and control efficiency improvement potential of electric appliances - mainly the oven - and utilize them at full capacity.
- **Sale:** Offer unsold bread to charity organisations.

City of Zürich:

- **Set economic incentive by** promoting enterprises to engage in the sector doing cascading use of materials, modify the function of municipal waste treatment agencies and set a differentiated waste tax system in relation to the reuse potential of products.
- **Involve public institutions** by setting public procurement standards sustaining closed-loop economy, promote service provisions based on renting and exploit the reuse and recycling potential of public institutions.
- **Inform** by establishing a material exchange platform for SMEs, by sustaining the creation of a closed-loop economy label or supporting existing ones and by giving the task of developing a quantitative regional material flow mechanism for the city.

Research Community:

- **Develop system transition knowledge** by not only focusing on material flows, but also on the interrelation of actors on different system levels and identifying the major drivers of change.
- **Specify the role of SMEs** within a regional closed-loop economy by clarifying in which stages of material flows, they play a pivotal role for promoting the development of clean material streams able to follow cascade use phases, and develop reverse supply chains.

- **Develop methods for quantifying regional material flows** enabling to set base lines for understanding the present system and monitor future developments

Back to the world

It can be concluded that the thesis goal of understanding present material flows and identify potential for action was achieved for the targeted case study. The gained knowledge serves as an example showing the links of a single business unit within the global market. In addition regional waste treatment possibilities and the environmental impacts deriving at each material flow stage are demonstrated. From SMEs perspective each business already has an existing potential for closing material flows, concretely by improving their purchase pattern and by-product management. Even larger opportunities can be identified within an active development of a closed-loop economy taking multiple interacting businesses into account. Because of their size and possibility to specialize in a specific activity, SMEs can either act as impulse for other institutions and companies in developing new ways of producing goods, or they can take new market shares created by the development of reverse logistics. The city is an essential actor for the development of closed-loop material flows as it can influence all other social systems: from setting the required legislative framework, supporting business initiatives engaging in circular material flows, to involving education and research initiatives. Even though developing sustainable material flows do not have the same priority in the political agenda as energy or climate change yet, the overuse and extraction of resources - such as tropical forest clearing and fossil fuel extraction - will approach its limits in the coming years. The need of effectively decoupling economic growth from material consumption has already been proved. Therefore why not shifting the focus from selling goods, toward providing people services based on closed material flows?

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