Environmental decision-making and prioritizing for environmentally sound consumption patterns

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1. Introduction

How does one improve one's personal environmental balance as a consumer? Numerous are those who would like to know how to respect the environment and at the same time take advantage of the benefits of the consumer society. There exist many recommendations on this topic but a lot of them concern only specific aspects of daily life that are not put into the global context of all environmental impacts. There are few studies addressing the total environmental load caused by various consumption activities and there are very few that address priorities for environmental decision-making. The need for prioritizing consumption patterns and alternatives that can make a significant difference is manifest.
The aim of this paper is twofold, starting with an overview on the most important environmental impacts, the paper focuses on decisions in order to identify priorities of action. Secondly, the paper proposes a palette of consumption patterns to illustrate an environmentally sound behavior and the potential improvement of the personal annual balance of a consumer.
The research questions are the following:

- What is the relative share of housing, private mobility, consumer goods and services, nutrition, public services and insurance in different environmental impacts?
- What are the key factors, key actors, key decisions and savings potentials of environmentally sound consumption patterns in each consumption domain?
- What are the conclusions and implications for consumers, policy makers and companies?

2. Approach and methods

The paper is based on extracts of a current study for the Swiss Agency for the Environment, Forests and Landscape, which assesses the environmental impact linked to consumption and aims to identify key decisions and actors for the improvement of the global environmental balance. It takes the perspective of consumers, illustrating with scenarios the potential environmental benefits and personal advantages of a series of environmentally sound consumption patterns. The **unit of analysis**, which is called a functional unit in the field of life cycle assessment (LCA), is the quantity Q of products needed to fulfill the demand of Swiss consumers per year. The analysis is mostly carried out on a country or national level and then reported as an average consumption of one person per year. It is a kind of macro-life cycle assessment combining product-based life cycle assessment and input/output-based life cycle assessment.
Product-based LCA according to the ISO14040 (1997) is a technique for assessing the environmental aspects and potential impacts associated with a product, by a) compiling an inventory of relevant inputs and outputs of a product system; b) evaluating the potential environmental impacts associated with those inputs and outputs; and c) interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study. **Input/output-LCA** is a newer method of LCA, which compliments – does not

replace – product-based LCA. This method makes use of national level economic input/output tables, linked with databases on environmental releases per sector.
The **environmental impact** was assessed using two different methods: the Ecoscarcity method[1], that weights all impacts in order to get a single indicator and a recently developed method called "IMPACT 2002+"[2], whose endpoint categories are human health, climate change, ecosystem quality and resources.
The overall approach and the structure of this paper can be divided in three complementary steps:

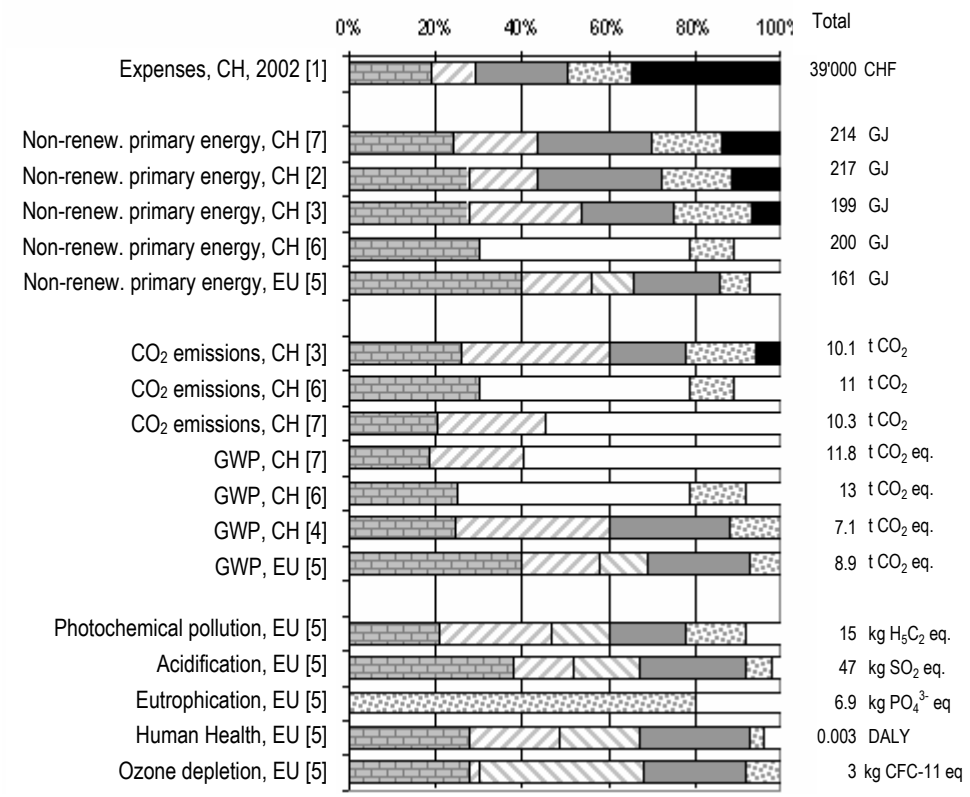
1. Assessment of the environmental impact per capita with life-cycle approaches.
2. Analysis and identification of key factors, decisions and actors in regard to environmentally sound consumption.
3. Drawing up of environmentally sound consumption patterns presenting important benefits for the environment.

3. Environmental impact of consumption domains and per capita

The diversity of products and services requires an aggregation of consumption activities in order to facilitate the analysis and the comprehensibility of results. Different options to classify environmentally sound consumption are listed in Hertwich et al. (2004). For the current study the UNEP proposal to use functions to classify consumption domains was followed. **Five consumption domains** have been defined: housing, private mobility, consumer goods and services, nutrition and public services and insurance.
Housing covers energy consumption and environmental impacts due to housing (construction and demolition, maintenance and heating, water consumption, hot-water heating and waste water treatment) and due to the electricity consumption of activities at home such as the use of household appliances or cooking.
Private mobility comprises all energy consumption and environmental impacts due to moving from one place to another with any means of transport (train, car, plane etc.). For each kilometer traveled the construction, the operation, the maintenance and the disposal of the vehicle as well as the infrastructure are taken into account. Commuting is included but not distances traveled at work; they have been attributed to the respective consumption domains.
Nutrition comprises the energy consumption and the environmental impacts due to the production of food. While the energy consumed for cooking at home has been attributed to housing, the meals consumed in restaurants and canteens account for the nutrition consumption domain. Spoilage has also been taken into account; the evaluations are based on the quantities bought and not on the quantities effectively ingested.
Consumer goods and services include all products and services consumed by Swiss residents that are not considered in the four other consumption domains defined for this study. For all products and services the energy consumption and environmental impacts of manufacturing, use and end of life are taken into account. Only the direct energy consumption of household appliances such as washing machines and televisions are comprised in the domain housing.
Public services and insurance cover the energy consumption and the environmental impacts of public services as well as health and social insurance. This domain has not been evaluated as closely as the other consumption domains because consumers can not directly influence its impact. The impact has been evenly allocated to the residents of the country.

[1] Cf. Braunschweig et al. (1997). The life cycle impact assessment method Ecoscarcity measures the environmental impact with environmental impact points (UBP).
[2] Cf. Jolliet et al. (2003).

The following section is based on a selection of studies representing the state of the art of macro-life cycle assessment on a country or European level. Quantitative results from different studies have been aggregated to the five consumption domains defined in order to make them comparable. Figure 1 summarizes results from selected studies specifying non-renewable primary energy consumption, carbon dioxide emissions and different environmental impact categories caused by consumption in Switzerland. The figure is supplemented with the consumer expenditures in Switzerland in 2002 and results of a European study. It may enable to evaluate the importance of a certain environmental impact in comparison to the total environmental impact per capita and year.



Bibliographic references:

[1] SWISS FEDERAL STATISTICAL OFFICE, 2003
[2] NICOLLIER , 2000
[3] ECOSPEED SA, 2004
[4] SWISS AGENCY FOR THE ENVIRONMENT, FORESTS AND LANSCAPE, 2001
[5] BIO INTELLIGENCE SERVICES, 2003
[6] JUNGBLUTH ET AL., , 2004
[7] KAENZIG ET AL., 2004

Legend:

- Housing
- Private mobility
- Transport of goods
- Consumer goods and services
- Nutrition
- Public services and insurances
- Non determined

Figure 1: Environmental impact of five consumption domains (per capita and per year). Comparison of the results of selected studies.

The quantitative assessments carried out by different authors show similar tendencies for the environmental impact and the non-renewable energy consumption per capita and year. The distribution of the expenses on the five consumption domains is not directly correlated to their primary energy consumption and their environmental impact. National statistics such as greenhouse gas inventories do not take into account the environmental load due to imported products and result in lower total environmental loads than macro-life cycle assessments.
Further analysis by the authors and the comparison of different studies and databases[3] reveal that private mobility, housing and active products generate a majority of the environmental impacts in the use stage. Consumer goods and services are responsible for high impacts through the whole life cycle while the main impact of nutrition is to be found in the agricultural production stage. The end-of life treatment and the disposal becomes only the most important life cycle stage in terms of environmental impact if the product or service implies toxic substances or if there is no adequate treatment.

4. Key factors, key decisions and key actors

Consumer demand shapes the offer, the amounts of production and consequently the waste to eliminate. For consumption activities three steps can be distinguished: Purchase, use and disposal. The decisions taken at each step influence the environmental impact along the life cycle of a product considerably: purchase or rent, frequent use or not, long or short lifetime, end of life treatment or disposal. Life cycle impacts from extraction of raw materials, production, use and disposal are separately assessed in order to identify key actors and decisions.
The following paragraph contains a summary of environmental decision-making matrices that were compiled for each consumption domain. Table 1 shows to what extent decisions taken in different life cycle stages influence the environmental balance and specifies key decisions and key actors in regard to environmentally sound consumption. The description of the influence ranges from high influence to no influence. High influence means that decisions do have a high influence on the environmental balance.
The key factors for **housing** are the thermal quality of buildings, the living space occupied per person, the energy sources and energy technologies, the behavior of consumers (e.g. room temperature, quantity of hot-water consumption) as well as the location, which determines the kilometers traveled per day to go to work, shopping and leisure. Beside the key decisions taken in the planning phase, the decisions concerning living space and thermal quality when buying or renting a house are crucial. The key actors are the architect, the builder-owner, the government, which influences the general conditions with urban and regional planning and financial incentives (e.g. subsidies and taxes). The remaining key decisions concerning room temperature, airing and hot water consumption in the use stage are taken by the occupant or the caretaker.
The distance traveled is by far the most important factor for **private mobility**, followed by the mode of transport and the occupancy. The choice of a certain type of vehicle implies the choice of a motor technology, which determines the emission level. The provision of infrastructure for private mobility is normally a public affair. Key decisions taken by policy-makers determine for instance the level of infrastructure and of financial incentives. The important decisions taken by the consumer, which is the most important actor as far as the environmental impact of private mobility is concerned, start with buying or renting vehicles or using transports services. As the environmental impact is very directly dependent on kilometers traveled, the choice of destinations and distances traveled is crucial.

[3] ecoinvent 1.1 (2004), Nicollier (2000), BioIntelligence Services (2003), Ecospeed (2004).

Table 1: Key decisions and key actors for an environmentally sound consumption. The influence of key decisions for the global environmental balance specified for different life cycle stages.

Domain	**Key phase**[4]				**Key decisions**	**Key actors**
	Decisions taken during **production**	**Purchasing** decisions	Decisions taken during the **use stage**	Decisions concerning **end of life treatment and disposal**		
Housing					• Thermal quality (insulation etc.) • Living space (m^2/capita) • Energy sources • Consumer behavior (°C, etc.) • Choice of building materials, building site	• Builder-owner, architect • Government (regulation, financial incentives) • Buyer-consumer
Private mobility					• Distances traveled (km) • Mode of transport • Occupancy • Vehicle type and motor technology	• Government (provision of infrastructure, regulation, financial incentives) • Buyer-consumer
Consumer goods and services					• Amount of products purchased • Energy and resource use efficiency • Useful time • Eco-design / Label • Recycling rate	• Government (regulation, financial incentives) • Producer • Buyer-consumer
Nutrition					• Production and consumption of cereals and milk products instead of meat products • Season (green house), origin (air transport), etc.	• Government (regulation, financial incentives) • Producer • Buyer-consumer

Legend :	High influence	Medium influence	Little influence	No influence

A majority of the environmental impacts due to **nutrition** occur in the agricultural production phase and is correlated to decisions taken by the producer concerning the type of cultivation and land use for instance. Consumers are key actors for the global environmental impact reduction of nutrition. The most influencing decision concerns the partial substitution of meat consumption by vegetables and diary products, which decreases at the same time water and energy consumption, land use and photochemical pollution. But consumers' behavior also influences the range of products offered; privileging food that was not transported by airfreight and not grown in heated greenhouses improves the environmental balance of nutrition.

[4] A key phase in the context of this paper is a phase in the life cycle of products and services in which key decisions influencing considerably the global environmental balance are taken.

As the environmental impact is more or less constant per unit produced, a key factor for all type of products in the domain of **consumer goods** is the amount of products purchased. For the analysis of other key factors and decisions, it is necessary to distinguish active, mobile, transported and passive products. As far as products are concerned that do not consume important quantities of energy or resources during use (passive products) the environmental impact is mainly due to production and disposal. Consequently the product designer and producer are key actors. Products that consume a significant amount of energy resources in the use stage (active products) such as washing machines or transported and mobile products cause an important impact in the use stage. But consumer attitudes, choosing quality products and an appropriate maintenance level for instance, determines market offers, increases the useful lifetime of a product and reduces the global environmental impact of products, especially of passive products. The useful lifetime and the end of life treatment (reuse, recycling, disposal) are key factors of passive products. Eco-design and labels are tools for producers to promote environmentally sound products. Energy and resource efficiency is a key factor for active products and weight is a key factor for mobile and transported products such as car parts and furniture.

In summary, for each consumption domain, the decision concerning disposal and end of life treatment influence the global environmental balance but normally not as much as decisions taken in the production stage purchase and use stage. This shows the importance of prioritizing measures early in the life cycle of products rather than at the end of the pipe.
The government and above all consumers are key actors for the environmental impact of all consumption domains. The role of companies and its potential for improvements is found amongst other in eco-efficiency and innovation of new environmentally sound products and services.

5. Environmentally sound consumption patterns and potential improvements

The study evaluates the environmental benefits of thirteen scenarios illustrating environmentally sound and financially viable consumption patterns compared to the average consumption per capita in Switzerland. Financial trade-offs are taken into account and discussed with the potential environmental benefits using the concept of E2-vectors[5] (environmental indicator versus expenses).
To provide an example, figure 2 illustrates potential and cumulative energy and cost savings per capita and year, adopting eight scenarios that can be cumulated.

[5] Cf. Goedkoop (1999) and figure 2.

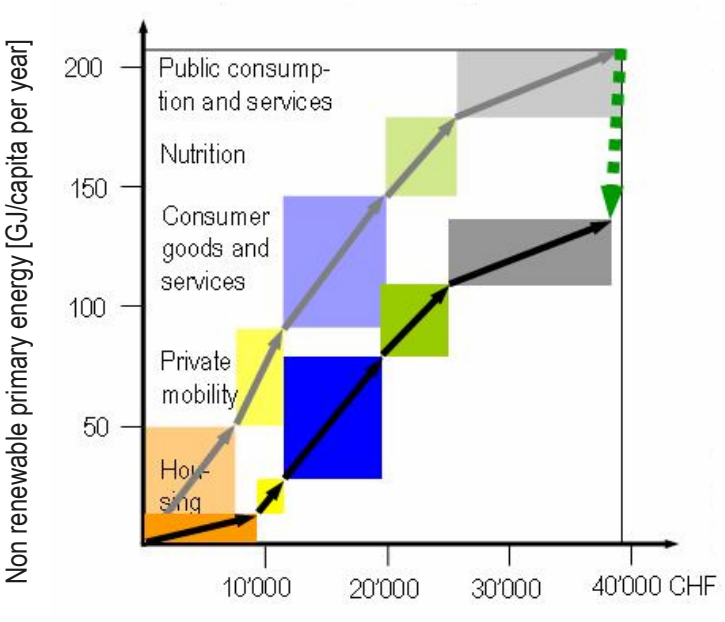


Figure 2: Potential energy and cost savings per capita and year adopting eight environmentally sound consumption patterns.

The environmentally sound consumption patterns considered in figure 2 are: living in a low energy flat, the optimization of the room temperature, buying wind power instead of the conventional Swiss electricity mix, using energy efficient household appliances and lighting carrying the energy efficiency label A, using public transport, traveling abroad by train instead of air-plane, a ten per cent prolongation of the use of passive consumer goods and a fifty per cent reduction of the meat consumption.
The potential energy savings per capita and year with these eight selected scenarios are about 71 GJ of the total non renewable primary energy consumption (cf. figure 2). This corresponds to a reduction of energy consumption of about one third. There is a similar high potential for reduction of the environmental impact and also an interesting potential for financial savings thanks to energy savings e.g..
In Switzerland the total non-renewable primary energy consumption amounts to about 214 GJ per capita and year, which is about five time higher than the average consumption in China and about 45% lower than the average consumption in the USA.
The scenarios illustrating environmentally sound consumption patterns considered in the study normally provide the same utility and functions as the consumption patterns they substitute. Some of them imply advantages or disadvantages compared to the status quo. For some consumers scenarios might require renouncing to a certain level of comfort for instance when traveling by train instead of traveling by airplane, other scenarios provide advantages such as the improved acoustic insulation that comes along with a low energy house. The choice and the adoption of scenarios depend on personal preferences and weighting.

6. Discussion and Conclusions

Validity of the evaluations

The study at the basis of this paper has been carried out assuming Swiss conditions, however much of the data used for the computations is valid for most western European countries. For instance the environmental impact data for automobiles used in this study correspond to the impacts of a generic European passenger vehicle. Some of the scenarios are depending on public infrastructure e.g. public transport and have to be adapted before they can be adopted in countries where the public infrastructure is more or less developed. In

general the key factors and decisions, the main conclusions and tendencies and the priorities identified are valid for other industrialized countries. The most important difference concerns energy supply: the electricity consumed in Switzerland contains a higher share of hydro-electricity than the average electricity mix. This implies that the scenarios would be even more favorable for the environment if they are adopted in other countries with a more fossil and nuclear based electricity supply mix.
Note: The comparison of costs focuses mainly on energy, because other natural resources such as air and water are free or generate just marginal costs for individuals in many industrialized countries. However this does not mean that only energy consumption is relevant.

General findings

Environmental decision-making is required every day and is an emerging issue in many countries as the rapidly increasing number of studies on this topic shows. At present consumers as well as managers are flooded with pieces of information on how to consume in a sustainable way. It is one of the main goals of this study to gain an overview and provide a basis for comparison of the environmental impact.
The evaluations allow describing priorities of action by putting specific environmental impact into the global context. One possible way of doing this is a relative comparison using inhabitant equivalents and another possibility is a comparison of the absolute impact of different consumption activities. An example for the latter comparison is to rank environmentally sound consumption patterns using indicators such as the “environmental-impact-points” (assessed with the Ecoscarcity method). To provide an example, the environmental impact of a journey of 650 kilometers by train is about five times smaller than that of the journey by plane.
Often it is easier to only evaluate the differences between consumption alternatives instead of evaluating the whole system. Another general finding illustrated by figure 2 is that it is more promising to focus on important decisions that can help to avoid environmental impacts rather than to focus on the main impacts itself. The consumption domain "consumer goods and services" for instance causes quite a high environmental impact but the potential improvements are not as easy to tap by consumers who want to maintain their level of consumption, as for instance in the private mobility or housing domain. Therefore it does not make sense that consumers provide as much effort for the domain "consumer goods and services" as for "housing" for instance. It is also a reason why this study focused on key factors, key actors and key decisions as they are summarized in chapter 4 and table 1.

Consumers’ perspective

The potential energy savings and the potential improvement of the environmental balance with small changes in lifestyle are about one third. Savings thanks to energy savings e.g. can be reinvested in sustainable products such as low energy houses and renewable energy to further improve the environmental balance. As time and budget and capability to adopt new behaviors are limited, prioritizing of consumption patterns and alternatives that can make a significant difference is crucial. Consumers willing to improve their personal environmental balance should pay attention to rebound effects. Financial savings achieved with energy efficiency improvements for instance should not be used to finance holiday trips by airplane.
As a conclusion it can be stated that the environmental impact per capita can be reduced very significantly by adopting a few realistic scenarios, which overall do not cost more than the average consumption and might imply advantages in other levels such as health, ethics, convenience, prestige, and aesthetics.

Implications for companies and policy makers

Several findings might also be of interest for **companies**. The applicability of results is depending on the economic sector and the life cycle stage considered. On the level of a production site or service center findings on housing, renewable energy use, mobility and consumer goods can directly be adopted to offices, heating, power supply, vehicle fleet, the choice of means of transport, and producer goods. For companies different contributions to more environmentally sound consumption are possible. For instance, these might include direct measures to increase eco-efficiency on-site and within the supply chain, or rather indirect influence by developing environmentally sound products.
Policy makers such as governments were also identified as key actors. Their role for more environmentally sound consumption can be the promotion with label-packets such as Minergie[6] for low energy houses, in order to avoid rebound effects and to achieve maximum environmental benefits. Governments' role should also be to legislate and set targets to promote the reinvestment of economic savings in additional environmental improvements. Thirdly, the communication of environmentally sound consumption alternatives utilizing appealing images and positive terms is probably a key factor for the successful implementation and broad adoption of environmentally sound consumption patterns. Tools and knowledge from business economics are waiting to be used for this end.

The authors hope that the study at the basis of this paper is of interest to consumers, policy makers as well as managers, and that it may help to prioritize and to select areas of action for more environmentally sound consumption.

[6] "Minergie" is a Swiss label for low energy houses defining an upper limit for energy consumption for heating, warm water and electricity use for ventilation (www.minergie.ch).

7. References

BRAUNSCHWEIG A., BÄR P., RENTSCH C., SCHMID L., WÜEST G. (1997): *Methode der ökologischen Knappheit – Ökofaktoren 1997.* Methode für die Gewichtung in Ökobilanzen. BUWAL, 107 p.

BIOINTELLIGENCE SERVICES (2003): *Study on external environmental effects related to the life cycle of products and services.* rapport final.

BRAUNSCHWEIG A., BÄR P., RENTSCH C., SCHMID L., WÜEST G. (1997): *Methode der ökologischen Knappheit – Ökofaktoren 1997.* Methode für die Gewichtung in Ökobilanzen. BUWAL, 107 p.

ECOINVENT, 2004 : *Database 1.1.*. Swiss Centre for Life Cycle Inventories, Duebendorf, Suisse.

ECOINVENT, 2004 : ec*oinvent reports.* Swiss Centre for Life Cycle Inventories, Duebendorf, Suisse.

ECOSPEED SA, 2004 : *ECO_2 private.* Base de donnée et outil de calcul disponible sur Internet, EcoSpeed SA, Zürich.
http://www.ecospeed.ch/ie/f/privat.html (consulté le 30.07.2004).

HERTWICH E., BRICENO T., HOFSTETTER P., INABA A. (EDITORS) (2005): *Proceedings: Sustainable Consumption: The Contribution of Research, Workshop.,* 10-12 February 2005, Gabels Hus, Oslo, Report 1/2005 Industrial Ecology Programme, NTNU.

HERTWICH E., KATZMAYR M. (2004) : *Examples of sustainable consumption: Review, Classification and Analysis.* Norwegian University of Science and Technology (NTNU), Industrial Ecology Programme (IndEcol), Report nr: 5/2004.

GOEDKOOP M., VAN HALEN C., TE RIELE H., ROMMENS P. (1999): *Product Service systems, Ecological and Economic Basics.* Ministère de VROM et EZ.

ISO 14040 (1997): *International Standard ISO 14040: Environmental management - Life cycle assessment - Principles and framework.* Geneva, Switzerland: International Organization for Standardization, 199.7.

JOLLIET O, MARGNI M, CHARLES R, HUMBERT S, PAYET J, REBITZER G, ROSENBAUM R. (2003): *IMPACT 2002+: A New Life Cycle Impact Assessment Methodology.* International Journal of LCA 8 (6), pp. 324 – 330.

JOLLIET O, MARGNI M, CHARLES R, HUMBERT S, PAYET J, REBITZER G, ROSENBAUM R. (2003): *IMPACT 2002+: A New Life Cycle Impact Assessment Methodology.* International Journal of LCA 8 (6), pp. 324 – 330.

JUNGBLUTH N., FAIST EMMENEGGR M., FRISCHKNECHT R. (2004) : *Gesamtpotential für die Reduktion von Umweltbelastungen im Bereich Ernährung und Wohnen.* Bericht im Auftrage des WWF Schweiz, ESU-Services, Uster, p. 33.

NICOLLIER T. (2000): Présentation d'un outil permettant d'évaluer la dépense énergétique de divers choix quotidiens et du concept d'esclave énergétique. Lausanne : Ecole Polytechnique Fédérale de Lausanne, p. 19 & annexes).

SWISS AGENCY FOR THE ENVIRONMENT, FORESTS AND LANDSCAPE (SAEFEL) (1995): *Vom Menschen verursachte Luftschadstoff – Emissionen in der Schweiz von 1900 bis 2010.*

SWISS FEDERAL STATISTICAL OFFICE (2003): *Enquête sur les revenus et la consommation (ERC) : Les dépenses des ménages en Suisse. Résultats détaillés de 2002.*

SIA (1998): *L'énergie thermique dans le bâtiment.* norme 380/1, Zürich.

WILTING H.-C. (2002): *The Effects of Dutch Production and Consumption on the Environment in the Netherlands and Abroad.* Fourteenth International Conference on Input-Output Techniques, 10-15 Octobre, 2002, Montreal, Canada.