Willi Haas
Edgar Hertwich
Klaus Hubacek
Katarina Korytarova
Michael Ornetzeder
Helga Weisz

THE ENVIRONMENTAL IMPACTS OF CONSUMPTION

Research Methods and Driving Forces

NTNU
Program for industriell økologi
Working Paper no. 3/2005

Reports and Working Papers from

Norwegian University of Science and Technology (NTNU)
Industrial Ecology Programme (IndEcol)

Working Papers no.3/2005
ISSN 1504-3681

Reports and Working Papers may be downloaded from the IndEcol web site:

Industrial Ecology Programme (IndEcol)
NTNU
NO-7491 Trondheim, Norway

Tel.: + 47 73598940
Fax.: + 47 73598943
E-mail: indecol@indecol.ntnu.no
Web: www.indecol.ntnu.no

International Institute for
Applied Systems Analysis
Schlossplatz 1
A-2361 Laxenburg, Austria

Tel: +43 2236 807 449
Fax: +43 2236 71313
E-mail: ornetz@iiasa.ac.at
Web: www.iiasa.ac.at/

Final Report
to the Society of Non-Traditional Technology

The Environmental Impacts of Consumption: Research Methods and Driving Forces

March 2005

Willi HAAS[1], Edgar HERTWICH[2], Klaus HUBACEK[3], Katarina KORYTAROVA[1],
Michael ORNETZEDER[1,4], Helga WEISZ[5]

[1] International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria;
[2] Department of Energy and Process Engineering, Norwegian University of Science and Technology, Trondheim, Norway;
[3] School of Earth and Environment, University of Leeds, Leeds LS2 9JT, UK
[4] Centre for Social Innovation, Vienna, Austria
[5] The Department of Social Ecology at the Institute of Interdisciplinary Studies of Austrian Universities (IFF), Vienna, Austria.

Contents

Tables

Figures

Abstract

The aim of this study is to develop an operational method to determine the direct and indirect environmental impacts of Austrian household's consumption pattern and to apply this method together with social research methods to evaluate the household's consumption pattern of two different settlements. The operational method is set up on the Household Environmental Impact (HEI) assessment based on household interviews, and without conducting a full consumer expenditure survey.

The empirical research is designed as a case-control study of the car-free settlement in Vienna and aims to evaluate how the consumption patterns of the inhabitants differ from a 'control group', what impact that has on the environment taking the income (or 'rebound') effect into account, and how the attitudes and social determinants of behaviour differ between the two groups. The environmental profile of the households is calculated by using consumer expenditure surveys, information from the national accounting tables (with environmental accounts), from product life cycle assessment, and data from the conducted survey. Survey research on the motivations, preferences, and social factors is used to evaluate the driving forces and social dynamics that determine the environmental profiles of the selected households.

Residents in the car-free settlement have changed their daily mobility routines for good. Daily mobility needs are coverd by public transport and by bicycle. The high importance of the issue “car-use” in the car-free settlement, the fact that car mobility is still a very important topic in the settlement, and the environmentally conscious micro-culture in the car-free settlement contributes to the stabilization of the car-free habit of the tenants. Due to that only people with low car mileage state adequate attitutes, and do have much more car-free friends.

Whereas the extremely low car traffic in the car-free settlement could be partly explained by settlement attributes, there is no empirical indication to explain air traffic.

The results show that car-free households have substantially lower environmental impacts in the categories of ground transportation and energy use; their CO_2 emissions of these two categories are less than 50% of those of the reference settlement. The car-free households have somewhat higher emissions in the categories air transport, nutrition, and ‘other’ consumption, reflecting the slightly higher income per-capita. As a result, the CO_2 emissions are only slightly lower than in the reference settlement.

The research is designed to lay the foundation for policy making through providing tools to determine the environmental impacts of consumption, as well as insight into alternative consumption patterns and factors that shape those patterns.

The Environmental Impacts of Consumption: Research Methods and Driving Forces

1 Introduction

The World Summit for Sustainable Development (WSSD) in Johannesburg recognized the necessity of "changing unsustainable patterns of consumption and production". In the "Plan of Implementation", the main document to emerge from the WSSD, world leaders call for "fundamental changes in the way societies produce and consume" (§13). While there is a broad agreement that sustainable development will not be achieved without such fundamental changes in consumption and production, we do not know what has to change and how such changes can be brought about. A better understanding of the environmental impacts of consumption and production patterns is required to understand the direction of change. The study of changing consumption patterns and examples of low-impacting consumption patterns can provide insights into the mechanisms of change. The analytical approach towards studying the environmental impacts of household consumption is based on a combination of economic input-output analysis, life-cycle assessment, and date on consumption often taken from consumer expenditure surveys. In a number of countries, statistical analysis has been used to analyse the consumer expenditure survey in order to identify which factors influence the level of household environmental impacts. Indicators for impacts are usually energy use or CO2 emissions. These analyses indicate that income, car ownership, and family size are important determinants for the per-capita impacts. For a review of this work, see Hertwich (2005).

In this report, we present a case-control study of an example of sustainable consumption, the car-free housing project in Vienna. This project is comprised of a building complex with 244 flats; tenants have signed a contract which obliges them not to own a car, but there is car-sharing available in the building complex. Our hypothesis is that the households in this settlement cause less impact than households in a carefully selected control group, a nearby thematic building complex of similar age and with a similar population structure. We develop a tool for household environmental impact (HEI) assessments based on data for Austria and we develop a simplified questionnaire for eliciting environmentally relevant information about the consumption patterns in the two settlements.

The challenge is to understand the extent of environmental pressures, as well as social and economic effects, of household consumption. This knowledge offers many insights for the discussion on sustainable consumption:

- What are the product groups with the biggest threat to sustainability?
- How wide do consumption patterns differ in their environmental impacts?
- What are the characteristics of various consumption patterns (high, average and low environmental impact)?
- What has to be done to promote these changes when assessing the attitudes, routines, social factors, and institutional framework conditions shaping the consumption patterns?

The assumption behind international declarations and policy efforts addressing sustainable consumption is that consumers have some degree of control over the environmental and social impacts of their choices. The hope is that consumers will express their preferences for a clean environment and fair trade through their purchase decisions if they have enough information about the relevant impacts of their consumption choices. Currently, such information is generally unavailable thus contributing to market failure. Regarding sustainability both the level of consumption and the composition of the basket of goods and services are important. Through conscious choices and public policies, the composition could be altered so that the basket includes items with a lower aggregate impact, i.e., fewer items with high and more items with low impacts. Over the last couple of years research efforts have focused on a wide range of questions related to these basic ideas.

This report starts with a review of some recent social science approaches and methods relevant for the evaluation of consumption behaviour and, ultimately, efforts to promote sustainable consumption (chapter 2). This overview illustrates the need for an integrated approach: sustainable development is closely connected to changes at the level of consumption. The crucial driving forces at this level should be understood in order to know on which aspects sustainable consumption projects have to focus in order to make a difference. The most important methods to evaluate the environmental impact of consumption on the household level are illustrated in chapter 3. In chapter 4 we introduce a new operational „environmental profile" tool (see Figure 1), which enables the identification and investigation of consumption patterns and the assessment of the overall environmental impacts of those patterns in Austria.

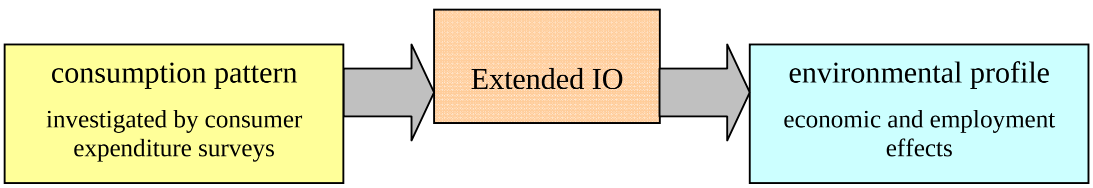


Figure 1: Consumption pattern and environmental impacts (operational "environmental profile" tool).

Chapter 5 presents the design of a first test survey on consumption patterns using the developed "environmental profile" tool. The main idea of this design was to measure and compare the consumption patterns of two different settlements in Vienna, a car-free demonstration housing project and a similar settlement without the 'car-free' feature. Some of the most important results of this survey are discussed in chapter 6. Chapter 7 provides a short summary of the study.

1.1 Background

The World Summit for Sustainable Development (WSSD) in Johannesburg recognised the necessity of "changing unsustainable patterns of consumption and production". In the "Plan of Implementation", the main document to emerge from the WSSD, world leaders call for "fundamental changes in the way societies produce and consume" (§13). They resolve to "encourage and promote the development of a 10-year framework of programmes in support of regional and national initiatives to accelerate the shift towards sustainable consumption and production to promote social and economic development within the carrying capacity of ecosystems by addressing and, where appropriate, de-linking economic growth and environmental degradation through improving efficiency and sustainability in the use of resources and production processes, and reducing resource degradation, pollution and waste" (§14).

In November 2002, the United Nations Environmental Programme (UNEP) joined IIASA and Japan's National Institute for Advanced Industrial Science and Technology (AIST) in organising a workshop on "Life-cycle Approaches to Sustainable Consumption" (Hertwich 2002). UNEP is responsible for the 10-year programme on the international level. At the workshop, 43 researchers presented the current state-of-the-art research methods, latest results and ideas for future work. To be successful, sustainable consumption research needs to utilise methods from several scientific disciplines, including economics, marketing research, sociology, and environmental systems analysis, in an interdisciplinary approach. The two elements of this research project are (1) modelling the environmental pressures associated with household consumption and (2) investigating consumption patterns. Both draw on economic sciences.

In our research, we compare two established approaches to measure environmental impact. The first approach is based in material flow analysis and measures the domestic material consumption and domestic material input of a household or a region (Haas 2002). The second approach is based on environmental input-output analysis and life cycle assessment. The environmental impact of a household is defined to include both the direct pressures caused by a household, such as emissions associated with a household's fuel combustion, as well as the indirect pressures, such as emissions associated with the production of the goods and services consumed by a household. The research approach goes back to the analysis of direct and indirect energy consumption, which can be based on input-output analysis (Herendeen and Tanaka 1976) or process-chain analysis (Boustead and Hancock 1979).

In recent years, a number of efforts have been undertaken to analyse household environmental impacts using data from consumer expenditure surveys. These efforts are either based only on input-output analysis (Kim 2002; Lenzen 1998; Munksgaard, Pedersen and Wier 2000) or a hybrid analysis which combines input-output and process chain analysis (van Engelenburg et al. 1994; Vringer and Blok 1995; Weber and Perrels 2000).

There are two problems with the existing methods. First, they take into account only a very incomplete list of environmental impacts; those associated with the combustion of fuels. This is insufficient especially given the global scope of production networks and the concern about sustainability. Second, they treat the imported goods as if they were produced domestically, i.e. assuming the same pollution intensities (kg of pollutant per €). We have worked on addressing both shortcomings. We have worked on methods to include land use and fresh water use (Hubacek and Sun 2001; Hubacek and Sun 2002). These analyses were also used to develop scenarios for future consumption and to evaluate scarcity using a comparative static input-output model. We have worked to investigate the importance of imports for the household environmental profile and found that the national differences in pollution intensities of different products are relevant and able to significantly influence recommendations as to which activities or product alternatives are more polluting (Hertwich et al. 2002).

An ongoing comparative econometric study (lead by Mette Wier of Denmark and Manfred Lenzen of Australia) compares direct and indirect energy consumption in seven countries based on I/O analysis. The study indicates that the determinants of household energy consumption vary among countries. In Japan, for example, population density is the most important explanatory variable for household environmental impacts. In Brazil, education seems to be a strong explaining factor. Current European studies suggest a strong correlation between household expenditures and household environmental impacts. The richer the household, the higher the impact. In some studies, household expenditures explain almost all of the variation (Alfredsson 2002). This is seemingly in contradiction to the environmental Kuznets curve hypothesis, which suggests that environmental protection is a luxury good and hence rich people will have less impact than poor people (De Bruyn 2000; Grossman 1994).

Research on factors influencing and shaping consumption patterns has been conducted in consumer economics, marketing research, anthropology and sociology. Marketing researchers have for example investigated the connection between values and consumer decision making regarding the purchase of organic food (Thøgersen and Ölander 2002). They found that there is only a weak connection, and that daily shopping behaviour is mainly driven by routines. Consumer economics has investigated the sensitivity of consumer expenditure patterns to relative price changes using econometric studies (Kletzan et al. 2002) and evaluated the dynamics of market penetrations using agent-based modelling (Janssen and Jager 2002). Anthropologists have focused on cultural determinants of consumer behaviour (Wilhite and Lutzenhiser 1999). In general, the motives and success of sustainable consumption initiatives are key concerns and project evaluation is important (Hobson 2002; Scherhorn and Weber 2002), as it should be for the development of policies and tools. On a more theoretical basis economists have addressed the question of needs (Segal 1998) and the connection of consumption to quality of life, or as Amatrya Sen calls it, the living standard (Nussbaum and Sen 1993; Sen 1998).

Since it is the declared policy intention to change consumption patterns, processes of change and lock-in of consumption patterns (habituation) are of special interest. One way to investigate potential future consumption patterns is to identify and study pioneers and to try to learn from their experiences. Another option is to look at situations of habit formation, that is when individuals shift from one stage in the human life cycle to another, e.g. when they move away from home, establish a family, or retire. Habits also change when people move (Rölle, Weber and Bamberg 2002). However the shift to more sustainable consumption patterns is strongly connected with the opportunity and willingness to learn about consumption alternatives. There is some empirical evidence that ecological housing projects – like the car-free project in Vienna – provide such learning-space especially if future users of the buildings are widely involved in the planning and construction phase (Rohracher and Ornetzeder 2002).

Most of analyses in that area investigate the situation today and attribute environmental pressures to different consumer activities and groups. To address the effect of changes in consumption patterns and to evaluate policies that are conducted in light of changing circumstances, e.g. the aging of the population, it is important to develop a capability for scenario analysis. Scenario analysis may not only be essential for informing consumers, but they are also important for policy analysis. We propose that this policy modeling should pay special attention to the life-cycle of consumers, who move through different household types (nuclear family -> student home -> single apartment etc). It is not known to which degree individuals change or preserve consumption patterns when they move from one household category to another. It is hence not known how this moment of change can be utilized effectively to promote sustainability. Our proposed project will build on related conceptual work by Duchin and Hubacek (2003) who recently used the social accounting matrix to propose a framework for analyzing lifestyle changes and demographic changes.

1.2 Research Questions

The aim of this study is to investigate the environmental impacts of two groups with distinct consumption patterns but similar demographic, socio-economic and geographical conditions in order to improve the understanding of 'driving' factors for household environmental impacts.

Our work aims to address a number of research questions related to the measurement and causes of environmental impacts:

1. How can consumption patterns be determined and their environmental impacts be quantified?
2. What activities, goods and services cause the largest impacts and have the highest impact intensities (impact per € spent)?
3. How do different households vary in the environmental impact of their consumption? By how much do they vary, and due to which consumer items?
4. Does this depend on the type of environmental pressure considered? Relevant pressures include greenhouse gas emissions, and emissions of acidifying and eutrophying substances.

Once the pattern of environmental impacts connected to household consumption can be determined, one can investigate why different households have different impacts and develop ways in which consumption patterns can be changed to reduce household environmental impacts. In order to explain different consumption patterns and different environmental impacts it is necessary to address the following social research questions as well:

5. How do the environmental impacts of the car-free settlement differ from those of the control group, and how large is the rebound effect?
6. How important are demographic and occupational factors (age, formal education, employment, family situation)?
7. What are the factors influencing the consumption patters?
8. How important are opportunities, infrastructure, service availability?
9. How important are habits and habit formation?
10. How important are values, intentions, and attitudes?

Furthermore, it is very important for sustainable consumption policies to address processes of change, because they indicate policy levers and the potential ability to influence consumer decisions.

It is clear that one single study cannot answer all these research questions. We aim at answering the frist five questions regarding environmental impacts and to provide some indications for questions 7-10. Our investigation can at best generate hypotheses for the latter questions, but this is also valuable as it can inform and stimulate future research.

1.3 Survey Design, Methods and Data

The main purpose of the surveys is to find out what differences in consumption patterns occur in different residential settlements and what are the reasons for more or less sustainable consumption patterns.

The proposed methodological concept is based on the triangulation paradigm (Fielding & Schreier 2001). The general idea of triangulation is that if diverse kinds of data support the same conclusion, confidence in the conclusions is increased. Applied problems such as the factors influencing sustainable consumption are so various and complex that applied research is forced to use the different strengths that different methods offer. In our case qualitative and quantitative social research methods are employed within one study, although in different phases of the research process (sequencing). Contrary to the most common procedure we suggest that a quantitative phase of data analysis is followed by a qualitative phase of data collection. Using such an approach allows us to complement findings on an aggregate (or sample) level with individual cases of consumption practices.

Two settlements will be investigated at the household level to get the information needed. One settlement is the car-free settlement in Vienna, Floridsdorf. In this project future inhabitants could participate in the planning of the building and certain environmental features were included such as solar technologies and community space rather than parking lots. Thus we could expect that the inhabitants' environmental impact is lower than the Austrian average. The assumption was that we can find consumption patterns that range in the upper end of sustainable consumption of modern urban societies. The second settlement was another thematic settlement with a similar year of construction and similar demographic and income characteristics of the inhabitants.

All data was investigated for the year 2003 only. Data on the consumption behaviour are expenditures in Euro and physical data such as kg, km, or kWh. The information gathered allows the identification of consumption patterns with general descriptors and give indication on the degree of environmental behaviour of the surveyed households.

The information gathered should allow the identification of consumption patterns with general descriptors and should give indication on the degree of environmental behaviour in the areas of interest.

Most of the information gathered can be directly used with the developed method (extended input-output table with an interface for consumer expenditures). In total 88 face-to-face interviews have been carried out in 2004.

2 Sustainable Consumption – Theoretical considerations

2.1 Defining Sustainable Consumption

Sustainable consumption patterns are patterns of consumption that satisfy basic needs, offer humans the freedom to realise themselves, and are replicable across the whole globe without compromising the Earth's carrying capacity. In most industrialised countries, current consumption patterns are unsustainable because they require too many resources, cause too many emissions, and produce social impacts in developing countries that are unacceptable. In many developing countries, consumption patterns are unsustainable because the consumption is insufficient to meet basic needs and allow humans a freedom from want (Sen 1998). They may also be unsustainable because they are based on resource exploitation or cause adverse side effects, such as soil erosion and salinisation. From our perspective, sustainable consumption refers to measures to achieve a more equitable distribution of consumption around the world and reduce the overall environmental impact. Not all measures that reduce the footprint of a person count as sustainable consumption, however. Such a definition would be too broad to be useful. We therefore derive our definition from a framework for analysing the impacts related to household consumption. For practical purposes, we will focus here on the "middle class" or "consumer class," i.e. that part of the global population characterised by a high resource use and high direct and/or indirect emissions.

In economists' view, the purpose of production is consumption. An evaluation of the environmental and social impacts of households needs to account for both the direct impacts of the household, such as emissions arising from fuel combustion in a household, and indirect impacts caused during the production of the goods and delivery of the services to the household, such a pesticide exposure during agricultural production or emissions from landfills.

If all the impacts that arise during the production of goods and the delivery of services are also allocated to consumption, in addition to the impacts that arise during the process of consumption, will sustainable consumption be all-encompassing? This would be impractical. While production and consumption are two sides of the same coin, we think it is still sensible to distinguish between sustainable production and sustainable consumption.

We distinguish between measures or actions that address production and those that address consumption. Clearly, the household environmental and social impact can be reduced through production-side measures alone. If, for example, the CO_2 emissions of all production processes are cut in half, all other things being equal, the indirect CO_2emissions of a household will also be reduced by half. If new cars, equipped with catalytic converters, replace older cars without a catalyst, the emissions of CO, NOx and VOCs by the consumer will be reduced. The first example is one of production processes becoming more sustainable, while in the second example the product itself is improved. None of these examples requires any change on part of the consumers. Of course there may be a rebound effect, as the price of the products may change, affecting the quantity of the specific products purchased, as well as the overall budget of the consumer. Changes in the eco-efficiency of products or services provided to the consumer belong to sustainable production, even if they reduce the direct impacts of households. The impacts should, in any case, be evaluated on a life-cycle basis.

Sustainable consumption consists of measures to reduce impacts that affect the behaviour of the consumer or require her actions. If in cold climates the room temperature is reduced, if consumers are encouraged to cycle instead of driving or to use dishwashers instead of running hot water, we have examples of sustainable consumption.

Changes in consumer activities and use behaviour are clearly examples of sustainable consumption. Changes in purchasing behaviour, however, are in a grey zone because they also concern production. We argue that a change in a diet to have more locally grown, seasonal food or less meat is an example of sustainable consumption. The selection of a highly efficient hybrid vehicle over a gasoline-guzzling sports utility vehicle is a similar case. In cases where the consumer takes a decision about buying a green product over a conventional one, we talk about sustainable consumption. The production of these goods is sustainable production, so that we have an overlap of the two. Sustainable consumption can be highly voluntaristic, as the preference for garment certified not to be produced in sweatshops, or encouraged through public policy measures, such as car-pooling to avoid road tolls and get access to less congested car-pool lanes on highways.

2.2 Environmental assessment methods

Various methods have been used in the effort to provide insights into the creation of environmental damage caused by human activity. Material Flow Analysis (MFA) provides the information about the material requirements for certain processes in society and has been applied at the household level. Substance flow analysis (SFA) can focus on specific elements and compounds of concern, such as chlorine or lead. Life-cycle assessment (LCA) describes the emissions and resource use associated with individual products and services. Economic input-output analysis (IOA) can be used in a similar manner, but describing more aggregate product groups.

In one of the most innovative applications of environmental assessments, Fritsche et al. (2002) used a life-cycle approach to evaluate the sustainability of consumption activities by examining environmental, economic and social impacts in the redevelopment of city quarters in Freiburg and Neuruppin and compare them to average German city quarters. The data on demand in the consumption areas housing, living and transport were converted into mass flows tracked throughout the process chain, through which environmental effects (CO_2, SO_2, material requirements) were tracked. In addition, Fritsche et al. also analyse the potential environmental and economic effects from closing production and consumption circles (often referred to as leak plugging) by moving production into the region. For this step they used disaggregated bottom-up modelling of regional production activities to calculate additional economic turnover of a regional economy.

Another interesting study chosen for this selective overview was the input-output (IO) analysis by Goedkoop et al. (2002); a model that assesses the worldwide environmental impacts created by consumption in the Netherlands. It has been developed to serve as an evaluation tool for the governmental policy measures on private consumption on a national level. Such environmental and economic evaluations are also necessary for the consumers as a source of information of the impact from their behaviour and about the possibilities how to change it through change in their consumption patterns (see below).

The model is based on measuring environmental loads[1] (EL) per value added (provided by the Dutch economic IO table). The data from a LCA database is combined with economic information from an IO table in order to calculate indirect environmental loads and with a consumer expenditure survey (for direct environmental load). The IO table for the Netherlands has been interlinked with three international IOTs[2] to give some rough estimate

---

1 Indirect environmental load is the load before the purchase of product/service (production, packaging, distribution), and can be calculated by IO. Direct environmental load is the load after the purchase of product/service (e.g. load coming from emissions). It can be calculated by LCA (not IO).

2 There are 3 types of "regional" IOTs: OECD countries in Europe, Other OECD countries, Non- OECD countries.

of worldwide EL for Dutch consumption. For each of these regions, 30 sectors were defined. The project has made use of DIMITRI and EDGAR for data on environmental stressors per sector and country; and the GTAP database for identifying the countries that contribute most to an industrial activity. The study did not focus on individual emissions, but aggregations have been made, mostly using the CML 2001 impact assessment method. The data on environmental loads per sector was taken from the national emission registry system. The study shows the power of using the eco—efficiency ratio (environmental load per value added) to make assessment on a societal level. The research showed the remarkable importance of the consumers' decisions through their relatively high contribution of direct environmental loads in the consumption domains food, housing & recreation (mainly through car use). It further provides a useful tool for government to selecting priority areas for environmental policies and it helps firms to focus on the most efficient products or production sites. The model can be used to extend IO datasets for other countries by providing a starting point of a worldwide LCA dataset to which each country can connect its own IO database.

2.3 Acceptance

There are numerous social science approaches to evaluate the acceptance of sustainable consumption measures. These methods include surveys, in-depth interviews, and focus groups. One such example is provided by the evaluation of the Perspectives project (Novem 1999) in the Netherlands through Gatersleben (2002). The *Perspective Project* studied of the possibility of reducing energy consumption through information induced behavioural change of consumption patterns. The environmental and economic evaluation is an integral part providing consumers with information on the impacts created through their behaviour and alternative behaviours (consumption patterns).

For this study twelve Dutch households were examined for two years to investigate how they use energy and possibilities to reduce their energy consumption. The goal for each household was to reduce both their direct and indirect energy consumption by 40% of their expected energy use. Within the same time period their income level was increased gradually by 20% above their previous income in order to determine whether energy-extensive lifestyles are compatible with rising disposable income. The households were recording their daily purchases into a so called "energy account" (similar to energy diaries), with categories such as country of origin, weight and price[3]. The coach assigned to each household evaluated the purchases/activities with them every week, provided feedback and additional information. The attempt to examine the rebound effect (where goes the money saved on low-energy-low-cost products) was based on the precondition that the whole financial supplement to income had to be spent (not saved). The study showed that it is indeed possible to lead a more energy efficient life style (reduced energy use by 40%) even with increased income.

In a follow-up study the possibility of long-term acceptance of changes was investigated (Gatersleben 2002). In this psychological study Gaterleben investigated households' perceptions (and awareness) of political measures for reducing energy use in the Netherlands. The findings show that if households are provided with relevant information about the effects of their lifestyles and suggestions for alternative consumption they might change their lifestyles toward more sustainable ones. Gatersleben found that the energy savings are acceptable as long as people are not asked to give up any of their utility (i.e. comfort, freedom and pleasure) they derive from consumption" (ibid). These alternatives may be based on the assumption that "people derive utility (and well-being) from the consumption of services that

3 The computer program used data on to calculate the energy intensity per guilder of certain products provided by the universities of Groningen & Utrecht and the Netherlands Energy Research Centre (Energieonderzoek Centrum Nederland).

goods deliver and not from goods themselves, therefore one should strive to deliver the same services by using less material resource" (Gatesleben, 2002). It is also important that this lifestyle fits in with current social trends and developments and the willingness and ability of the household as such to change its behavior, lifestyle and habits. (Gatesleben, 2002).

2.4 Well-being

While data from consumer expenditure surveys and IO tables provide us with information about environmental loads from the consumption of goods and services, which consumers use to satisfy their needs, we also want to know how much these purchases contribute to well-being. On the aggregate level, well-being surveys have shown that life-satisfaction has not increased with economic growth. However, we do not know, for example, how living in different settlement types, engaging in ever more spare time activities, consuming luxury items or purchasing organic food affect well-being.

The common approach to evaluate well-being involves asking individuals about their subjective well-being (SWB). These subjective social indicators supplement measures of standard of living, which have long dominated welfare research in the social sciences. They are aimed at monitoring the subjective side of social change (Schwarz and Strack, 1991; (van Praag and Frijters 1999). There are established questions that have been used for a long time and across many countries. There have been many studies investigating different factors that may influence SWB, such as wealth, health, life participation, social recognition, self-esteem, national differences, and genetic make-up. However, there are serious concerns about biases and context effects in measurement of global SWB. Reports of SWB do not reflect a stable inner state of well-being (Schwarz and Strack, 1991). There are various strategies of avoiding such bias and context effects. The implications and seriousness of these effects are subject of controversy (Kahneman 1999; Schwarz and Strack 1999; van Praag and Frijters 1999).

Measuring objective well-being (OWB) has been proposed by Kahneman.[4] This involves the measurement of psycho-sociological variables and the development of statistical models that relate these variables to external measures, situations, and SWB. Kahneman's own research in the field addresses experiences of pain (Redelmeier et al. 2003). OWB could be derived from a record of instant utility over the relevant period (p. 5). Such a record is obtained from asking subjects repeatedly at random times about their well-being, using electronic devices to measure their reactions.

A different approach was chosen by Van Praag and Freijters (1998), the so-called Leyden approach. They attempted to estimate utility functions and shadow prices for amenities like climate and environmental variables. The Leyden approach takes as its starting point the concept of cardinal utility from classical economics.

The Leyden approach is interesting in relation to the notion of "the hedonic treadmill" (introduced first by Brickman and Campbel (1971; in Kahneman et al., 1999), who defined it as: "if people adapt to improving circumstances to the point of affective neutrality the improvements yield no real benefits". This concept may also provide explanation why there is no increase in reported SWB despite an increase in income in the wealthiest nations (which was observed by Diener and Suh, 1999). Related to this is also the notion of the "satisfaction treadmill", which is used to explain a mechanism that could produce treadmill like effects without any change in hedonic experience. The hypothesis is that "improved circumstances could cause people to require ever more frequent and more intense pleasures to maintain the

4 Kahneman recently received the Nobel prize in economics for introducing experimental research methods to economics. He and his collaborator Amos Tversky showed that humans are not rational decision makers.

same level of satisfaction with their hedonic life. The “satisfaction treadmill causes subjective happiness to remain constant even when objective happiness improves” (Kahneman, 1999, p. 14). In general terms, the better living conditions we have (objective happiness), the less we perceive the improvements and thus the less happy/satisfied we are (subjective happiness). While adaptation level is about adjusting to improvements, which is becoming usual, the aspiration level is about our ever-higher expectations of our achievements and thus no chance to satisfy all the needs.) The recognition that aspiration levels adjust and that people will never be fully satisfied does not mean that they cannot be made more (objectively) happier (Kahneman, 1999, p. 15).

The basic difference between SWB and OWB is that SWB is influenced by comparing the experiences (memories) in one’s life. The objective WB aims at avoiding this bias by measuring the instant perception of happiness (or pain). Besides these, there are efforts to find a common framework for research on quality of life, which has been dealt so far separately in various fields (van Kamp et al., 2003).

2.5 Evaluation of the socio-economic and institutional context

Consumption decisions are ultimately a matter of individual, group or organisational choice, but consumption patterns and levels are embedded into the current spider web of economic, social and cultural norms and institutions (Charkiewicz 1998 quoted after Mont 2003). Approaches within this category are based on the understanding that environmental problems we are facing now originate from activities and norms that are deeply rooted in our society. Many attempts to address the unsustainable patterns of consumption often work against existing institutions and thus require a systems approach (Mont 2003, p. 3).

Within institutional economics and evolutionary approaches the concepts of path dependencies and lock-in effects have been used to describe the seemingly paradox situation that there are products on the market available that seem to be (technically) superior to existing products. Yet, these products often do not obtain a significant market share. The most popular example is the QWERTY keyboard (David, 1985). Even though it might be more ergonomically efficient to switch to another type of keyboard, there are high costs involved in getting used to a new keyboard. Further increasing returns to scale and thus lower costs per unit of production make the product affordable for more people, which in turn accelerates the market penetration of the product. More recent examples of such lock-in effects are the software products MS office and windows.

Recent research building on these concepts has focussed on the question how certain aspects in the decision making process of consumers and firms affect the diffusion dynamics of green products. For example, Jansen and Jager (2002) used simulation experiments based on multi-agent modelling, where consumers and firms are simulated as populations of agents who differ in their behavioural characteristics. Jansen and Jager’s stylised experiments provide some insights into the co-evolvement of firm and consumer behaviour which can be used as basis for empirical studies.

A much wider angle was used by Haas (2003). He was using material flow analysis as a tool for observing a town community and its metabolism over different stages in economic development (transition from agricultural to industrial society). He was able to show how over a period of some 170 years production and consumption coevolved with new technologies and institutions and how these changes are manifested in the village’s metabolism.

3 Evaluating environmental pressures of household consumption

In the 1990s the notion of sustainable development (WCED 1987) became the leading environmental paradigm. One important idea which emerged from the sustainability concept is that it is not the growth of the monetary economy (measured by the GDP), but the growth of the physical economy which causes environmental pressures. This supported a conceptual shift: the focus moved from the output side of the production system, which had been the major environmental paradigm of the 1980s (Dryzek 1997, Fischer-Kowalski 1997) to a complete understanding of the biophysical dimension of the economy (Cleveland and Ruth 1997).

Today sustainability science is seen as a field of research which seeks "to understand the fundamental character of interactions between nature and society" (Kates et al. 2001: 641). The precise nature of this interaction is biophysical: It is the continuous throughput of materials and energy on which each socio-economic system depends and which constitutes its relation to the natural environment. Such an understanding of society as a socially organized and thermodynamically open system has been termed anthropogenic (Baccini and Brunner 1991), social (Fischer-Kowalski and Haberl 1993) or industrial (Ayres and Simonis 1994) *metabolism*.

A number of operational tools have been developed to analyse the biophysical aspects of social metabolism, its associated driving forces and environmental pressures. In this section we give a brief introduction to the concept of social metabolism and describe three analytical frameworks: material flow analysis (MFA), input-output analysis (IOA) and life cycle analysis (LCA).

3.1 Social Metabolism

The application of the biological concept[5] of metabolism ("*Stoffwechsel*") to social systems can be traced back to Marx who, influenced by Liebig and Moleschott, talks about the "metabolism between man and nature as mediated by the labour process" in *Das Kapital* ((Marx 1990)). Such a biophysical approach to the economy was not unusual at the turn of the 19th century but arguably did not form an integrated school of thought until recently (see (Martinez-Alier 1987; Fischer-Kowalski 2002)).

The analogy to the biological concept generates from the observation that biological systems (organisms, but also higher level systems such as ecosystems) and socio-economic systems (human societies, economies, companies, households etc.) decisively depend on a continuous throughput of energy and materials in order to maintain their internal structure (Baccini and Brunner 1991, Fischer-Kowalski and Haberl 1993, Ayres and Simonis 1994).

[5] Contrary to the 19th century notion, the modern version of biological metabolism is concerned with the biochemical conversions of matter and energy that occur *inside* organisms and less with material and energy exchange relations between the organism and its environment. The biological function of metabolism can hardly be exaggerated. It is seen as *the* constituting operation securing the maintenance of the organism.

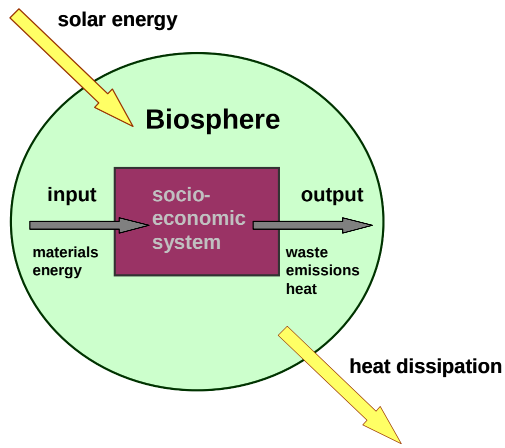


Figure 2: Simplified representation of social metabolism

Contrary to the biological notion, the social concept links material and energy flows to social organization, recognizing that the quantity of economic resource use, the material composition and the sources and sinks of the output flows are historically variable as a function of the socio-economic production and consumption system (Boyden 1992), (Gellner 1989), (Sieferle 1997), (Weisz et al. 2001b).

Today, social or industrial metabolism, along with increasingly sophisticated and standardized methods to account for its energy flow, material flow, and land use aspects, is one of the core paradigms in industrial ecology. Social metabolism provides the heuristic basis for empirical analyses of the biophysical structure of economies and for developing strategies towards more sustainable production and consumption patterns.

3.2 Material Flow Accounting and Analysis (MFA)

Material flow accounting (MFA) is a specific environmental accounting approach (for an overview of environmental accounting approaches see (UN et al. 2003, Daniels 2002), aiming at the quantification of social metabolism. MFA is applicable to various geographic and institutional scales (Brunner and Rechberger 2004, Grünbühel et al. 2003, Hendriks et al. 2000). MFA at the national level (denoted as economy-wide MFA) is probably most advanced in terms of methodological standardization and indicator development.

Economy-wide MFAs are consistent compilations of the annual overall material throughput of national economies, expressing all flows in tonnes per year (EUROSTAT 2001). After the seminal work of Robert Ayres and Allen Kneese (Ayres 1978, Ayres and Kneese 1969), MFA was “reinvented” in the 1990s as a consequence of the growing importance of the notion of sustainable development. In recent years, methods for economy-wide material flow accounting have been harmonized (Eurostat 2001) and a large number of material flow studies for both industrial and developing countries have been published to date [6].

[6] (Schandl et al. 2000); (Machado 2001), (Giljum 2004), (Xiaoqiu Chen and Lijia Qiao 2001), (Scasny et al. 2003); (Pedersen 2002), (Mäenpää and Juutinen 2001), (Muukkonen 2000), (German Federal Statistical Office - Statistisches Bundesamt 2000), (German Federal Statistical Office - Statistisches Bundesamt 1995), (Hammer and Hubacek 2003), (De Marco et al. 2000); (Femia 2000); (Schandl et al. 2004); (Rapera 2004), (Mündl et al. 1999), (Barbiero et al. 2003); (Isacsson et al. 2000); (Weisz et al. 2004); (DETR/ONS/WI 2001), (Schandl and Schulz 2002); (Castellano 2001), (Adriaanse et al. 1997); (Matthews et al. 2000); (ETC-WMF (European topic centre on waste and material flows) 2003) (Eurostat 2002).

Source: Eurostat (2001), slightly modified

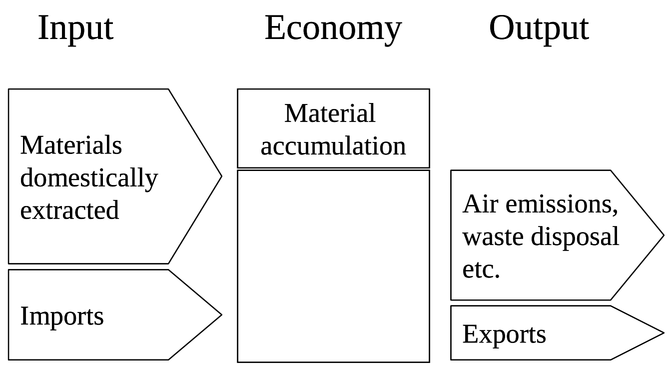


Figure 3: Scope of economy-wide material flow accounts

MFA makes use of the mass balance principle (inputs equal outputs plus stock increases). This requires a sufficient precise definition of the physical boundaries of the economic system (Fischer-Kowalski 1998) (Eurostat 2001) and a comprehensive coverage of the inputs, outputs and stock changes. For the purpose of material flow analysis highly aggregated indicators are derived from MFA. The convention is to aggregate all solid materials (.i.e. biomass, gross ores, industrial and construction minerals, fossil fuels and the physical volume of traded commodities) that cross the defined boundary of the socio-economic system, but not water and air because the socio-economic throughput of these materials exceed that of all others by orders of magnitude (Matthews et al. 2000) (Eurostat 2001).

Overall, these indicators are intended to represent a proxy for aggregated environmental pressure comparable to aggregated energy use or aggregated land use.

According to the DPSIR (Driving Forces-Pressure-State-Impact-Response) indicator system an extension of the Pressure-State-Response system of the OECD ((OECD 1994)) and the EEA typology of indicators (Smeets and Weterings 1999) the basic set of MFA indicators; i.e. domestic extraction (DE), direct material input (DMI), domestic material consumption (DMC), physical trade balance (PTB), total material requirement (TMR), total material consumption (TMC), and net additions to stock (NAS) can be regarded as type A *pressure* indicators. By relating these MFA indicators to macro-economic parameters (predominantly GDP) resource efficiency indicators (type C according to the EEA typology) can be derived which measure either material use per unit of GDP (resource *intensity*) or vice versa GDP per unit of materials used (resource *productivity*). For benchmarking national economies commonly per capita values are used.

Compared to other sustainability indicators, aggregated mass flow indicators are rather new, and the significance of the existing indicators as well as options for their improvement are still intensively discussed[7]. There is, however, a consensus arising in favour of DMI and DMC, as methods and data sources which are applied to account for “unused extraction” (an important part of TMR and TMC) are considered as not reliable. The political interest in MFA and derived indicators has been increasing in Europe and in the OECD since the

[7] E.g. (Cleveland and Ruth 1999), (Ayres et al. 2002), (Weisz et al. 2001a), (Haberl et al. 2004), (Bringezu et al. 2003), Eurostat 2002, (Weisz and Amann 2003), (Schandl et al. 2002).

publication of the “Communication towards a Thematic Strategy on the Sustainable use of Natural Resources” (Commission of the European Communities 2003) MFA indicators gradually are being applied to specify political targets. For example, the Japanese government recently defined a target for reducing economy-wide material use in its official sustainability programme “Towards Establishing a Sound Material Cycle Society”. using an MFA derived indicator (DMI) to specify the target (OECD 2003).

Technically spoken DMI measures the direct material factor inputs of the production system and DMC measures the apparent domestic material consumption, i.e domestic raw material supply plus imports of materials minus exports of materials. Thus, for evaluating environmental pressures associated to household consumption (which is a part of final consumption), MFA indicators cannot be used directly, as MFA indicators do not specify the material requirements of final demand categories. Conceptually the same is true for other environmental indicators, such as primary energy supply, land use, emissions, or wastes. Therefore an additional step in the empirical analysis is needed that makes use of the NAMEA scheme in combination with standard static input-output analysis.

3.3 Life-cycle assessment

Life cycle assessment is a tool to assess the environmental impacts of product systems and services, accounting for the emissions and resource uses during the production, distribution, use and disposal of a product (ISO 1997). LCA has developed from the analysis of cumulative or embodied energy demand (Boustead and Hancock 1979; Casler and Wilbur 1984). It uses (physical) process analysis sometimes in combination with (monetary) input-output analysis. LCA analysts have collected data on a wide range of emissions and resource uses. Methods have been developed to aggregate different pressures to impact indicators, taking into account environmental mechanisms and human values (Udo de Haes et al. 2002). This type of assessment can help producers reduce the environmental impact of a product during its life-cycle, e.g. taking into account the energy and detergent consumption during the use of a washing machine, or the environmental load associated with the disposal of mobile phones. LCAs can, in principle, also inform consumer decisions. Environmental product declarations, which list the environmental impact indicators of specific products or product lines, are one information tool based on LCA which is supposed to help the consumer make decisions (Bogeskär et al. 2002). As the practice in Nordic countries shows, the label often informs the purchasing departments of institutional customers; private consumers are often at loss as what to do with this information. Even if the feat of producing life-cycle information for all products on the market could be achieved, consumers would most likely feel overwhelmed and disempowered by this information. While environmental product declarations are useful for some purposes, more ways need to be found to inform policy makers and influence consumers if one wants to achieve sustainable consumption.

Life-cycle assessment consists of three distinct analytical steps: the determination of processes involved in the life-cycle of a product, the determination of environmental pressures (emissions, resource uses etc) produced in each of those processes, and the assessment of environmental impacts and aggregation to impact indicators. The ISO 14040 standard for LCA defines the first two steps as inventory analysis and the third step as impact assessment (ISO 1997). ISO defines two additional, procedural steps, goal and scope definition (i.e., planning the LCA) and interpretation (i.e. discussion and conclusions). It is not always straight-forward to attribute e.g. an investment to the production of a specific piece of product. LCA can be seen as constructing a causal link between production processes, the associated environmental stresses, and the produced products. The causal link can be constructed in different manners: (1) One can divide all the existing emissions by the total number of products produced over a period. This is the more common, attributional mode, which attributes responsibility for the existing emissions evenly across the produced products. (2) One can ask what happens when one additional product is produced. This marginal perspective is relevant, for example, when looking at electricity production, where the existing base load of coal or hydropower stations has significantly different emissions from the newly built gas fired or wind power plants (Baumann and Tillman 2004).

LCA practice today can build on the cumulative effort of data collection. Standard LCA software already includes databases for many basic materials and a number of important commodities. More extensive databases, such as EcoInvent, are available for purchase. Some industry associations have produced their own data. SimaPro, the most widely used software tool, now also contains data from input-output analysis, so that hybrid assessments can be constructed. The data represents conditions in industrialized countries. Data from developing and emerging countries, however, is still lacking. There is hence a lack of data especially on a number of agricultural products and manufacturing products, and the available data may be biased.

Life-cycle impact assessment methods have been developed for a large number of stressors, including for minerals, different land use classes, and several hundreds of toxic chemicals (Udo de Haes et al. 2002). There are competing methods, which means that the modeler or decision maker needs to select one method. The Society for Environmental Toxicology and Chemistry (SETAC) and the United Nations Environment Programme (UNEP) have formed the Life-Cycle Initiative (UNEP 2004), with the aim to promote the creation, publication,

We know of two attempts to model household environmental impacts using process LCA. Rønning et al. (Rønning et al. 1999) calculate the CO2 emission of the average Norwegian; they are able to account for only for half of the emissions. This is not surprising, as several IO-based analyses show that process LCA often misses on the order of 50% of the emissions by not being able to trace all the inputs back to the source. Frischknecht et al. (2002) investigate the most important consumption categories in Switzerland, but not the entire household consumption.

3.4 Input-output analysis

Input-output analysis is an analytical framework created by Nobel Prize laureate Wassily Leontief in the late 1930s (Leontief 1936), (Leontief 1941) and was originally designed to analyse the interdependence of industries in an economy. Today the compilation of input-output tables is standard in national accounting statistics in almost all countries of the world and input-output methods are routinely applied in economic analyses. Since the late 1960s, IO analysis was extended to also address economy-environment relationships, focusing predominantly on energy use and pollution, see e.g. (Cumberland 1966), (Ayres and Kneese 1969), (Bullard and Herendeen 1977), (Griffin 1976). (Leontief 1970), (Proops 1977) (Duchin et al. 1994), (Duchin 1992); (Duchin 1998).

In principle, a standard, static input-output model is used to calculate gross output and factor inputs required to satisfy a given final demand. Alternatively, final demand can be deduced for a given gross output. In most cases a static open IO model is based on an IO table of the general form shown in Figure 4.

j i	sectors 1..n	final demand 1.................m	total output
1 2 . . n	z_{ij} inter-industry flows	y_{ik}	x_i
1 2 . q	f_{lj} factor inputs		
total input	x_i		

The IO table consists of the following matrices and vectors:

Z with elements **{**z_{ij}} n x n matrix of flows of inter-industry deliveries
Y with elements **{** y_{ik} **}** n x m matrix of flows from production sectors to final demand sectors
F with elements **{**f_{lj}**}** q x n matrix of factor input flows to production sectors
x with elements **{**x_i**}** n x 1 vector of total sectoral output (gross production or gross output)
$\mathbf{x}^T$ with elements **(Växjö kommun)** 1 x n vector of total sectoral total input (the transposed vector of gross production or gross output)

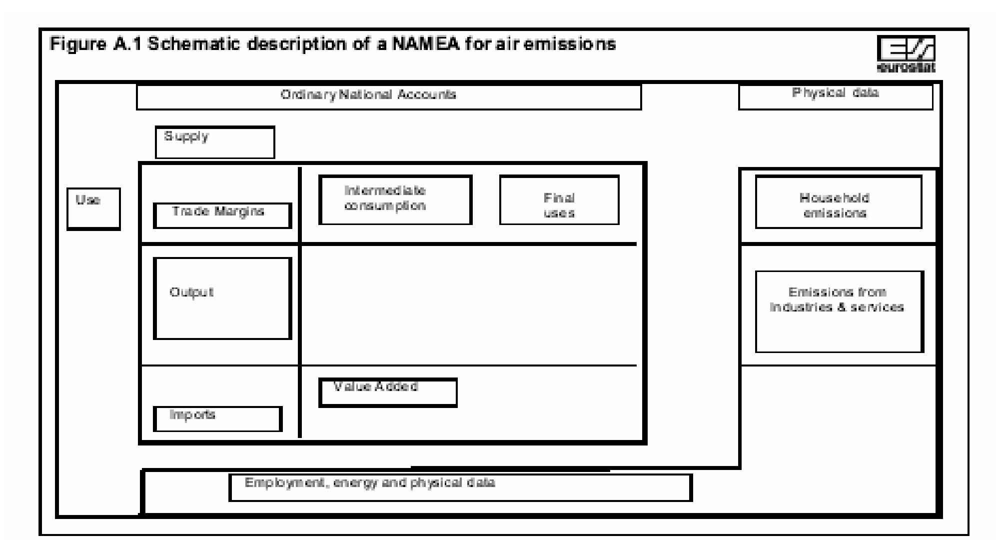
Figure 4: Scheme of an input-output table

Matching environmental tables which show the emissions and resource use of each industry sector are required to determine the emissions and resource use from a unit final demand. This analysis does usually not include direct emissions from the household, which have to be derived from process analysis. Different final demand vectors can be used, including those of a single households or that of many households.

The empirical basis: input-output tables and NAMEA

Input-output tables represent (1) the flows of commodities and services between the industries of an economy in the inter-industry table, (2) the deliveries of commodities and services from the producing sectors to final demand sectors in the final demand table, and (3) the requirements of primary factors of production in the factor input (or value added) table. In principle the variables in the input-output tables may be measured in physical units (such as e.g. pieces, tonnes, joule) or in monetary units, or a mixture of both (Leontief 1970). The advantage of measuring the flows of commodities in physical units as compared to monetary units lies in the fact that physical units explicitly represent the quantity of the flows, whereas a measurement in monetary units always combines quantity and unit prices (Duchin 2004)[8]. The convention in national accounting, however, is to measure the variables in monetary units. Therefore, national statistical offices routinely provide monetary input-output tables, whereas input-output tables in physical units are available only for a small number of countries and points in time. For Austria sufficiently dis-aggregated and up to date IO tables are only available in monetary units.

To determine environmental pressures associated with household consumption additional vectors of biophysical factor inputs are needed. These vectors are provided by the NAMEA system. NAMEA stands for "national accounting matrix including environmental accounts" (Eurostat 2001b). Figure 5 illustrates how national accounting supply and use tables and environmental accounts can be expanded to a NAMEA. In Figure 5 the NAM consists of the supply and use tables of the conventional national accounts in which household consumption has been added. The right-hand side of the figure shows that production activities in industries result in emissions as well as in goods and services covered by the traditional accounts. Household consumption and related emissions are singled out (Eurostat 2001b).



Source: Eurostat 2001b, p 11

Figure 5: The NAMEA system for air emissions

[8] The question monetary vs. physical input-output analysis has been a matter of intensive discussion recently, see (Hoekstra 2003), (Hubacek and Giljum 2003) (Suh 2004), (Giljum et al. 2004), (Dietzenbacher 2004), (Weisz and Duchin 2004).

Apart from air emissions the environmental accounts may include also emissions to water, energy use, waste generation or use raw materials. In addition to supply and use tables also input-output tables can be the expanded to a NAMEA. This is the type of NAME which we used in our study.

If connected to IO tables the environmental accounts can be interpreted as additional biophysical factor inputs (Leontief 1970, Duchin 2004) and the computation of direct and indirect factor inputs needed to provide a given final demand, can be done as described in the previous section.

In a NAMEA the different evnrionmental accounts are dis-aggregated by economic sector according to the standard NACE classification (two digit level).

4 Operational environmental profile tool

4.1 NAMEA and NACE

With NAMEA (National Accounting Matrix including Environmental Accounts) environmental data have been organized according to economic activities. This brings together data on economic activities and a wide range of consequences of that activity (NAMEAs for Air Emission 2001). The classification used by NAMEA is NACE, the European Union's statistical classification of economic activities (Eurostat 1996a). Both NAMEA and the input-output table use the two digits aggregation level of NACE. This provides a powerful fundament for analysis.

01	Agriculture, forestry, fishing (1)
10	Mining of coal and lignite
11	Extract. o. crude petrol. a. nat. gas, min. o. metal ores (2)
14	Other mining and quarrying
15	Manufacture of food products and beverages
16	Manufacture of tobacco products
17	Manufacture of textiles
18	Manufacture of wearing apparel
19	Manufacture of leather, leather products, footwear
20	Manufacture of wood and of products of wood

Table 1: The first 10 economic activities as examples of the 2-digit NACE classification

NAMEA data at European level were first published by Eurostat in 1999 for the years 1990-1999. In the following years data have been put into this new and common framework to allow further analysis. In Austria NACE consists of 65 economic activities. However, NAMEA provides data just for 40 economic activities. The Austrian NAMEA data for the aggregation level of at least 40 economic activities are available for the following indicators:

Category	Indicator	Source
Air	CO2, CH4, N2O, SO2, NOx, NH3, NMVOC, CO	NAMEAs for air emissions – Results of pilot studies, European Communities 2001
Water	waste water, CSB, BSB5, TOC, N, NH4-N, P, AOX, Zn, Cu, Pb, Cr, Ni, Hg	NAMEA-Wasser (Water), Federal Environmental Agency, Vienna, 1999
Waste	Hazardous Waste, halogenated solvents, halogen free solvents, paints and laquers, waste oil, other hazardous waste, non-hazardous wate	Integrated NAMEA with air emissions, energy use, some material flows and expenditure; S. Gerhold, Statistik Austria, 2002
Energy use	Final energy consumption	Statistische Nachrichten 4/2000 (statistical news 4/2000)

Table 2: Available NAMEAs for an aggregation level of at least 40 economic activities

This adds up to 30 indicators. In order to keep the numbers at a manageable size for each category indicators have been selected that are

- fairly independent from each other and
- pointing at different environmental problem areas.

With these criteria the underlined indicators have been selected.

4.2 Matching Consumer Expenditure and Economic Activities (NACE)

Data on the level of national accounts are structured by economic activities while consumer expenditure classifications are structured by products and services. With COICOP (Classifications of Expenditure According to Purpose) a new classification has jointly been developed by the statistical office of the OECD and Eurostat and was first published in 1999. It covers all areas of individual consumption. It is the common standard for consumer expenditure surveys and is one of the classification schemes within a set that is used for generating national accounts.

01-12 - Individual consumption expenditure of households
01 - Food and non-alcoholic beverages
02 - Alcoholic beverages, tobacco and narcotics
03 - Clothing and footwear
04 - Housing, water, electricity, gas and other fuels
05 - Furnishings, household equipment and routine household maintenance
06 - Health
07 - Transport
08 - Communication
09 - Recreation and culture
10 - Education
11 - Restaurants and hotels
12 - Miscellaneous goods and services
13 - Individual consumption expenditure of non-profit institutions serving households (NPIS
14 - Individual consumption expenditure of general government

Table 3: COICOP top level

04.5 - Electricity, gas and other fuels
04.5.1 - Electricity (ND)
04.5.2 - Gas (ND)
04.5.3 - Liquid fuels (ND)
04.5.4 - Solid fuels (ND)
04.5.5 - Heat energy (ND)

Table 4: COICOP example for levels 2 and 3 (ND means non-durable goods)

However, there is no direct link or correspondence table for the link between COICOP and NACE. A further classification is needed to establish the link between the two of them. The current national classification is named classification of products and services according to activities (CPA). CPA has on the 2-digit level an identical structure as NACE and at the lowest aggregation level the same products and services as COICOP.

This means that we can use the CPA classification for the development of surveys and questionnaires for investigating the consumption pattern in the two reference settlements: the standard and the car-free settlement. As soon as reference data from consumer expenditure surveys are used the correspondence between COICOP and NACE via CPA is necessary. Therefore we have established these links for the focal areas food, transport, restaurants and hotels and energy use.

4.3 Design of the operational tool

Household environmental impact assessment has been pioneered in the field of energy analysis with the calculation of embodied and direct energy use by different household groups. The first analyses of this type by Herendeen and colleagues (Bullard III and Herendeen 1975; Herendeen 1978; Herendeen and Tanaka 1976) already combined energy input-output analysis to estimate the energy use for the products and services consumed by a household with data on the consumption of different energy carriers by the households themselves. Today, this type of analysis also takes into account emissions and potentially resource use and material flows beyond energy. For a review of the literature, see (Hertwich 2004). The objective of this type of analysis is to quantify the contribution of different household activities or demand classes, such as food, clothing, transportation and dwellings, to the overall household environmental impact (HEI). In addition, some studies aim at identifying factors that determine the HEI of different households, such as income, urbanity, family size and age, and to investigate changes over time. In this study, we use a HEI analysis for a different purpose, the evaluation of a specific example of sustainable consumption, and that is the car-free housing project in Vienna.

Traditionally, information on household consumption is derived from consumer expenditure surveys. In this study, we have used the average household consumption as derived from the Austrian consumer expenditure survey as a reference. We decided to focus our survey of the car-free housing project and the reference settlement on items that we knew were important for the overall HEI, instead of trying to quantify all consumption of the households. A number of critical assumptions had to be made, but as a result it became feasible to actually carry out a survey with a sufficient response rate.

The critical consumption items that we assessed were household's direct energy use and transportation. We also enquired about food consumption in general and about hotels and restaurants, because these appeared to be important in a first assessment. The assessment of direct energy use and of transportation of the households is based on process life cycle assessment (LCA). The data was mostly derived from the Eco-Invent database, but some calculations were carried out for public transport and district heating supply. The remaining items were calculated using the Austrian input-output analysis for the year 2000 and the emissions estimates contained in the National Accounting Matrices including Environmental Accounts (NAMEA). These calculations are documented in the following.

4.3.1 Combining Input-Output Tables and Emissions

The common way of combining input-output tables and emissions to derive emissions intensities is

$$M = F\left(I - A\right)^{-1} y$$

where the input-output coefficients include both domestic and imported products donated by the superscript *d* and *i* respectively $A=A^d+A^i$. The matrix may also include capital requirements, although those are commonly not included (Peters and Hertwich 2004). The vector F represents the direct emissions or resource use per unit activity of a sector, and y the final demand. The emissions and resource use, however, are usually recorded by industry sector, whereas demand contains products. There are two options to bridge the gap between the demand for commodities and emissions by industries. The first option is to use a market share matrix to translate the demand for commodities into a demand for industry output, and to use an industry-by-industry input-output table. The second option is to assign the emission produced by industries to the commodities produced by these industries.

The input-output table published by Statistics Austria is a commodity by commodity table, calculated using the commodity-technology assumption. This means that it has been assumed that commodities are produced with the same technology independent of which industry has produced them. The table is in the 2-digit NACE code, with 57 commodities. The NAMEA table is in a more aggregated code with 40 industries. Since the assignment of factors to commodities using the commodity-technology assumption frequently results in negative values, a problem that is especially severe at high aggregation levels (Miller and Blair 1985), we have chosen to instead work using the industry-technology assumption.

$$A = BD$$

$$D = V\hat{q}^{-1}$$

$$B = U\hat{g}^{-1}$$

Where U is the use matrix, V the make matrix, and A is the coefficients matrix. g the output by industry, whereas q is the total amount of commodities produced; the vectors are obtained by summing the different dimensions of the make matrix. The A-matrix includes both domestic and imported goods, because the use table includes the total use of commodities, independent whether they are imported or not. Emissions are allocated from 40 industries to 57 commodities also using the industry-technology assumption,

$$E_c = E_{40}\hat{g}_{40}^{-1}PV$$

$$F = E_c\hat{q}^{-1}$$

Where P is the 40x57 permutation matrix and E_{40} is the emissions table.

The results where checked by calculating the total emissions in Austrian industry by multiplying the matrix by the final use minus imports, $E = M(y - q^i)$, and comparing this to the original total. It was found that in all the 6 categories, the error was around 2%. A small error is expected as a result of the industry-technology assumption, because the imports do not have the same composition as the domestically produced products.

These calculations were all performed in basic prices. To calculate the emissions multiplier in purchaser prices, information on the margins was used.

$$m_c^p = \frac{q_c^b}{q_c^p} m_c^b + \sum_i \frac{q_i}{q_c^p} m_i$$

Where q indicates the household demand for the commodity c; p and b purchaser and basic prices, respectively; and i the 3 different types of margins: wholesale trade, retail trade, and transport. Information on the production of these margins was used to calculate the intensity of the margins.

The input-output analysis based on the NAMEA data indicates that direct emissions or energy use of households plays an important role. Upstream emissions, however, account for ca. 50-90% of the total of emissions that households are responsible for. A sorting of the NACE sectors according to CO_2 emissions shows that electricity, gas and water utilities are important. Land transport is the next most important category, and the most important one for NOx emission. Furthermore, food products, hotels and restaurants, real estate (i.e. renting flats), petroleum and the retail sector are important.

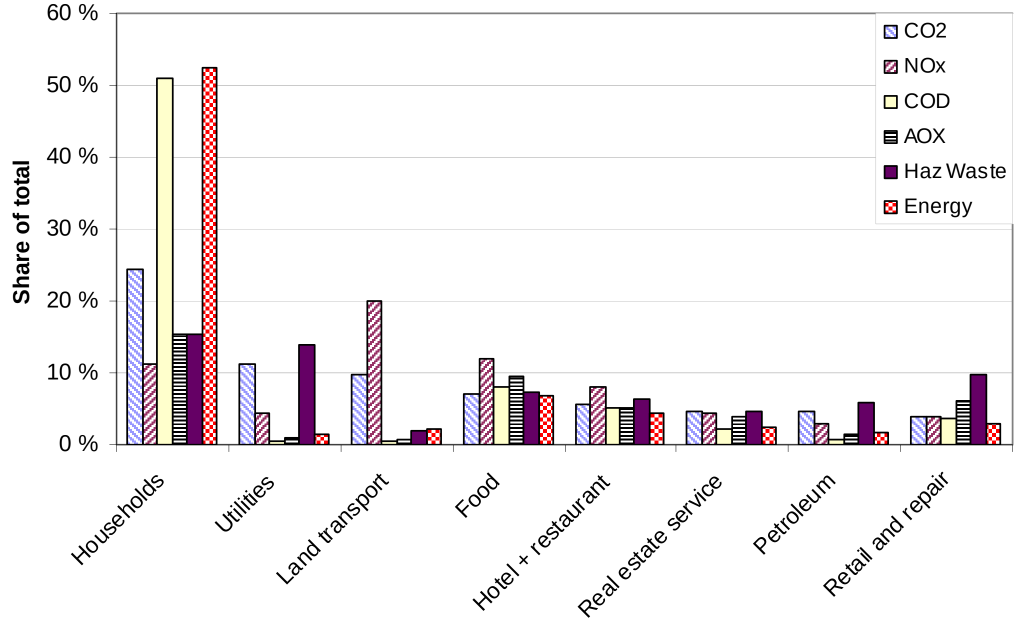


Figure 6: Direct effects of the households and indirect (upstream) effects of household consumption.. Source: Own calculation based on 1995 NAMEA data and Austrian input-output table for 1995

This analysis was used to decide that information needed to be collected on the households direct impacts, on energy consumption, transport, food, and hotels and restaurants.

The following table presents the average per capita direct and indirect emissions in Austria as obtained from the input-output calculations. It was later found that this assessment did not include direct emissions from transport, which are on the order of 0.6 t CO_2/person. It does not include emissions connected to so-called bunker fuels, in Austria primarily air transport, which adds 1.2 t CO_2/person to mobility.

Emissions	Indirect								Direct	Total
Areas of consumption	Energy	Shelter	Food	Clothing	Care	Mobility	Recre-ation	Other		
CO_2 [t]	0.84	0.57	0.45	0.21	0.10	0.90	0.51	0.42	1.29	5.30
NO_x [kg]	1.23	1.56	2.41	0.64	0.37	4.36	1.79	1.23	1.70	15.27
COD [kg]	0.19	0.75	1.26	0.67	0.34	0.60	1.65	1.90	7.33	14.70
AOX [g]	0.47	1.90	2.09	1.41	2.28	1.59	2.94	3.98	2.93	19.60
Toxic waste[kg]	16.15	9.23	7.10	4.55	1.46	10.07	8.99	11.42	12.64	81.60
Energy [GJ]	3.35	7.04	8.14	4.41	1.57	7.61	7.16	7.13	51.25	97.66

Table 5: Distribution of HEI according to the input-output calculation

4.3.2 Emissions Factors for Energy and Transport

4.3.2.1 Energy

For electricity, the life-cycle inventory (LCI) results for the Austrian grid average, including imports, at the low-voltage grid was obtained from EcoInvent (Frischknecht 2004). Eco-electricity (Ökostrom) was calculated to be 100% wind power, using a Swiss LCA as a basis. Gird losses were assumed to be the same as for the Austrian average. The CO_2 emissions are 0.3 kg/kWh and 0.03 kg/kWh for grid and green power, respectively. Data for district heating was obtained from Fernwärme Wien, and the direct emissions are 0.12 kg/kWh of heat sold. This does not include emissions due to producing and maintaining the infrastructure, which were ignored. This probably introduced a substantial error, but no better data are available at this point.

4.3.2.2 Car

The data is based on the LCA of a Golf A4 (Schweimer and Levin 1999). Data relating to producing and maintaining the car was captured in a per-km component. This assumes that all cars about as much pollution to produce and maintain as the Golf A4. The fuel-related and direct emissions were captured in a per-liter component. For each household, fuel use was estimated given on statements about fuel efficiency and km driven. Thus, the total emissions were calculated. Similar procedures were used for all cars, whether owned, shared, or rented.

4.3.2.3 Train, Bus, Airplane

LCI data per passenger-kilometer was obtained from EcoInvent (Frischknecht 2004). This data is based on systems characteristics and occupancy rates in Switzerland. The number of passenger kilometers was estimated from the expenditure on these different means of transportation. Following prices were assumed: 5.7 c/km for the train (this is the cost for a trip Vienna-Salzburg with the Vorteilscard (discount membership), which most train users own), 3.5 c/km for the bus (based on a trip to Krakow with Eurolines). Air travel distances were derived directly from information on the destination, since air fares vary widely

4.3.2.4 Public transportation system in Vienna

A report on the operations of the public transportation system was obtained from the web site of the Wiener Verkehrsbetriebe (the Viennese public transport company). This report includes data on the electricity consumption of the subway, tram and commuter trains, and on the liquefied natural gas consumption of the buses. Fuel cycle emissions for LNG buses were obtained from (Beer et al. 2000). The same data for electricity was used. The fuel use for the system was normalized by passenger data, and the fraction of passengers with an annual pass was used to estimate the fuel use per annual pass (345 kWh and 33 L LNG). The buses and the infrastructure were neglected. The average pass owner makes ca. 900 trips per year. CO_2 emissions are 165 kg/annual pass.

5 Survey Design

5.1 Research strategy

The main purpose of the survey is to obtain information on consumption patterns and household characteristics in the two residential settlements as a basis fur further analysis, including the assessment of household environmental impacts with the new tool. The survey can hence also be seen as a first test of our tool. In order to find different consumption patterns and to assess the ecological impact of sustainable consumption projects we decided to select a car-free settlement in Vienna and an average settlement with similar characteristics, exept the SC feature. The survey was carried out by face-to-face interviews using a comprehensive standardised questionnaire asking for household consumption patterns and other characteristics such as income and education. In addition to this main survey qualitative interviews with selected households have been carried out.

The applied methodological concept is based on the triangulation paradigm (Fielding & Schreier 2001). The general idea of triangulation is that if diverse kinds of data support the same conclusion, confidence in the conclusions is increased. Factors influencing sustainable consumption are so various and complex that applied research is forced to use the diverse strengths that different methods offer. In our case qualitative and quantitative social research methods are employed within one survey, in different phases of the research process (sequencing). Contrary to the most common procedure we decided that the quantitative phase of data collection is followed by a qualitative phase. Using this approach allows us to complement findings on an aggregate (or sample) level with more detailed analyses of individual cases of consumption practices.

In order to match these requirements of the Viennese settlements a set of investigation tools has been developed:

- a questionnaire in German (see a brief translation in chapter 5.3, the longer German version in the appendix)
- an interview guide for the building administration
- an interview guide of questions for the tenants council in the car-free settlement (Mieterbeirat)
- an interview guide for in-depths interviews with inhabitants of both settlements

5.2 Questionnaire design

Starting point for the design of the standardised questionnaire was the assumption that some specific areas of household consumption are of major importance with regards to environmental impacts (see chapter 4.3): energy (electricity, gas, steam) and water, transport, manufactured food (alcoholic and non-alcoholic beverages and tobacco), and hotels and restaurants. The questionnaire had to cover these consumption areas as completely as possible. Moreover the respective questions in the questionnaire had to fit to the definitions provided by COICOP (see table 6).

In general, consumption data have been investigated for one year – the year 2003 – covering the expenditures of the entire household. Most of the surveyed data are expenditures in Euro and physical data such as kg, km, and kWh. The information gathered should allow the identification of consumption patterns with general descriptors and should give indication on the degree of environmental behaviour of and damage created by households.

01 - Food and non-alcoholic beverages	
01.1 - Food	
01.2 - Non-alcoholic beverages	
02 - Alcoholic beverages, tobacco and narcotics	
02.1 - Alcoholic beverages	
02.2 - Tobacco	
02.3 - Narcotics	
04 - Housing, water, electricity, gas and other fuels	
04.1 - Actual rentals for housing	
04.2 - Imputed rentals for housing	
04.3 - Maintenance and repair of the dwelling	
04.4 - Water supply and miscellaneous services	
04.5 - Electricity, gas and other fuels	
07 - Transport	
07.1 - Purchase of vehicles	
07.2 - Operation of personal transport equipment	
07.3 - Transport services	
11 - Restaurants and hotels	
11.1 - Catering services	
11.2 - Accommodation services	

Table 6: Selected COICOP categories that correspond with the identified economic activities of high environmental impact according to NACE

In addition to these four main consumption areas the questionnaire covers several other consumption related questions, regarding the available household income, some key data of the appartment and regarding the existing household facilities and equipment. Furthermore the questionnaire includes items to gather personal information (age, gender, education, occupation, etc.) from the respondent and all other persons living in the household. Finally there is an additional part, asking for selected theory-related information about the role of the respondent in the planning process, about the social life in the settlement (with a special focus on environmentally friendly behavior), about personal attitudes, beliefs and behaviour (for an English summary of the standardised questionnaire see Table 7).

The hypothesis-testing part of the quantitative survey is built around the idea that there are social and individual reasons for the development of sustainable consumption patterns.

In order to compare different settlements we started with the following assumptions. The sustainability of consumption patterns is higher,

- if more attractive opportunities for sustainable consumption are offered close to the appartment;
- if people have been involved in the planning process of the settlement;
- the higher the general ecological awareness in the settlement;
- the stronger the social control regarding ecological behavior;
- the more the topic “car-free-living” is part of the identity of the residents;
- the higher the social cohesion is within the settlement;
- the more social contacts are established within the settlement;
- the more information about ecological consumption is available in the settlement.

Regarding individual reasons for sustainable consumption we are concentrating on the following hypotheses. The sustainability of the individual consumption pattern (on the household level) is higher,

- the higher the respondents are educated;
- the better the respondents are informed about sustainable consumption;
- the higher the respondents rate their general ecological awareness;
- the stronger respondents are social linked to other persons with high ecological awareness

In addition to the societal and individual level we assume that moving to a new appartment could also be reason to change consumption patterns (caused by new social contacts, changed shopping facilities, etc.). Because this is true for both studied settlements differences in the environmental impact of consumption had to be observed in comparison to the impact of to the average Viennese household and in comparison to the former consumption behavior of the respondents (households).

Introduction to the questionnaire
- Information will be handled confidentially
- Purpose of investigation
- Feedback to the settlements (summary report for the settlements (anonymous) and presentation)

1. General data
    - Number of questionnaire
    - Address
    - Persons permanently living in the household
    - Age, Gender (all household members)
    - Occupation (all household members)
    - Education
    - Voluntary service
2. Available household income
    - Persons with income
    - Net salaries
    - Social aids and allowances
    - Changes in debt and savings
    - Rent and operating costs
3. Household facilities and equipment
    - Key data of the appartment and of other real estate (e.g. weekend house)
    - Household appliances (multiple choice list with information on eco-efficiency)
    - Audio-visual, photographic and information processing equipment
    - Computer
    - Internet access
    - Phone (including mobiles, year and cost of purchase, running costs)
4. Energy consumption
    - Electricity (expenditure and kWh)
    - Hot water, steam (expenditure and kWh)
    - Gas (expenditure and kWh)
5. Transport
    - Car (model, fuel consumption per 100km, annual km, frequency of use, purpose of use, maintenance, year of manufacture, year of purchase, purchase costs)
    - Bicycle (annual km, operating costs, year of manufacture)
    - Public transport within Vienna (units?)
    - Public transport with destinations in Austria (in km)
    - Public transport with destinations abroad (in km)
    - Car sharing
    - All-inclusive trips (expenditure, destination, duration of stay, number of persons)
6. Restaurants and hotels
    - Catering services
    - Accommodation
7. Food, beverages and tobacco
    - Total expenditures
    - Meat
    - Biological products
    - Alcoholic beverages
    - Non-alcoholic beverages
    - Food from gardening
    - Purchases directly from producers
8. Attitudes and other information
    - Participation in the planning process
    - Social life in the settlement
    - Personal attitudes and behaviour
    - Use of media
    - Membership
    - Ecological motivations
    - Motivations (concerning: choosing this settlement, consumption patterns, mobility, etc.)
    - Conditions/available offers for sustainable consumption

Table 7: English summary of the standardised questionnaire

The information gathered should allow the identification of consumption patterns with general descriptors and should give indication on the degree of environmental behaviour in the areas of interest.

The following descriptors will be used to compare the data between various households, between the settlements and with Austrian consumer expenditure surveys and the consumption data for households used for the analyses with the Austrian input-output table. Most of the information gathered can be directly used with the developed method (extended input-output table with an interface for consumer expenditures).

- Total expenditure for each of the selected four most polluting consumption activities
- Expenditures for food, beverages and tobacco
- Expenditure profile in this category concerning meat, biological food, own production and directly purchased from producers
- Expenditures transport
- Expenditure profile between modes of traffic
- Expenditures Restaurants and Hotels
- Expenditure profile concerning quality products
- Expenditures for energy (exclusive transport)
- Expenditure profile for the various energy carriers

Table 8: Descriptors of consumption patterns

The draft version of the questionnaire has been pre-tested in a small-sized pilot study comprising five interviews. More than 20 details have been changed on the basis of the feedback, including changes of wording and content. A second revision after the first interview phase in the car-fee settlement resulted in a further reduction of content.

5.3 Qualitative Interviews

So far we have described a tool and a survey design to enable the description of consumption patterns. Although the standardised questionnaire is designed to collect some “subjective” information, the methods described are limited to address the attitudes and reasons for various degrees of the sustainability of different consumption patterns. Therefore qualitative interviews are a valuable extension to gain additional insights.

At the core of the qualitative survey there are in-depths interviews with some of the interviewed households. For this part of the survey we designed an interview guide starting with the present consumption pattern and focusing on main differences to reference consumption patterns. In some cases the interviewee’s consumption pattern might be significantly more environmentally friendly then the average. Then this is the guideline for the first part of the interview. The second part would focus on possible changes of the present consumption pattern.

The interviews should provide insights on individual and contextual reasons for specific types of consumption. One major idea is that consumption patterns are not a given thing but the result of individual “histories” embedded in and shaped by specific institutional contexts. The interviews should focus on those individual “histories” producing new insights on social learning of sustainable (or non-sustainable) consumption.

1. The environmental impact of your household in the year 2003 is far below the average of your settlement. How would you explain this result? Did you expect such a result? To which extent does this result match with your expectations? How important is an ecologically sound lifestile for you and your Family? 2. Did you change your consumption patterns in the last 5 to 7 years? Which changes could you report? What are the reasons for these changes? Why did you move to this settlement? What motives have been important? 4. Why do you live without car? 5. What aspects of the social life in the settlement do like, what do you like less? 6. Could you describe the influence of the settlement (the people) on your consumption pattern? 7. Did you change your consumption pattern since you have moved to this appartment? 8. Your consumption pattern in detail: private transport, food and beverages, hotels and restaurants, and energy consumption of the household. Private transport (below average/average/above average): How do you valuate theresult? Food and beverages (below average/average/above average): How do you evaluate theresult? Hotels and restaurants (below average/average/above average): How do you evaluatethe result? Energy consumption (below average/average/above average): How do you evaluate the result?

Table 9: Interview guide for qualitative interviews

The respondents for the qualitative interviews have been selected on the basis of the results of the quantitative survey. The qualitative interviews have been conducted only after the first results from the quantitative survey have been available. In order to deepen our understanding of sustainable ways of consumption we decided to concentrate this part of the survey to households with CO_2 emissions clearly below the average of the settlement.

5.4 Sampling

For the purpose of this study we had to apply a two-step sampling strategy. First we had to find – starting from the chosen car-free settlement as a prominent example for sustainable consumption – a comparable "standard" settlement in Vienna. In a second step it was necessary to select a limited number of households in each settlement. Due to limited resources the total number of interviews was restricted to 100.

The car-free settlement is located in the 21st district of Vienna (Floridsdorf) 6 km far from the city centre on the northern side of the Danube river. It was completed in the year 1999 as the first large-scale demonstration project for car-free housing in Austria. The project is located close to the old Danube, a shut down sidearm of the Danube which is a popular recreation area in Vienna. Access to the city centre is available through public transport. The appartment complex includes 244 flats of different sizes (50-130 m^2). Tenants have to commit themselves to not own a private car. This car-free status is even part of the tenancy agreement. Future tenants have had the possibility to participate in the planning process to a large extent. Several features of the settlement have been demanded by users, including improved insulation (12-15 cm). Another outcome of the participatory planning was a unique statute which gives special rights to the tenants, e.g. most common facilities in the settlement are administrated by a board of tenants. The appartment complex includes 9 buildings, each 6 stories high. Basement garages are much smaller than in comparable buildings and are used for bikes and for a limited number of car-sharing automobiles (at the moment 3 cars). The money saved from not providing one parking space per flat was invested in common areas and facilities, such as social rooms, gardens on the roof, sauna, additional facilities for bikes, a shop floor, a laundromat, a distribution/storage room for organic food, a "children's house", and a playground. Solar energy is used for hot water heating during the summer season. The heating system is connected to the municipal district heating network, to a certain extent space heating needs are also covered by heat-pumps on the site (GEWOG 2000).

Since the appartments in the project are restricted to persons (families) without private cars we assume that inhabitants' environmental awareness is far above Austrian average. The assumption is that we find consumption patterns that range in the upper range of sustainable consumption of modern urban societies.

The search for the second settlement was mainly driven by the idea to find a project as similar as possible except for the car-free attribute. Especially the following criteria have been of importance.

- Location: Vienna
- Financial structure: Social housing project
- Dimension: Number of flats (±100)
- Location: Distance to the city centre (±3 km), district with comparable qualities (10., 11., 20., 21. or 22. district), similar surroundings (e.g. shopping facilities)
- Public transport: distance to the next underground station (±500m)
- Participation: Planning with future tenants
- Age: Year of completion (±1 year)
- Building development: specific density (±0,5)
- Building standard: comparable insulation, comparable window quality
- Heating system: municipal district heating

Based on this criteria the "Frauen-Werk-Stadt", another thematic housing project focusing on architecture from and for women initiated by the city of Vienna, was selected after an extensive search. In the following table both settlements are described by some general information. We can see that the project "Frauen-Werk-Stadt" is larger in terms of number of appartments and was completed two years before the car-free project. Both settlements are located in the same district, not more than 500 meters away from each other. As a housing project highlighting the usability of architecture, the "Frauen-Werk-Stadt" is also equipped with several facilities for common use, e.g. generous entrance areas, a communication centre, a laundromat, special rooms for bicycles, a shop floor.

	Car-free settlement	Reference settlement
Location	21st district of Vienna	21st district of Vienna
Financial structure	social housing project: GEWOG and *domizil*	social housing project: Stadt Wien, Wohnbauvereinigung für Privatangestellte
Dimension	244 flats	357 flats
Public transport	tramway-station in front of the settlement, three minutes ride to the next underground station	tramway-station in front of the settlement, five minutes ride to the next underground station
Participation	future tenants had the possibility to participate in the planning phase, common rooms and the green space	participation of the future tenants in planning the communication areas and common rooms
Age	completed in 1999	completed in 1997
Building development	density: 2,44/appartment	density: 1,9
Building standard	minimisation of heat demand by good insulation: South: 11cm, East/West: 12cm, North: 13 cm	
Heating system	district heating in combination with heat pump, solar panels	District heating

Table 10: The two settlements in comparison

In the second step of our sampling strategy it was necessary to select households in each settlement. The primary aim was to create a representative sample in both housing projects using random selection but due to a very limited willingness to take part in the survey (in both settlements) we had to turn to a convenience sample. Interviewers asked as many as residents as possible. Every resident who was willing to give information was in the sample. The aim was to conduct 50 interviews in each settlement.

5.5 Conducting the Survey

The empirical part of the survey started with some exploratory interviews in order to learn more about the car-free settlement. Interviews have been conducted with the responsible person from the building administration, the chairman of the tenants' board, and with two other residents.

After the completion of the standardized questionnaire a small pilot survey was carried out. In total, five interviews have been conducted in order to test the questionnaire under realistic conditions. The experiences from the pilot survey led to some major changes of the questionnaire.

The interviews in both settlements have been carried out by special trained interviewers. A total number of 9 interviewers have been engaged in the quantitative part of the survey (7 women, 2 men). During the survey three comprehensive interview instructions have taken place.

Before starting to contact people directly we informed residents of both settlements about the survey by mailing and posters. The interviews in the car-free settlement have been conducted during June and July 2004. Due to the length of the questionnaire interviews have taken between 30 minutes and more than one hour. Based on this experience we decided to reduce the questionnaire as much as possible. The second round of interviews in the reference settlement had taken place in September and October 2004. As a result a total of 88 quantitative interviews are available for the data analysis. Finally some qualitative interviews with low-emission households have been carried out to complement our findings and interpretations.

Task	Number of interviews	Period
Exploratory Interviews	4	April 2004
Pre-test	5	June 2004
Interviews car-free-settlement	42	June-July 2004
Interviews reference settlement	46	Sept.-October 2004
Qualitative Interviews	4	November 2004

Table 11: Main steps of the survey

6 Results

6.1 Two Viennese settlements by comparison

Both samples are showing a very similar socio-economic structure. The households in both groups are of similar size, the level of education is far beyond the Viennese average, and also the available living space is of similar dimension. Due to the fact that both settlements are relatively new and located in the same district of Vienna it is not astonishing that the selected settlements are inhabited by people with similar socio-cultural background. We are concerned with rather homogenous social milieus.

In both settlements – in the car-free and the reference project – the average household size is clearly above the Viennese average. Although large volume housing projects at the periphery typically attract young families this is only partly true for our cases. In the car-free settlement as well as in the reference project nearly every second household is childless. Every fourth household in the car-free project is a single household. Just as many households are inhabited by only two persons. All in all it seems that there are slightly more larger families and in total more children in the reference settlement than in the car-free project. Nevertheless, in comparison to the Viennese average in both samples we find much less singles and more families with children.

Respondents in both samples are much better educated that the Viennese population. Especially in the car-free settlement there is an extremely high percentage of people with an university degree, with nearly 50% of the residents. The concept of the project – to organise mobility without private car – was obviously attractive for persons with high formal qualifications in particular. According to the high level of education people in both settlements are working in white-collar jobs. Males could be often find in trendsetting industries like IT or in the educational sector, e.g. as scholars at the university. Many of the female occupants are working as schoolteachers, in the consultation service or in the health care system.

Given the high percentage of well educated persons in both samples it is notable that the average family income in the selected settlements is only a little bit above the Viennese average. In relation to the number of persons per household it is even clearly below this reference. Moreover there are in both samples large differences between high and low-income households. Families with very different financial resources are living next to each other.

The size of the flats is ranging between 50 and 130 sqm. The average size in the car-free project is 86 sqm, compared to 82.6 sqm in the reference project. Similar to the financial situation of the households in both projects flats are larger compared to the Viennese-wide average (70 sqm), per capita the living space is below average. In the car-free settlement on average 33.50 sqm living space is available per person, compared to 30 sqm in the reference settlement. In other words the average “consumption” of living space in the reference project is 10% below the car-free settlement and even 20% below the Viennese average.

	Car-free project	Reference settlement	Vienna average
Size of household			
average size of household	2.57	2.76	1.96
average number of children per household	0.67	0.91	0.55
households with 1 person	26.2%	15.2%	38.8%
households with 2 persons	26.2%	34.8%	32.7%
households with 3 and more persons	47.6%	50.0%	28.5%
households with no children	57.1%	52.2%	64.5%
households with 1 child	21.4%	10.9%	20.4%
households with 2 children	19.0%	30.4%	11.9%
households with 3 children	2.4%	6.5%	2.6%
households with 4 or more children	0	0	0.7%
Occupation			
white-collar worker	52.40%	52.20%	
blue-collar worker	8.70%	2.50%	
civil servant	14.30%	6.50%	
self-employed	2.40%	4.30%	
Retired	11.90%	6.50%	
in-training	7.10%	8.70%	
Unemployed	4.80%	4.30%	
Education			
secondary school	7.20%	8.70%	33.24%
vocational school	4.80%	15.20%	28.60%
technical school	4.80%	10.90%	10.56%
A-levels	38.10%	39.10%	15.76%
university degree	45.20%	23.90%	11.84%
Average annual net income (Euro)	32.282	30.867	28.320
minimum (Euro)	9.100	7.000	
maximum (Euro)	72.800	75.000	
Average annual net income per capita (Euro)	12.560	11.180	19.720
minimum (Euro)	5.250	2.333	
maximum (Euro)	36.400	37.500	
Average size of flat (sqm)	86.00	82.60	70.90
Average size per person (sqm)	33.50	30.00	36.20
minimum (sqm)	50	47	
maximum (sqm)	130	107	

Table 12: Summary of selected socio-economic attributes

Table 13 shows a variety of selected household equipment for both samples. With a few exceptions, households in the reference settlement are to a greater extent equipped with electronic appliances; mainly a higher share of TVs and more kitchen equipment. Households in the car-free project are particularly less interested in things like TV sets or microwaves, whereas personal computers and internet connections are available in both samples to a large extent. All in all the differences regarding direct household equipment are not that significant.

Completely different is the situation concerning private means of transport. As expected the biggest difference between both groups refers to car ownership. We found only one out of 42 households (2.4%) in the car-free settlement with a privately owned car. (This is possible because under specific conditions it is allowed to own a car in the settlement, e.g. professional reasons or specific disabilities. The interviewed administrator of the car-free building has assumed that up to 10% of all households have a car.). In contrast two-thirds of all reference households have at least one car, 11% with even two or more. In both samples households are well equipped with bicycles. On average almost every member of the household has a bike. Car-free households have slightly more bikes, but the difference is not significant at all.

Selected equipment	Car-free project	Reference settlement
Dishwasher	85.7%	91.3%
Washing machine	85.7%	93.5%
Dryer	9.5%	6.5%
Electric range	100.0%	98.0%
Microwave	35.7%	69.6%
TV set (average number)	0.93	1.24
none	19.0%	6.5%
one	69.0%	69.6%
two and more	11.9%	23.9%
Personal computer (average number)	1.02	1.09
none	16.7%	13.0%
one	69.0%	67.4%
two and more	14.3%	19.6%
Internet	73.8%	76.1%
Private car	2.4%	67.4%
second car	0.0%	10.9%
Motorcycle	0.0%	10.9%
Bicycles (average per household)	2.7	2.5

Table 13: Selected household appliances and transport vehicles

Car-free households spend on average 33% more for their heating and warm water demand per sqm than households in the reference settlement (see table 14). Regarding the electricity demand the situation is contrary. The average electricity bill in the reference settlement is about 28% higher than in the car-free settlement. This result is explained by the fact that these households are equipped with more electrical devices. In total, car-free households have to spend 11% more for both forms of energy. This is due to the fact, that in the car-free settlement heating and warm water are provided by three different sources (district heating, heat pump and solar collectors). Because of transaction costs, the price per kWh is above the price for district heating only.

Selected energy costs	Car-free project	Reference settlement
Average expenditures for heating and warm water per month (Euro)	79.63	57.55
minimum (Euro)	47.67	23.00
maximum (Euro)	150.00	200.00
Average expenditures for electricity per month (Euro)	31.86	39.37
minimum (Euro)	12.00	13.33
maximum (Euro)	90.00	100.00
Total energy costs per month (Euro)	111.50	96.90
Total energy costs per month and sqm (Euro)	1.30	1.17

Table 14: Energy costs

As expected the results for transport and mobility show significant differences between the two settlements. Car-free households use public transport instead of the automobile; whereas in the reference households the car is the most important means of transportation. Regarding air trips both groups are on a similar level, indeed car-free households exceed the reference group, in number of flights as well as in average mileage. However, the overall distance of the average car-free household – covered by car, train, and aeroplane – was clearly below the reference group. While car-free households covered an average distance of about 9,400 km, the distance for reference households was more than 17,000 km.

Selected types of transport	Car-free project	Reference settlement
by car		
households with 0 km in 2003	59.5%	27.3%
total (all households) in 2003 (km)	(42 hh) 23.778	(46 hh) 505.018
therefore by car-sharing	8.778	4.240
average distance per household in 2003 (km)	566	10.979
by train		
total (all households) in 2003 (km)	77.600	5.700
average distance per household in 2003 (km)	1.848	124
by airplane		
share of households without flights in 2003	42.9%	52.2%
total (all households) in 2003 (km)	291.800	286.900
average distance per household in 2003 (km)	6.948	6.237
total distance by car, train, airplane per household (km)	9.362	17.340

Table 15: Selected information on transport (does not include commuting by public transport or walking/biking)

In the car-free settlement cars play indeed a very limited role to meet private transport needs – therefore residents cope well with aim and label of the project. Six of ten car-free households did not use a car in 2003 at all. As already mentioned, only one of 44 households owns a car. This household alone is responsible for more that 60% of total car mileage in the car-free settlement. The remaining mileage was covered with car-sharing or rental cars. The most important reason to use a car is to do a bigger purchase, e.g. people use a car to carry furniture. The situation is quite different in the reference project. Most of these households own at least one private car which is the major means of mobility of the family. On average each household in the reference settlement covers a distance of 11,000 km per year. The reference value in the car free settlement is with about 570 km extremely low.

Table 16 shows a comparison of selected food consumption. According to these results car-free households spend much more for vegetables that the households in the reference settlement, but slightly less for meat. Thus the diet in the reference settlement is closer to the typical Austrian food consumption pattern. However, in both groups households spend more money for vegetables that for meat. Aside from this general difference regarding vegetable and meat consumption we found similar consumption structures. In both groups approximately one third of consumed vegetables are locally grown (close to Vienna) and nearly two-thirds are organic. Vegetables from abroad are of little importance in both settlements. Most of the consumed meat is fresh and not frozen. Moreover, in both settlements meat is bought to a large extent from organic farmers.

Selected food consumption	Car-free project	Reference settlement
Average expenditures for vegetables per week (Euro)	30.40	18.40
of which locally grown	32%	36%
of which overseas	5%	3%
of which frozen	16%	23%
of which organic	62%	62%
Average expenditures for meat per week (Euro)	11.60	15.40
of which local grown	20%	21%
of which overseas	1%	0%
of which frozen	4%	4%
of which organic	63%	51%

Table 16: Food consumption

In a previous post-occupancy evaluation of the car-free settlement, conducted 18 months after opening (Gutmann and Havel 2000), the tenants were asked among other things about their motivation to move to the car-free settlement[9]:

The most often mentioned motive was the “offer of common social and green areas above average” (56%), which was followed by three other nearly equally important reasons: “acceptable price-performance relationship” (53%), “ecological concept/application of the alternative energy” (53%) and “car-free housing” (53%).

[9] The question: “What were the most important reasons for renting an apartment in the car-free settlement?” From 10 given options 5 had to be chosen.

Regarding the car-free feature it is surprising that for almost half of the car-free feature was not a significant motivation. This can be explained by the fact, that most of them had no car when they decided to move, or planned to dispose of it; and therefore the car-free feature of the settlement was taken as given. Another surprise was the relatively high evaluation of the location (41%) – the 21st district –, which can be explained by the proximity to the popular recreation area (Alte Donau – a sidearm of the Danube River), despite cumbersome public transport connections.

Other relevant factors have been: communication and community/companionship (41%) (preferred mainly by couples with children), and a good floor plan of the apartments (32%). The urgent need for housing was not a very important factor (28%), i.e. for many it was a long-planned decision to move. Participation was an important factor for 28% of the inhabitants. 71% of those, who prefer participation, belong to the socially and culturally active tenants. The architecture of the settlement was only for 21% an important factor.

Table 17 shows selected results from our survey. (This ranking results from a list of various motives. Each issue had to be rated. The figures are showing combined results for very important and rather important.) Similar to the post-occupancy evaluation the location close to the “Alte Donau” is still very important for respondents in the car-free settlement, ranked with 85% at the first place of all motivations. Although the reference settlement is not that near to that popular recreation area, this aspect of the settlement location was an important reason to chose the “Frauen-Werk-Stadt” as well (5th place in the reference ranking). Even more important than in the post-occupancy evaluation the respondent of our survey highly ranked the generous provision of common areas (indoor and outdoor) and common facilities. This special feature of the car-free settlement was possible because of a significant reduction of parking space. The car-free project therefore was and is still especially attractive for people who have been living without a car for many years. Although the reference project is equipped to a large extent with similar common facilities, occupants did not mention this fact as an important motivation. Only 17% of all respondents of the reference settlement have ranked common facilities as very or at least rather important.

The ecological aspects of the car-free settlement are still seen as one of the important reasons to settle in that project. Nearly 60% say it was important to move to an ecological building. However, in comparison to some other reasons, concerning the location of the building and the quality of the apartment (healthy environment, no noise pollution, and sunny apartment), ecology is less of a priority.

In contrast, in the reference settlement “traditional” motivations for moving are dominant. Respondents live here mainly because their need for living space had increased in the last years or because they have found an apartment with a good fitting floor plan. But there are also some similarities between those two groups. To live in a healthy and quiet environment are very often mentioned reasons in both settlements.

Five most important motivations	Car-free project	Reference settlement
Ranking for the car-free project		
1. recreation area “Alte Donau”	85%	58%
2. generous common areas and facilities	81%	17%
3. to live in a ”green“ and healthy environment	73%	61%
4. quiet site/no noise pollution	71%	61%
5. bright, sunny apartment	68%	54%
Ranking for the reference settlement		
1. need for more living space	44%	63%
2. good floor plan	46%	61%
3. to live in „green“, healthy environment	73%	61%
4. quiet site/no noise pollution	71%	61%
5. recreation area “Alte Donau”	85%	58%

Table 17: Motivations to move to the settlement

6.2 Environmental impact of household consumption

The evaluation of emissions based on bottom up calculations for the two settlements in table 18 indicates that in some categories, the car-free settlement has lower per capita environmental impacts, while in other categories the reference settlement is better. The difference is never more than 20%. For all indicators, the average Austrian household has higher impacts, and it also has higher expenditures. Please note that the numbers for toxic waste generation and energy use are somewhat more uncertain than the other numbers. The data for primary energy use for the energy and transport categories was estimated. The assessment of toxic waste was based only on the IO table. Because of uncertainties in the emissions factors used in connection with the IOA and the data in the underlying LCA, the emissions estimates for AO_X, COD, and NOx are more uncertain than those for CO_2, which can be calculated quite accurately from a carbon balance.

	CO_2 [t]	NO_x [kg]	COD [kg]	AO_X [g]	Toxic waste[kg]	Energy [GJ]	Expenditure [k€]
Car-free	**4.2**	**14**	**10**	**15**	**61**	**75**	**12.7**
Reference	**4.5**	**13**	**9**	**13**	**54**	**80**	**11.2**
Average	**7.0**	**16**	**11**	**16**	**72**	**101**	**14.3**

Table 18: Comparison of per capita household environmental impact and expenditure between the two settlements and the average Austrian

We put most effort into understanding the CO_2 emissions, because global warming is probably the most important impact connected to household consumption. For the other impact categories, a substantial portion of the impact is due to the expenditures not tracked in the survey, i.e. from the input-output analysis. These numbers are only indicative and strictly proportional to the expenditure level. Figure 7 shows a comparison of the two settlements and the Austrian average using the categories we have distinguished in our calculations. The households in the car-free settlement have lower CO_2 emissions. The difference is even larger when one looks at CO_2 emissions per Euro spent. Households in the car-free settlement have a somewhat lower share of transportation (35%, versus 44% for the reference settlement and 42% for the average Austrian household). In the car-free housing project, the emissions associated with energy are 25% lower than in the reference settlement, because there households use 30% less electricity and have more subscribers of green electricity, which causes only 10% of the emissions of the grid-average. The emissions related to energy are much lower in the two Viennese settlements than in Austria on average. This is related to the use of district heating for heating and hot water. Since waste incineration, an important heat source in Vienna, is treated as "carbon neutral," the CO_2 emissions are much lower than those from oil and natural gas combustion, the most important heating fuels in suburban and rural areas.

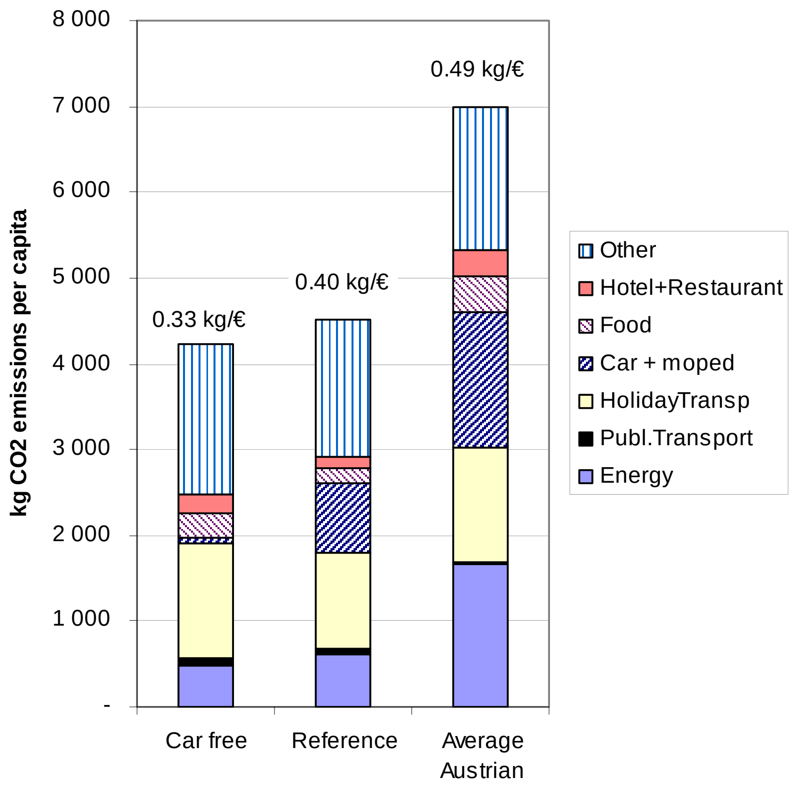


Figure 7: Per capita CO_2 emissions calculated according to the bottom up approach for the two settlements in comparison with the average Austrian

The study shows that the two reference settlements are indeed fairly similar. This was of course part of the study design. The aspect in which they differ is the car-free feature. It was our hypothesis that this would extend to other areas of behaviour as well. Although tenants in the car-free settlement show environmental awareness on a much higher level, ecological sound behaviour is more or less restricted to every day transport (extensive use of bicycles and public transport for daily needs), and does not apply, e.g. for air trips. Since we did not find a difference in the consumption of organic food, which was high in both settlements, we did not further investigate behaviour not related to energy use and transportation. The overall differences between the settlements in CO_2 emissions and energy use are small, and much lower than the variations inside the settlements. This may come as a surprise, but this result is not that difficult to explain.

- For the car-free settlement, 53% of the emissions are estimated from the IOA, i.e. it belongs to the categories food, hotels and restaurants, and 'other.' To estimate the 'other' emissions, we just used a typical expenditure pattern as derived from the consumer expenditure survey. Any systematic variation in these expenditures is not covered by our assessment. In the categories assessed by LCA, the reference settlement had 33% higher CO_2 emissions per capita than the car-free settlement.
- The rebound effect is important (Hertwich 2005). It is assumed here that everybody spends their income; any money saved by not owning a car goes to some other purpose. The "other" category has only 14% of the emissions intensity of cars (Table 19), but this is more than 0. If the money saved is spent on air transport, much higher emissions can result. As far as we could determine, these households eat more out and have a higher consumption in the 'other' category.
- For the car-free settlement, air transport accounts for 64% of the CO_2 emissions associated with energy and transport. For the reference settlement, this number is only 43%. The per capita CO_2 emissions of energy and transport not considering air transport are 720 kg in the car-free settlement and 1500 kg in the reference settlement. The car-free settlement has a lower emissions intensity in holiday transport, because of the use of trains and buses. This is not because the households do not use airplanes; in fact they travel slightly more by airplane than the reference settlement.

	Energy	Public Transport	Holiday Transport	Car moped	Food	Hotel Restaurant	Other	Total Average
Car-free	**0.96**	**0.35**	**4.50**	**0.54**	**0.24**	**0.18**	**0.19**	**0.33**
Reference	**1.50**	**0.47**	**7.37**	**1.45**	**0.24**	**0.18**	**0.19**	**0.40**
Average	**3.08**	**0.40**	**6.52**	**1.49**	**0.24**	**0.18**	**0.19**	**0.49**

Table 19: CO_2 emissions intensity in kg CO_2/€.

Past investigations of energy use and of CO_2 emission of household based on CES have shown that both variables are a strong function of income (Herendeen 1978; Herendeen and Tanaka 1976; Wier et al. 2001). Income elasticities of energy use are commonly between 0.6 and 0.9 (Hertwich 2004). This result may to a certain degree be a modelling artefact, because indirect energy use and emissions were mostly determined with IOA and are hence naturally correlated with the expenditure level. Environmental differences between e.g. buying on luxury car or two inexpensive family cars at the same cost cannot be distinguished. Similarly, spending more money on buying organic food results is modelled as resulting in higher impacts compared to buying the same products from conventional consumption. This problem of course also affects our study. The relationship between CO_2 emissions and household environmental impacts still provides some interesting insights.

Figure 8a indicates that in our two samples, there is a fairly wide scatter of CO_2 emissions especially for higher income. The situation changes when we subtract out air transport, as Figure 8b shows. There is a high correlation between income and CO_2 emissions for the two groups that do not own a car. The income elasticities are similar, 0.88 and 0.82, as the power-law fit in Figure 8b shows. For the car-owning tenants of the reference settlement, however, the correlation is much lower and the elasticity is only 0.44. Table 19 indicates the CO_2

intensity of the different categories investigated. It shows that many categories have a similar CO_2 intensity. Only those items with intensities significantly different from the average can cause substantial deviations from a linear relationship between expenditure and CO_2 emissions. These are for our two samples air flights, energy, and car use. The physical infrastructure of the buildings conditions the energy use, so that only car use and air planes contribute to a substantial difference among the samples. There seems to be no correlation between car use and income in the reference settlement.

Looking at our whole sample, there is little correlation between income and air transport (r^2=0.03) and absolutely no correlation between the CO_2 emissions of ground transport and air travel. In our sample, there is hence no indication that the money saved from not owning a car is systematically diverted to air travel.

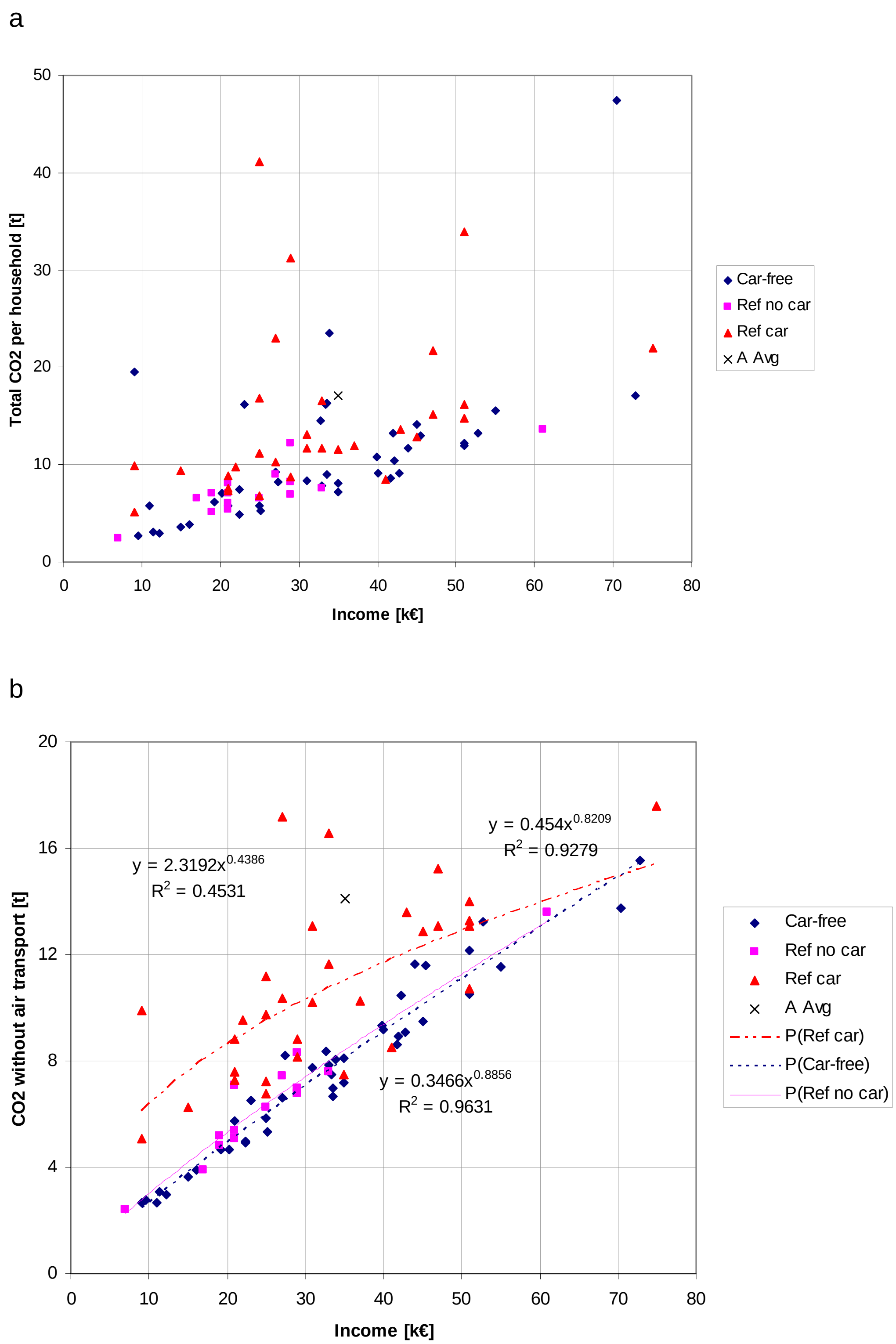


Figure 8: Total CO_2 emissions per household, (a) with and (b) without air transport, as a function of household income. For the reference settlement, we distinguish between households with and without cars

6.3 Social causes of consumption

One of the central hypotheses of this study was that there is a kind of social dynamic within sustainable consumption projects – like the car-free settlement in Vienna – which contributes to lower emissions per household (or person) compared to similar settlements without such a thematic focus. The calculation of CO_2 emissions per household shows, that the emissions in the car-free settlement are in fact lower than in the reference settlement. Per capita the difference is 9%. In consideration of person equivalents the emissions of the car-free project are even about 11% lower.

As expected the lower overall emissions in the car-free settlement are mainly caused by very low car emissions. However, table 20 shows that differences between the two settlements are very different for other main sectors of consumption. Households in the car-free settlement show lower emissions per capita in only two areas: car mobility and energy demand (heating, warm water, electricity). In all other areas (like public transport, air traffic, food, hotel and restaurant and others) CO_2 emissions are lower in the reference settlement. While lower emissions regarding energy consumption in the car-free settlement are mainly caused by the purchase of green electricity, the main reduction of CO_2 emissions are due to changed mobility patterns. Therefore social and institutional differences between the two selected settlements should first of all be discussed in order to explain the car-free status.

Selected areas of consumption	Car-free project	Reference settlement
	in kg CO_2 per capita	
Energy (heating, warm water, electricity)	489	620
Public transport	88	62
Holiday transport (mainly airtravel)	1,336	1,119
Car, motorbike, etc.	57	817
Food	292	163
Hotel and restaurant	212	128
Other	1,730	1,615
total	4,202	4,524

Table 20: CO_2 Emissions per person equivalent in selected areas

One of the obvious advantages – from an ecological point of view – of the car-free project is the availability of sustainable consumption services offered in easy reach in the settlement. Above all there are some car-sharing automobiles on the site, there is plenty and easy accessible space for bicycles and special facilities to service bikes. In addition different suppliers of organic food offer special prices for delivery directly to the settlement.

In which way and to what extent do these offers influence the consumption behavior in the settlement? What differences can we find when we compare the two selected settlements?

We know from some of the qualitative expert interviews that car-sharing in the car-free project was less “successful” than the car-sharing company has expected in the beginning. They started with five cars, but due to little interest the company had to reduce the number to three. The results from the survey could also be interpreted in this way. Only 41% of all respondents have used car-sharing during the studied period, the year 2003 and covered an average distance of about 600 km. Although it is very easy to rent a car in the car-free settlement, tenants use this offer quite hesitantly. Most car-free households cover their mobility needs by means of public transport and bicycle. In comparison to this only 7% of households in the reference settlement (without car-sharing facility) have used car-sharing in 2003. Having in mind that 33% of the reference households do not have a car, it is likely that an improved accessibility to car-sharing in this settlement and in an average standard settlement would increase the use of car-sharing.

Another important point is the use of bicycles for daily mobility needs. According to our results it is clear that bicycles are a major means of transportation in the car-free settlement; and the existing facilities support this mode of transport to a certain extent. Easy access to and space for bikes were already important topics during the planning process of the building. Future tenants have argued for additional bicycle sheds – against the landscape planner's initial concept – and finally succeeded. Although households in both settlements are quite well equipped with bicycles (with approximately one bike per person), the use patterns differ significantly. While in the car-free project 36% of all respondents have used their bicycle on more than 200 days in the year 2003, only 9% showed the same extensive bike use in the reference settlement.

Despite this large difference it is difficult to assess the role of the bike-friendly facilities. Those conditions are important, but perhaps only a part of the overall setting. It seems that many people, when they move to the car-free settlement, change their mobility habits. For example, 41% of the respondents say that they have started to use their bicycle much more often than before (reference settlement: 22%). In one of the interviews this change is described in the following words:

> *"…it is because of this settlement that I am living again in a bicycle-friendly environment. When I came here, I have bought a new bike, and I use it a lot. I was used to do things this way many years ago, than I had no bike for about 10 years. Since I moved here, I starting using my bike for many different trips"* (interview 1).

In both projects it was possible for future tenants to participate in the planning process to a certain extent. In the car-free project the participation process was much more comprehensive and more people have been involved. These differences are also reflected by the results of our survey: 45% of the interviewed car-free households but only 11% of the reference households have participated.

In the adjoining neighborhood the tenants of the car-free settlement are often labeled as "eco cranks"; mainly because they try to live without car. But what do tenants themselves think about the ecological awareness in the car-free settlement? Most of the respondents think that there are much more eco friendly people in the car-free settlement than in similar settlements in Vienna. In contrast to that only a minority in the reference settlement feels confident with this statement. Differences between the two settlements in behaviour are also indicated in the importance of waste separation and green consumption as a topic of daily conversations in the settlement. One third of all respondents in the car-free settlement think that green consumption is a relevant and frequent topic. In the reference settlement only one of all interviewed persons (46) shares that opinion. What we therefore can conclude is that there is a clear difference in the perception of the general ecological awareness in both settlements. Ecological awareness plays a more important role as part of the social norms and thus acts as reinforcing certain behaviours in the car-free settlement than in the reference settlement.

	Car-free project	Reference settlement
Statements	Very and fairly true	
In this settlement we have much more eco friendly people than in similar settlements	92%	27%
Waste separation is very important in this settlement	44%	20%
Green consumption is an important topic of conversation in this settlement	34%	2%

Table 21: Ecological awareness in the settlement

Another important element of the social conditions within groups and more specifically a settlement is social control. For our problem it was important to measure forms of social control regarding the ecologically relevant behavior. Here the relevant question is as follows: To what extent do tenants recognize how other people in the settlement live? We have used several items to measure this question. In all cases the results show clear differences between the two settlements. In the car-free settlement the share of well informed tenants is much higher than in the reference group. Although it seems that social control is not a big issue in general. With one exception: Due to the important role of private car (non)use in the car-free settlement, every second respondent believe that it would not be possible for tenants to buy a car without everybody knowing it.

	Car-free project	Reference settlement
Statements	Very and fairly true	
Everybody knows everthing about other people in the settlement	24%	19%
Sometimes I observe that neigbours do not seperate their waste	26%	11%
If somebody from the settlement buys a new car, everybody will know it	49%	5%

Table 22: Social control regarding ecological behavior

Although both case settlements have been developed around a specific theme, car-free living versus for women-designed housing, the identification with the settlement seems to be much higher in the car free project. Eight of ten respondents in the car-free settlement think that “many tenants are proud to live especially in the car-free settlement”. In comparison, in the reference settlement only three out of ten respondents think that this view is shared by their neighbours. This is further exemplified with the following statements:

	Car-free project	Reference settlement
Statements	Very and fairly true	
Many tenants are proud to live in our settlement	82%	29%
Compared to other new settlements in the neighbourhood our settlement is very special	72%	36%

Table 23: Identification with the settlement

With regards to social cohesion the comparison between the two settlements shows also significant differences: While most of the respondents in the car-free settlement are convinced that social cohesion is very strong in their neighbourhood, in the reference settlement only a minority believes this to be true. Similarly, more than eight of ten car-free tenants think that "the solidarity within the settlement is very strong", that "there is a good neighbourhood atmosphere" and that it is "very common to help each other". Only this last point regarding the helpfulness in the settlement seems to be of some relevance in the reference settlement as well.

	Car-free project	Reference settlement
Statements	Very and fairly true	
The solidarity within the settlement is very strong	87%	24%
There is a very "good heighbourhood" in this settlement	85%	18%
To help each other is very common in this settlement	85%	47%

Table 24: Social cohesion in the settlement

We know from some of the qualitative interviews that there is a very active community in the car-free settlement. Every year there are some self-organised festivities and flea markets in the courtyard. Moreover most of the common facilities in the car-free settlement are managed by some residents themselves. Therefore it is not surprising that all respondents (100%) in the car-free settlement say that there are "many joint activities for all residents." In the reference settlement only one out of ten describes the social live in the immediate neighbourhood according to this statement. In general, residents in the car-free settlement maintain much more social contacts to neighbours within the settlement. On average respondents in the car-free settlement estimate that they have 16 friends in the settlement and know more than 100 by sight, compared to 7 friends and 62 known neighbours in the reference settlement. In the car-free settlement it is also more likely that people did know some residents before they moved in.

	Car-free project	Reference settlement
Questions	Number of people (average)	
How many people in the settlement would you call "friends"?	16	7
How many people did you already know bevor you moved to this settlement?	2,7	0,2
How many residents do you know by sight?	101	62

Table 25: Social contacts within the settlement

Finally there are also clear differences between the two settlements regarding the possibilities and ease to get information on ecological issues. Respondents in the car-free settlement are more or less in complete agreement that it is easey to get information on ecological consumption in the settlement. Most of this information is provided by residents which are active in various initiatives (outside the settlement). Most residents are registered on the internal mailing list that works as an effective means to spread information to most of the neighbours. One third of the respondents in the car-free settlement think that ecological consumption is an important topic of conversation. After all three out of ten respondents stated that ecological questions are often on the agenda in conversations with neighbours. The situation in the reference settlement is completely different. The neighbourhood is not seen as a source of ecological relevant information at all.

	Car-free project	Reference settlement
Statements	Very and fairly true	
It's easey to get information on ecological consumption in the settlement	87%	0%
Ecological consumption is an important topic of conversation in the settlement	34%	2%
Ecological questions are often on the agenda in conversations with my neighbours	29%	2%

Table 26: Information about ecological consumption in the settlement

As we have learned from the above presented results resondents describe their settlements in very different terms. The car-free settlement seems to be a kind of small village within the city: a village where people know each other, a place with a colourful social life, and with plenty ecologically aware residents. In contrast to that description the reference settlement seems to be a typical Viennese settlement: It is a nice place to live but the neighbourhood feeling is not dominant in any way. One can enjoy urban anonymity, if desired. But is there an empirical relationship between those diverse social conditions in the settlements and the ecological impact of households? Table 27 indicates that there is in fact a correlation between the perception of the "social live" in the settlement and the ecological impact; even if it is not the overall CO_2 emission which could be explained by settlement attributes. But there is a notable statistical relationship between ecological awareness, social control in the neighbourhood, social contacts in the settlement, and the availability of ecological relevant information in the settlement and the car mileage per year. On the other hand there is absolutely no correlation between those items and air traffic.

	CO_2 per capita (t)	Air traffic (km)	Car traffic (km)
Settlement attributes		Kendall-Tau-b	
Ecological awareness	-.052	-.150	.305(**)
Social control	.135	.022	.180(*)
Identity	-.022	-.069	.129
Cohesion	.177(*)	-.006	.159
Social contacts	.207(**)	.006	.258(**)
Information	.039	-.105	.339(**)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 27: Correlations between settlement attributes, CO_2 per capita, air traffic, and car traffic

The high empirical variance of CO_2 emissions per capita in both samples is mainly a function of air traffic (Pearsons r= .897). Households with high air traffic mileage score high in CO_2 emissions. It seems that air traffic (measured in km per household) is not dependent on other (observed) variables. It is neither a factor of settlement attributes nor of individualattributes of the respondents. All in all, only few individual factors correlate with measured ecological behaviour. As table 28 shows – similar to community attributes – some empirical interrelations between individual attributes and car use. There is an empirical relationship between ecological awareness concerning traffic and the actual car milage per year. And it seems that households with low car mileage have more friends which do not own a car as well. Other sociological variables, like education, level of information, or specific indicators of ecological awareness, show absolutely no correlation.

	CO_2 per capita (t)	Air travel (km)	Car travel (km)
Attributes and Statements		Kendall-Tau-b	
Education (respondent only)	-.008	.060	-.085
I regularly read articles about ecological issues in newspapers and magazines	-.125	-.088	.081
I am very interested to watch reports on ecological issues in TV and radio	-.022	-.034	.138
Ecological consumption is very important regarding energy	.014	.057	.120
Ecological consumption is very important regarding traffic and mobility	.194(*)	.148	.343(**)
Ecological consumption is very important regarding food	-.078	-.049	.045
Ecological consumption is very important regarding waste	-.074	-.081	.045
Many friends of mine are interested in ecological issues	.027	-.070	.121
Many friends of mine do not own a car	.199(*)	.089	.369(**)
Many friends of mine prefer organic food	.074	-.108	.082

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 28: Correlations between individuell attributes, CO_2 per capita, air traffic, and car traffic

7 Conclusions

Our study indicates that the car-free housing project has indeed lower CO_2 emissions, measured per household, per capita, or per € spent, than the reference settlement. Both settlements have lower emissions than the Austrian average, which can be explained by the lower expenditure and factors connected to larger family size, the use of district heating, and lower mobility needs. Both avoiding car use and purchasing green electricity are effective in reducing the respective CO_2 emissions in the car-free settlement. Due to the importance of air transport and of the residual expenditure categories estimated by IOA, the difference between the two settlements is small. More detailed data on nutrition and other expenditure would be needed to confirm that there is indeed no systematic difference in the remaining expenditure categories.

The results show that there is no empirical connection between income and air transport and absolutely no correlation between the CO_2 emissions of ground transport and air travel. Moreover, there is no indication that the money saved from not owning a car is systematically diverted to air travel. The emissions saved from not using a car are higher than those from buying green electricity.

Moving to the car-free settlement is not the main reason that people do not use a car anymore. Many residents have decided to live without a car long before they moved to the car-free settlement. Nevertheless, the high importance of the issue "car-use" in the car-free settlement, the fact that car mobility is still a very important topic in the settlement contributes to the stabilization of the car-free habit of the tenants. It seems that residents in the car-free settlement have changed their daily mobility routines permanently. In the car-free settlement most of these needs are coverd by public transport and by bicycle. The ecologically conscious micro-culture in the car-free settlement helps to reproduce and stabilize these habits on a daily basis.

Whereas the extremely low car traffic in the car-free settlement could partly be explained by settlement attributes, there is no empirical indication to explain air traffic. In our sample sociological variables, like age, education, income, or personal attitudes do not explain actual consumption patterns. The only exception again is car traffic. People with low car mileage state adequate attitutes, and do have much more car-free friends.

More research is needed to understand the reasons for car-free livestyles in detail. We suppose that households without cars – in car-free settlements but also in standard settlements – run through a kind of "career" from car ownership to public transport and bicycle. Since we are not able to discover significant differences between car-free and car-owning households in our data more qualitative research on this question is needed.

What we also can learn from this investigation for the development and promotion of more sustainable consumption patterns is that there is an urgent need to limit air travel. In addition, households not owning a car have lower CO_2 emissions and energy use. Thus the promotion of such a lifestyle will help to promote and stabilize sustainable consumption patterns.

We have demonstrated that the sustainability of consumption patterns of specific populations can be studied without administering a full-scale consumer expenditure survey, and that interesting results can be obtained. A combination of LCA and IOA is required to study the emissions associated with production and consumption patterns, and the approach should be informed by using available statistical information on household consumption patterns. Improving the sustainability of consumption patterns requires looking at the entire set of consumption patterns and specifically limiting air transport, which is growing at a high rate.

8 References

Adriaanse, A., Bringezu, Stefan, Hammond, A., Moriguchi, Yuichi, Rodenburg, Eric, Rogich, Don, and Schütz, Helmut (1997): Resource Flows, The Material Basis of Industrial Economies. Washington DC: World Resources Institute

Alfredsson, Eva. 2002. "Green consumption: Energy use and carbon dioxide emissions." Pp. 200 in Social and Economic Geography. Umeå: University of Umeå.

Ayres, Robert U. (1978): Resources, Environment and Economics. Applications of the Materials/ Energy Balance Principle. New York: John Wiley & Sons

Ayres, Robert U. and Kneese, Allen V. (1969): Production, Consumption and Externalities. In: American Economic Review 59(3), pp. 282-297

Ayres, Robert U. and Simonis, Udo E. (1994): Industrial Metabolism: Restructuring for Sustainable Development. Tokyo, New York, Paris: United Nations University Press

Ayres, Robert U., Ayres, Leslie W., and Warr, Benjamin (2002): Is the US Economy Dematerializing? Main Indicators and Drivers. Fontainebleou: INSEAD

Baccini, Peter and Brunner, Paul H. (1991): The metabolism of the anthroposphere. Berlin: Springer

Barbiero, Giulia, Camponeschi, Stefano, Femia, Aldo, Greca, Gianna, Tudini, Angeli, and Vannozzi, Miri (2003): 1980-1998 Material-Input-Based Indicators Time series and 1997 Material Balances of the Italian Economy. Rome: ISTAT

Baumann, H., and A.-M. Tillman. 2004. The hitch hicker's guide to lca. Lund: Studentlitteratur.

Beer, T., T. Grant, R. Brown, J. Edgward, P. Nelson, H. Watson, and D. Williams. 2000. Life-cycle emissions analysis of alternative fuels for heavy vehicles. CSIRO Atmospheric Research Report C/0411/1.1/F2. Aspendale, Australia: CSIRO.

Bogeskär, M., A. Carter, C.-O. Nevén, R. Nuij, E. Schmincke, and H. K. Stranddorf. 2002. Evaluation of environmental product declaration schemes. Reference B4-3040/2001/326493/MAR/A2. Brussels: European Commission, DG Environment.

Boustead, I., and G. F. Hancock. 1979. Handbook of industrial energy analysis. Chichester, UK: Ellis Horwood.

Boyden, Stephen V. (1992): Biohistory: The Interplay Between Human Society and the Biosphere - Past and Present. Paris, Casterton Hall, Park Ridge, New Jersey: UNESCO and Parthenon Publishing Group (Man and the Biosphere Series; 8

Brand, I. and Dirks, J. 2003. Pilot Tailoring via Internet, a strategy to promote energy efficiency within Dutch households. NOVEM Netherlands Agency for Energy and the Environment. In: eceee 2003 Summer Study proceedings ISBN: 91-631-4001-2.

Bringezu, Stefan, Schütz, Helmut, and Moll, Stephan (2003): Rationale for and Interpretation of Economy-Wide Materials Flow Analysis and Derived Indicators. In: Journal of Industrial Ecology 7(2), pp. 43-64

Brunner, Paul H. and Rechberger, Helmut (2004): Practical Handbook of Material Flow Analysis. New York: Lewis Publishers

Bullard III, C. W., and R. A. Herendeen. 1975. Energy impact of consumption decisions. Proceedings of the IEEE 63:484-493.

Bullard, Clark and Herendeen, Robert A. (1977): The energy cost of goods and services: an input-output analysis for the USA, 1963 and 1967. In: Thomas, John A. G. (Ed.): energy analysis. Guildford; Boulder, Colorado: IPC Science and Technology Press Ltd., Westview PressBd. 7, pp. 71-81

Castellano, Hercilio (2001): Material Flow Analysis in Venezuela., unpublished

Casler, S. D., and S. Wilbur. 1984. Energy input-output analysis. Resources and Energy 6:187-201.

Cleveland, Cutler J. and Ruth, Matthias (1997): When, Where and by How Much Do Biophysical Limits Constrain the Economic Process? A Survey of Nicholas Georgescu-Roegen's Contribution to Ecological Economics. In: Ecological Economics 22(3), pp. 203-224

Cleveland, Cutler J. and Ruth, Matthias (1999): Indicators of Dematerialization and the Materials Intensity of Use. In: Journal of Industrial Ecology 2(3), pp. 15-50

Commission of the European Communities (2003): Communication from the Commission to the Council and the European Parliament. Towards a thematic strategy on the sustainable use of natural resources. Brussels:

Cumberland, John (1966): A Regional Interindustry Model for Analysis of Development Objectives. In: *Papers of the Regional Science Association* (17), pp. 65-94

Daniels, Peter L. (2002): Approaches for Quantifying the Metabolism of Physical Economies: A Comparative Survey. Part II - Review of Individual Approaches. In: *Journal of Industrial Ecology* 6(1), pp. 65-88

De Bruyn, Sander M. 2000. Economic Growth and the Environment-- An Empirical Analysis. Dordtrecht: Kluwer.

De Haan, Gerhard/Udo Kuckartz: Umweltbewusstsein. Denken und Handeln in Umweltkrisen, Opladen 1996

De Marco, Ottilia, Lagioia, Giovanni, and Pizzoli Mazzacane, Elsa (2000): Materials Flow Analysis of the Italian Economy. In: *Journal of Industrial Ecology* 4(2), pp. 55-70

DETR/ONS/WI (2001): Total Material Resource Flows of the United Kingdom, (revised and updated 2002 by ONS). Department of Environment, Transport and the Regions of the UK, Office for National Statistics of the UK, Wuppertal Institute

Dietzenbacher, Erik (2004): Waste Treatment in Physical Input-Output Analysis, in: International Conference on Input-Output and General Equilibrium: Data, Modelling and Policy Analysis. Brussels, September 2004.

Dryzek, John S.(ed.) (1997): *The Politics of the Earth*. Oxford, USA: Oxford University Press

Duchin, Faye (1992): Industrial Input-Output Analysis. Implications for Industrial Ecology. In: *Proceedings of the National Academy of Science* 89, pp. 1-5

Duchin, Faye (1998): *Structural Economics: Measuring Change in Technology, Lifestyles, and the Environment*. Washington, DC, Covelo, CA: The United Nations University, Island Press

Duchin, Faye (2004): Input-Output Economics and Material Flows. Rensselaer Polytechnic Institute, Department of Economics (Rensselaer Working Papers in Economics; 0424)

Duchin, Faye, and Klaus Hubacek. 2003. "Linking Social Expenditures to Household Lifestyles: The Social Accounting Matrix." Futures 35:61-74.

Duchin, Faye, Lange, Glenn-Marie, Thonstadt, Knut, and Idenburg, Annemarth (1994): *The Future of the Environment. Ecological Economics and Technological Change*. New York - Oxford: Oxford University Press

Ecoinvent, v.1.1. Eco-Invent Centre, Zürich.

Empacher, C. 2000. Zielgruppen oekologischen Konsumverhaltens. Öekologisches Wirtschaften, Ausgabe 2/2000, Berlin: IÖW/VÖW. http://www.isoe.de/ftp/zielgruppen.pdf

ETC-WMF (European topic centre on waste and material flows) (2003): Zero Study: Resource Use in European Countries. An estimate of materials and waste streams in the Community, including imports and exports using the instrument of material flow analysis. Copenhagen: ETC-WMF, prepared by Moll, S., Bringezu, S., and Schütz, H.

Eurostat (2001): *Economy-wide Material Flow Accounts and Derived Indicators. A methodological guide*. Luxembourg: Eurostat, European Commission, Office for Official Publications of the European Communities

Eurostat (2002): Material use in the European Union 1980-2000. Indicators and Analysis. Luxembourg: Eurostat, Office for Official Publications of the European Communities, prepared by Weisz, H., Fischer-Kowalski, Marina, Amann, C., Eisenmenger, N., Hubacek, K., and Krausmann, F.

Femia, Aldo (2000): A material flow account for Italy, 1988. Eurostat Working Paper No 2/2000/B/8. Luxembourg:

Fischer-Kowalski, Marina (1997): Wie erkennt man Umweltschädlichkeit? In: Fischer-Kowalski, Marina et al. (Eds.): *Gesellschaftlicher Stoffwechsel und Kolonisierung von Natur. Ein Versuch in Sozialer Ökologie*. Amsterdam: Gordon & Breach Fakultas, pp. 13-24

Fischer-Kowalski, Marina (1998): Society's Metabolism. The Intellectual History of Material Flow Analysis, Part I, 1860 - 1970. In: *Journal of Industrial Ecology* 2(1), pp. 61-78

Fischer-Kowalski, Marina (2002): Exploring the history of industrial metabolism. In: Ayres, Robert U. and Ayres, Leslie W. (Eds.): *Handbook of Industrial Ecology*. Cheltenham, UK and Lyme, US: Edward ElgarBd. 2, pp. 16-26

Fischer-Kowalski, Marina and Haberl, Helmut (1993): Metabolism and Colonization. Modes of Production and the Physical Exchange between Societies and Nature. In: *Innovation - The European Journal of Social Sciences* 6(4), pp. 415-442

Fleissner, Peter, Böhme, W., Brautzsch, H. U., Höhne, J., Siassi, J., and Stark, K. (1993): *Input-Output-Analyse. Eine Einführung in Theorie und Anwendungen*. Wien, New York: Springer Verlag

Frischknecht, R., N. Jungbluth, and M. Nauser. 2002. Embodied greenhouse gas emissions in switzerland: A case study for the trade with products from the energy and food sector. Ulster, Switzerland: ESU Services.

Gellner, Ernest (1989): *Plough, Sword and Book. The Structure of Human History*. Chicago: University of Chicago Press

German Federal Statistical Office - Statistisches Bundesamt (1995): *Integrated Environmental and Economic Accounting - Material and Energy Flow Accounts.* Wiesbaden: (Fachserie 19, Reihe 5;

German Federal Statistical Office - Statistisches Bundesamt (2000): *Integrated Environmental and Economic Accounting - Material and Energy Flow Accounts.* Wiesbaden: (Fachserie 19, Reihe 5;

Giljum, Stefan (2004): Trade, material flows and economic development in the South: the example of Chile. In: *Journal of Industrial Ecology* forthcoming

Giljum, Stefan, Hubacek, Klaus, and Sun, Laixiang (2004): Beyond the simple material balance: a reply to Sangwon Suh's note on physical input-output analysis. In: *Ecological Economics* 48(1), pp. 19-22

Griffin, James (1976): Energy Input-Output Modeling. Palo Alto: Electric Power Research Institute

Grossman, Gene M. 1994. "Pollution and growth: what to we know?" in The Economics of Sustainable Development, edited by Ian Goldin and L. Alan Winters. Paris: OECD.

Grünbühel, Clemens M., Haberl, Helmut, Schandl, Heinz, and Winiwarter, Verena (2003): Socio-economic Metabolism and Colonization of Natural Processes in *SangSaeng* Village: Material and Energy Flows, Land Use, and Cultural Change in Northeast Thailand. In: *Human Ecology* 31(1), pp. 53-87

Gutmann, R., Havel, M. “Autofreie Mustersiedlung” Wien- Floridsdorf. Sozialwissenschaftliche Dokummentation & Evaluierung. Pilotprojekt. Endbericht 7/2000. Wohnbund. Wien.

Haas, W., Hubacek, K., Hertwich, E., Korytarova, K., Ornetzeder, M., Weisz, H. Approaches for evaluating sustainable consumption initiatives. Final report to the Society for Non-Traditional Technology, Japan. IIASA. Laxenburg. 2004a.

Haas, W., Hubacek, K., Hertwich, E., Korytarova, K., Ornetzeder, M., Weisz, H. Investigating household consumption: Combining quantitative and qualitative methods. Sustainable household consumption: environmental loads, underlying motivation and institutional constraints. In: Proceedings of International Workshop: Driving Forces of and Barriers to Sustainable Consumption. Leeds. 5th and 6th March, 2004b.

Haas, Willi. 2002. "What do social systems consume? A different view on sustainable consumption." Pp. 48-56, in: Life-cycle Approaches to Sustainable Consumption -- Workshop Proceedings, edited by Edgar Hertwich. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Haberl, Helmut, Fischer-Kowalski, Marina, Krausmann, Fridolin, Weisz, Helga, and Winiwarter, Verena (2004): Progress Towards Sustainability? What the conceptual framework of material and energy flow accounting (MEFA) can offer. In: *Land Use Policy* 21(3)

Hammer, Mark and Hubacek, Klaus (2003): Material Flows and Economic Development, Material Flow Analysis of the Hungarian Economy. Laxenburg, Austria: IIASA Interim Report IR-02-057

Hendriks, Carolyn, Obernosterer, Richard, Müller, Daniel, Kytzia, Susanne, Baccini, Peter, and Brunner, Paul H. (2000): Material Flow Analysis: a tool to support environmental policy decision making. Case studies on the city of Vienna and the Swiss lowlands. In: *Local Environment* 5(3), pp. 311-328

Herendeen, Robert A, and Jerry Tanaka. 1976. "Energy Cost of Living." Energy 1:165-178.

Herendeen, R. A. 1978. Total energy cost of household consumption in norway, 1973. Energy 3:615-630.

Hertwich, E. G. 2004. Lifecycle approaches to sustainable consumption: A critical review. *Environmental Science & Technology*:submitted.

Hertwich, E. G. 2005. Consumption & the rebound effect: An industrial ecology perspective. *Journal of Industrial Ecology* 9 (1-2).

Hertwich, E.G., Katzmayr, M. Examples of Sustainable Consumption: Review, Classification and Analysis. IIASA. 2003.

Hertwich, Edgar G, Kristine Erlandsen, Knut Sørensen, Jørgen Aasness, and Klaus Hubacek. 2002. "Pollution embodied in Norway's import and export and its relevance for the environmental profile of households." Pp. 63-72 in Life-cycle Approaches to Sustainable Consumption -- Workshop Proceedings, edited by Edgar Hertwich. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Hertwich, Edgar G., William S. Pease, and Catherine P. Koshland. 1997. "Evaluating the Environmental Impact of Products and Production Processes: A Comparison of Six Methods." Sci. Total Environ. 196:13-29.

Hertwich, Edgar G. 2002. "Life-cycle Approaches to Sustainable Consumption -- Workshop Proceedings, 22 November 2002." Pp. 278. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Hobson, Kersty. 2002. "Competing discourses of sustainable consumption: Does the 'rationalisation of lifestyles' make sense?" Environ. Politics 11:95-120.

Hoekstra, Rutger (2003): *Structural Change of the Physical Economy. Decomposition Analysis of Physical and Hybrid-Unit Input-Output Tables*. Amsterdam: Tinbergen Institute (Research Series;

Hubacek, K., Korytarova, K., Haas, W., Hertwich, E., Ornetzeder, M., Weisz, H. Approaches for evaluating sustainable consumption initiatives. Paper for the 2nd International Workshop on Sustainable Consumption at the Tokyo International Exhibition Center, 12th and 13th December, 2003.

Hubacek, Klaus and Giljum, Stefan (2003): Applying physical input-output analysis to estimate land appropriation (ecological footprints) of international trade activities. In: *Ecological Economics* 44(1), pp. 137-151

Hubacek, Klaus, and Laixiang Sun. 2001. "A scenario analysis of China's land use and land cover change: incorporating biophysical information into input-output modeling." Structural Change and Economic Dynamics 12:367-397.

Hubacek, Klaus, and Laixiang Sun. 2002. "Changes in China's economy and society and its effects on water use." Pp. 87-100 in Life-cycle Approaches to Sustainable Consumption -- Workshop Proceedings, edited by Edgar Hertwich. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Isacsson, Annica, Johnsson, K., Linder, Irene, Palm, Viveka, and Wadeskog, Anders (2000): Material Flow Accounts - DMI and DMC for Sweden 1987-1997. Luxembourg: Eurostat, Office for Official Publications of the European Communities

ISO. 1997. Iso 14040: Environmental management -- life cycle assessment -- principles and framework. Geneva: International Standard Organization.

Janssen, M.A and Jager W. 2002. “Stimulating diffusion of green products: Co-evolution between firms and consumers.” Journal of Evolutionary Economics (2002) 12: 283–306.

Kahneman, D. 1999. Objective happiness, *in:* Kahneman, D., Diener, E., Schwarz, N. (eds.). Well-being – the foundation of hedonic psychology. Russell Sage Foundation. New York.

Kahneman, Daniel, Ed Diener, and Norbert Schwarz (Eds.). 1999. Well-being -- The foundation of hedonic psychology. New York: Russell Sage Foundation.

Kates, Robert W., Clark, William C., Corell, Robert, Hall, J. M., Jaeger, Carlo C., Lowe, Ian, McCarthy, James J., Schellnhuber, Hans J., Bolin, Bert, Dickson, Nancy M., Faucheux, Sylvie, Gallopin, Gilberto C., Grübler, Arnulf, Huntley, Brian, Jäger, Jill, Jodha, Narpat S., Kasperson, Roger E., Mabogunje, Akin, Matson, Pamela A., Mooney, Harold A., Moore III, Berrien, O'Riordan, Timothy, and Svedin, Uno (2001): Sustainability science. In: *Science* 292, pp. 641-642

Kim, Ji-Hyun. 2002. "Changes in consumption patterns and environmental degradation in Korea." Structural Change and Economic Dynamics 13:1-48.

Kletzan, Daniela, Angela Köppl, Kurt Kratena, and Michael Wüger. 2002. "Economic modelling of sustainable consumption patterns for mobility and heating." Pp. 117-132 in Life-cycle Approaches to Sustainable Consumption -- Workshop Proceedings, edited by Edgar Hertwich. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Lenzen, M. 1998. "Energy and greenhouse gas cost of living for Australia during 1993/94." Energy 23:497-516.

Leontief, Wassily (1936): Quantitative input-output relations in the economic system. In: *Review of Economics and Statistics* 18, pp. 105-125

Leontief, Wassily (1941): *The Structure of American Economy*. New York: Oxford University Press

Leontief, Wassily (1970): Environmental Repercussions and the Economic Structure. An Input-Output-Approach. In: *Review of Economics and Statistics* 52(3), pp. 262-271

Machado, J. A. (2001): *Material Flow Analysis in Brazil.*, unpublished

Mäenpää, Ilmo and Juutinen, Artti (2001): Materials Flows in Finland. Resource Use in a Small Open Economy. In: *Journal of Industrial Ecology* 5(3), pp. 33-48

Martinez-Alier, Joan (1987): *Ecological Economics. Energy, Environment and Society*. Oxford: Blackwell

Marx, Karl (1990): *Capital I*. Harmondsworth, Middlesex, England: Penguin Books1

Matthews, Emily, Amann, Christof, Fischer-Kowalski, Marina, Bringezu, Stefan, Hüttler, Walter, Kleijn, René, Moriguchi, Yuichi, Ottke, Christian, Rodenburg, Eric, Rogich, Don, Schandl, Heinz, Schütz, Helmut, van der Voet, Ester, and Weisz, Helga (2000): *The Weight of Nations: Material Outflows from Industrial Economies*. Washington, D.C.: World Resources Institute

Matthews, Emily, Christof Amann, Stefan Bringezu, Marina Fischer-Kowalski, Walter Hüttler, René Kleijn, Yuichi Moriguchi, Christian Ottke, Eric Rodenburg, Don Rogich, Heinz Schandl, Helmut Schütz, Ester van der Voet, and Helga Weisz. 2002. The Weight of Nations: Material Outflows from Industrial Economies. Washington DC: World Resources Institute.

Miller, R. E., and P. D. Blair. 1985. Input-output analysis: Foundations and extensions. Englewood Cliffs, NJ: Prentice-Hall.

Mündl, Andreas, Schütz, Helmut, Stodulski, Wojciech, Sleszynski, Jerzy, and Welfens, Maria J. (1999): Sustainable Development by Dematerialization in Production and Consumption. Strategy for the new environmental policy in Poland. Wuppertal Institute for Climate, Energy and Environment, 4-89

Munksgaard, Jesper, Klaus Alsted Pedersen, and Mette Wier. 2000. "Impact of household consumption on CO_2 emissions." Energy Econ 22:423-440.

Muukkonen, J. (2000): TMR, DMI and material balances, Finland 1980-1997. Luxembourg: Eurostat, Office for Official Publications of the European Communities

Nussbaum, Martha C, and Amartya Sen. 1993. The Quality of Life. Oxford: Clarendon.

OECD (1994): *Environmental indicators. Core set.* Paris: OECD

Pedersen, Ole G. (2002): *DMI and TMR for Denmark 1981, 1990, 1997. An assessment of the Material Requirements of the Danish Economy*. Statistics Denmark

Peters, G., and E. G. Hertwich. 2004. Production factors and pollution embodied in trade: Theoretical development. 2004/5. Trondheim: Norwegian University of Science and Technology, Industrial Ecology Program.

Proops, John L. R. (1977): Input-output analysis and energy intensities: a comparison of some methodologies. In: *Applied Mathematical Modelling* 1(March), pp. 181-186

Prose, Friedemann/Wortmann, Klaus: Energiesparen: Verbraucheranalyse und Marktsegmentierung der Kieler Haushalte (Endbericht), Stadtwerke, Kiel 1991 (http://www.nordlicht.uni-kiel.de/welsko.htm., 9th of February 2004)

Rapera, Cora L. (2004): *Southeast Asia in Transition. The Case of the Philippines 1981 to 2000. Part 1*. Laguna: SEARCA Publishing

Redelmeier, D. A., J. Katz, and D. Kahneman. 2003. Memories of colonoscopy: A randomized trial. 104 (1-2):187-194.

Rohracher, Harald, and Michael Ornetzeder. 2002. "Contextualising green buildings: Improving Social learning processes between users and producers." Built Environment 28.

Rölle, Daniel, Christoph Weber, and Sebastian Bamberg. 2002. "Neue Mobilität am neuen Wohnort? Individuelle Informationen nach dem Umzug als Beitrag zu einer nachhaltigen Mobilität." Pp. 389-401 in: Nachhaltiger Konsum: Auf dem Weg zur gesellschaftlichen Verankerung, edited by Gerhard Scherhorn and Christoph Weber. Munich: ökonom verlag.

Rønning, A., K. Magnussen, and I. S. Modahl. 1999. A life over 365 days: Co2 balance and human life-cycle. OR 04.99. Fredrikstad, Norway: Østfold Research.

Scasny, Milan, Kovanda, Jan, and Hak, Tomas (2003): Material flow accounts, balances and derived indicators for the Czech Republic during the 1990s: results and recommendations for methodological improvements. In: *Ecological Economics* 45(1), pp. 41-57

Schandl, Heinz and Schulz, Niels B. (2002): Changes in United Kingdom´s natural relations in terms of society's metabolism and land use from 1850 to the present day. In: *Ecological Economics* 41(2), pp. 203-221

Schandl, Heinz, Grünbühel, Clemens M., Haberl, Helmut, and Weisz, Helga (2002): Handbook of Physical Accounting. Measuring bio-physical dimensions of socio-ecomonic activities. MFA - EFA - HANPP. Vienna: Federal Ministry of Agriculture and Forestry, Environment and Water Management, 1-75

Schandl, Heinz, Grünbühel, Clemens M., Thongmanivong, Sithong, Pathoumthong, Bounnam, and Inthapanya, Phousy (2004): *National and Local Material Flow Analysis for Lao PDR.* Laguna: SEARCA Publishing

Schandl, Heinz, Weisz, Helga, and Petrovic, Brigitte (2000): Materialflussrechnung für Österreich 1960 bis 1997. In: *Statistische Nachrichten* 55 (NF)(2), pp. 128-137

Scherhorn, Gerhard, and Christoph Weber (Eds.). 2002. Nachhaltiger Konsum: Auf dem Weg zur gesellschaftlichen Verankerung. Munich: ökonom verlag.

Schwarz, N., and F. Strack. 1999. Reports of subjective well-being: Judgmental processes and their methodological implications. In Well-being -- the foundation of hedonic psychologyedited by D. Kahneman, E. Diener and N. Schwarz. New York: Russell Sage Foundation.

Schweimer, G. W., and M. Levin. 1999. Sachbilanz des golf a4. Mit bilanzplänen und ergebnistabellen. Z 99.519.501.00. Wolfsburg: Volkswagen.

Segal, Jerome M. 1998. "Consumer expenditures and the growth of need-required income." Pp. 176-197 in The Ethics of Consumption: Good Life, Justice, and Global Stewardship, edited by David A Crocker and Toby Linden. Lanham: Rowman & Littlefield.

Sen, Amartya. 1998. "The Living Standard." Pp. 287-311 in The Ethics of Consumption: Good Life, Justice, and Global Stewardship, edited by David A Crocker and Toby Linden. Lanham: Rowman & Littlefield.

Sieferle, Rolf P. (1997): *Rückblick auf die Natur: Eine Geschichte des Menschen und seiner Umwelt*. München: Luchterhand

Singh, Simron J. (2003): *In the Sea of Influence: A World System Perspective of the Nicobar Islands*. Lund: Lund University (Lund Studies in Human Ecology 6;

Smeets, Edith and Weterings, Rob (1999): Environmental indicators: Typology and overview. Copenhagen: 1-19

Suh, Sangwon (2004): A note on the calculus for physical input–output analysis and its application to land appropriation of international trade activities. In: *Ecological Economics* 48(1), pp. 9-17

Thøgersen, John, and Folke Ölander. 2002. "Human values and the emergence of a sustainable consumption pattern: A panel study." J. Econ. Psych 23:605-630.

Udo de Haes, H. A., O. Jolliet, G. Finnveden, M. Goedkoop, M. Hauschild, E. G. Hertwich, P. Hofstetter, W. Klöpffer, W. Krewitt, E. W. Lindeijer, R. Mueller-Wenk, S. I. Olson, D. W. Pennington, J. Potting, and B. Steen. 2002. Life cycle impact assessment: Striving towards best practice. Pensacola: Society of Environmental Toxicology and Chemistry.

UNEP. 2004. Unep/setac life-cycle initiative United Nations Environment Programme. http://www.uneptie.org/pc/sustain/lcinitiative/home.htm. 12 Feb 2004.

van Engelenburg, B C W, T F M van Rossum, K Blok, and K Vringer. 1994. "Calculating the energy requirements of household purchases: A practical step by step method." Energy Pol. 22:648-656.

van Praag, B. M. S., and P. Frijters. 1999. The measurement of welfare and well-being: The leyden approach. In Well-being -- the foundation of hedonic psychologyedited by D. Kahneman, E. Diener and N. Schwarz. New York: Russell Sage Foundation.

Vringer, K, and K Blok. 1995. "The direct and indirect energy requirements of households in the Netherlands." Energy Pol 23:893-910.

Växjö kommun. Fossil fuel free växjö http://www.vaxjo.se/agenda21/environmentalinfo/engfff.html. 15-Jan-2003 2003.

WCED (1987): *World Commission on Environment and Development: Our Common Future*. New York: Oxford University Press

Weber, Christoph, and Adriaan Perrels. 2000. "Modelling lifestyle effects on energy demand and related emissions." Energy Pol. 28:549-566.

Weisz, Helga and Amann, Christof (2003): Cross-Country Analysis of Indicators Derived from Economy Wide MFAs: An International Survey. Final Report to EUROSTAT and the DG environment. Vienna: IFF Social Ecology

Weisz, Helga and Duchin, Faye (2004): Physical and monetary input-output analysis: What makes the difference? Rensselaer Polytechnic Institute, Department of Economics (Rensselaer Working Papers in Economics; 0422)

Weisz, Helga, Amann, Christof, Eisenmenger, Nina, Hubacek, Klaus, and Krausmann, Fridolin (2004): Material use in the European Union 1970-2001. Luxembourg: Eurostat, Office for Official Publications of the European Communities, forthcoming

Weisz, Helga, Amann, Christof, Bruckner, Willi, and Schandl, Heinz (2001a): Material Flow Analysis and Environmental Indicators. The Positioning of of MFA in the European Discussion about Environmental Indicators. Wien: Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft

Weisz, Helga, Fischer-Kowalski, Marina, Grünbühel, Clemens M., Haberl, Helmut, Krausmann, Fridolin, and Winiwarter, Verena (2001b): Global Environmental Change and Historical Transitions. In: *Innovation - The European Journal of Social Sciences* 14(2), pp. 117-142

Wier, M., M. Lenzen, J. Munksgaard, and S. Smed. 2001. Effects of household consumption patterns on co2 requirements. *Economic Systems Research* 13 (3):259-274.

Wilhite, H., and L. Lutzenhiser. 1999. "Social loading and sustainable consumption." Adv. *Consumer Res*. 26:281-287.

Xiaoqiu Chen and Lijia Qiao (2001): A Preliminary Material Input Analysis of China. In: *Population and Environment* 23(1), pp. 117-126

9 Appendix

9.1 Questionaire

1. InterviewerIn:	2. Fragebogen Nr.: (bitte fortlaufend nummerieren)
3. Siedlung: **(bitte ankreuzen)** o autofreie Siedlung (1) o Standardsiedlung (2)	4. Stiege/Tür:
5. Datum: **(TT/MM/JJ)** 6. Uhrzeit:	7. Seit wann gibt es HH in Siedlung? **(MM/JJ)** **Wenn Bezug nach 1.1.2003, dann ist der HH nicht geeignet**

Konsumerhebung in zwei Siedlungen Wiens

Orientierungsjahr: 2003

Einleitungs-Statement

Autofreie Siedlung:

Mag. Rötzer von der Hausverwaltung (GEWOG) und Hr. Frank Uhl-Ortner vom BewohnerInnenbeirat sind informiert und unterstützen die Befragung.

Wir wollen für einige Konsumkategorien die Konsummuster der Haushalte erheben, um diese dann im Vergleich mit Durchschnittsdaten für Österreich diskutieren zu können. Wir wollen nicht nur Ausgaben diskutieren, sondern aus den Informationen die damit in Verbindung stehenden ökologischen und ökonomischen Effekte sowie die Arbeitsplatz-Effekte in der österreichischen Wirtschaft berechnen. Aus diesem Grund stellen wir Fragen zum Haushaltsbudget, zu Ausgaben und Verbrauch in ausgewählten Bereichen.

Alle Fragen beziehen sich auf das Jahr 2003.

Manche Fragen werden Ihnen vielleicht etwas eigenartig vorkommen. Bitte fragen Sie bei diesen nach. Wir können Ihnen gerne erklären, wozu wir die Antworten benötigen.

Alle Informationen werden **absolut vertraulich** behandelt. Wir verwenden nach außen nur Gesamtzahlen für Haushaltsgruppen ohne Namensnennung. Sie werden auf jeden Fall über die Ergebnisse der Studie informiert.

Die Beantwortung dauert zwischen 1/2 und 1 Stunde.

Weitere Infos:

IIASA-Broschüre

8. Familienname, Vorname der interviewten Person

(interviewte Person muss volljährig sein) ______________________________

Falls nachfragen erforderlich sind: Tel.: ______________________________

Teil 1: Sozial-Daten:

9. Anzahl von Personen, die im Jahr 2003 in diesem Haushalt gelebt haben (mehr als 9 Monate):

_______ Anzahl Personen

10. Liste der Verwandtschaftsverhältnisse und sonstige Beziehungen der im Haushalt lebenden Personen mit Geschlecht und Alter:

Person	**Verwandtschaft** **Sonstige Beziehung**	**Geschlecht**		**Alter in Jahren**	**Mieter*)**	
		m (1)	w (2)	(im Jahr 2003)	Ja (1)	Nein (2)
(a)						
(b)						
(c)						
(d)						
(e)						
(f)						
(g)						

(a)....(interviewte Person)

*) ....UnterzeichnerIn des Mietvertrages

(Beispiele für Verwandtschaftsverhältnisse Vater, Mutter, Tochter und Beispiele für sonstige Verhältnisse MitbewohnerIn, Lebensgefährte etc.)

11. Weitere Personen, die zeitweise (mehr als 2 Monate/60 Tage) in diesem Haushalt leben:

□ ja (1) □ nein (2)

Person	**Verwandtschaftsverhältnis/ Beziehung**	**Wochen pro Jahr im HH**	**Alter**	**Grund (z.B. Internatsbesuch)**
1				
2				
3				

12. Berufliche Betätigung, Ruhestand, Ausbildung, ehrenamtliche Tätigkeit

	Tätigkeit 2003									Höchste abgeschlossene Ausbildung										Ehrenamtliche Tätigkeit					
PERSON	Angestellte/r (1)	ArbeiterIn (2)	Beamter/in (3)	Selbständige/r (4)	PensionistIn (5)	In Ausbildung (6)	Arbeitslos (7)	Kurzbe-zeichnung der Tätigkeit	Stunden/Woche	Volksschule (1)	Hauptschule (2)	AHS-Unterstufe (3)	Sonderschule (4)	Polytechnische (5)	Berufsschule (6)	Fachschule/HAK (7)	Matura (8)	Universität (9)	Sonstige	In der Siedlung	Stunden pro Jahr	Beschreibung	andere	Stunden pro Jahr	Beschreibung
(a)																									
(b)																									
(c)																									
(d)																									
(e)																									
(f)																									
(g)																									

(a) = interviewte Person; (b) bis (g) = weitere Personen im Haushalt (siehe Frage 10)

Teil 2: verfügbares Haushaltsbudget 2003 (alle Beträge in Euro)

13. EINNAHMEN 2003 (alle Einkommensarten vorlesen und evt. Gemeinsam berechnen)			
Einkommensart	Monatliches durchschnittliches		Jahresnettoeinkommen 2003
	(Felder zur Berechnung	Anzahl	
Unselbstständige Erwerbstätigkeit			
Werkverträge			
Selbstständige Erwerbstätigkeit			
Pension			
Arbeitslosengeld/ Notstandshilfe			
Einkommen aus Gelegenheitsarbeit			
Familienbeihilfe, Kinderabsetzbetrag			
Wochengeld			
Karenzurlaubsgeld, Sondernotstandsgeld			
Pflegegeld			
Sozialhilfe			
Stipendien, Schüler- oder sonsti			
Einkünfte aus Vermietung und Verpachtung			
Einkünfte aus Vermögen			
Einkünfte aus Unterhaltszahlungen			
Sonstige private Zuwendungen			

14. Alternative Einschätzung des Haushaltsnetto-Einkommens

Jährliches Netto-Einkommen aller im Hauhshalt lebender Personen inkl. Transferzahlungen

Bereich (Euro)			**ankreuzen**
0	7.999	1	
8.000	9.999	2	
10.000	11.999	3	
12.000	13.999	4	
14.000	15.999	5	
16.000	17.999	6	
18.000	19.999	7	
20.000	21.999	8	
22.000	23.999	9	
24.000	25.999	10	
26.000	27.999	11	
28.000	29.999	12	
30.000	31.999	13	
32.000	33.999	14	
34.000	35.999	15	
36.000	37.999	16	
38.000	39.999	17	
40.000	41.999	18	
42.000	43.999	19	
44.000	45.999	20	
46.000	47.999	21	
48.000	49.999	22	
50.000	51.999	23	
52.000	53.999	24	
54.000	55.999	25	
56.000	57.999	26	
58.000	59.999	27	
60.000	61.999	28	
62.000	63.999	29	
64.000	65.999	30	
66.000	67.999	31	
68.000	69.999	32	
70.000	71.999	33	
72.000	73.999	34	
74.000	75.999	35	
76.000	77.999	36	
78.000	79.999	37	
80.000	81.999	38	
82.000	83.999	39	
84.000	85.999	40	
86.000	87.999	41	
88.000	89.999	42	
90.000	91.999	43	
92.000	93.999	44	
94.000	95.999	45	
96.000	97.999	46	
98.000	99.999	47	
100.000	und mehr	48	

15. AUSGEWÄHLTE AUSGABEN 2003			
Ausgabenart	Monatliche Ausgaben in Euro		Jahressumme
		Anzahl Monate	
Spareinlagen			
Kreditrückzahlungen			
Versicherungen			
Ausgaben für Bildung			
Kinderbetreuung			
Sonstige größere Ausgaben über Euro 2.000 wie z.B. Anschaffung einer Küche (abgesehen von Reisen, Energie, Mobilität/Fahrzeuge)			

Falls keine Detailangaben möglich sind, Schätzung der Gesamtausgaben für 2003 (ohne Miete und Betriebskosten und ohne Kosten für Energie und Mobilität)

Teil 3: BESTÄNDE (ohne Fahrzeuge)

16. Wohnung in der autofreien Siedlung/Referenzsiedlung

Eckdaten zur Wohnung		
Nutzfläche		m^2
Lage (ankreuzen)		Oberster Stock (1)
		Mittelgeschoß (2)
		Erdgeschoß (3)
Außenmauern (ankreuzen)		Eine (1)
		Zwei (2)
		Drei (3)
Gesamtvorschreibung (Miete plus Betriebskosten)		Euro/Monat (Durchschnitt)

17. Andere Immobilien (z.B. Wochenendhaus, Schrebergarten)

Verwendungszweck/ Beschreibung		
Nutzfläche		m^2
Gesamtausgaben inkl. Gebühren, Abgaben und Steuern (ohne Energie)		Euro/Monat (Durchschnitt) oder Jahresausgaben

18. Haustiere

Art	**Gewicht** **Schätzung (kg)**	**Ausgaben für Futter/monatlich**

19. Elektrische Geräte und andere große Haushaltsgeräte

Gerätetyp	**Anzahl**	**Alter**	**Energieeffizienz (bei mehr Geräten mehrere Kreuze)**								
		In Jahren	A (1)	B (2)	C (3)	D (4)	E (5)	F (6)	G (7)	weiß nicht (8)	nicht kategorisiert (9) *)
Kühlschrank **)											
Gefriertruhe											
Kombigerät ***)											
Geschirrspüler											
Waschmaschine											
Wäschetrockner											

*) weil zu alt

**) mit und ohne Eisfach

***) Gefrier- und Kühlschrank in einem Gerät – mit zwei Türen

Bei mehreren Geräten sind Mehrfach-Angaben vorzunehmen

Typ	**Anzahl**	**Preisklasse**		
		Niedrig (1)	Mittel (2)	Hoch (3)
Elektroherd				
Mikrowelle				
Stereoanlage				
TV				
Satellitenempfänger				
Kabelanschluss				
Computer				
Sonstiges:				

Kommunikationsendgeräte	Anzahl
Telefon (Gerät)	
Mobiltelefon (Gerät)	

Internet	**Anzahl**	**Einwahl-verbindung (1)**	**ISDN (2)**	**Breitband (3)**
Internetzugang				

Teil 4: Energieverbrauch im Haushalt

20. Energieverbrauch Autofreie Siedlung/Referenzsiedlung

Heizung und Warmwasser	Firma	Bitte ankreuzen
Anbieter	GTE (1)	
	Wien Gas (2)	
	Fernwärme (3)	
	Andere (4):	
Ausgaben	Betrag-Brutto **monatlich** (Euro) (Bitte auf **MONAT** umrechnen)	kWh monatlich (falls verfügbar)
Heizung		
Warmwasser		

Wenn das Jahr 2003 nicht verfügbar ist, können die Monatsbeträge aus x-beliebigen 365 Tagen lt. Abrechnung genommen werden, die zum größeren Teil in das Jahr 2003 fallen.

Strom	Firma	Bitte ankreuzen
Anbieter	Wien Energie (1)	
	Öko-Strom (2)	
	Andere (3):	
Ausgaben	Betrag-Brutto **monatlich** (Euro) (Bitte auf **MONAT** umrechnen)	kWh monatlich (falls verfügbar)
Strom		

Wenn das Jahr 2003 nicht verfügbar ist, können die Monatsbeträge aus x-beliebigen 365 Tagen lt. Abrechnung genommen werden, die zum größeren Teil in das Jahr 2003 fallen.

Kochen	Energieträger	Bitte ankreuzen
	Strom (1)	
	Gas (2)	

Heizbedarf	Durchschnittliche Woche	Bitte ankreuzen
Anwesenheit während der Heizperiode	Täglich (auch untertags) (1)	
	Morgen, Abend und Wochenende (2)	
	Morgen, Abend ohne Wochenende (3)	
	Noch seltener als 3 (4)	
Bevorzugte Raumtemperatur		In Grad Celsius
Anteil der meistens beheizten Wohnungsfläche		In %

21. Andere Immobilien (z.B. Wochenendhäuser)

Heizung und Warmwasser	Bitte ankreuzen	**Monatliche** Bruttoausgaben *)	**Monatlicher** Verbrauch (falls verfügbar)	Einheit
Stromanbieter (1) **)				kWh
Leitungsgebundes Gas (2) **)				kWh
Fernwärme (3) **)				kWh
Heizöl (4)				Liter
Butan, Propan (5)				Flaschen
Holz (6)				Festmeter
Pellets/				Kilogramm
Kohle, Koks (8)				
Solar (Kollektoren)				m^2 Panel
Solarzellen (10)				m^2
Wärmepumpe (11)				kW installierte

*) auf **monatliche** Kosten umrechnen: z.B. wenn im Jahr Euro 240 für Kohle ausgegeben werden, dann Euro 20 eintragen.

**) Wenn das Jahr 2003 nicht verfügbar ist, können die Monatsbeträge aus x-beliebigen 365 Tagen lt. Abrechnung genommen werden, die zum größeren Teil in das Jahr 2003 fallen.

Strom	Firma	Bitte ankreuzen
Anbieter	Wien Energie (1)	
	Öko-Strom (2)	
	Andere (3):	
Ausgaben	Betrag-Brutto **monatlich** (Euro)	kWh monatlich
Strom		

Teil 5: Transport

22. Motorisierte Fahrzeuge im Jahr 2003 (Nutzung, nicht Besitz ist dabei ausschlaggebend)

PKW, Kleinbus, Motorrad, Moped													
Art	Modell	Benzin (1)	Diesel (2)	Baujahr	Neu gekauft (1)	Gebraucht (2)	Bei Kauf im Jahr 2003: Kaufpreis (Euro)	Bei Leasing: monatliche Leasingrate (Euro)	PS	Verbrauch Lit./100km	Jahres-km (privat)	Jahres-km (dienstlich)	Jährliche Ausgaben für Treibstoff *) (nur privat)
PKW													
Klein-bus													
Motor-rad													
Moped													

*) falls verfügbar

23. Ausgaben im Zusammenhang mit motorisierten Fahrzeugen

Weitere Kosten	Betrag in Euro im Jahr
Instandhaltung und Reparatur	
Pannenhilfe (auch Mitgliedsbeiträge)	
Versicherung	
Steuer	

24. Car-Sharing bzw. Autovermietung 2003

Art	Modell oder Autoklasse	Ausgaben für Car-Sharing oder Anmietung	Benzin	Diesel	PS	Verbrauch Lit./100km	Jahres-km (privat)	Anmerkung zur Nutzung (z.B. wie oft im Jahr, für welche Zwecke)
PKW /Kleinbus								

25. Fahrräder

Art (Sportrad, Mountain-bike, Trekking etc.)	Kauf-jahr	Kauf-preis	Nutzung 2003					Geschätzte Anteile an der Gesamtbenutzung in Prozent	
			0x	1-12x	12-52x	52-200x	200-365x	Für Alltagswege %	Für Freizeit-aktivitäten %

26. Öffentlicher Verkehr im Alltag

	Anzahl im Haushalt	Euro pro (bitte ankreuzen)Woche / Monat / Jahr	Benutzung		
			täglich	Mehrmals pro Woche	seltener
Jahreskarte *)					

Semesterkarte					
Wochenkarten					
Einzelfahrscheine					
ÖBB-Vorteilskarte(n)					

*) wenn Preis unbekannt, dann freilassen, Preis kann leicht recherchiert werden

*) Bitte bei Jahreskarten angeben, wenn diese nicht nur in der Kernzone Wien gilt

27. Urlaubs- und sonstige Reisen (inkl. Kurzurlaube, Besuche etc.) **–** nur **private** Reisen

	Gesamtausgaben in Euro (2003)	Jahres-km für gesamten Haushalt *)**)	Anzahl Fahrten (in 2003)
Bahn			
Bus			
Schiff			
Private Flugreisen, ohne Pauschalreisen (Angabe der Zielorte)			
Pauschalreisen (Pauschalreisen sind Reisen die Reise z.B. Flug und Beherbergung beinhalten)			

*) alle Reisen sämtlicher Haushaltsmitglieder – 3 Personen Wien-Salzburg = ca. 3 Pers x 300km x 2 (hin/retour)

**) falls km nicht geschätzt werden kann, Zielort und Anzahl der reisenden Personen aus dem Haushalt angeben

28. Typische Urlaube (letzten 3 Jahre)

Urlaub	**Ja** (1)	**Nein** (2)	**Typische Dauer in Wochen**						**Typische Zielorte (ankreuzen)**			
			1	**2**	**3**	**4**	**5**	**6**	**Wien Umgebung (1)**	**Österreich (2)**	Europa (3)	**Fernurlaub (4)**
Winter												
Sommer												
Zusätzliche Kurzurlaube												

Teil 6: Hotels und Restaurants (Inland und Ausland)

29. Ausgaben für Hotels und Restaurants im Inland und Ausland

*)	In Urlauben: Ausgaben in Euro (Jahressumme)	Im Alltag (Jahressumme)
Restaurants		
Cafes, Bars und dergleichen		
Kantinen		
Beherbergung inkl. Voll- und Halbpension (**ohne** Pauschalreisen)		

*) sämtliche Ausgaben aller Haushaltsmitglieder

Teil 7: Ausgewählte Lebensmittel und Rauchen

30. Schätzung der Lebensmittelausgaben für Gemüse und Fleisch

Art						
Gemüse (auch Erdäpfel, Zwiebel und Pilze)	Euro/Woche	davon: Schätzung in Prozent				
		aus Wien und Umgebung	%	frisch	%	Biologisch:
		aus restlichem Österreich	%	konserviert	%	.... %
		aus restlichem Europa	%	gekühlt	%	
		von Übersee	%	tiefgekühlt	%	
		Summe:	100 %		100 %	
Fleisch ohne Tierfutter	Euro/Woche	davon: Schätzung in Prozent				
		aus Wien und Umgebung	%	frisch	%	Biologisch:
		aus restlichem Österreich	%	konserviert	%	.... %
		aus restlichem Europa	%	gekühlt	%	
		von Übersee	%	tiefgekühlt	%	
		Summe:	100 %		100 %	

31. Schätzung der Ausgaben für Tabakwaren

	Euro pro Monat
Tabakwaren	

32. Schätzung der zu Hause zubereiteten Mahlzeiten einer durchschnittlichen Woche

Mahlzeiten zu hause zubereitet	Frühstück Personen x Anz. pro Woche (z.B. 3x7)	Mittagessen Personen x Anz. pro Woche (z.B. 3x2)	Abendessen Personen x Anz. pro Woche (z.B. 2x6+1x2)
Personen x Anzahl			
Davon vegetarisch in %			

Wie viele von den angeführten Abendessen sind gemütliche gemeinsame Abendessen (alle anwesend):

_____________ (Anzahl pro Woche)

33. Inanspruchnahme von Angeboten

	Euro/**Monat**	Einkauf-Bestellung pro **Monat**
Gemüsekiste		
Bestellungen. Biosäfte		
Biogeschäfte		

Teil 8: Fragen zur Siedlung

34. Waren Sie an der Planung dieser Siedlung beteiligt? ☐ ja (1) ☐ nein (2)

Falls ja:

Wie intensiv war diese Planungsbeteiligung? (Punkte 1-10, 1=sehr gering, 10=sehr intensiv): ______ Punkte

35. In welchem Ausmaß treffen die folgenden Aussagen auf ihre **Siedlung** zu:

	trifft sehr zu (1)	trifft eher zu (2)	trifft tlw. Zu (3)	trifft eher nicht zu (4)	trifft gar nicht zu (5)
In dieser Siedlung leben viel mehr ökologisch eingestellte Personen als in vergleichbaren Siedlungen in Wien					
Mülltrennung hat in unserer Siedlung einen sehr hohen Stellenwert					
In unserer Siedlung weiß jeder von jedem alles					
Der Vandalismus in der Siedlung ist sehr gering					
Bei Vandalismus in der Siedlung weiß man immer, wer der Verursacher war					
Bei Vandalismus in der Siedlung werden die Verursacher immer zur Verantwortung gezogen					
Wenn sich jemand ein (neues) Auto kauft, weiß das die „ganze Siedlung“					
Ich weiß über ausgefallene Hobbies meiner Nachbarn Bescheid					
Ich beobachte manchmal, dass Nachbarn ihren Müll nicht trennen					
Viele BewohnerInnen sind darauf Stolz, speziell in unserer Siedlung zu wohnen					
Unsere Siedlung ist im Vergleich zu den umliegenden Neubauten etwas ganz besonderes					
Der menschliche (soziale) Zusammenhalt innerhalb unserer Siedlung ist sehr stark ausgeprägt					
Nur wenige Personen ziehen von hier wieder weg					

Die Nachbarschaft in der Siedlung ist sehr gut					
Die gegenseitige Hilfe innerhalb der Siedlung ist ausgezeichnet					
Viele meiner Freunde wohnen hier in der Siedlung					
In unserer Siedlung gibt es sehr viele gemeinsame Aktivitäten, an denen alle BewohnerInnen teilnehmen können (z.B. gemeinsame Feste)					
In Gesprächen mit Nachbarn geht es oft um ökologische Themen					
Ökologischer Konsum ist ein wichtiges Gesprächsthema in der Siedlung					
Es ist leicht, Informationen über ökologische Konsummöglichkeiten in der Siedlung zu bekommen					
Ich interessiere mich sehr für Informationen über umweltfreundliche Einkaufsmöglichkeiten					

36. Zu wie vielen Personen aus der Siedlung unterhalten Sie freundschaftliche Kontakte?

Anzahl: ________

37. Wie viele davon haben Sie bereits vor Ihrem Einzug gekannt?

Anzahl: ________

38. Wie viele BewohnerInnen kennen sie „vom Sehen“ (man kennt den Namen nicht, würde die Person aber wiedererkennen)?

Anzahl: ________

39. In welchem Ausmaß treffen die folgenden Aussagen zu:

	trifft sehr zu (1)	trifft eher zu (2)	trifft tlw. Zu (3)	trifft eher nicht zu (4)	trifft gar nicht zu 5)
Fernseh- und Radioberichte zu ökologischen Themen verfolge ich mit großem Interesse					
Wenn es möglich ist, bevorzuge ich Produkte, die lokal hergestellt wurden, weil damit weite Transportwege vermieden werden können					
Bei Lebensmittel achte ich sehr auf die Qualität, auch wenn ich dadurch mehr für Lebensmittel ausgebe					
Lärm und Gestank in der Stadt sind mir unerträglich geworden					
Ich befürchte, unsere Kinder werden keine Aussicht haben, in einer sauberen Umwelt zu leben					
Wenn die Menschheit überhaupt eine Überlebenschance haben					

will, muss die Umweltzerstörung gestoppt werden					
Viele Freunde von mir interessieren sich für ökologische Themen					
Viele Freunde von mir haben kein eigenes Auto					
Viele Freunde von mir bevorzugen biologische Nahrungsmittel					
Seit wir in dieser Siedlung wohnen, kaufen wir viel öfter biologische Lebensmittel					
Seit wir in dieser Siedlung wohnen, benützen wir viel öfter das Fahrrad					
Seit wir in dieser Siedlung wohnen, fahren wir viel weniger oft am Wochenende aufs Land					

40. Lesen Sie regelmäßig eine Zeitschrift, die vor allem über umweltrelevante Themen (Energie, Abfall, biologische Lebensmittel etc.) berichtet? ☐ ja (1) ☐ nein (2)

Wenn ja: Welche?

____

41. Lesen Sie regelmäßig in Tages- oder Wochenzeitschriften Beiträge über umweltrelevante Themen (Energie, Abfall, biologische Lebensmittel etc.)? ☐ ja (1) ☐ nein (2)

Wenn ja: Welche Themen interessieren Sie dabei am meisten?

____

42. Sind Sie Mitglied bei einer der folgenden Organisationen?

	Ja (1)	Nein (2)
Greenpeace		
Global 2000		
WWF		
Alpenverein		
Naturfreunde		
Umweltspürnasen-Club		
Österreichisches Ökologie-Institut		
Arbeitsgemeinschaft Erneuerbare Energie		
Vier Pfoten		
Verkehrsclub Österreich (VCÖ)		
ARGUS		
Sonstiges:		

43. Wie wichtig ist ihnen ökologisches Konsumverhalten in folgenden Lebensbereichen?

	sehr wichtig (1)	eher wichtig (2)	tlw. Wichtig (3)	eher unwichtig (4)	sehr unwichtig (5)
Energieverbrauch					
Verkehr					
Ernährung					
Abfall					

44. Was sind aus Ihrer Sicht die drei größten Umweltprobleme

1.	
2.	
3.	

45. Wie wichtig waren für Sie folgende Gründe, in diese Wohnung zu ziehen?

	sehr wichtig (1)	eher wichtig (2)	eher unwichtig (3)	sehr unwichtig (4)	Grund nicht vorhanden (5)
gestiegener Bedarf an Wohnfläche					
in „grüner“, gesunder Umgebung leben					
in einem umweltfreundlichen Gebäude wohnen					
den Energieverbrauch reduzieren					
Möglichkeit zur Mitbestimmung					
niedrige Betriebskosten					
mit Freunden in der Nachbarschaft wohnen					
Vorbild für andere sein					
bessere Bedingungen für die Kinder haben					
das innovative architektonische Konzept					
viele Gemeinschaftsflächen und -einrichtungen					
die günstige Infrastruktur					

die Nähe zum Arbeitsplatz					
Wechsel des Arbeitsplatzes					
die Helligkeit der Wohnung					
die ruhige Lage					
Naherholungsgebiet alte Donau					
Kündigung der alten Wohnung					
der Wohnungsgrundriss					
der günstige Kaufpreis/die günstige Miete					
Sonstiges:..					

46. Welcher der genannten Gründe war für Sie persönlich am wichtigsten?
(bitte nur **einen** Grund nennen)

____

Vielen Dank für Ihre Mitarbeit!

9.2 Tables

Table A1: Emission factors from LCAs and other sources used for the calculation of emissions

CARS		(a) carbon dioxide	(a) methane	(a) Nitrogen oxides	(a) sulfur oxides (SO2)	(w) COD	(w) AOX	Energy (MJ)			kg CO2/MJ
Car	kg per km	0.02666667	0.00011333	0.00006	0.0001	5.3333E-06	2.6667E-08	0.57066667	0.57066667		0.04672897
Gasoline	kg per l fuel used	2.47692308	0.00032695	0.00148615	0.00148615	3.7946E-05	6.9354E-08	35.5785231	35.5785231		0.06961849
Diesel	kg per l fuel used	2.33629	0.00006633	0.0059697	0.0008844	3.7946E-05	6.9354E-08	39.1485231	39.1485231		0.0596776
Vehicle type	Fuel	CO2	CH4	N2O	NOX	SO2	NMVOC	NH3	CO	PM10	Energy (MJ)
Mopeds	Gasoline	2.30681	0.00431145	0.00004422	0.0019899	0.00011792	0.2708475	0.00003685	0.5159	0.00010318	32.2
Motorcycles	Gasoline	2.30681	0.00364078	0.00003685	0.0052327	0.00011792	0.0875556	0.00003685	0.521796	0.00011055	32.2
		kg									MJ
Emissions pro Jahreskarte (Fuel chain only)		CO2	CH4	N2O	CO	NOx	NMVOC	Particles	COD	AOX	Energy
U+StrassenBahn		115.386949	0.21229198	0.00504642	0	0.18708694	0.1646242	0	0.06112215	1.019E-06	1384.68954
Bus		49.9196695	0.09309344	0.00067459	0.02529713	0.35415982	0.1022004	0.00209123	0	0	819.320374
Total		165.306618	0.30538542	0.00572101	0.02529713	0.54124676	0.26682461	0.00209123	0.06112215	1.019E-06	2204.00991
Energy											
		CO2, fossil	CH4	N2O	CO	SO2	Nox	MNVOC	COD	AOX	Energy
		kg/kWh	kg/kWh	kg/kWh	kg/kWh	kg/kWh	kg/kWh	kg/kWh	kg/kWh	kg/kWh	
Electricity, Low voltage, Austrian Average		3.0E-1	5.5E-4	1.3E-5	1.6E-4	4.9E-4	4.3E-4	7.0E-5	1.6E-4	2.6E-9	7.00E+00
Wind		2.0E-2	3.9E-5	1.7E-6	3.4E-4	1.5E-4	8.6E-5	8.0E-6	1.0E-4	5.4E-10	4.00E+00
Grid		1.9E-2	4.5E-5	6.1E-9	4.5E-5	8.7E-5	4.2E-5	9.8E-6	8.2E-5	1.2E-9	0.00E+00
Ökostrom		3.9E-2	8.4E-5	1.7E-6	3.9E-4	2.4E-4	1.3E-4	1.8E-5	1.9E-4	1.7E-9	4.00E+00
Heat, co-gen		2.8E-1	1.7E-3	2.3E-5	7.8E-4	1.3E-4	1.2E-4	1.4E-4	5.3E-5	1.1E-10	4.50E+00
Fernwärme		1.2E-1	6.6E-6	2.3E-5	2.2E-5	2.3E-5	8.3E-5	1.4E-4	5.3E-5	1.1E-10	
Heizöl leicht		3.1E-1	2.9E-4	3.6E-6	1.4E-4	4.6E-4	3.2E-4	1.6E-4	9.9E-4	3.7E-9	
Erdgas		2.3E-1	1.1E-3	2.4E-6	7.1E-5	1.2E-4	1.6E-4	7.5E-5	4.3E-5	1.3E-10	
Emissionen Bahn, Bus, Flug		CO2	CH4	N2O	CO	NOx	NMVOC	Particles	COD	AOX	Energy
		kg/km	kg/km	kg/km	kg/km	kg/km	kg/km	kg/km	kg/km	kg/km	
Bahn		0.010836	1.8981E-05	7.3924E-07	5.2215E-05	4.6094E-05	8.5084E-06	6.9687E-05	3.9137E-05	3.9393E-10	
Bus		0.107051	0.00012841	3.3486E-06	0.00040932	0.00119879	0.00020189	9.4179E-05	0.00034582	1.2669E-09	
Schiff		0	0	0	0	0	0	0	0	0	
Flug		0.482037	0.0008818	5.8503E-06	0.00051641	0.00192487	0.00067518	5.4895E-05	0.0013786	1.9281E-09	

Table A2: prices used to calculate consumed energy and distances in transport

	€/km	€/km	€/km	€/km	€/kWh	€/kWh	€/kWh	€/kWh	€/kWh
	Bahn	Bus	Schiff	Flug	Strom	Ökostrom	Fernwärme	Gas	Öl
Variable cost	0.057	0.0375	0.1	0.05	0.1304	0.181	0.0311039	0.0438	0.046895531
Fixed cost					47.7 per hh	0	3.0516 per m2 year	96.8	

Table A3: CO_2 emissions for the individual households in the car-free settlement (1:42), the reference settlement (43:88) and the average Austrian (100).

HH	persons	PE	Income	CO2 Emissions per household in kg								No. cars		Total CO2	
	v9		€	Energy	Publ. Transport	Holiday Transport	Car + moped	Food	Hotel	Other	SUM		per PE	per person	Per €
1	4	2.36	31000	1535	212	5899	984	932	597	3509	1.37E+04	0	5.79E+03	3.42E+03	4.41E-01
2	4	2.68	33440	1667	0	14499	0	498	253	5087	2.20E+04	0	8.21E+03	5.50E+03	6.58E-01
3	4	2.41	33850	986	331	152	400	1017	2783	2003	7.67E+03	0	3.18E+03	1.92E+03	2.27E-01
4	4	2.41	42800	806	331	380	0	872	273	6258	8.92E+03	0	3.70E+03	2.23E+03	2.08E-01
5	2	1.7	41720	1116	165	190	0	436	127	6996	9.03E+03	0	5.31E+03	4.52E+03	2.16E-01
6	1	1	15000	594	165	0	0	451	27	2242	3.48E+03	0	3.48E+03	3.48E+03	2.32E-01
7	5	3.53	32736	2250	331	7413	225	997	539	4149	1.59E+04	0	4.51E+03	3.18E+03	4.86E-01
8	2	1.7	33584	1088	34	2023	38	1009	1032	4124	9.35E+03	0	5.50E+03	4.67E+03	2.78E-01
9	2	1.7	33600	653	165	17410	0	312	1149	4235	2.39E+04	0	1.41E+04	1.20E+04	7.12E-01
10	4	2.58	27400	3856	331	228	38	436	452	3546	8.89E+03	0	3.44E+03	2.22E+03	3.24E-01
11	4	2.95	42200	2071	165	327	0	1122	242	6439	1.04E+04	0	3.51E+03	2.59E+03	2.46E-01
12	2	1.7	42000	1618	331	15958	23	748	988	5394	2.51E+04	0	1.47E+04	1.25E+04	5.97E-01
13	1	1	9100	786	0	8735	0	436	25	1050	1.10E+04	0	1.10E+04	1.10E+04	1.21E+00
14	3	2.35	33000	892	331	628	0	997	941	4011	7.80E+03	0	3.32E+03	2.60E+03	2.36E-01
15	3	2.5	45000	2432	165	0	0	1090	461	6765	1.09E+04	0	4.37E+03	3.64E+03	2.43E-01
16	1	1	16020	747	181	0	472	481	279	1758	3.92E+03	0	3.92E+03	3.92E+03	2.45E-01
17	3	2.35	25000	975	339	19	212	810	534	3002	5.89E+03	0	2.51E+03	1.96E+03	2.36E-01
18	1	1	22400	585	165	323	11	249	1122	2588	5.04E+03	0	5.04E+03	5.04E+03	2.25E-01
19	4	2.78	39859.3	1177	292	29	31	1198	141	5931	8.80E+03	0	3.16E+03	2.20E+03	2.21E-01
20	4	2.63	51000	1001	331	2695	5	436	561	7943	1.30E+04	0	4.93E+03	3.24E+03	2.54E-01
21	1	1	35608.45	420	165	0	0	1070	796	4838	7.29E+03	0	7.29E+03	7.29E+03	2.05E-01
22	3	2.08	40080	1298	331	38	127	1309	329	5723	9.15E+03	0	4.40E+03	3.05E+03	2.28E-01
23	1	1	12270	456	165	48	42	748	54	1385	2.90E+03	0	2.90E+03	2.90E+03	2.36E-01
24	2	1.38	11052.4	568	165	0	0	436	329	1193	2.69E+03	0	1.95E+03	1.35E+03	2.43E-01
25	4	3	43941.6	1842	331	904	0	4281	199	4203	1.18E+04	0	3.92E+03	2.94E+03	2.68E-01
26	1	1	19200	1270	165	0	0	411	601	2476	4.92E+03	0	4.92E+03	4.92E+03	2.56E-01
27	4	3.1	52800	3694	496	1157	0	1587	380	7706	1.50E+04	0	4.85E+03	3.75E+03	2.84E-01
28	1	1	11400	1003	165	0	0	312	0	1745	3.23E+03	0	3.23E+03	3.23E+03	2.83E-01
29	1	1	9600	1307	165	0	0	312	0	1392	3.18E+03	0	3.18E+03	3.18E+03	3.31E-01
30	3	2.25	45485	1965	0	9641	2503	623	423	6923	2.21E+04	1	9.81E+03	7.36E+03	4.85E-01
31	4	3.2	55000	1645	281	3471	188	872	1956	7056	1.55E+04	0	4.83E+03	3.87E+03	2.81E-01
32	1	1	20200	1052	165	23	11	212	462	2897	4.82E+03	0	4.82E+03	4.82E+03	2.39E-01
33	1	1	22400	650	165	11	115	62	264	3675	4.94E+03	0	4.94E+03	4.94E+03	2.21E-01
34	3	2.03	27000	1015	165	4144	0	623	845	3315	1.01E+04	0	4.98E+03	3.37E+03	3.74E-01
35	2	1.7	35000	1157	331	599	0	374	253	5672	8.39E+03	0	4.93E+03	4.19E+03	2.40E-01
36	4	2.46	21000	2618	33	0	0	1122	86	2723	6.58E+03	0	2.68E+03	1.65E+03	3.13E-01
37	4	2.9	51000	303	331	1323	212	498	1140	7425	1.12E+04	0	3.87E+03	2.81E+03	2.20E-01
38	2	1.7	72800	1609	331	5822	459	187	309	12581	2.13E+04	0	1.25E+04	1.06E+04	2.93E-01
39	2	1.8	23140	1256	331	4539	0	312	342	3229	1.00E+04	0	5.56E+03	5.00E+03	4.32E-01
40	2	1.7	46406.1	701	331	8	63	174	890	7239	9.41E+03	0	5.53E+03	4.70E+03	2.03E-01
41	2	1.7	25200	1289	331	0	0	249	501	3675	6.04E+03	0	3.56E+03	3.02E+03	2.40E-01
42	2	1.7	42000	790	165	1947	0	1262	200	6438	1.08E+04	0	6.35E+03	5.40E+03	2.57E-01

43	3	2.5	51000	1155	343	86	2212	810	268	7852	1.27E+04	1	5.09E+03	4.24E+03	2.50E-01
44	5	3.18	45000	654	331	34	3190	748	452	6464	1.19E+04	1	3.73E+03	2.37E+03	2.64E-01
45	4	2.46	29000	631	0	133	0	150	185	4882	5.98E+03	0	2.43E+03	1.49E+03	2.06E-01
46	1	1	21000	1060	165	0	0	374	58	3409	5.07E+03	0	5.07E+03	5.07E+03	2.41E-01
47	3	2.6	25000	1394	0	828	0	623	217	3652	6.71E+03	0	2.58E+03	2.24E+03	2.69E-01
48	2	1.7	29000	631	13	23138	2001	187	261	4318	3.05E+04	1	1.80E+04	1.53E+04	1.05E+00
49	2	1.7	25000	795	597	18698	4673	436	498	2379	2.81E+04	1	1.65E+04	1.40E+04	1.12E+00
50	1	1	17000	446	165	0	0	249	123	2720	3.70E+03	0	3.70E+03	3.70E+03	2.18E-01
51	2	1.65	21000	515	165	93	0	224	537	2944	4.48E+03	0	2.72E+03	2.24E+03	2.13E-01
52	1	1	9000	280	11	0	7869	249	136	785	9.33E+03	1	9.33E+03	9.33E+03	1.04E+00
53	4	2.46	29000	1203	22	0	2103	623	72	4589	8.61E+03	1	3.50E+03	2.15E+03	2.97E-01
54	3	2.25	47000	2200	0	0	3386	199	317	7922	1.40E+04	2	6.23E+03	4.67E+03	2.98E-01
55	2	1.7	37000	974	331	0	2122	399	107	6083	1.00E+04	1	5.89E+03	5.01E+03	2.71E-01
56	4	2.36	33000	4954	7	0	8231	436	72	4520	1.82E+04	1	7.72E+03	4.56E+03	5.52E-01
57	2	1.7	25000	3147	0	0	4245	324	328	3538	1.16E+04	2	6.81E+03	5.79E+03	4.63E-01
58	5	3.01	21000	6158	331	0	0	349	72	2993	9.90E+03	0	3.29E+03	1.98E+03	4.72E-01
59	3	2.25	47000	1236	331	0	4721	374	860	7017	1.45E+04	2	6.46E+03	4.85E+03	3.09E-01
60	2	1.7	19000	1297	420	0	221	249	152	3024	5.36E+03	0	3.15E+03	2.68E+03	2.82E-01
61	1	1	9000	252	0	0	3190	561	43	631	4.68E+03	1	4.68E+03	4.68E+03	5.20E-01
62	5	3.01	21000	1387	0	0	3144	498	147	3049	8.22E+03	1	2.73E+03	1.64E+03	3.92E-01
63	2	1.7	21000	439	0	0	2252	162	248	3310	6.41E+03	1	3.77E+03	3.21E+03	3.05E-01
64	3	1.93	4000	376	215	0	0	623	0	55	1.27E+03	0	6.58E+02	4.23E+02	3.17E-01
65	4	2.46	29000	2168	331	0	225	312	248	4542	7.83E+03	0	3.18E+03	1.96E+03	2.70E-01
66	4	2.73	51000	2112	0	14461	1668	1745	1502	5730	2.72E+04	1	9.97E+03	6.80E+03	5.34E-01
67	2	1.7	27000	2018	331	0	0	312	161	4285	7.11E+03	0	4.18E+03	3.55E+03	2.63E-01
68	1	1	19000	1046	165	0	0	571	30	2925	4.74E+03	0	4.74E+03	4.74E+03	2.49E-01
69	2	1.7	33000	2041	0	0	4463	299	431	4616	1.18E+04	1	6.97E+03	5.92E+03	3.59E-01
70	5	3.6	27000	2105	31	0	3124	336	217	3879	9.69E+03	1	2.69E+03	1.94E+03	3.59E-01
71	4	2.36	31000	1368	165	0	6533	498	489	3790	1.28E+04	3	5.44E+03	3.21E+03	4.14E-01
72	4	2.58	27000	890	12	0	12281	748	478	2720	1.71E+04	1	6.64E+03	4.28E+03	6.34E-01
73	4	2.58	21000	1052	43	13	0	561	63	2902	4.63E+03	1	1.80E+03	1.16E+03	2.21E-01
74	4	2.8	29000	296	331	0	0	461	136	4686	5.91E+03	0	2.11E+03	1.48E+03	2.04E-01
75	2	1.7	25000	1350	841	0	53	312	90	3767	6.41E+03	1	3.77E+03	3.21E+03	2.57E-01
76	2	1.7	25000	705	149	48	1410	25	163	3815	6.31E+03	1	3.71E+03	3.16E+03	2.53E-01
77	4	2.8	61000	1610	331	38	474	561	671	9776	1.35E+04	0	4.81E+03	3.37E+03	2.21E-01
78	2	1.7	51000	703	3	0	749	374	887	7855	1.06E+04	1	6.22E+03	5.29E+03	2.07E-01
79	1	1	33000	721	165	19	0	131	90	5753	6.88E+03	0	6.88E+03	6.88E+03	2.08E-01
80	1	1	21000	725	420	1947	58	561	747	2455	6.91E+03	0	6.91E+03	6.91E+03	3.29E-01
81	2	1.7	51000	1191	165	0	2064	1371	651	7444	1.29E+04	1	7.58E+03	6.44E+03	2.53E-01
82	2	1.7	75000	636	187	6806	2859	249	1596	11304	2.36E+04	1	1.39E+04	1.18E+04	3.15E-01
83	3	2.03	0	2162	0	0	3597	125	322	-876	5.33E+03	1	2.63E+03	1.78E+03	
84	2	1.7	15000	1336	26	0	2258	162	25	2357	6.16E+03	1	3.63E+03	3.08E+03	4.11E-01
85	4	2.41	31000	1346	103	0	3028	374	60	4715	9.63E+03	1	3.99E+03	2.41E+03	3.11E-01
86	2	1.7	41000	517	331	0	0	187	742	6190	7.97E+03	1	4.69E+03	3.98E+03	1.94E-01
87	3	2.35	43000	1087	0	0	4448	162	875	6476	1.30E+04	2	5.55E+03	4.35E+03	3.03E-01
88	3	2.35	35000	1229	165	7809	0	1052	375	4420	1.50E+04	1	6.40E+03	5.02E+03	4.30E-01
100	1	1	14306	1829	23	1337	2214	430	292	2059	8.18E+03	0	8.18E+03	8.18E+03	5.72E-01
Averages															
car free	2.571	1.95	32 697	1 303	226	2 633	147	752	545	4 537	**10142**		5 193	3 944	0.31
reference	2.75	2.02	31 409	1 342	171	1 685	2 256	445	361	4 602	**10862**		5 355	3 950	0.35
Carfree/r	0.94	0.96	1.04	0.97	1.32	1.56	0.06	1.69	1.51	0.99	**0.93**		0.97	1.00	0.90

Working Papers published by
The Industrial Ecology Programme
Norwegian University of Science and Technology

1/2004	Erlend Sletten Arnekleiv & Stig Larssæther	*Grønn innovasjon - perspektiver, metoder og utfordringer: En litteraturstudie*
2/2004	Glen Peters & Edgar Hertwich	*A Comment on "Functions, Commodities and Environmental Impacts in an Ecological-economic Model"*
3/2004	Anders Hammer Strømman & Edgar Hertwich	*Hybrid Life Cycle Assessment of Large Scale Hydrogen Production Facilities*
4/2004	Anders Hammer Strømman & Asle Gauteplass	*Domestic Fractions of Emissions in Linked Economies*
5/2004	Glen Peters & Edgar Hertwich	*Production Factors and Pollution Embodied in Trade: Theoretical Development*
6/2004	Glen Peters, Tania Briceno & Edgar Hertwich	*Pollution Embodied in Norwegian Consumption*
7/2004	Anders Hammer Strømman & Edgar Hertwich	*Approaches to Avoid Double Counting in Hybrid Life Cycle Inventories*
8/2004	Anders Hammer Strømman	*Life Cycle Analysis - Its Structural, Emissions And Institutional Regimes As Policy Constraints*
9/2004	Johan Pettersen, Glen Peters & Edgar Hertwich	*Marine Ecotoxic Pulse Effects In LCIA*
1/2005	Øivind Hagen	*Skaper samfunnsansvarlige merkevarer samfunnsansvarlige virksomheter? Om forholdet mellom merkevarebygging og organisasjonsutvikling*
2/2005	Tania Briceno, Glen Peters, Christian Solli & Edgar Hertwich	*Using Life Cycle Approaches To Evaluate Sustainable Consumption Programs: Car-sharing*

Program for industriell økologi (IndEcol) er et tverrfaglig universitetsprogram etablert i 1998 for en periode på minst ti år ved Norges teknisk-naturvitenskapelige universitet (NTNU). Programmet omfatter et studieprogram opprettet i 1999 og et stort antall doktorgradsprosjekter og forskningsprosjekter rettet mot vareproduserende industri, energi- og byggesektoren. Tverrfaglig forskning og undervisning står sentralt ved IndEcol, og målet er å knytte sammen teknologiske, naturvitenskapelige og samfunnsvitenskapelige bidrag i letingen etter bærekraftige løsninger på produksjon og forbruk av energi og ressurser.

The Industrial Ecology Programme (IndEcol) is a multidisciplinary university programme established at the Norwegian University of Science and Technology (NTNU) in 1998 for a period of minimum ten years. It includes a comprehensive educational curriculum launched in 1999 and a significant number of doctoral students as well as research projects geared towards Norwegian manufacturing, energy and building industries. The activities at IndEcol have a strong attention to interdisciplinary research and teaching, bridging technology, natural and social sciences in the search for sustainable solutions for production and consumption of energy and resources.

NTNU-IndEcol
Industrial Ecology Programme
NO-7491 Trondheim

Tel.: + 47 73 59 89 40
Fax: + 47 73 59 89 43
E-mail: indecol@indecol.ntnu.no
Web: www.indecol.ntnu.no

ISSN: 1504-3681