Workshop Proceedings
SETAC-Europe meeting
Prague Congress Center
21 April 2004

LIFE-CYCLE APPROACHES TO SUSTAINABLE CONSUMPTION

Scope And Feasibility

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Industrial Ecology Program **Norwegian University for Science and Technology**
IndEcol **NTNU**

Workshop Proceedings

Life-cycle approaches to sustainable consumption: Scope and Feasibility

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SETAC-Europe meeting, Prague Congress Center

21 April 2004, 15:00-18:00, Club room C

Overview

The 2002 World Summit for Sustainable Development in Johannesburg called for a comprehensive set of programs focusing on sustainable consumption and production. According to world leaders, these programs should rely on life cycle assessment (LCA) to promote sustainable patterns of production and consumption. While cleaner production is a well-established activity, policy makers do not know how to achieve sustainable consumption and how life cycle assessment might help them in this endeavour. This is why we organized this workshop, which took part during the annual meeting of the Society of Environmental Toxicology and Chemistry in Europe (SETAC-Europe), one of the most pre-eminent scientific organisations in the development of LCA.

In this workshop researchers presented proposals for how to use LCA in the work with sustainable consumption. The proceedings includes two case studies for the use of LCA and input-output analysis for assessing household environmental impacts, a paper which outlines different options for using LCA in connection to sustainable consumption, a paper on the use of LCA in connection with marketing of sustainable solutions, and a paper on assessing the acceptability of solutions that have been identified to be more environmental over the life-cycle. These presentations were discussed, and participants are asked for their feedback and critical evaluation. The proposals and the discussion will be used to provide input to the European Commission and its work on sustainable production and consumption. The workshop results will be used in a further evaluation of feasibility and scope of LCA-based approaches to sustainable consumption. This is the basis for recommendations for future research, development and implementation activities.

This workshop was sponsored by the 6th framework programme for research of the European Commission through contract NMP2-ct-2003-505281.

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Schedule

15:00 Political issues on Sustainable Consumption, Guido SONNEMANN, UNEP
15:20 LCA and Green Marketing as tools to promote Sustainable Consumption in Mexico, Jessica RODRÍGUEZ
15:40 Feasibility and Scope of Life-Cycle Approaches to Sustainable Consumption, Edgar HERTWICH
16:00 Discussion + Coffee
16:30 Life-cycle approach to assess the environmental impact of consumption - Key factors, key decisions and key actors, Olivier JOLLIET
16:50 Comparing the Environmental Impacts of Households' Consumption Patterns, Katarina KORYTAROVA
17:10 Quantitative Evaluation Method of Social Acceptability of Products and Services for Activity-Based Calculation of Life Cycle CO2 Emissions, Toshisuke OZAWA
17:30 Discussion

Please note that this workshop is part of the FESCOLA project, conducted by the Norwegian University of Science and Technology (NTNU) for the European Commission. The background paper by Hertwich is also available at the workshop or from the author.

Papers will be available at

http://www.indecol.ntnu.no

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Political issues on Sustainable Consumption

Guido Sonnemann

Associate Programme Officer
Division of Technology, Industry and Economics
United Nations Environment Programme*

Introduction

Sustainable consumption is the topic of today. In this century, it can be expected that nine billion people will live on the planet and that the world output will quadruple. Global environment trends continue to pose grave challenges and threats, as underlined by figures in UNEP's third Global Environmental Outlook report. For instance: concentrations of CO_2 emissions continue to climb; just under the third of the world's fish stocks are now ranked as depleted, overexploited or recovering and the world's forests have declined significantly since 1990. Unless humankind cuts the link between economic growth and the degradation of the environment, modern societies will simply not be able to sustain quality of life.

During the last 10 years the need for sustainable consumption policies has been increasingly expressed on the international policy level:

- The 1992 - Rio Declaration on Environment and Development – which calls upon States to reduce and eliminate unsustainable patterns of production and consumption in order to achieve sustainable development and a higher quality of life for all people.
- Agenda 21 with its chapter 4 on sustainable consumption and production.
- The 1999 – UN Guidelines for Consumer Protection which gives governments a comprehensive framework for policy setting for more sustainable consumption and production.

Finally in 2002 sustainable consumption was a top priority on the agenda for the World Summit on Sustainable Development in Johannesburg again. The third chapter of the Summit's Plan of Implementation calls for the development of a 10-year framework of programmes to accelerate the shift towards sustainable consumption and production patterns. This will promote social and economic development within the carrying capacity of ecosystems.

As can be seen, there is much expression of the desirability of sustainable consumption at the international level. However, the challenge now is to move to implementation to make real changes towards sustainable development.

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The main lessons learnt in developing policies for sustainable consumption have been that:

- A mix of instruments (regulatory framework, voluntary measures and economic instruments) is needed.
- Tools are important to promote changes in the unsustainable patterns of consumption and production. However there is also a need for a sectoral approach. This is linked to the integration of environmental considerations into sectoral policies.

A key aspect for UNEP is the social-economic dimension of sustainable consumption. This is especially relevant for developing countries. The poor of the world deserve the same aspirations of long life and prosperity enjoyed by the majority of people in the developed countries. The key question of sustainable development is how to provide them with what they need and what they want without damaging the Earth's life support systems. Therefore the mission of UNEP is ´Environment for development´.

This issue is, of course, especially pressing in the Asia-Pacific region. Two thirds of current population growth is in this region. Already there are more middle-income earners—earning over US $7,000—in Asia and the Pacific than in Europe and North America combined. Yet, this relative prosperity—and consumer power—is enjoyed by only 26 per cent of the region's population.

The opportunities for change and targeted actions on sustainable consumption can best be explained by some concrete examples on what has been done since 1998 in the Sustainable Consumption Programme of UNEP DTIE:

- Promote and monitor the implementation of sustainable consumption, including public green procurement by governments, through UN Guidelines on Consumer Protection and further means, among others with Consumers International;
- Facilitate communication campaigns, with special focus on advertising agencies and young people;
- Strengthen network of Cleaner Production Centres, and assist small and medium sized enterprises, in particular in developing countries, with life cycle management and eco-design;
- Strengthen scientific base for sustainable consumption and production through Life Cycle Initiative with SETAC and other partnerships and improving its applicability for product and service development as well as for consumer information tools;

Results received so far in 10-year framework of programmes

As a follow-up of the World Summit Plan of Implementation, UNEP and UNDESA have initiated work in developing the 10-year framework of programmes in order to support regional and national initiatives on sustainable consumption and production. The work has been conducted in co-operation with other UN agencies and other stakeholders, notably with the regional offices and national governments.

The first phase of the work consists of organising regional expert meetings which identify region-specific priorities, and indicate the needs for support at the global level for technical, cross-cutting activities. So far four regional meetings have been held, hosted by

respectively Argentina, Indonesia, Nicaragua and the Republic of Korea[1]. Further meetings will be held – in 2004 - in Europe, Africa, West Asia and Northern America.

The results achieved so far are promising, since the process of translating first findings into regional strategies has started. Latin America has developed its regional strategy on sustainable consumption and production, identifying policy instruments and needs for capacity building, technical and financial assistance, and has established a Regional Council of Government Experts (reporting to the Environment Ministers Forum), supported by UNEP's Regional Office as a secretariat. Asia Pacific has confirmed the strong will of governments to take action and adopted a number of recommendations for future actions and will create "Help Desk" at UNESCAP, which may serve as the focal point for initiatives on SCP in the region. The issue will be brought forward in co-operation with UN ESCAP (Economic and Social Affairs), aiming at heads of state level in April next year (Shanghai Summit).

Follow-up meetings in both regions, should consolidate the findings and identify concrete programmes and partners. It is expected that (pilot) projects will be proposed for themes such as water, food, construction, shelter, transport and tourism. Prospects for tangible progress exist also on issues such as consumer awareness and education, product information, business strategies, involvement of civil society, implementing sustainable consumption guidelines, strengthening Cleaner Production Centres, procurement schemes, more effective enforcement of environmental law, governmental approaches for integrated consumption and production policies.

A first international review meeting was held in Marrakech, Morocco. The meeting was very well attended and adopted the so-called "Marrakech process", in which informal task forces and roundtables on specific issues will contribute to, in particular, regional processes, with a first review of progress made in two years time from now (2005).

Policy issues that need attention

Although the start of the ten-year framework is indeed encouraging, there are a number of policy issues that need full attention in order to safeguard that the "Marrakech process" will be truly meaningful and will result in tangible progress.

The issue of sustainable consumption and production is broad and complex. Different types of policies for different stakeholders in many regional and national settings need to be developed and implemented. Overall thematic challenges like energy consumption and the related CO2 emissions as well as water consumption, chemicals management and bio-diversity need to be addressed. Proper mixes of voluntary, economic and legal instruments need to be applied. A focus of global support activities is highly necessary. After analysing the first results of the process so far, the central issues factors for success appear to be in the following areas:

- Voluntary instruments (awareness raising, information campaigns, education, working with youth, training, partnerships like the Life Cycle Initiative) are rather undisputed and will get much attention in the future work. Important as they are,

[1] Full meeting reports are available at www.uneptie.org/sustain

stronger incentives are needed to significantly influence consumption and production patterns: "getting the prices right" (cost internalisation, removal of subsidies and trade barriers) and establishing regulatory frameworks for e.g. sustainable procurement based on product information, including standards, to promote the development of more sustainable products and services. These instruments are mostly complex and have many linkages as can be seen by the following comment made by ASEAN:

"One of the criteria in the ISO environmental labelling draft standards is to promote LCA as a means to assess a product's environmental impact. The use of ISO environmental labelling standards, when fully developed, would have the potential to be used as a trade barrier as LCA is technically difficult and costly to implement, and developing countries are likely to lack the necessary expertise to conduct LCAs. Furthermore, LCA-based environmental labels might have qualifying criteria based on 'non-product-related process and production methods (NPR-PPMs). Singapore, as an export-oriented economy, needs to pay close attention to developments in this area. A simple example of a product based on NPR-PPM is a pencil derived from an environmentally sustainable forest. A consumer cannot differentiate between this pencil and one that is derived from a forest that is not managed in an environmentally sustainable manner.[2]

- Participation of developing countries has been encouraging so far. Many start to appreciate potential benefits of their engagement in this agenda. There is a need to further analysis the opportunities with regard to eradication of poverty and creation of jobs. Relatively small-scale but constructive options, such as establishing and/or expanding the support network for small and medium sized enterprises (e.g. through NCPC's) might help to keep such governments interested, provided that such networks – which primarily provide technical, engineering advice - would increasingly help to market products on the domestic and global markets, thereby helping business to overcome the perceived technical barriers such as lack of knowledge about issues such as life-cycle analysis, eco-design, eco-labelling and standardisation. A better representation and involvement of developing countries in relevant institutions such as ISO, Life Cycle Initiative would be a key issue as well.

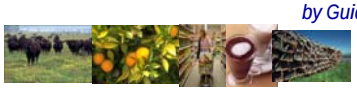
UNEP has taken a leading role in developing the issue of sustainable consumption further. It is no secret that there is still a long way to go to achieve sustainable development - governments have just started to go in the right direction. Activities and initiatives on all levels of society are needed. Today is a good opportunity to see where we are on a regional and local level and a good opportunity to learn from each other how to promote sustainable consumption.

[2] http://www.aseansec.org/7013.htm

Workshop on life-cycle approaches to sustainable consumption
Prague, 21 April, 2004

Political issues in relation to life-cycle approaches to sustainable consumption

by Guido Sonnmann
UNEP DTIE



Overview

- ✓ *UNEP – who we are and what we do*
- ✓ *Introduction to policy issues on sustainable consumption on the international level*
- ✓ *10-year framework of programmes: results received so far*
- ✓ *Policy issues that need attention*
- ✓ *Summary*

UNEP - Mission

To provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.

´Environment for Development´

UNEP – 3 roles

- Assess the State of the World's Environment & Understand Env. Challenges (GEO);
- Stimulate solutions to environmental problems
  - ✓Promoting International Environmental Law
  - ✓Voluntary Initiatives
- Build capacity and networks to enable implementing solutions

Current situation: a quick assessment

- Productivity/efficiency gains being overtaken by production increases (rebound effects)
- Problems of production process understood but those of the use and disposal of a product still largely unknown
- Emerging global consumer class
- Environmental concerns not integrated into economic and social programmes
- De-linking of economic growth from environmental damage needed

SC during last 10 years

Increasing reference to the need for sustainable consumption policies:

- 1992 - Agenda 21 with its chapter 4 on sustainable consumption and production.
- 1999 – UN Guidelines for Consumer Protection which gives governments a comprehensive framework for policy setting for more sustainable consumption and production.

World Summit on Sustainable Development

- Plan of Implementation
- Chapter 3:
  Encourage and promote development of **10-year framework of programmes** to promote sustainable consumption and production patterns
  Use science-based approaches such as **life-cycle analysis**
- Regional and national initiatives

Main lessons learnt

Needs in developing SC policies:

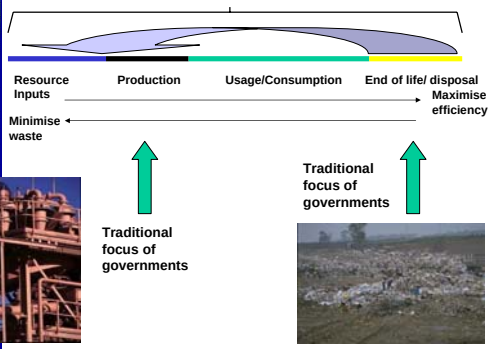
- Instruments (regulatory framework, voluntary measures and economic instruments).
- Integrated life-cycle based tools to promote changes in the unsustainable patterns of consumption and production.
- Sectoral approach and integration of environmental considerations into sectoral policies.

Function-based approach

"Human needs should be met by products and services that are aimed at specific 'functions' such as food, shelter and mobility, and that are provided through optimized consumption and production systems that do not exceed the capacity of the ecosystem."

Life Cycle Initiative Brochure, UNEP / SETAC, 'International Partnership', 2003.

"Life cycle view" of policy



Sustainable Consumption Programme

- **UN Guidelines** on Consumer Protection;
- Sustainable **procurement**;
- **Awareness** raising (youth, advertising, media);
- **Life-Cycle Initiative**, national indicators;
- **Eco-design** of products and services;
- Consumer **information**, civil society;
- Capacity building, **training** and techology transfer.

Meetings to develop regional strategies

- **Latin America and Caribbean**
  (Argentina, Nicaragua)
- **Asia Pacific**
  (Indonesia, Republic of Korea)
- **Africa**
  (Morocco, 19-20 May 2004)
- **Europe**
  Baltic region (June 2004), Russia (September), Multi-stakeholder conference (November) 2004

The 10-year framework has to make a difference by ...

- Focusing on concrete outputs and by avoiding "**SCP Flying Circus**"
- Focus on **implementation** by means of pilot projects in the following two areas:

1. **meeting basic needs** of the poor (following the thematic cycle of CSD);
2. **resource efficiency** in selected industry sectors and for selected areas,

- Addressing the **barrier-to-trade** discussion related to product standards
- Setting a legislative framework on **product information**

In summary – UNEP seek to

- Contribute to decoupling economic growth and environmental degradation – diminish rebound effects.
- Foster scientific work like Life Cycle Initiative that is applicable within government and industry.
- Help improve eco-efficiency (production and consumption) in all countries.
- Encourage life cycle thinking in government and business decision making processes.
- Promote sustainable procurement and strengthen the necessary consumer information tools.
- Establish platforms for all stakeholders to report on experiences with sustainable consumption.

Connect world-wide to our newsletters SC.net and LC.net

- **Regional programmes in:**
  - **Latin America and Caribbean -> UNEP ROLAC**
  - **Europe (SCOPE) -> UNEP ROE**
  - **Northern American -> UNEP RONA**
  - **Asia Pacific -> UNEP ROAP**
  - **Africa -> UNEP ROA**

Write to sc@unep.fr or visit
http://www.uneptie.org/sustain/10year/unep-undesa
http://www.uneptie.org/sustain/lcinitiative

Life cycle assessment and Green Marketing as tools to promote Sustainable Consumption in Mexico

Jessica Rodríguez, Nydia Suppen

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Abstract

In 2003 the Latin American and the Caribbean region has recognized the need of a national and regional strategy on sustainable consumption and production. The region has identified life cycle assessment, ecodesign, green market opportunities and integrated sustainable development, as key topics to support sustainable consumption and production.

Mexico faces the challenge of implementing nature conservation policies while raising the standard of living, thus the promotion of sustainable consumption and production patterns becomes very important. At the same time, life cycle assessment, ecodesign and green marketing are developing fields in Mexico by academics, most industry and consumers are unaware of the applications and benefits that these tools can provide.

The paper shows an analysis of the Mexican green products and market, a niche, because there is lack of information and campaigns on green products and sustainable consumption. In Mexico, the most successful example is the organic agriculture that responds to the increasing demand of the developed countries and benefits from premium prices in the international market.

Descriptions of the green consumer profile in Mexico are presented, as a result of a descriptive marketing research for Mexico City. The actual consumer-producer relationship and market dynamics show a quite active participation of NGOs in the process of commercialization of green products in the country. Finally the potential of implementing effective life cycle assessment and green marketing activities in the country is discussed.

TECNOLÓGICO DE MONTERREY

Life cycle assessment and Green Marketing as tools to promote Sustainable Consumption in Mexico

Jessica RODRIGUEZ, Nydia SUPPEN

Research Center for Environmental Quality

Campus Estado de México
2004: Año de la Calidad

TECNOLÓGICO DE MONTERREY

Sustainable consumption and production in Latin America

Two Regional Government´s Experts Meetings on Sustainable Consumption and Production were held in Latin America in 2003

Recommend to the forum of Environment Ministers of Latin America and the Caribbean the elaboration of a national and regional strategy on Sustainable Consumption and Production.

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2004: Año de la Calidad

TECNOLÓGICO DE MONTERREY

Sustainable consumption and production in Latin America

- ***To carry out*** campaigns to increase awareness and knowledge of sustainable production and consumption at all levels of society in Latin America.
- ***To promote*** the supply and demand of sustainable products and services.
- ***Capacity building*** for the productive and financial sectors through workshops, training, information and technical assistance in topics such as life cycle assessment, ecodesign and green marketing.

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TECNOLÓGICO DE MONTERREY

LCA in México (2001~)

The Federal Environmental Protection Agency and our Center, have developed environmental performance indicators for different industrial sectors considering different life cycle stages and life cycle impact categories.

There are not LCI databases but the Pollutant Release and Transfer Register and the System of Indicators of Environmental Law Compliance, which will make emission and compliance data publicly available, present an enormous potential for the developments of LCA studies in Mexico.

The Secretary of Economy included LCA as an important tool for the Mexican Industry in "100 Immediate Technological Improvements for small and medium enterprises" (2001)

The Mexican Cleaner Production Center has introduced some concepts of LCA in Cleaner Production workshops.

The ISO14040 mirror committee was formed in 2002.

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TECNOLÓGICO DE MONTERREY

LCA in México (2001~)

Our Research Center is currently:

1. **Developing life cycle inventory databases for electricity, construction materials, base metals, fossil fuels, resins and waste disposal.**
2. **Mexican impact category models for criteria pollutants and water usage.**

Only one LCA study has been performed for the leather industry (SMEs)

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TECNOLÓGICO DE MONTERREY

Green consumer survey in Mexico City

- **400 Survey performed**
- **A, B, C, D, E Socioeconomic levels interviewed**
- **Interviews in Coca-Cola, Guillete, Monterrey Tech, Bancomer (bank) and outside supermarkets**

$$n = \left(\frac{z\sigma}{d}\right)^2 = \left(\frac{(1.96)(0.50)}{0.05}\right)^2 = 384.16 \cong 384$$

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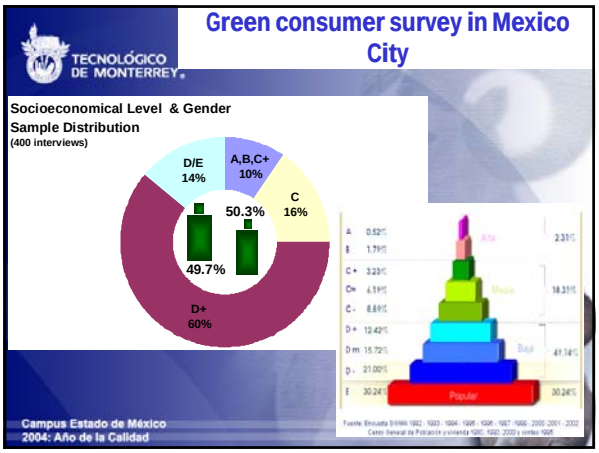
Green consumer survey in Mexico City
TECNOLÓGICO DE MONTERREY
Socioeconomical Level & Gender
Sample Distribution
(400 interviews)
A,B,C+ 10%
C 16%
D+ 60%
D/E 14%
50.3%
49.7%
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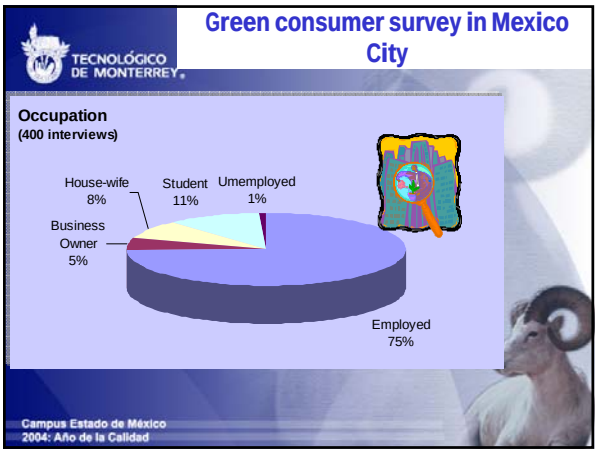
Green consumer survey in Mexico City
TECNOLÓGICO DE MONTERREY
Occupation
(400 interviews)
House-wife 8%
Student 11%
Umemployed 1%
Business Owner 5%
Employed 75%
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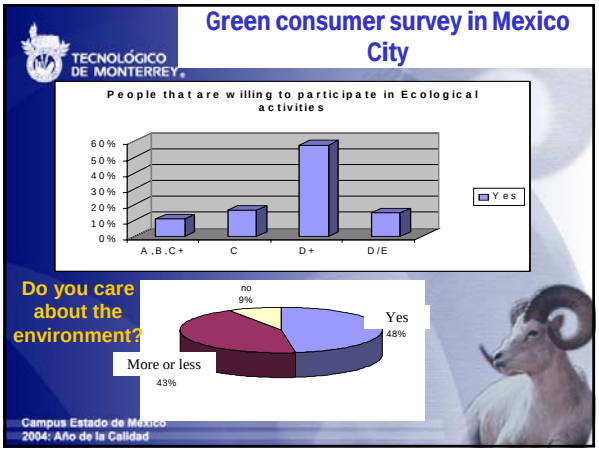
Green consumer survey in Mexico City
TECNOLÓGICO DE MONTERREY
People that are willing to participate in Ecological activities
60%
50%
40%
30%
20%
10%
0%
A ,B ,C +
C
D +
D /E
Yes
Do you care about the environment?
no 9%
Yes 48%
More or less 43%
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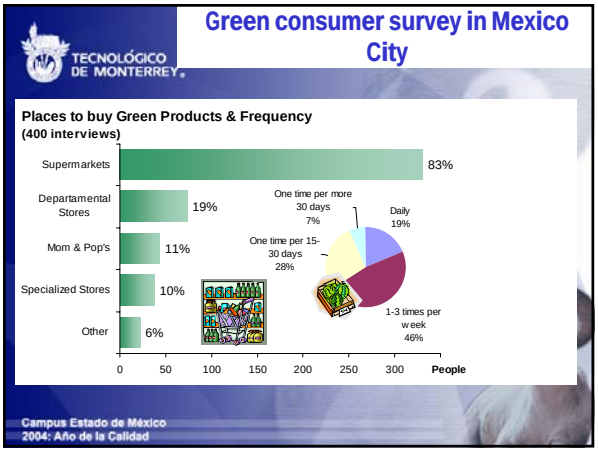
Green consumer survey in Mexico City
TECNOLÓGICO DE MONTERREY
Places to buy Green Products & Frequency
(400 interviews)
Supermarkets 83%
Departamental Stores 19%
Mom & Pop's 11%
Specialized Stores 10%
Other 6%
One time per more 30 days 7%
Daily 19%
One time per 15-30 days 28%
1-3 times per week 46%
0
50
100
150
200
250
300
People
Campus Estado de México
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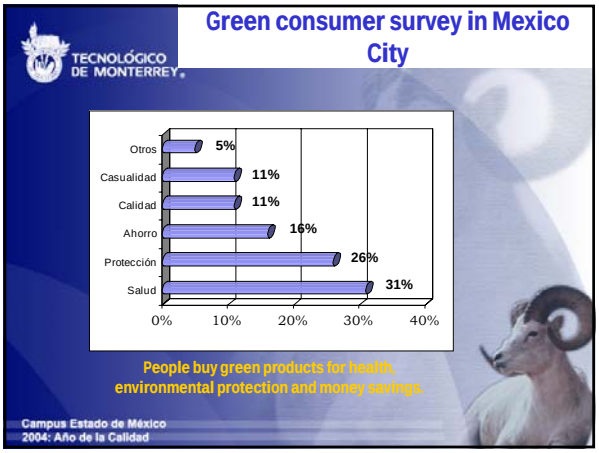
Green consumer survey in Mexico City
TECNOLÓGICO DE MONTERREY
Otros 5%
Casualidad 11%
Calidad 11%
Ahorro 16%
Protección 26%
Salud 31%
0%
10%
20%
30%
40%
People buy green products for health, environmental protection and money savings.
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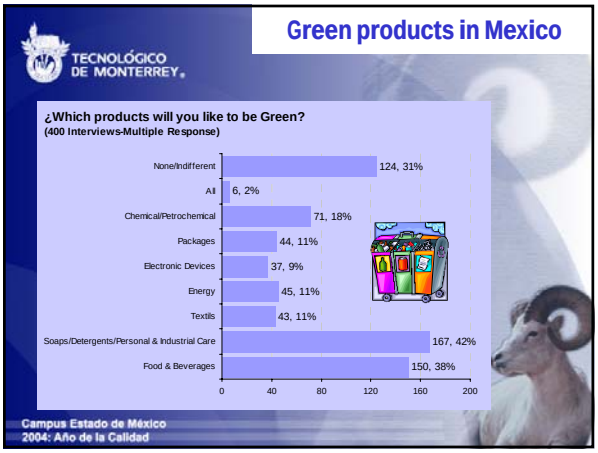
Green products in Mexico
TECNOLÓGICO DE MONTERREY
¿Which products will you like to be Green?
(400 interviews-Multiple Response)
None/Indifferent 124, 31%
All 6, 2%
Chemical/Petrochemical 71, 18%
Packages 44, 11%
Electronic Devices 37, 9%
Energy 45, 11%
Textils 43, 11%
Soaps/Detergents/Personal & Industrial Care 167, 42%
Food & Beverages 150, 38%
0
40
80
120
160
200
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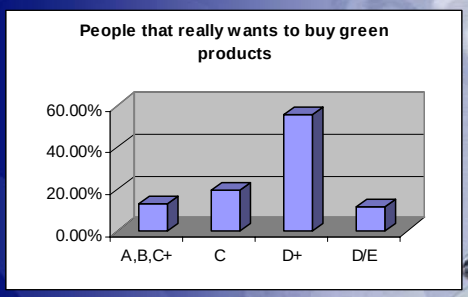
Green products in Mexico



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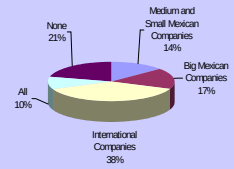
Green products in Mexico

¿Which brand do you think take care more about environment?

Companies that take care of the environment

Brand	Frequency	Percent
Body Shop	28	7.0%
3M	35	8.8%
Basf	16	4.0%
Ford	8	2.0%
Bimbo	**118**	**29.5%**
Kimberly Clark	**120**	**30.0%**
General Electric	28	7.0%
None	12	3.0%
Other	35	8.8%
Total	400	100.0%



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Mexican green consumers

- Mexican know organic products mainly
- The low socieconomical levels show more environmental consciousness
- The is no information on environmental attributes of products
- Mexicans do care for health and environmental protection and are willing to pay an overprice

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2004: Año de la Calidad

Organic products in Mexico

- The organic production in Mexico:
  - Almost 140 Million dollars, with an annual growth rate of 42%.
  - This alternative production is practiced by more than 33,000 producers and it creates 164,000 jobs.
  - 80% of the production is for exportation.
- In Mexico there are 262 organic production zones located in 28 states of the Mexican Republic. The most important are in the south, Chiapas, Oaxaca, Michoacán, Chihuahua and Guerrero, which concentrate 82.8% of the total organic surface.

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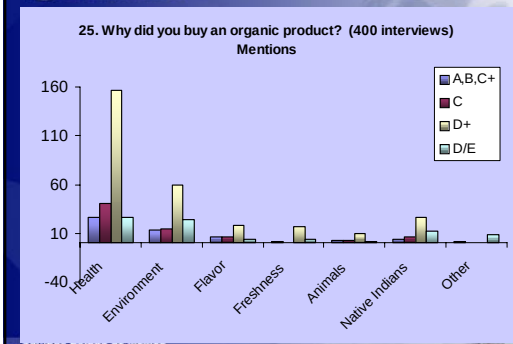
Organic products in Mexico



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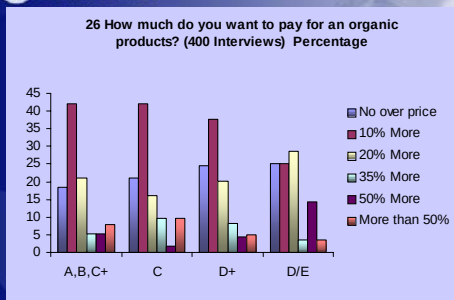
Organic products in Mexico



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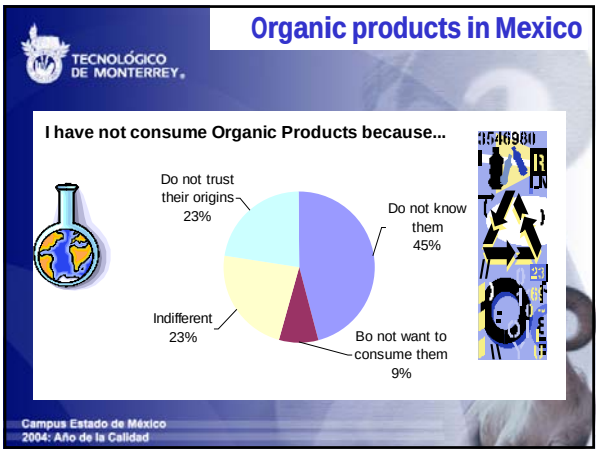
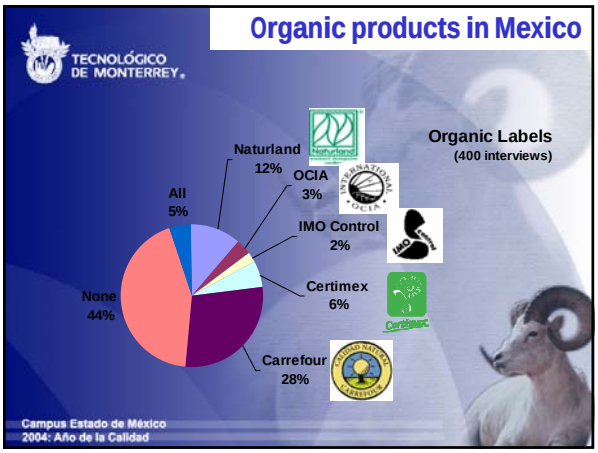
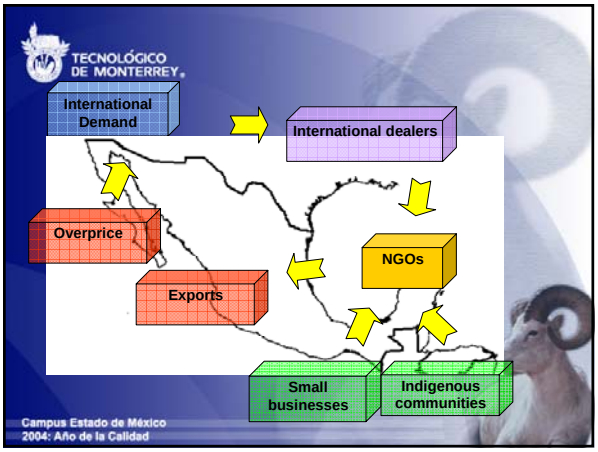
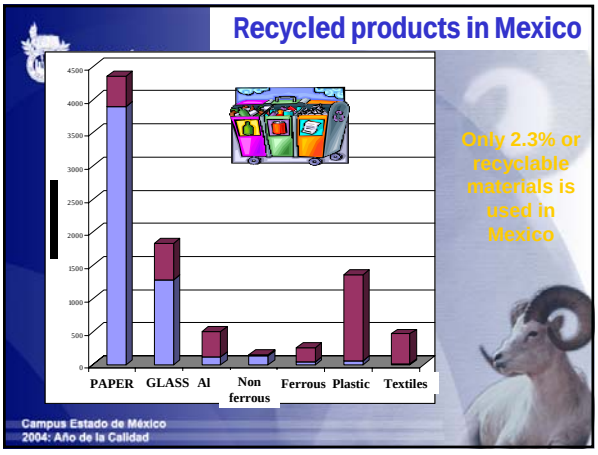






NGO´s	Principal activities
Agromercados	Organic coffee, agricultural products, and natural compost distribution
Agrupación Sierra Madre	Recyclable and recycled products, didactic ecological material edition and distribution
Bioplaneta	Organic, agro ecological, craft, cosmetic and food products marketing and distribution
Granja Orgánica (Dana)	Localization and training from organic producers, commercialization and distribution from them products
The Green Corner	Organic products distribution
El Manantial	Recyclable, recycled, reusable organics products and production training
Naturalia	Recyclable, recycled and natural products distribution
GRUPEDSAC	Organic and natural products distribution, and producers training
Mano a mano	Organic producers training, commercialization and distribution from natural, organic, recycled products
Nocoon	Organic products development, training for composition and commercialization of liquid and solid compost
Mercado Ocelotl	Group foundation that includes an Information, training, assistance integral programme, a wide selection of artistic activities and a natural restaurant

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Bio Design
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Premium prices
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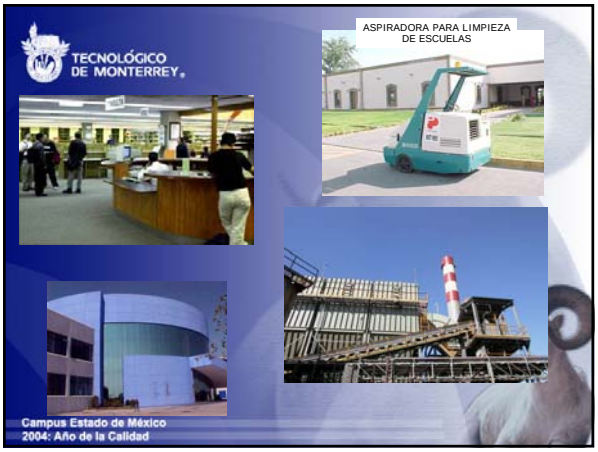
TECNOLÓGICO DE MONTERREY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ASPIRADORA PARA LIMPIEZA DE ESCUELAS
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Symbolic Awareness
Pluralistic Sharing
Symbolic Creation
Tangible Creation
new earth
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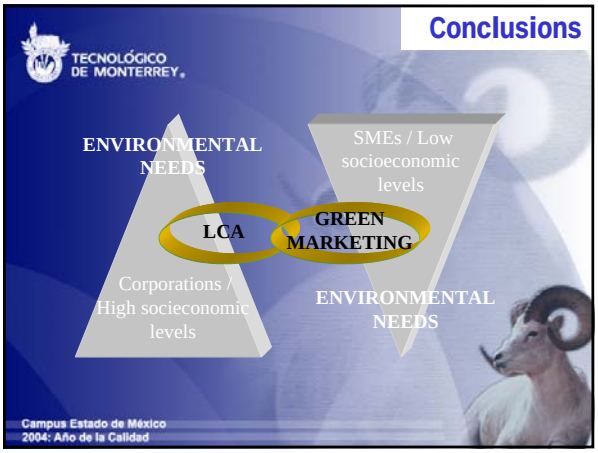
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Using Life-cycle Assessment for Sustainable Consumption

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Abstract

The 2002 World Summit for Sustainable Development in Johannesburg called for a comprehensive set of programs focusing on sustainable consumption and production. According to world leaders, these programs should rely on life cycle analysis (LCA) to promote sustainable patterns of production and consumption. Cleaner production is a well-established activity and it uses LCA. UNEP, the European Union, and a number of national organizations have now begun to work on sustainable consumption. In developing sustainable consumption policies and activities, the use of LCA presents interesting opportunities which are not yet well understood by policy makers. This paper outlines how life cycle approaches can be used in the area of sustainable consumption, to inform policy making, select areas of action, identify which lifestyles are more sustainable, advise consumers, and evaluate the effectiveness of sustainable consumption measures. The investigations necessary need to go beyond product life-cycle assessments and integrate LCA with input-output analysis, consumer expenditure surveys, time-use studies and panel methods. This paper describes for the use of LCA in the form of simple matrix equations and then discusses the current state-of-the-art. These approaches still need to be developed and tested and require additional efforts to collect data. Current research is mostly descriptive; policy makers, however, require more strategic analysis addressing their decision options.

KEYWORDS: Life-cycle assessment, sustainable consumption, rebound effect

Introduction

At the World Summit for Sustainable Development (WSSD) in Johannesburg, world leaders recognized that it is necessary to "chang[e] 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" (United Nations General Assembly 2002, §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 […]" (§ 14). This 10-year program will be set in motion at the 12th meeting of the UN Commission on Sustainable Development in April 2004.

The Johannesburg Plan of Implementation calls for the adoption of tools, policies and assessment mechanisms based on life-cycle analysis to promote sustainable patterns of production and consumption and to increase the eco-efficiency of products and services (United Nations General Assembly 2002, §13). It is remarkable that the UN General Assembly singles out Life Cycle Assessment (LCA) as the tool that will help achieve sustainable consumption and production. One needs to ask: Is LCA up to the task? And how will it be able to make such a significant contribution? LCA has long been used in cleaner production, but not in sustainable consumption. This paper outlines and discusses different ways in which LCA, alone or in combination with other scientific methods and tools, can be used to promote sustainable consumption.

LCA 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). Methods have been developed to aggregate different stressors 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, other ways need to be found to inform policy makers and influence consumers if one wants to achieve sustainable consumption.

We define sustainable consumption patterns as patterns of consumption that satisfy basic needs, offer humans the freedom to develop their potential, and are replicable across the whole globe without compromising the Earth's carrying capacity. Sustainable consumption policy consists of measures to reduce impacts that affect the behavior of the consumer or require her actions (Hertwich and Katzmayr 2003). The state of sustainable consumption can hence be seen as the aim of sustainable consumption policies.

In this paper, we describe how life-cycle approaches can be used in a sustainable consumption program. We argue that, to be useful for sustainable consumption, life-cycle investigations need to go beyond traditional product LCA to answer the following types of questions.

1. What are the environmental and social impacts of households, including upstream and downstream impacts? How do they develop over time?
2. What are the social, technical, institutional factors that influence the level of these impacts? What are the differences between different social groups? Which lifestyles cause fewer impacts?
3. What are the important consumer activities, "functions," and items that produce

the largest impacts? What are the trends in these activities?

4. Where do consumers have the largest leverage to change impacts, where producers, retailers, or policy makers at different levels?
5. How can we know that a policy measure or consumer initiative in fact reduces impacts? The "rebound effect" has been shown to eat up a significant portion of energy savings, and that may be true also for other measures. How can we thus measure the effectiveness of policy measures, taking the "rebound" into account?

Some of these questions have already been asked, and answered, in energy analysis, especially in the investigation of energy efficiency or conservation. Since the combustion of fossil fuels is maybe the most important source of emissions, both the methods and results of energy analysis have some bearing on the questions of sustainable consumption. We will site key literature sources when discussing each question, without trying to present a comprehensive review.

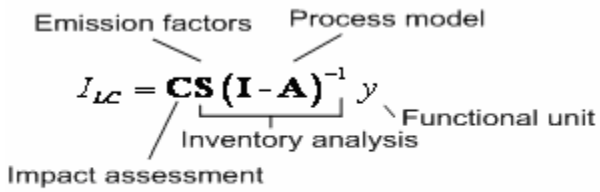
We will systematically go through the different uses of life-cycle approaches in sustainable consumption. First we outline how LCA-type investigations can be used and for what, and then we analyze what has been achieved already and how the field needs to develop further to achieve the goals set by policy makers.

The Conceptual Basis

Life-cycle Assessment

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 evaluation of environmental pressures and aggregation to impact indicators. The ISO 14040 standard for LCA define the first two steps as inventory analysis and the third step as impact assessment. 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 products gets 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. In this paper, we are most interested in attributional analysis.

In the attributional mode, LCA is a linear exercise. It can be represented by a set of linear equations which can be written in matrix form.



(1)

Where I_{LC} is the life-cycle impact, expressed as a vector of impact indicators for different impact categories; y is the vector representing the functional unit; **I-A** represents the matrix of production, use and disposal processes that contributes to the product life-cycle; S represents the table of emissions factors per unit process; and C the table of characterization factors per impact category. All attributional LCAs can be represented in this general manner. The matrix representing the production processes can be a physical process matrix, representing e.g. how many kg of iron and coal are used for producing x kg steel, or an economic input-output table, representing the trade between industry sectors in monetary terms.

The notation we have chosen for this presentation is that of input-output analysis. One should note that despite the notational and mathematical similarity (Heijungs and Suh 2002), there are significant differences between input-output economics and engineering-based LCA analysis. Input-output analysis presents the trade between industry sectors, LCA presents the flow of specific, physical products between production, use and disposal processes. LCA is therefore very technology-specific and can resolve differences e.g. between different alloys of steel or different colors of paint. Input-output analysis, on the other hand, deals better with non-physical inputs like "overhead", it can calculate value-added and employment, and it has a more complete coverage of the economy. Input-output analysis is hence being integrated into LCA (van Engelenburg et al. 1994; Suh et al. 2004). **I-A** includes representations of use and disposal processes, not just relationships on the production side. **y** represents the functional unit, and it includes commonly only one none-zero item. The functional unit is delivered by a process in **I-A** and y calls that process. It is common to operate with larger functional units in LCA, such as 1 million hours of watching TV or the washing of 1000 kg of cotton clothes.

LCA practice today can build on the cumulative effort of data collection. Standard LCA software usually 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 limited data from input-output analysis, so that hybrid assessments can be constructed. The data bases represent 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 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. 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, and exchange of life-cycle inventory data and the improvement and standardization of LCA methods.

The Impacts of a Country's Consumption

In order to determine the environmental pressures caused by a country, region, city or whatever geographical unit, the analysis needs to include all the goods purchased in this region, as well as their use and disposal. This means that the inventory $\mathbf{S(I-A)}^{-1}$ needs to be so comprehensive as to include all processes needed to produce, use and dispose of these goods. Instead of having a functional unit that calls on a single process, we need to call on all the goods purchased and their use and disposal. This means that **y** needs to represent all the goods used in a region. The consumption vector of a region can be seen to be made up of the per-capita consumption patterns of different socioeconomic or demographic groups **H** and the size of these populations **p**. The advantage of this decomposition of the consumption vector is that we can then ask how much impact is caused by which products. We arrive hence at an equation for the impact connected to a region's consumption,

$$\mathbf{I} = \mathbf{CS}\left(\mathbf{I} - \mathbf{A}\right)^{-1} \mathbf{Hp} \qquad (2)$$

This treatment is similar but not identical to the use of a social accounting matrix for representing household demand, suggested by Duchin (Duchin 1998; Duchin and Hubacek 2003). Decomposition analysis can be used to analyze historical changes in the overall impacts and attribute them to changes in population size, household composition, consumption patterns, economic structure, and emissions factors.

The Impacts of a Household

For a household, it is interesting to know which products and services contribute how much to the total household environmental impact. If the household consumption vector h is diagonalized and used instead of y in equation 1, we can see the environmental impact per product used in a household. This allows the household to pinpoint the areas where the most significant gain can be achieved. Different goods and services, however, are purchased for different purposes. It may also be interesting to know how much different activities, such as nutrition, housing, leisure, education, getting to and from work, contribute to the overall impact of the household. In this case, a demand matrix containing products purchased for different activities would be used instead of y in equation 1. Different experiences that are produced in the household from goods and services purchased, such as a ski trip or a dinner party, can be assessed in a similar manner.

An important aspect in evaluating the environmental impact of households or individual consumers is that they have a resource constraint. Nobody has more than 24 hours per day, and most households also have a limited budget. It is therefore also interesting to look at the emissions intensity (emissions per hour, emissions per dollar) of different activities. The emissions intensity of expenditures of all products used can be calculated as

$$\mathbf{M_M} = \hat{\boldsymbol{\pi}}^{-1}\mathbf{CS}\left(\mathbf{I}-\mathbf{A}\right)^{-1} \qquad (3)$$

where pi is the price vector (i.e. the identity vector if a monetary input-output matrix is used for I-A). The emissions intensity of time use is

$$\mathbf{M_T} = \hat{\boldsymbol{\tau}}^{-1}\mathbf{CS}\left(\mathbf{I}-\mathbf{A}\right)^{-1}\mathbf{F} \qquad (4)$$

where F is the table goods or services required for each activity and tau represents the time use for each of these activities. The problem with using time intensities is the question of what to do with fixed costs. Should the emissions associated with housing be allocated to the activities conducted in the house, e.g. sleeping, eating etc? Or should it just be seen as a fixed cost and not be counted?

In any case, it is obvious that when a household shifts expenditures from items that are more emissions intensive to those that are less intensive, the overall household environmental impact will decrease. The same can be seen from the perspective of time use.

Evaluation of Sustainable Consumption Measures

It is clear that a sustainable consumption policy, beyond general approaches such as internalizing external costs and extended producer responsibility, needs to consider specific sustainable consumption measures (Hertwich 2003). Similarly, citizens who are concerned about the environment may want to take specific actions to reduce their environmental footprint. The question is whether these measures are successful in achieving their aim. This is something that should be evaluated before the measure is taken, and controlled after it has been implemented. Car sharing is a much cited example of sustainable consumption: individuals who participate in a car sharing organizations drive less, walk and bike more, and use more public transport than those who own a car. The day-to-day mobility of car sharers therefore causes less impact, but it usually also costs less. Here we have a classic rebound effect: the environmental thing to do is cheaper, and the money saved will likely be spent on something else.

When evaluating the environmental effect of car sharing, we need to compare both the emissions associated with mobility and the emissions associated with spending the

money saved with car sharing. This can be done as a predictive exercise by looking at what the marginal expenditure is and assessing its impact. It can be done retrospectively by comparing the total household environmental impact of a car-sharer with a regular motorist in a case-control or intervention study. For the predictive exercise, econometric research is required to determine the marginal expenditure, while for the ex-post evaluation, a panel study with an adequate statistical design is needed. The achieved reduction in environmental impacts can be quantified with the following equation.

$$\Delta \mathbf{I} = \mathbf{CS}\left(\mathbf{I} - \mathbf{A}\right)^{-1}\left(\mathbf{h}_1^m - \mathbf{h}_2^m + \Delta \mathbf{h}^{nm}\right) \qquad (5)$$

The reduction in environmental impacts is the result of the difference in the mobility-associated activity pattern between the car-owning household h_1^m and the car-sharing household h_2^m, plus the difference between the non-mobility associated activities of the two households, Δh^{nm}. The latter term is written as a single item because, in predictive studies, it may be derived from the incremental spending patterns as households get richer, i.e. through an analysis of consumer expenditure surveys.

Evaluation of Sustainable Production Measures

Sustainable production commonly looks at reducing the life-cycle impacts of a specific product. Sustainable production measures affect the production structure A or the emissions factors S. Today, LCA is used to compare a potentially improved product with the currently available alternative. The improvement can be in the design of the product or in the production methods. The comparison is based on the concept of a functional unit: it is important that the function is the same. Improvements may, however, also affect the costs and - as a result - the demand for this and other products. While the evaluation of the direct effects just requires a before-after evaluation of the product(s) under question, the evaluation of the rebound effects needs to also look at shifts in expenditure. Both predictive and ex-post evaluations can be relevant and can be designed in about the same manner described in the previous section.

Practical challenges

Modeling the Impacts of a Country's Consumption

It is clearly a tremendous challenge to model all the stressors that are connected to all the products consumed in a country. The EcoInvent database has LCA data on 2500 products (ecoinvent 2003). This covers a significant fraction of the typical household consumption in terms of household impacts, especially energy and food (Frischknecht et al. 2002). Many manufacturing goods, however, are not included. To surmount this challenge, several simplifications have been taken: products have been aggregated to larger classes of products and calculated by input-output analysis, only a single proxy indicator (energy consumption, land use) or pollutant (CO_2) is modeled, and domestically produced products are used to represent imported products as well. Lenzen (1998) presents an

analysis of the energy and greenhouse gases embodied in Australia's final consumption. He follows the national accounting convention of presenting private and public final consumption, as well as a trade balance. This investigation showed that 59% of the CO_2 emissions were associated with private final consumption, 10% with public final consumption, and 31% with export. 81% of the CO_2 emissions occurred in Australia, while 19% were embodied in the imports.

Most analyses that address a country's consumption also look at the distribution of the private consumption across the population, i.e. at the emissions of different household types. They are therefore included in the following section.

The Impacts of a Household

There has been a fair amount of descriptive work on household environmental impacts. Herendeen and Bullard (Bullard III and Herendeen 1975; Herendeen and Tanaka 1976; Herendeen 1978) presented the calculations of household direct and indirect energy consumption. They used national input-output models with data on the energy consumption of different industry sectors and the direct consumption by households. The household expenditure for different items came from consumer expenditure surveys. Their investigation already included an analysis of the variation of energy consumption with household income. Direct energy consumption flattens out with rising income, while indirect energy consumption continues to rise. As a result, a large share of the total "energy cost of living" for poor households is related to the combustions of fuels in the household, while for rich people two thirds of these energy costs are related to the purchase of goods. In the input-output models used, products are commonly represented by output of domestic industry sectors. There are commonly 50-400 sectors in an input-output table. This resolution is sufficient for aggregate analysis, but it does not capture differences in product qualities. Vringer and Block (1995; 2000) and Wilting (Wilting 1996; Wilting and Biesiot 1998) therefore developed a more detailed hybrid model in which process analysis, in physical units, is combined with input-output analysis, in monetary units, to better represent the direct and indirect household energy consumption. They conducted a detailed analysis of household energy consumption based on the Dutch consumer expenditure survey. They found that the level of consumer expenditure accounted for much of the variance in per capita energy consumption, as indicated in Figure 1. Other significant explanatory variables were the number of household members, car ownership, and urban or rural households. In general, singles consume more energy than larger families, urban households consume less than rural or suburban households, and the ownership of a first and second car lead to increases in energy consumption, all assuming the same expenditure level. While these items were not found to be sufficient to explain all the variance, no other items were identified to be significant explanatory variables. Vringer and Block (Vringer and Blok 1995) also notice a number of limitations of the analysis. One of the more interesting one – from the perspective of using this data as a basis for scenario analysis – is that the method assume the same energy intensity per unit expenditure and does therefore not systematically address what might be called luxury consumption: the purchase of hand-made chairs or designer watches, for example, which potentially have a lower intensity *per unit expenditure* than mass-produced chairs or watches. A more extensive review of studies of household

energy and CO2 consumption on the national level is provided by Munksgaard et al. (Munksgaard et al. forthcoming).

There are very few studies considering impacts other than energy consumption and CO2 emissions. Weber and Perrels (2000) include NO_X, which is also a combustion-related pollutant, in their calculations. Most studies are also use domestic emissions intensities for imported products. A notable exception to both limitations is the work by Nijdam et al. (Goedkoop et al. 2002; forthcoming), which for the Netherlands includes imports from OECD Europe, other OECD countries, and the rest of the world, modeled in a 30 by 30 input-output model for each of the three exporting regions. The model also includes data on many types of pollutants and resource uses. While there are limitations in the low resolution and the uncertainty in the data especially for developing countries, this study points in the direction this field needs to develop to provide a richer and more reliable picture of the environmental pressures caused by household consumption. Hertwich et al. (2002) have evaluated the effect of the imports to Norway on the emissions of acidifying substances and greenhouse gases, taking the emissions intensities of Japan, the US, and China as representative for different trading partners.

We need to use the ability to model the impact of households on a national or regional level as a tool to track developments, to project trends and develop policy scenarios, and as an element in the empirical analysis of household environmental impacts. Empirical analysis should combine consumer expenditure surveys and household impact models to identify how differences in household characteristics, such as household size, housing type, income, education etc correlate with environmental impacts. One option is to use lifestyle classes as developed in marketing research as a way of classifying consumers and studying their environmental impacts (Duchin 1998; Duchin and Hubacek 2003).

A better analysis of the impacts of consumption is clearly needed. This analysis needs to cover more pollutants and realistically reflect production conditions in a global economy. Research is needed to determine the degree of resolution (i.e. product specificity) that is required for different purposes. While it is in general clear that a combination of traditional process LCA and input-output analysis can provide results that are both specific and cover the complete product range, it remains an open methodological question of how to best integrate the two tools. Depending on the purpose of the analysis, different processes will require a detailed modeling through process analysis. These basic modeling questions need to be solved to improve the quality of the models. There are further significant challenges to develop data from many impact categories, to model global value chains, and understand the uncertainty in the models. There is a need for more empirical research and a systematic evaluation of regional and inter-country variability, for example for food. The improvement of the modeling tools and the underlying data should occur in parallel with the development of new research approaches and applications.

Evaluation of Sustainable Consumption Measures

So far research has focused on empirical investigations of the environmental impacts of existing, average consumption patterns. To formulate an effective sustainable consumption policy and to stimulate effective action, more strategic analysis is needed.

This analysis should identify promising courses of action, evaluate specific activities and measures to see which ones should be implemented, and provide feedback about measures that have been taken.

It is clear that the analysis of household environmental impacts described in the previous section identifies the activities and purchases which cause the largest overall environmental impacts. They also allow for an identification of the activities with the highest impact intensities. This analysis can hence be used to identify promising measures for sustainable consumption policy and develop suggestions for consumer action. In the "consumer's guide to effective environmental choices", Brower and Leon (1999) present recommendations to consumers based on an analysis of what environmental impacts are associated with which products and household activities. They used impact intensities of the type calculated by eq. (3). Similar recommendations are derived from ecological footprint calculations (Wackernagel and Rees 1996) and footprint calculators. On-line or downloadable calculators for environmental impacts, such as CO2 emissions, have also been tried as a tool to raise awareness and inform consumer choices. They have, however, not yet had a larger impact (Hertwich and Katzmayr 2003).

Equations (2) and (5) can be used for scenario analysis, which should systematically explore different courses of action. Specific sustainable consumption measures can be evaluated using equation (5). So if a measure has been identified, maybe based on the analysis of environmental impacts of a household, we can either predict the expected changes in household environmental impacts, or we can measure the changes through a before-after comparison. Backcasting exercises can be used to find out how much lifestyle changes and expected technological changes can contribute to reducing environmental impacts to a specific level.

A comprehensive evaluation of sustainable consumption measures, as suggested in this paper, has to our knowledge not yet been conducted. Hubacek et al. (2003) describe an ongoing project in which the effect, and rebound, of a car-free housing project in Vienna is being evaluated. Fritsche et al. (2002) evaluated two city-quarter developments in Germany that were guided and followed up by an LCA-type evaluation. This project is very interesting, but it did not include a complete assessment of the households' environmental impact.

Evaluation of the rebound effect for sustainable production measures

It is common to use LCA in sustainable production, so its basic use does not need to be elaborated here. What is of interest to sustainable consumption is that technical progress and specific sustainable production measures may reduce the environmental impacts of specific products and activities, and this will occur at the same time as sustainable consumption measures. More importantly, however, there may be a behavioral response to sustainable production measures, something discussed in the literature under the inaccurate term "rebound effect."

The concept of the rebound effect has been suggested in response to energy efficiency measures. In the policy debate, the general notion of the rebound effect is that a technical

or policy measure produces secondary effects which at least in part off-set the initial, positive effect of the primary measure, so that the measure is less effective in achieving the primary policy goal. The rebound effect is often understood as the behavioral response to a technical improvement. The behavioral response, for economists, covers changes in purchasing behavior as a result of changes in market prices. The discussion addresses both cost reductions as a result of improvements in technical energy efficiency (Khazzoom 1980) and economy-wide effects (Brookes 1978). Greening et al. (2000) distinguish between following effects: pure price effect, income effect, secondary effects on the cost of producing other products, effects on the fuel supply (and the market power of OPEC) and transformational effects.

Numerous empirical studies have focused on the price and income effects. Greening et al. (Greening et al. 2000) present a survey of studies in the United States which indicates that the rebound effect is somewhere between 0 (for white goods) and 50% (for space cooling), but typically less then 30% (space heating, lighting, automotive transport). Schipper and Grubb (2000) review studies covering 80-90% of energy use in OECD countries and find that the rebound is on the order of 5-15%. They also review the issue of economy-wide effects and find no evidence for *substantial* macro effects.

Interestingly, the discussion of the rebound effect in energy economics focuses on reductions in the price of energy services as a result of energy efficiency measures, and the effect this has on demand. As Binswanger (2001) has pointed out, the cost of an energy service also includes capital costs and time spent on part of the consumer. Discussions of a *time rebound* have recently appeared in the sustainable consumption literature (Jalas 2002; Hofstetter and Madjar 2003). This effect results when the time-saving due to technical progress leads to increased consumption. For example, transportation research has shown that faster transport implies that people expand their radius of action but keep total travel time constant.

LCA traditionally focuses on the functional unit and neglects cost and thereby also the rebound effect. Goedkoop et al.(Goedkoop et al. 1999), however, developed the E2-vector, which consists of the environmental impacts and value added, as a way to display the impact intensity or eco-efficiency of a specific function. This concept allows for a graphical representation at least of the rebound effect, which is presented as a vector with the slope of average or marginal expenditure. In other words, a specific impact intensity of spending the money saved is used to calculate the overall impact of a product service systems. They used the E2 vector to quantify the effect of three "product-service systems", car sharing, vegetables by subscription, and laundry-services.

Conclusions

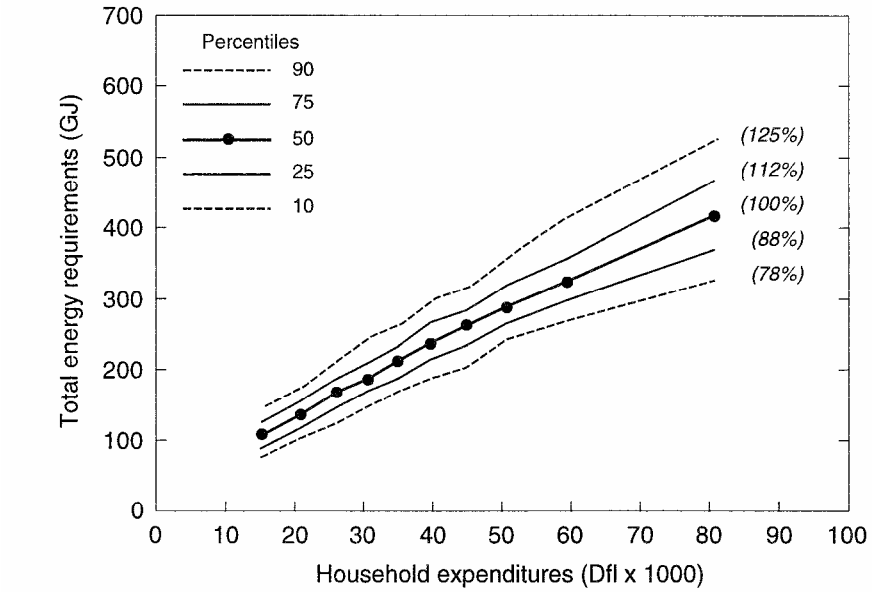
The Johannesburg Plan for Implementation calls for the use of life-cycle analysis to promote and achieve sustainable consumption and production. LCA has proven useful in the context of sustainable production. It has been little used in sustainable consumption. Questions that one needs to answer when addressing sustainable consumption – who causes how much of which impact and how can consumption patterns be changed to reduce these impacts – require an analysis that extends beyond traditional LCA. Previous research on direct and indirect household energy consumption indicates how life-cycle

methods can be extended to answer questions relevant for sustainable consumption. This includes the combination with input-output analysis, the use of consumer expenditure data, and the analysis of trade. A systematic extension in this direction, however, can go further than energy analysis has gone: changes or differences in consumer expenditure can be observed in panel studies of sustainable consumption measures; price and income elasticities can be measured and used in scenario analysis. We have also described how life-cycle methods can be used to conduct prospective and ex-post evaluation of sustainable consumption and production measures, something that is obviously of relevance to the 10-year set of activities in sustainable consumption and production called for by Johannesburg. The methods described in this paper have been used for some of the research questions outlined. Other research designs have not yet been tested. The indications are, however, that LCA needs to be combined with economic and sociological investigations to be useful as a tool for sustainable consumption. While a further method development and data collection is advisable, efforts should focus on developing and testing new research designs that are directly relevant to policy making.

ACKNOWLEDGMENT

This work is part of the FESCOLA project financed by the European Union's 6th framework programme through grant NMP2-ct-2003-505281. The ideas described here have been developed while the author was at the International Institute of Applied Systems Analysis in Austria. I would like to thank Faye Duchin, Katarina Korytarova and Line Sommerfeldt for their feedback.

FIGURE



Total household energy requirements vs. household expenditures (in Dutch guilders) based on the Dutch consumer expenditure survey from 1990 (Vringer and Blok 1995).

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Lifecycle Approaches to Sustainable Consumption

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Industrial Ecology Programme
Norwegian University of Science & Technology
www.indecol.ntnu.no

Workshop
"Lifecycle Approaches to Sustainable Consumption: Scope and Feasibility"
Prague, 21 April 2004

- ✓ The "development of the 10-year framework of programmes on sustainable consumption and production" is one of the three stated priorities of the European Union after the Johannesburg World Summit on Sustainable Development
- ✓ "production and consumption policies to improve the products and services provided, while reducing environmental and health impacts, using, where appropriate, science-based approaches, such as life-cycle analysis."
- ✓ **What is the scope and feasibility of using life-cycle approaches for sustainable consumption?**

What type of questions?

1. What are the **environmental and social impacts of households?**
   How do they develop over time?
2. What are the **factors** that influence the level of these impacts? What are the differences between different social groups?
   Which lifestyles cause fewer impacts?
3. What are the important consumer activities with the largest impact? What are the trends in these activities?
4. Where do consumers have the largest leverage to change impacts, where producers, retailers, or policy makers at different levels?
5. How can we know that a policy measure or consumer initiative in fact reduces impacts? How can we thus measure the effectiveness of policy measures, taking the "rebound" into account?

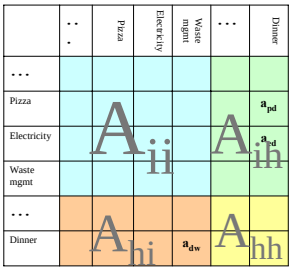
Life cycle analysis (LCA)

- ✓ **LCA is a "compilation and evaluation of the inputs, outputs and environmental impacts of a product system throughout its life cycle" (ISO 14040).**
- ✓ **Calculation of environmental stressors *per functional unit,* i.e. per product, service.**
- ✓ **Sustainable consumption requires the aggregation and comparison of environmental impacts of different products. There is no functional unit, and no equivalence between households' consumption patterns.**

General structure of LCA

$$I_{LC} = \mathbf{CS}(\mathbf{I}-\mathbf{A})^{-1} y$$

Modelling the entire life-cycle



Contrary to IO analysis, the A matrix also includes processes in households, such as the heating of a frozen pizza or the combustion of fuel in a moped.

Process Analysis & Input-Output Analysis

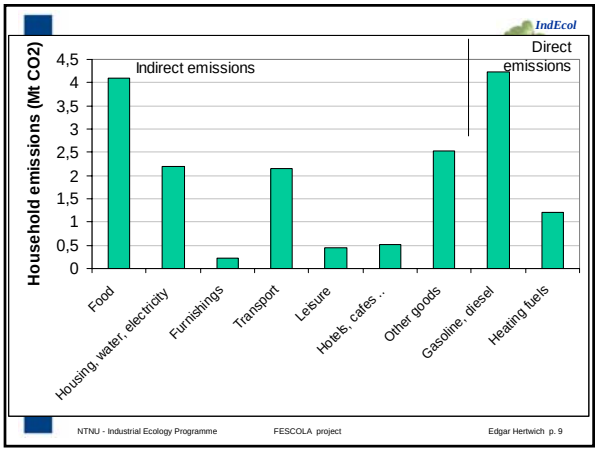
- ✓ LCA databases contain much information about production processes especially for energy, materials, and basic manufacturing processes. Many important commodities can be modelled.
- ✓ LCA often neglects input of services or capital required to produce products.
- ✓ LCA does not provide a complete coverage of all products that are consumed by a household.
- ✓ Input-output analysis provides a complete upstream coverage of all products and all production processes =>
- ✓ **LCA and IO can be used complementary or integrated in hybrid analysis**

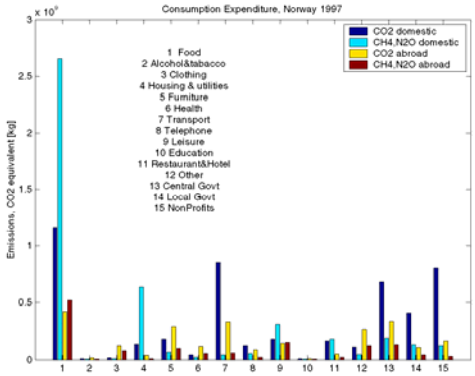
The impact of one household

$$\mathbf{I}_h = \mathbf{CS}\left(\mathbf{I} - \mathbf{A}\right)^{-1}\mathbf{h}$$

household consumption vector

- ✓ **No functional unit (y)**
- ✓ **A comprehensive inventory of all production and use processes is needed (in A and S)**
- ✓ **The household consumption vector (or matrix!) can come from Consumer Expenditure Surveys, "impact calculators" or targeted surveys.**





What household consumption classification?

Consumer expenditure items

- ✓ **Food**
- ✓ **Transportation**
- ✓ **Leisure**
- ✓ **Clothing**
- ✓ **House**
- ✓ **Household effects**
- ✓ **Hygiene**
- ✓ **Education**

Activities

- ✓ **Eating (includes shopping, cooking)**
- ✓ **Leisure (includes transportation etc)**
- ✓ **Clothing**
- ✓ **Housing**
- ✓ **Personal care**
- ✓ **Working**

Construct meaningful categories for different purposes of analysis:
A dinner party, a theatre visit, raising a child
=>basis for meaningful social science analysis

The impact of consumption on the national level

Population in different household types

$$\mathbf{I}_{cons} = \mathbf{CS}\left(\mathbf{I} - \mathbf{A}\right)^{-1}\mathbf{Hp}$$

Consumer expenditure for different household types

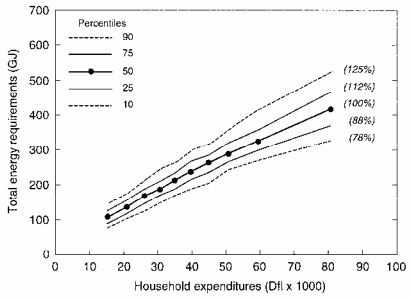
- ✓ **Calculate and build scenarios for the development of impacts on the national level.**
- ✓ **"Decompose" national impacts**

The impact of different population groups

- ✓ Different impact classes
- ✓ Urban/suburban/rural
- ✓ Differentiation by life-stage: Single households, couple, core family, retired couple
- ✓ Age cohorts
- ✓ Income
- ✓ "Lifestyles" from marketing: "Agrarian heartlands", "inner-city melting pots
- ➢ Social analysis
- ➢ Scenario analysis (Ageing)

Household Types in 9 EU countries

	Total
1. Agrarian Heartlands	0.13
2. Farming Town Communities	0.13
3. De-Industrial Legacy	0.11
4. Old Wealth	0.10
5. Career-focused Materialists	0.09
6. Midscale Metro Office Worker	0.08
7. Greys, Blue Sea & Mountain	0.07
8. Blue-collar Self-sufficiency	0.07
9. Educated Cosmopolitans	0.06
10. Inner City Melting Pot	0.06
11. Hardened Dependency	0.05
12. Lower Income Elderly	0.04
13. Non-Private Residences	0
Households (thousands)	133,564



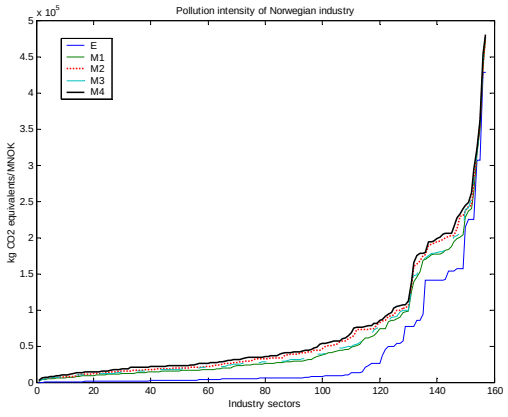
Distribution of energy requirements as a function of household expenditures, NL 1990

Source: Vringer & Blok, 1995, *Energy Policy*

Impact Intensities

$$\mathbf{M_M} = \underbrace{\hat{\boldsymbol{\pi}}^{-1}}_{\text{prices}} \mathbf{CS}\left(\mathbf{I}-\mathbf{A}\right)^{-1}$$

- ✓ What is the impact intensity of different activities and products?
- ✓ What is the "rebound effect" when shifting between different activities or life-styles?
- ✓ Which impacts should we target?



Effectiveness of a sustainable consumption measure: Car sharing

$$\Delta \mathbf{I}_h = \mathbf{CS}\left(\mathbf{I}-\mathbf{A}\right)^{-1}\left(\underbrace{\mathbf{h}_1^m - \mathbf{h}_2^m}_{\text{Change in mobility pattern}} + \underbrace{\Delta \mathbf{h}^{nm}}_{\text{Rebound effect}}\right)$$

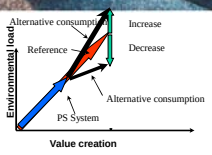
Evaluate sustainable consumption measures:

- ✓ Intervention studies (before – after comparison)
- ✓ Case-control studies (comparing 2 groups of consumers)
- ✓ Cross-sectional studies

Comparing sustainable consumption measures

- ✓ Car-free settlement case study, Vienna

- ✓ Car sharing example (Mats, Pre)



What should SC address?

- ✓ Critical decisions
  - Lifestyle choices
  - Habit formation
  - Transition between life-phases
- ✓ Social effects: social groups, neighborhoods
- ✓ Effects of infrastructure
- ✓ Market shifts and behavioural shifts

➢ Explore possibility of having an impact

LCA for Sustainable Consumption

Product-specific tools:

- o Environmental Product Declarations
- o Green products / marketing
- o User-education

Integrated Product Policy

Question

- ✓ What is the scope of the introduced approaches?
  - What options exist?
  - What are the potential benefits of these options?
  - Who uses the findings, how and for what?
  - How large would the effect be?
- ✓ What is the feasibility of the different option?
  - What are the problems?
  - What are the barriers?
  - And how can they be overcome?

Life-cycle approach to assess the environmental impact of consumption - Key factors, decisions and actors

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How to achieve sustainable consumption is an important issue in many countries. Communication of the knowledge on sustainable consumption in positive terms and with appealing images for instance has been identified as a very important step to achieve sustainable consumption patterns. Life-cycle approaches can provide a scientific basis for such campaigns. But there is still a need for reliable assessments of the environmental impacts of all consumption activities and there is even a stronger need for prioritising of consumption patterns and alternatives that can make a significant difference.

A current study of the life-cycle group at the Swiss Federal Institute of Technology Lausanne on the environmental impacts of Swiss consumption aims to:

1. Determine the environmental impact of the consumption of Swiss citizens
2. Identify key factors, key decisions and key actors in regard of sustainable consumption
3. Elaborate sustainable consumption patterns suitable for communication

Several studies evaluating the environmental impact of consumption in different European countries have been gathered and compared. The comparison per consumption domain (housing, mobility, nutrition, goods and services, public consumption) shows a majority of similar tendencies but also significant divergences between the studies elaborated for different countries. Differences in consumption habits, scope and system boundaries but also different approaches explain a good part of the dissimilarities observed.

Combined use of Input/Output-LCA models and process LCA seems to be the approach that allows assessing the biggest share of the environmental impact of all economical activities of regions and countries, but raises difficulties in countries like Switzerland with poor economical Input/Output data (nomenclatures of both economical and environmental data).

How to spend money in a sustainable way? At present consumers are awash with pieces of information on how to consume sustainable and not seldom the information seem contradictory. Whenever possible, life cycle impacts from extraction of raw materials, production, use and disposal are separately assessed in order to identify the key actors and decisions. The study draws up hierarchical trees with the most important decisions in regard to sustainable consumption based on life-cycle assessments (choice of living place, building type, mobility mode, etc.). Further it is setting up a list of consumption patterns where there is either no significant gain or where favourable consumption patterns are not established.

ENVIRONMENTAL IMPACT OF SWISS CONSUMPTION

LIFE-CYCLE APPROACHES TO ASSES THE ENVIRONMENTAL IMPACT OF CONSUMPTION

KEY FACTORS, KEY DECISIONS AND KEY ACTORS

Josef Känzig, Prof. Olivier Jolliet,
Industrial Ecology - Life Cycle Systems,
Swiss Federal Institute of Technology Lausanne (EPFL)

Workshop "Lifecycle approaches to sustainable consumption"
SETAC Europe meeting in Prague, April 21, 2004

Contents

I. Context
II. Goal & system bounderies
III. Method
IV. Comparison of different studies
V. Environmental impact per capita and consumption domain
VI. Key factors, decisions and actors
VII. Sustainable consumption patterns

Context

How to achieve sustainable consumption?

Needs:

- **Assessments** of the environmental impacts of all consumption activities
- **Prioritising** of consumption patterns and alternatives that can make a significant difference
- **Communication** of the knowledge on sustainable consumption with appealing images and in positive terms

Goal & Approach

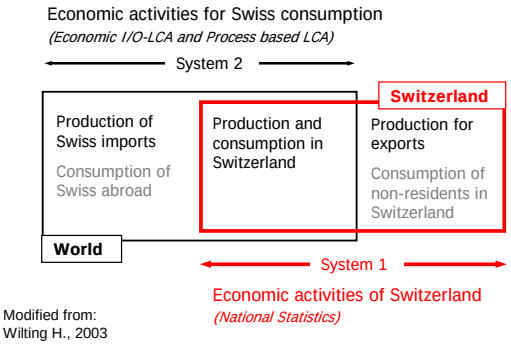
Current study at EPFL:

1. Define **consumption domains**
2. Assess **the environmental impact of Swiss consumption** with life-cycle approaches
3. Analyse and **identify key factors, decisions and actors** in regard to sustainable consumption
4. Elaborate **sustainable consumption patterns** suitable for communication purposes

Scope

- **Time reference :** 1990 to 2004
  most recent possible
- **Geographic reference :** Switzerland & Imports – Exports
  - comparaison with EU and USA
- **Functional unit:** Quantity Q of products needed to fulfil the demand of Swiss consumers per year.

System bounderies



Modified from:
Wilting H., 2003

Consumption domains

- **Lodgement** (including electricity consumption of houshold appliances)
- **Privat mobility** (Work related mobility allocated to corresponding domain if possible)
- **Nutrition** (including transport)
- **Consumption goods** (heterogeneous!)
- (Public) **services** (Banks, insurances, army, ...)

LC approaches

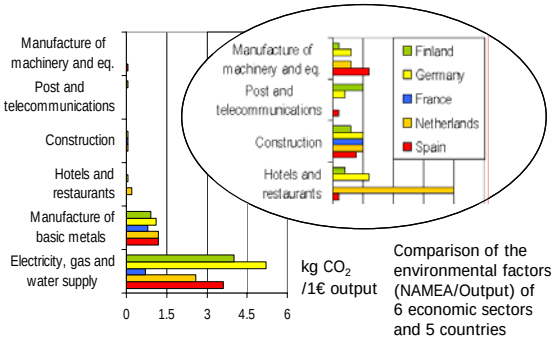
Evaluation	Per economic sector	Per consumption domain
Production stage	• CH-I/O tables 1990 (G. Antille, 1997), 37 sectors (NCT) • Dutch and German environmental data 1996, 60 sectors (NACE/NOGA)	• Statistics • Process based LCA
Use stage		• Statistics • Process based LCA
End of life stage		• Statistics • Process based LCA

Economic Input/Output-LC approaches

Difficulties when using I/O-LC approaches for countries like Switzerland with poor data per economical sector:

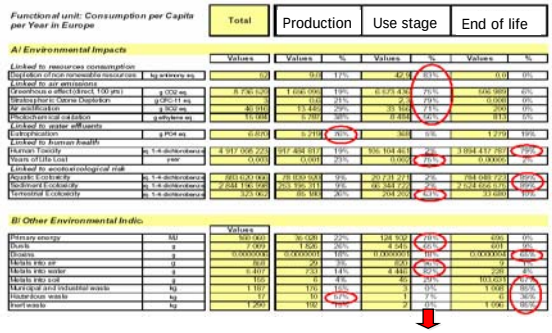
- Conversions of both economical and environmental nomenclatures in order to combine all data:
  - Conversion from NCT (CH) to NOGA/NACE (Europe) e.g.
- Use of environmental factors (NAMEA/Output) from other countries that vary greatly because of:
  - different structure of national economies, sectors and industries
  - different inventory methods for environmental data
  - ...

I/O-LC approaches (Kg CO_2/€)



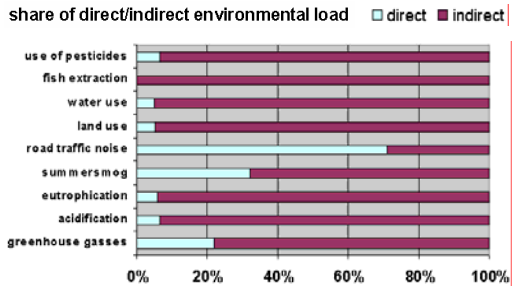
Comparison of the environmental factors (NAMEA/Output) of 6 economic sectors and 5 countries

Summary study on Europe (BIO)



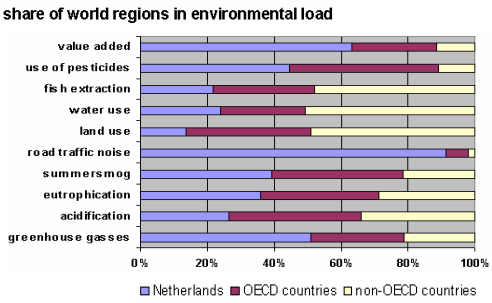
Use stage dominates the environmental impact!

Study on Netherlands (RIVM 2004)



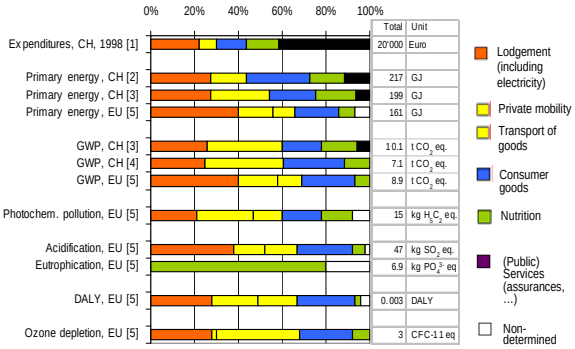
A majority of the impacts is not direct (don't occur during the use stage) => consumers are not aware of!

Study on Netherlands (RIVM 2004)

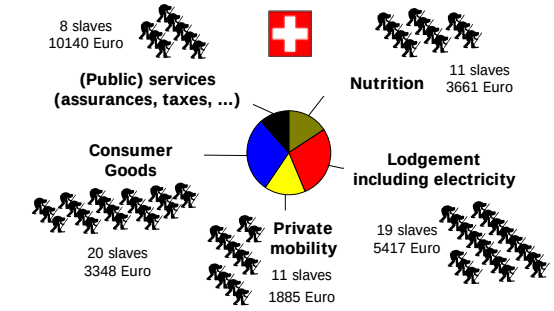


A good part of the environmental load occurs abroad and is due to imports

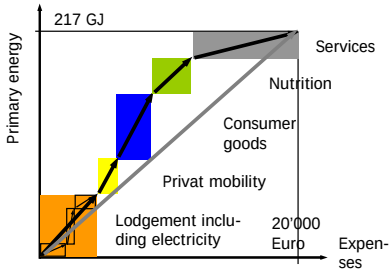
Results and comparisons



Distribution of primary energy consumption and expenditures per capita /year



E2 vectors (Energy & expenditures /capita)

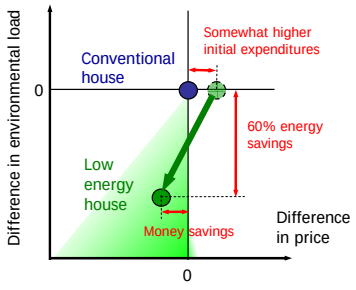


(Public) services: High expenditures, low energy consumption.
Mobility and consumption goods: Little expenses, high energy consumption.

Key factors, decision and actors (1st results)

Domain	Key factors & decisions	Key actors
Lodgement including electricity (Use stage!)	Energy (heating) & materials • Thermical quality (isolation) • Living space (m²/capita) • Room temperature	• Builder-owner, Architect • Government (regulation, financial incentives) • Consumer
Privat mobility (Use stage!)	Energy (Gasoline) Infrastructure (rail)	• Consumer • Government (regulation, financial incentives)
Consumer goods (Whole life cycle)	Energy consumption & type Materials	• Consumer • Government (regulation, financial incentives)
Nutrition (Production!)	Landuse, eutrophisation, water consumption. Origin (region, greenhouse,…) Transport (air, last mile, …) Season, vegetable or meat	• Consumer • Producer • Government (regulation, financial incentives)
(Public) services	Number of employees Arny	• Companies • Government

E2 vecteurs (Greener alternative)



Higher investment results in money savings and lower environmental load over the whole life cycle

Consumers decisions (3 lists)

Hierarchisation of consumers decisions in terms of the potential gain par act of consumption. 3 lists:

I. Crucial decisions
- Holiday destination
- Lodgement
  - Low energy house
  - Living space (m^2/capita)
  - Room temperature
- Commuting (distance, mode of transport)

II. Small but frequent decisons
- Food & shopping

III. Decisions without significant gain or where favorable consumption patterns are not established
- Recycling aluminium yogurt covers

Conclusions & Outlook

- Assessments of the environmental impacts of all consumption activities :

  => Combined use of I/O-LCA models and process-LCA

  Difficulties in countries like Switzerland with poor economical Input/Output data
  - conversion of nomenclatures
  - using data from other countries

  Next step: Process-LCA with ecoinvent
- Prioritising of consumption patterns and alternatives that can make a significant difference.
- Communication of the knowledge on sustainable consumption with appealing images and in positive terms

Evaluating the Environmental and Social Impacts of Households' Consumption

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Introduction

The World Summit for Sustainable Development (WSSD) in Johannesburg recognised the need 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).

However, a better understanding of what impacts consumption causes throughout the lifecycle of products can yield powerful policy insights only when it is combined with an understanding of how products are consumed and the factors that influence consumption patterns. With insights into why some consumption patterns are more popular than others, such a tool can provide a sound basis for the development of sustainable consumption policies.

In our project "*The Environmental Impacts of Consumption: Research Methods and Driving Forces*[3]" we focus both on developing methods to evaluate the initiatives as well as to understand the motivation to consume and to consume more consciously. Our case study is focused on a car-free settlement in Vienna Floridsdorf. In this paper, we will focus on the research questions and summarize the approaches and insights gained so far.

1. Project Objectives and Approaches

1.1 Objective

The objective of our project is to develop a general model for calculating the environmental loads (both direct and indirect) from household consumption. We expect the model to be internationally comparable, as well as applicable to other sustainable

[3] This research has been conducted for the research program "Lifecycle approaches to sustainable consumption" of the Society for Non-Traditional Technology (SNTT) and the National Institute for Applied Industrial Science and Technology (AIST) in Japan.

consumption initiatives.

We focus not only on the environmental approaches to evaluate consumption patterns, but we also consider motivation, behavioural aspects, acceptance of reduction measures and of alternative lifestyles, relations between consumption and well-being, as well as the socio-economic-technical environment in which the consumer patterns are embedded.

1.2 Research Questions

Such a wide view requires inclusion of the social aspects of consumption. In our literature review of the social science approaches to evaluation of consumption we posed the following research questions: How can consumption patterns be determined and their environmental impacts be quantified? How do different households vary in the environmental impact of their consumption? How are changes in lifestyles accepted? How do they influence well-being? How do the socio-economic variables influence the consumption patterns and habit formation?

In our own research project we especially focus on these questions:

- What are the average consumer expenditures with the biggest threat to sustainability?
- To what extent do consumption patterns differ concerning their environmental impacts at the national level?
- What are the reasons for the various levels of environmental impact of consumption patterns?
- What are the employment and economic effects of the various consumption patterns?
- What are the most promising changes in consumption taking environmental impacts, employment and economic effects into account?
- What has to be done to promote these changes when assessing the attitudes, routines, social factors, and institutional framework conditions shaping the consumption patterns?

1.3 Approaches to Consumption Research

Unlike mainstream economics, which assumes fixed preferences, we consider the consumer decision-making under high uncertainty. Another important insight that we gained from the review on current state-of-the-art social science research on consumption[4] is that individuals or groups do not always behave intentionally environmentally friendly. It is one or more of the areas of their behaviour (rather than all areas) that can be more environmentally friendly in comparison to the other areas of behaviour, as well as to the other people within the same areas.

Research indicates that consumption patterns are fairly stable and suggests that behaviour changes are most likely when external circumstances also change or consumers move from one phase in their life to the next. The follow-up study to the so called “Perspective project” in the Netherlands showed that the effect of a 2-year-change in household

[4] Most of which concerns energy consumption

consumption behaviour was only temporary and the people returned back to their old lifestyles after the cease of expert advice and financial incentives. An intervention study in Stuttgart showed that families who moved to Stuttgart could be influenced in their choice of transportation behaviour through targeted information about public transportation just after their move.

These insights are useful for understanding how new habits are created, and when substantial changes in lifestyle are easier to be adopted by individuals.

Therefore, we assume that habits, as stable factors in decision making, are more likely to change when significant events happen in one's life or when one moves from one stage in life to another.

We also work with the assumption that not only infrastructure (solar collectors, insulation, green electricity provision, bio-shops) and information provision (efficient user guides, information on impact of various products[5] etc), but also social learning are of importance. This of course includes the participation of the future tenants on the planning phase of the construction project. However, for the long term success of a sustainable consumption initiative, it is vital that the involved individuals have a chance to interact with other peers who hold similar values towards environmental issues, and thus gain motivation to pursue more sustainable lifestyles.

For purposes of developing a suitable survey, which will enable to reveal the driving forces for consumption, we focus not only on purely environmental aspects (impacts) of consumer behaviour, but also on consumption in terms of the whole social context, where these patterns and habits are embedded. (See below – our survey hypotheses and conclusions in review)

1.4 Research areas and conclusions from the review of literature

Besides the already mentioned insights from the review, we have also focused on the types of questions that are used in subjective well-being (SWB) and objective happiness research (see the Table 2). These are important for designing our own surveys. We also learned that aspects such as comparative poverty and comparative income are closely related to our perceived well-being and the satisfaction extracted from consumption. Consumers perceive their own standing in comparison with their peers, neighbours and co-workers. They also compare their own past and present living standards and the socially constructed norms.

Survey questions have been developed to capture these effects. For instance, Income Evaluation Question (IEQ), which is used within the Leyden approach (van Praag, 1999), determines the perception of ones level of well-being relative to a reference and quantifies this in monetary terms.

The advantage of the "Objective Happiness" (OH) proposed by Kahneman (1999) over the SWB is that by measuring the OH we avoid the contextual and assimilation biases.

[5] The PiTH project of the Dutch government is an attempt to introduce computer software that personalizes information and advice according to the type of consumer; this information is to be obtained by each household in the NL. (Brand and Dirks, 2003).

However, this approach is still being developed. One of the ways to avoid personification when asked about one's relative standing is to focus the question on the life conditions of one's future grandchildren.

The so called hedonic treadmill and related adaptation levels and the satisfaction treadmill with its aspiration level (Kahneman, 1999) explain the motivation factors behind our consumption.

It is also worth mentioning the research measuring unhappiness and closely linked measures such as time use, well-being and consumption, health considerations, as well as national and cultural differences on perception of satisfaction with ones life. Of interest is also the model of Jager (Jansen and Jager, 2002), who developed the so-called "consumat approach", which reflects the realities of non-optimal behaviour, as well as processes of social comparison and habit formation. His model integrates explicit modelling of need satisfaction[6] drivers and context dependent methods of cognitive processing.

In terms of environmental behaviour research Empacher (2000) characterizes the different types of consumers and the strategies to motivate each of them to sustainable consumption measures.

2. Methods

In our research, we compare two settlements of similar age and demographic variables in Vienna in terms of consumption behaviour, environmental impacts, motivation, and well-being. One of the settlements is a car-free housing project. Consumption behaviour and environmental impacts are also compared to the Austrian population at large. The method used in the research is a combination of quantitative and qualitative social research designs with extended Input-Output analysis and LCA. At the core of our research is a quantitative survey which determines the consumption patterns, basic socioeconomic and demographic variables, and a few selected factors related to well-being. Qualitative, in-depth interviews with selected households are used in a follow-up to gain a "rich" description of the individual motivations and social processes that shape consumption in the two settlements. The environmental impacts are modelled using an extended input-output table with an interface to both consumer expenditure surveys and emissions data. In the following, we explain this model in more detail.

First, we select the environmental indicators (e.g. CO2, household waste, energy) from NAMEA[7] that are most relevant in terms of the households' contribution to the pollution

[6] The effort to identify the basic needs required to a "good life" dates back to Aristotle. Explicitly based on his framework, Sen (1998) and Nussaum (1998) relate basic needs theory to economic development with the proposition to define needs as "capabilities to function". Nussbaum also introduces a set of needs-universal accross cultures. In the area of psychology Maslow (1958) and Max-Neef (1992) have proposed a set of needs.

[7] NAMEA – National Accounting Matrix including Environmental Account. NAMEA organizes the environmental data according the economic activities as defined by NACE – the EU's statistical classification of economic activities (Eurostat, 1996a). The coherency between the NAMEA and IO table is ensured by the identical 2-digit aggregation level of NACE (same both for the IOT and NAMEA). Aggregations of the NACE were needed (NAMEA for 40 sectors, NACE for 60).

of the environment. NAMEA data show the direct impact caused by the economic activities (e.g. by manufacture of food products and beverages).

Then we calculate the direct and indirect consumption. The data from direct consumption is taken from the consumer Expenditure Survey of Austria[8] (CES, (1999) and the environmental loads from consumption is calculated using the standard technology factors (the input-output coefficients) and environmental indicators. The indirect consumption is provided from the Austrian Input Output Table (IO) and the indirect loads are calculated by extending the IO by these very same indicators. The results are used for assessment of the environmental profiles for the average Austrian household according to the consumer expenditure. Based on the results from our surveys we develop such environmental profiles also for the car-free and reference settlement.

In order to detect rebound effects we pay attention to expenditure shifts (e.g. from car travels to flight trips). We will use these elements to develop scenarios for future environmental loads due to household energy consumption in Vienna. The scenarios will reflect possible changes in consumption patterns concerning its environmental loads, which are especially relevant for the policy implications of sustainable measures. These changes will reflect the changes in demographics, income and employment.

3. Expenditures with the highest environmental impact

NAMEA was used to create the environmental profile for each economic activity (see Figure 1). The only activity dominating regarding almost all indicators is consumption in private households. More than 50% of the Austrian CO_2 emissions are finally caused by households. Approximatly 30% of the CO_2 emmisions are caused by households directly (e.g. heating and private traffic), the rest (20%) are caused indirectly by the economic activities that are necessary to satisfy private households‘ consumption of goods and services.

From these activities we select four economic activities, which cause in total more than 50% of the upstream pollution regarding CO2, NOx, CSB[9]. These four economic activities are:

- private transport meaning purchase of vehicles, repair and fuel
- food, alcoholic and non-alcoholic beverages and tobacco
- hotels and restaurants, and
- electricity, gas, steam and water.

The remaining part is caused by other categories of final consumption like export and government. Households are also responsible for more than 50% of the final energy use

[8] CES uses the classification COICOP (Classification of Expenditure according to Purpose), which covers all areas of individual consumption. COICOP is also used for compilation of the national accounts. But there is no direct link between COICOP and NACE. Therefore the national Classification of Products and services according to activities (CPA) has to be used (Haas et al., 2004). CPA level is thus useful for development of our surveys.

[9] In case of AOX and hazardous waste private households are responsible for less than 40%

in Austria.

This analysis shows that private household consumption is indeed a crucial entry point for reducing environmental impacts and the mesures have to target the households' behaviour in these four economic activities.

4. Survey Design

The purpose of our study is to enable comparison of consumption patterns of the two settlements in Vienna and to provide possible explanation of the driving forces behind more or less sustainable consumption patterns and the lifestyles in general.

In contrary to common practices in the survey design, we propose that the quantitative and qualitative social research methods are employed within one study, although in different phases of the research process (sequencing).

This is possible because the quantitative survey is rather focused on descriptions (e.g. of actual behaviour) than on hypothesis testing.

With this approach it will be possible to complement findings on an aggregate (or sample) level with individual cases of consumption practices.

4. 1 Our Assumptions

Assumption 1: We assume that we can observe different consumer patterns in both settlements. This statement is based on the fact that the tenants of the car-free settlement have committed themselves to live without a car. Therefore the difference should be obvious at least in terms of the behaviour in mobility area.

Assumption 2: However, based on experience from previous studies (Prose und Wortman, 1991; de Haan und Kuckartz, 1995), one should also expect that there are no significant differences between the settlements, but between the different consumer configurations **within** the two settlements. (See the Tables X1-X4)

Assumption 3:

Our general assumption is that the environmental awareness of the inhabitants in the car-free settlement is higher than the Austrian average. This statement is based on the fact that the car-free tenants could participate in the planning phase of the construction process (Haas et al, 2004b) and that they enter the social learning process through the interaction with people of similar values.

Figure 4: Hypotheses

	Car-free settlement	Standard settlement
Sustainable consumption	**x**	
Non-sustainable consumption		**X**

1: Starting assumption (Assumption 1)

	Car-free settlement	Standard settlement
Sustainable mobility	**x**	
Non-sustainable mobility		**X**

2: Differentiation by mobility (Assumption 2)

	Car-free settlement	Standard settlement
Sustainable energy consumption	**x**	**X**
Non-sustainable energy consumption	**x**	**X**

3: Differentiation by energy use (Assumption 2)

	Car-free settlement	Standard settlement
Sustainable food consumption	**x**	**X**
Non-sustainable food consumption	**x**	**X**

4: Differentiation by foodstuff and meat consumption (Assumption 2)

4.2 Settlements

The survey will be conducted simultaneously in the car-free settlement in Floridsdorf and in a common settlement with comparable features in terms of construction and demographics (e.g. year of construction, material etc, age structure, family structure).

4.3 Motivation in Floridsdorf

In the previous post evaluation research (after 18 months) in Floridsdorf, the tenants were asked about their motivation to move to the car-free settlement[10].

The motive number one was the "offer of common social areas and green areas" (56%), which was followed together by these motives: "acceptable price-performance relationship" (53%), "ecological concept/application of the alternative energy" (53%) and "car-free housing" (53%).

In terms of the "motive car-free housing", it was surprising that for almost half of the respondents the car-free feature was not a significant motivation. This can be explained by the fact that most of them had no car or planned to dispose it anyway; and therefore for them the car-free feature of the settlement was taken as given. Another surprise was the relatively high motivation factor (41%) - the location – the 21st district, which can be explained by the proximity to the relaxation area (Alte Donau) and large green areas; even despite of the cumbersome public transport connections.

Other factors were: communication and community/companionship (41%) (preferred by

[10] The question: "What were the most important reasons for renting an apartment in the car-free settlement?"
from the 10 options maximum 5 was to be chosen.

the majority of the couples with children; a good ground 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. Participation is an important factor for 28% of the inhabitants. Seventy-one percent of those who prefer participation belong to the socially and culturally active citizens. The architecture of the settlement was important only for 21%, (a compromise with the price).

4.4 Descriptors of consumption patterns

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.

Figure 5: Descriptors of consumption patterns

Total expenditure for the selected four economic 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 (excl. transport)
Expenditure profile for the various energy carriers

4.6 Survey Structure

Here we provide the information sections of the survey:

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

General data
- Number of questionnaire
- Address
- Persons permanently living in the household
- Age, Gender
- Occupation

Available household income
- Persons earning money
- Net salaries
- Social aids and allowances
- Changes in debt and savings
- Rent and operating costs

Food, beverages and tobacco
- Total expenditure
- Meat

Biological products
Alcoholic beverages
Non-alcoholic beverages
Food from gardening
Purchases directly from producers

Mobility (private trips only)

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
Public transport with destinations in Austria
Public transport with destinations abroad
Car sharing

Private trips

All-inclusive trips (expenditure, destination, duration of stay, number of persons)

Restaurants and hotels

Catering services
Accommodation

Energy consumption

Electricity (expenditure and kWh)

Hot water, steam (expenditure and kWh)

Gas (expenditure and kWh)

Other products

Household appliances (multiple choice list with information on eco-efficiency)

Audio-visual, photographic and information processing equipment

Computer

Internet access

Phone (including mobile ones, year and cost of purchase, running costs)

Other important expenditures

e.g. Weekend house

Subjective information

Motivations (concerning: choosing this settlement, consumption patterns, mobility, etc.)

Consumer satisfaction

Life style indicators

Well-being

Ecological knowledge

Ecological motivations (e.g. low-cost versus high-cost situations)

Learning processes (changes over the years)

Structural/institutional conditions

Social control

Social dynamic indicators

Conditions/available offers for sustainable consumption

Figure 6: English summary of the developed 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 four areas of our interest.

4.7 Questions

Our quantitative survey will include consumption-related questions and theory-related questions about the motivation, lifestyle and structural conditions.

The qualitative part will focus first on the current consumption patterns and second on the possible changes of the present consumption patterns. The interview should provide explanation of different consumers types in terms of both the individual (own values, habits) and contextual factors (role of norms and social learning).

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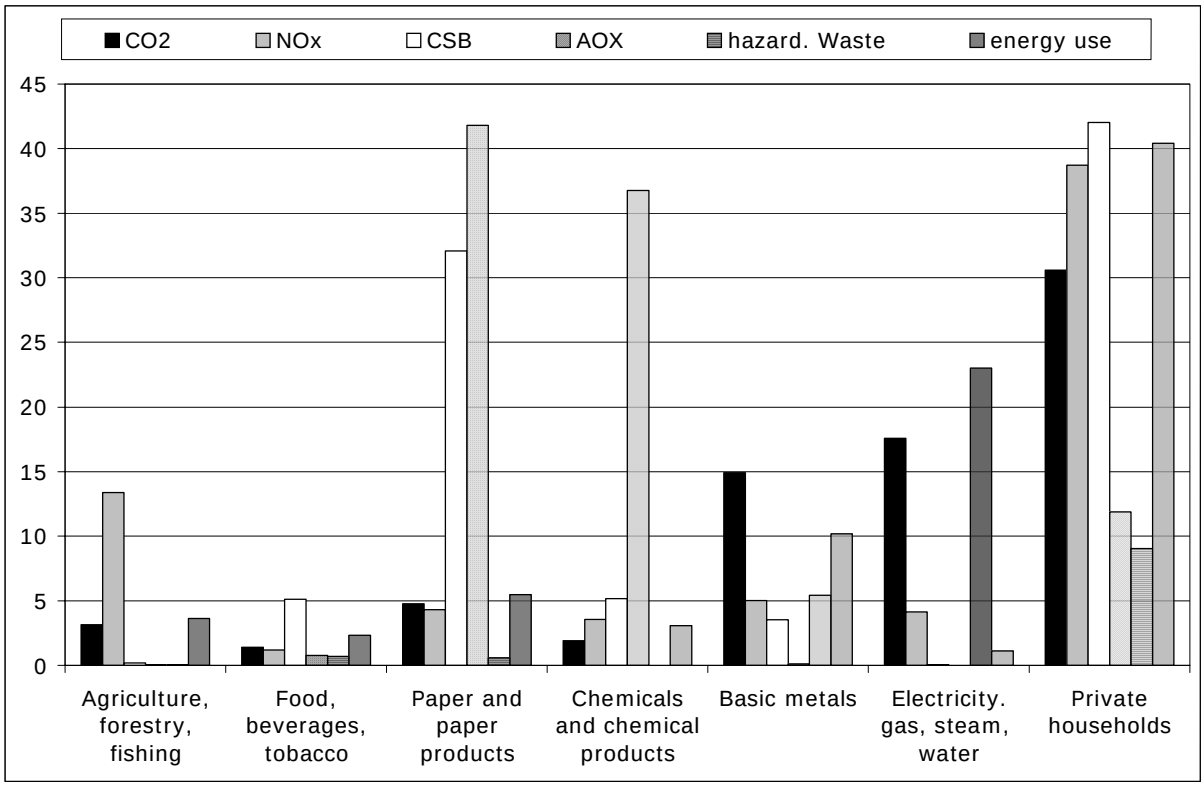
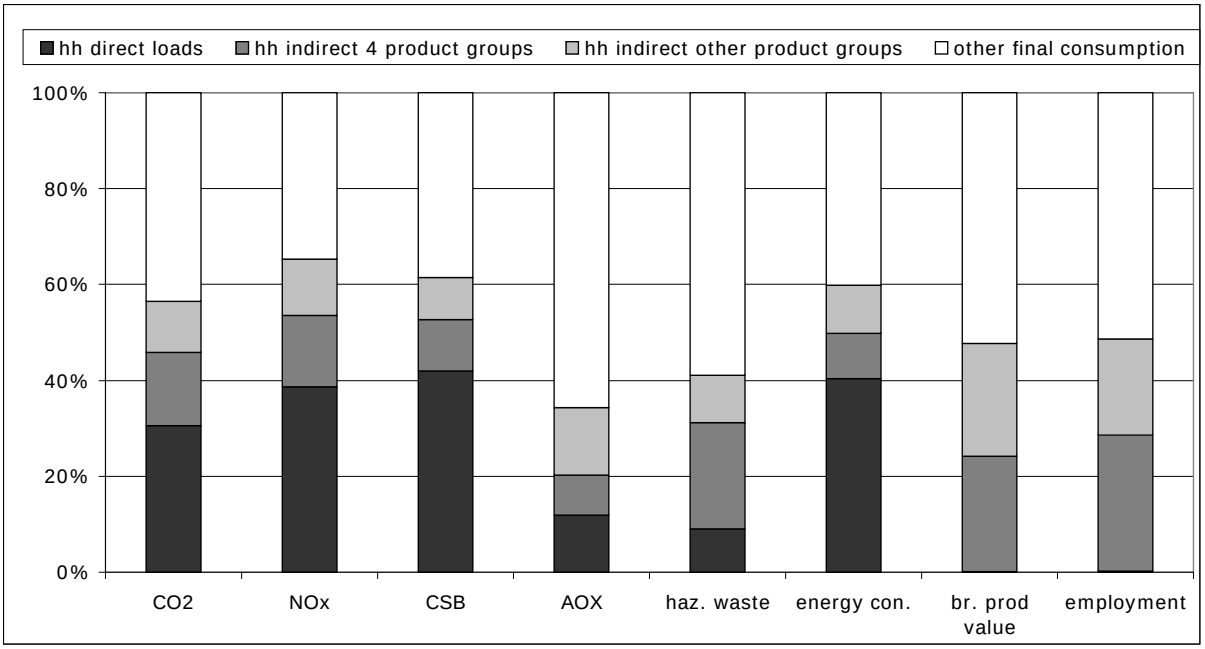
APPENDIX

Figure 1: Some selected economic activities and their environmental impacts concerning 6 selected indicators. The numbers indicate the percentage of the total emission of this indicator (e.g. paper and paper products cause 42% of the AOX emission in Austria).



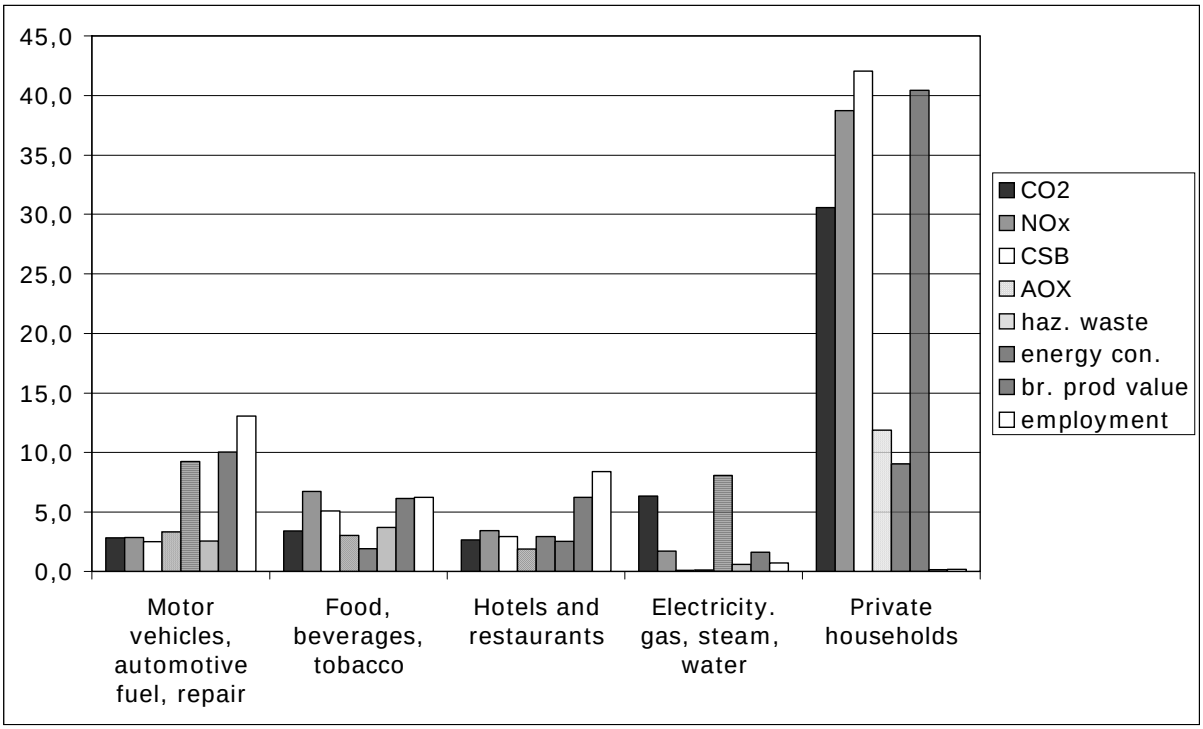
Source: Haas et al. (2004a). The calculation based on 1995 NAMEA

Figure 2: Household direct and indirect consumption's share of the total environmental impact by indicators.



Source: Haas et.al. (2004a). The calculation based on 1995 NAMEA data and Austrian Input-output table for 1995

Figure 3: Household consumption's upstream effects plus direct effects at the household level.



Source: Haas et.al. (2004a). The calculation based on 1995 NAMEA data and Austrian Input-output table for 1995

Table 1: Survey questions, focus and other information from the area of behaviour

Details	**Survey**
	World Value Survey II
Question	"All things considered, how satisfied are you with your life as a whole these days?"
Focus	life satisfaction, pleasant affect, unpleasant affect
	Affect balance Scale
Questions	5q on pleasant emotions (0 - 5) & 5q on unpleasant moods (0 to 5)
	Subjective side of social change
Focus	wealth, work satisfaction, health, life participation, social recognition, self-esteem, national differences, and genetic make-up
	Objective happiness
Focus	instant utility - asking subjects repeatedly at random times about their well-being;
Label	"Good/Bad" experiences of moments of life – sum them up into total utility of the episode
	Leiden approach (3 approaches/improvements)
1	**Income Evaluation Question (IEQ)**
Question	"While keeping prices constant what after tax total monthly income would you consider for your family to be: very bad, bad, sufficient, insufficient, good, very good."
	"Here is a list of income levels per month, after tax: please evaluate these amounts using verbal qualifications, such as "very bad", "bad", "insufficient", "sufficient", "good", "very good": $2000, 4000, 6000, 8000, 10000. "
Identifier	verbal labels, which are translated into numerical evaluation on a bounded scale, e.g. [0,1].
2	**Age Evaluation Question (AEQ)** - analyze the age norm of respondents (reply to be a numeral answer)
Question	"When I think of the others adults, I consider people to be young, if they are younger than…years old; somewhat young;
	Education Evaluation Question (EEQ) - similar
3	**Cantril question** - measuring satisfaction with the life as a whole
Question	"Here is the ladder with ten steps which denote the ´ladder of life´. The bottom step stands for the worst possible life. If you climb up …Can you indicate where you are at the moment?"
Focus	measuring well-being and welfare
Factors	family size, income, age and religion and variables called "problem intensities" in categories health, partner, job, sleep, alcohol and drugs, family, sexual problems, parents and neighbourhood.
Development	utility functions and to derive shadow prices for amenities like climate and environmental variables
	Measuring Unhappiness (Clark and Oswald, 1994)
Questions	12 questions: "Have you been able to concentrate on whatever you are doing?" through "Have you been able to face your problems?" to "Have you been thinking of yourself as a worthless person?"
	Relative Standing
Question	Respondents are asked to evaluate trade-offs between absolute and relative consumption" (Howarth, 2002)
Focus	measuring social dimensions of consumer behavior
	Health-income-WB (change in health as a change in income)
Focus	asking about equivalent income change that would be necessary to change general satisfaction with life to the same extent as a change in health satisfaction would do
	Health related Quality of Life vs. Quality of environment
Focus	Integration of the indicators

	(Subjectivly perceived) Income inequality (Ferrer-i-Carbonell, 2002)
Question	'How satisfied are you today with the following areas of your life? (scale 0-totally unhappy to 10 totally happy) How satisfied are you with your household income…..'
Focus	individual responses to Income Satisfaction Question posed in the German Socio-Economic Panel (GSOEP).
	individual subjective satisfaction with income is used instead of objective income
Variables	income, education, and the number of children, number of adults, education, and having a partner
1	**Relative positioning (Johansson- Stenman et al., 2002; Solnick and Hemenway, 1998)**
Question	Individuals answer to hypothetical questions regarding their choice among alternatives states or outcomes
Focus	the choice reveals their concern for relative positions
2	**Solnick and Hemenway (1998)**
Question	In state *A*, the respondent would earn an annual income of $50,000 while a typical member of society would earn $25,000. In state *B*, the respondent would earn $100,000 in comparison with a typical income of $200,000.
Focus	to evaluate two alternative states of the world
3	**Positioning of a grandchild** (Johansson-Stenman et al., 2002)
Question	For example, in one society the grandchild's income was $2500/month which was lower than the average income of $3000/month. In the other society the grandchild's income was $2300 which is higher than the average income of $2000/month.
	decide in which society the grandchild would be most content
	choice between alternative societies, described by an imaginary grandchild's income and the average income
	Relative Income and Relative Consumption (Alpizar et al., 2001)
Questions (3)	1. relative income experiment, 2. the relative consumption experiment and 3. questions regarding the respondent's socio-economic status
	Extended Measures of Well-Being: Living Conditions in the United States: 1998 based on the data from SIPP. Within US Census
Focus	to examine to what extent were the households in the USA benefiting from the economic growth in the mid 1990s
Questions	5 topical areas: household's possession of appliances, housing conditions, neighbourhood and community conditions (including threat of crime, problems with traffic, abandoned buildings, relations, police and fire protection, medical services, and quality of schools); ability to meet basic needs (also financial); and availability of help from relatives if necessary
BEHAVIOUR	**Austrian "Survey on Environmentally Concerned Purchase Behaviour"** (within Austrian Consumer Expenditure Survey)
	"Do you pay attention when purchasing … to environmentally friendly/ biological products, which can be mostly identified by
Question	a specific label (e.g. Austrian environmental label 'Ja, natuerlich!')
Areas	Nutrition, Detergents, Paints, Lacquier/Varnish (Lacken), Big household appliances and Furniture

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Evaluating the Environmental Impacts and Social Drivers of Households' Consumption

IIASA
2004
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Presentation to SETAC Workshop 2004:

Life-cycle approaches to sustainable consumption. Scope and Feasibility

10/18/2004

Overview

- Project
- Our Approach (to evaluation of SC initiatives)
- Research Questions
- Review of Literature
- Case Study Floridsdorf
- Environmental Impact
- Survey

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The Environmental Impacts of Consumption: Research Methods and Driving Forces

Objective:

To assess environmental load of consumption

And to better understand the driving forces that influence patterns of consumption

Case Study:

- In 'sustainable' (car-free) and 'unsustainable' (car-dependent) settlements in Vienna

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Research steps

1. **Project planning & indicator selection**
2. **Literature review**
3. **Preparation and design of a household survey**
4. **Development of an operational 'environmental profile' tool for Austrian households**
5. Execution of a standardized survey
6. Qualitative interviews
7. Analysis of the surveys
8. Preparation of scenarios
9. Analysis, policy implications & applicability in other contexts

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Our Approach

- **Methods**: combination of the quantitative and qualitative social research designs with input-output analysis, applied to the two settlements in Vienna:
  - applying both quantitative & qualitative social research methods in different phases (sequencing) of a single study is beneficial, because :
  - it enables us to complement findings on an aggregate (or sample) level with individual cases of consumption practices

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Research Questions

- How can consumption patterns be determined and their environmental impacts be quantified?
- How do different households vary in the environmental impact of their consumption?
- How are changes in lifestyles accepted?
- How do they influence well-being?
- How do the socio-economic establishments influence the consumption patterns and habit formation?

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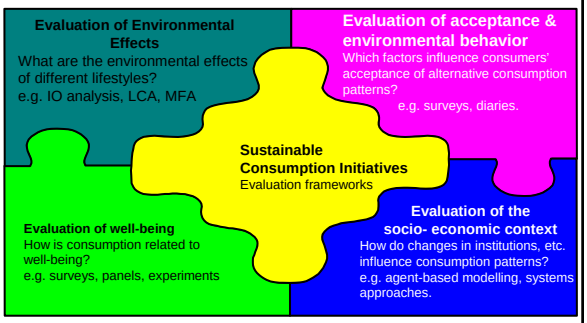
Literature Review of Evaluation



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Conclusions from Review

- **CONSUMER DECISION MAKING** under high uncertainty (contra to fixed preferences)
  - Environmental behavior is not always intentional or consistent
  - Preferences are also partly socially constructed & based on comparison & also influenced by habits
  - Habits, are very stable factors in decision making & difficult to change
    - embedded in socio-economic setting
    - participants in SC projects reverted to their old lifestyles after the expert advice & financial supplement stopped
  - not only infrastructure and information provision, but also **social learning, interactions & networks** are of importance (PiTH project) > socially "ordered" levels of consumption & habit creation

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Review II

- However, decision-making processes may be more easily influenced when significant events happen in one's life; or when one moves from one stage in the life to another
- People are not going to give up the perceived utility they get from the product (Moll, 2002);
  - i.e a SC measure/initiative will not be accepted if it reduces the perceived optimal level of comfort>> perceived Well-being
- **Many attempts to address the unsustainable patterns of consumption often work against existing institutions**

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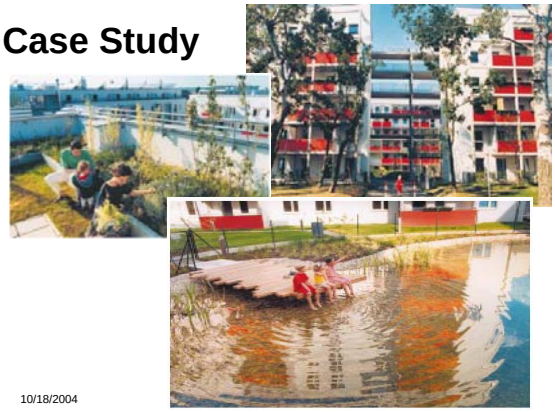
Case Study



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Car-Free Settlement: Vienna- Floridsdorf

- Initiator & developer
  - City of Vienna;
  - Gemeinnützige Wohnungsbau
  - GmbH (GEWOG) (non-profit housing association)
- **Time frame:**
- 1992 – 1999

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Location in Vienna (Wien)

Location: 21st district, Floridsdorf (6 km from centre)

Size of the site: 11,400 m^2

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Car-Free „City“: Vienna- Floridsdorf

- “Binding commitment not to buy a car”
  - Leasehold agreement
  - In case of violation: financial penalty
- 244 rental apartments
  - In: city development area “Floridsdorf East” (3.500 HU & ca. 1.900 jobs)
- Ratio of parking spaces per dwelling: 0.1
  - Exemption from **Vienna’s garage law:**
  - Decreasing ratio of parking spaces per dwelling: from 1.0 to 0.1

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Facilities

- Transportation:
  - a tram line linked to a commuter train line connects the site with underground & busses;
  - car-sharing
  - walking:
- Instead of **parking spaces -** community facilities :
  - workshops (e.g. for bicycles),
  - space for events / meetings,
  - gym, sauna, communal laundry facilities,
  - children's house, youth room, recreation-room for adults
  - gardens on roofs
- **Energy system:**
  - Solar energy
  - Earth heat

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Motivation

- Offer of common social areas and green areas (56%),
- Acceptable price-performance relationship (53%),
- Ecological concept/ Application of the alternative energy (53%)
- Car-free housing (53%)
- Communication and community/companionship (41%)
- Location (41%) (despite limited public transportation)
- A good ground plan of the apartments (32%)
- Urgent need for housing (28%) (long-planned decision)
- Participation (28%) (71% of socially & culturally active citizens)
- Architecture of the settlement (21%) (a compromise with the price)

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Measuring environmental impact

- We develop a general model for calculating the environmental loads (both direct & indirect) from household consumption, which is:
  - able to calculate also “rebound effects”
  - focusing on expenditure shifts (e.g. from car travels to flight trips)
- We expect the model to :
  - Be internationally applicable, as well as suitable for evaluating other SC initiatives

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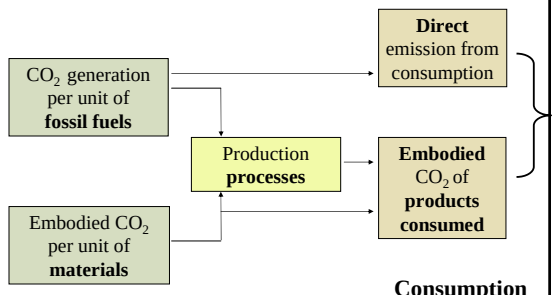
Assessment of Environmental Impact



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4 Areas of household consumption with highest environmental impact

- **1. Private transport meaning purchase of vehicles, repair and fuel**
- **2. Manufactured food, alcoholic and non-alcoholic beverages and tobacco**
- **3. Hotels and restaurants**
- **4. Electricity, gas, steam and water**

- >> use more than 50% of the final energy in Austria.
- >> cause more than 50% of the pollution regarding CO2, NOx, CSB (in case of AOX and hazardous waste private households are responsible for less than 40%)

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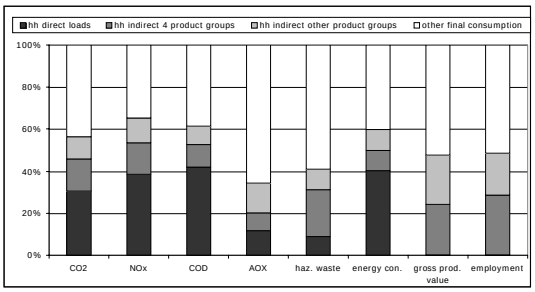
*Share of household's **direct & indirect** consumption on the total environmental impact (by indicator).*



10/18/2004 *Source: Calculation based on 1995 NAMEA data and Austrian IOT*

Design of the household survey

- Description of consumers
- Assessment of consumption patterns
  - based on Austrian consumer survey (14-days diary, 7,000 households)
  - and IO categories
- Explanation of personal 'Paradigm shift' (e.g. Motivation for living without a car)
- Potential for acceptance of new behaviours
- Comparison of well-being

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Survey Assumptions

CONSUMPTION

	Car-free	Standard
Sus	X	
Non-sus		X

MOBILITY

	Car-free	Standard
Sus	X	
Non-sus		X

ENERGY

	Car-free	Standard
Sus	X	X
Non-sus	X	X

FOOD

	Car-free	Standard
Sus	X	X
Non-sust	X	X

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Discussion

- Example for other initiatives?
- Encouragement for changing consumption patterns?
- Implications for policy makers and city planners?

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Survey: Some of Descriptors of Consumption Patterns

Total Expenditure for the selected 4 economic activities
Expenditures for Food, Beverages & Tobacco
Expenditure Profile in Food category concerning meat, biological food, own production & directly purchased from producers
Expenditures Transport
Expenditure Profile between Modes of Traffic
Expenditures for Energy (excl. transport)
Expenditure Profile for the various Energy Carriers

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Survey: Subjective Questions

Motivations (choosing this settlement, consumption decisions, mobility…)
Consumer satisfaction
Life-style indicators
Well-being
Ecological knowledge
Ecological motivations (e.g. low-cost versus high-cost situations)
Learning processes (changes over the years)
Structural/institutional conditions
Social control
Social dynamic indicators
Conditions/available offers for sustainable consumption

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Quantitative Evaluation Method of Social Acceptability of Products and Services for Activity-Based Calculation of Life Cycle CO2 Emissions

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Abstract

Attempts to reduce household CO_2 emissions have shown limited success. Especially approaches relying primarily on technological progress that increases the energy- or eco-efficiency of technologies and services have often failed to attain expected reductions in fossil fuel consumption due to lack of consideration of consumer behavior. In order to turn un-sustainable consumption pattern to more sustainable manner, such concept needs to be expanded by including the consideration of consumers' social acceptability of various products and services. Therefore, we proposed developing a quantitative evaluation methodology to predict social acceptability of products and services. Applying Quality Function Deployment (QFD), social acceptability was estimated from the sum of the multiplications of importance level of each requirement obtained from survey results and characteristics evaluation of each requirement with engineering scales. Then, the estimated acceptability values were compared with the values directly obtained from the survey results for verification of the suggested methodology. The results showed that the estimated social acceptability based on the consumers' requirements reasonably fit the directly asked acceptability for some activities. It implied that once the model has been developed, it will be made possible to predict the social acceptability of a newly developed eco-efficient technology with few input parameters. Furthermore, combining the activity-based calculation of life cycle CO_2 emissions with a hybrid approach with the predicted social acceptability data allows the evaluation of the effectiveness of introducing a new technology to a society toward sustainability.

1. Introduction

In order for a society to attain sustainability, it is critical to turn the current un-sustainable consumption pattern to more sustainable manner. Toward this end, producers need to know what kind of products they should produce and supply; and policy-makers need to know what kind of policies to implement. In order to make such decisions, a science-based quantitative indicator or evaluation methodology is desired. Life Cycle Assessment (LCA) has been applied to evaluate the environmental aspects of products.

However, when consumer behavior is taken in account in the consumption system, only discussion on "environmental-friendly" by itself is not socially accepted. Therefore, the concept of eco-efficiency, maintaining or increasing quality of life while minimizing the use of natural resources and environmental burden, should be adopted. Moreover, social acceptance is a prerequisite for all the eco-efficient products and services. Therefore, development of appropriate eco-efficiency indictor and quantitative evaluation methodology for social acceptability of products and services is necessary.

One way of knowing consumers' social acceptability is directly asking consumers about their preferences on a product or service for each objective activity at each given scenario. However, it will require a conduct of frequent surveys on individual products and services, involving a multitude of consumers. The purpose of this research is to develop a model which estimates consumers' preferences on the choice (social acceptability) of products and services to achieve an objective activity. We applied Quality Function Deployment (QFD)[1], which has been used in the field of products development, for the development of such methodology. The main features of this model are: (1) that it requires neither many input data nor conducting survey to predict consumer acceptability of products and services; and (2) that it estimates social acceptability based on the importance levels of consumers' requirements and characteristics evaluation of the alternatives with physical and engineering scales. Once developed, this model will be helpful in predicting social acceptability of newly developed environment-friendly products or services, before manufacturing them. In this paper, we discuss how to develop and apply such a modeling tool toward suitable consumption.

2. Suggested Evaluation Methodology

The details on the concept and development procedure of this suggested methodology can be found elsewhere [2][3][4]. The following is the briefly description. Our assumptions with regard to this suggested methodology are that consumers select products and services based on the specific and specialized requirements for each consumption activity, and that the specific and concrete requirements for each activity can be conceptually narrowed down to fewer number of upper-level requirements, such as "economy," "healthy," "convenient," etc. The upper conceptual requirements are called in this paper "elementary requirements," and the specific and concrete requirements for each consumption activity are called "secondary requirements." Figure 1 shows the conceptual and targeted example of the suggested methodology. If we could extract the elementary requirements and quantify the importance value of each item, it might be possible to evaluate social acceptability of a certain product (e.g. Alternatives 1 - 5) quantitatively. In specific, where the importance level of an elementary requirement is expressed as$\{A_i \mid i = 1 \cdots i\}$(such as economical, healthy, convenient, safe, comfortable, environmentally-friendly and reliable), the importance level of secondary requirement is expressed as $\{B_j \mid j = 1 \cdots j\}$ (such as low price, less wasting, good for health, good nutrient balance, quick preparation, etc.), and the correlation levels between the elementary requirement and secondary requirement is $\{X_{i,j} \mid i = 1 \cdots i\ ,\ j = 1 \cdots j\}$, the secondary requirements of the products and services would be expressed as:

$$B_j = \sum_{i=1}^{i} A_i X_{ij} \quad . \qquad (1)$$

Then, the social acceptability of product could be evaluated by the summation of the acceptability values of the product on each secondary requirement, which is obtained by multiplying the importance level of secondary requirement by the characteristic evaluation of the product on each secondary requirement measured by physical or engineering criteria. When the characteristic of the alternative on each secondary requirement is expressed as $\{C_{kj} \mid j = 1 \cdots j,\ k = 1 \cdots k\}$, the acceptability values (V_k) of the mean would be expressed as:

$$V_k = \sum_{j=1}^{j} B_j C_{kj} \quad . \qquad (2)$$

The hypotheses of this research are: (1) the priorities of the consumers' elementary requirements for products and services are universal in the same cluster and could be defined quantitatively according to clusters; and (2) once the importance levels of elementary requirements have been quantified, the importance levels of secondary requirements for products and services could also be quantified according to their correlations. If the above hypotheses are correct, it would be possible that once the importance levels of elementary requirements are determined according to the cluster (e.g. purchase of durable goods, purchase of expendable supplies, dining, energy consumption, information and communication, and leisure, for this paper), the user can estimate the social acceptability of given alternatives with using the importance levels of elementary requirements that the concerning activity belongs. Therefore, no matter what the activity, only required input parameters for this methodology for the estimation of social acceptability of a particular product/service is the provision of the defined importance levels of elementary requirements specific to the cluster that the concerning activity belongs. In order to test the above hypotheses, we are currently developing the necessary components of this suggested methodology.

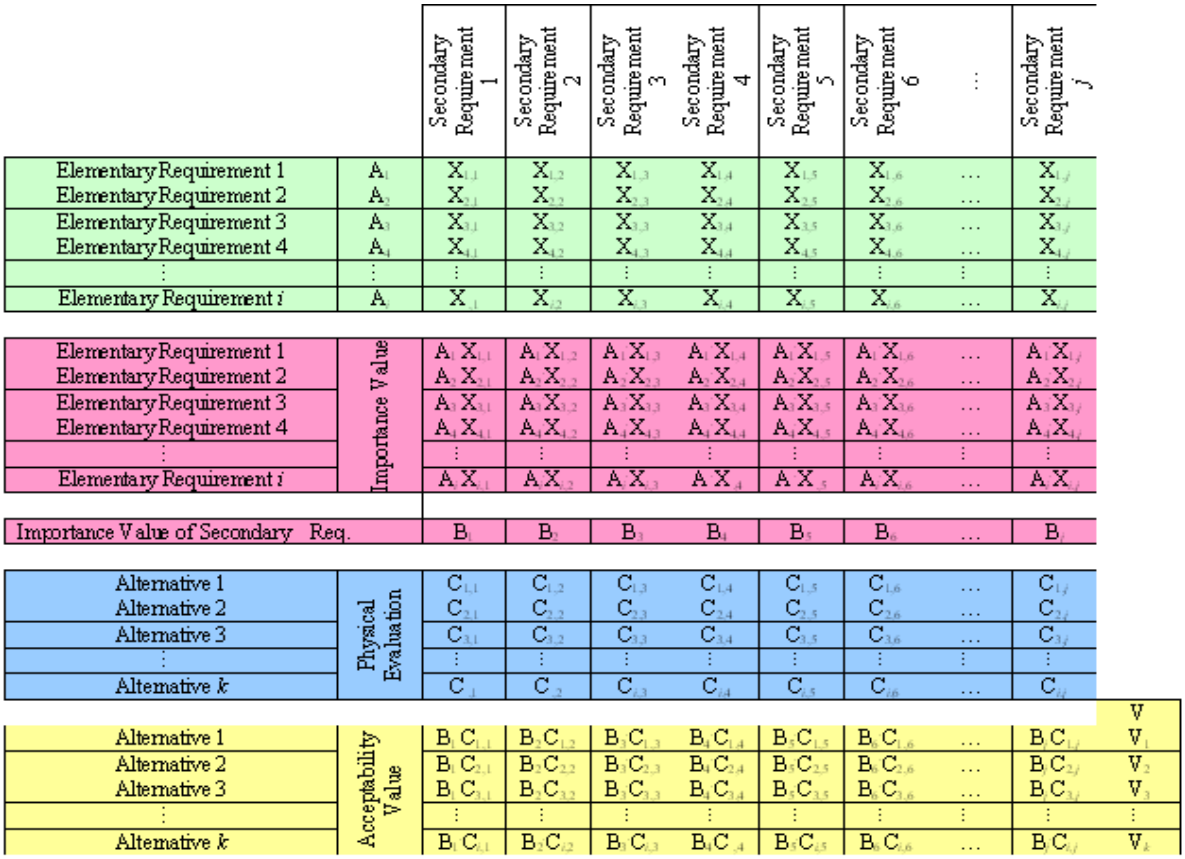

Figure 1 Conceptual example of the suggested quantitative evaluation methodology of social acceptability of products/services.

3. Research Methods

We conducted the Internet survey to measure the directly asked social acceptability and importance levels of the requirement items defined for 27 patterns of consumption activities, respectively. The clusters and consumption activities used for this study are shown in Table 1.

Table 1. Consumption activities used for this study

Cluster	Activity	
Purchase of durable goods	1. Type of residence 2. How to use a vehicle for traveling purpose 3. Type of vehicle	
Purchase of expendable supplies	4. How to do the laundry for white shirt 5. Lighting of living room 6. Type of Camera	19. How to clean the house 20. Type of TV 21. How to kill mosquitoes
Dining	7. How to enjoy dinners on weekday evenings 8. How to obtain coffee 9. Vegetable	
Energy Consumption	10. Heating system 11. Type of heater 12. Type of cooling device	22. How to dry wet towels on rainy day 23. How to cook beef stake at home 24. How to make hot water for coffee
Information and Communication	13. How to communicate with friends 14. Type of Internet connection 15. Personal computer	25. How to print greeting cards 26. How to obtain restaurant information 27. How to obtain weather forecast
Leisure	16. How to enjoy movies 17. How to learn English conversation 18. Accommodation type while traveling	

The survey panel was the Internet consumer monitors (total number approximately 40,000 people) of Nikkei Research, Inc. For this survey, responses were obtained from a total of 3,159 people (approximately 350 people per activity surveyed). Using an example of "how to enjoy dinner on holiday evening," the questionnaire and results are explained in the following sections. We asked questions of "preference for consumption activities (Q1)" and "importance level of the requirement items (Q2)." In this study, the answer obtained from Q1 is called "directly asked social acceptability value." In order to determine directly asked social acceptability, alternatives were provided, such as "cook whatever available in the house," "go grocery shopping and cook," "buy everyday dish," "order a house delivery" and "eat out," and the respondents were asked to choose one and only one alternative that the respondents would most likely be choosing. The results are shown in Table 2.

Table 2 Survey results on the choice of "how to enjoy dinner on holiday evening"

Q1: Assume you are going to have dinner with your family or friends on holiday evening. Which of the following dinner will you pursue? Answer based on the assumption that all methods are available.	(%)

Cook whatever available in the house	7.60
Go grocery shopping and cook	42.10
Buy everyday dish	3.40
Order a house delivery	6.60
Eat out	40.30

In order to determine the average importance levels of secondary requirement items, we asked the respondents to evaluate the importance levels of given requirements by ranking method. The results are shown in Table 3.

Table 3 The results of the mean values of the importance levels of secondary requirement items.

Secondary Requirement	Score	Secondary Requirement	Score
Low price	1.43	Good taste	2.21
Less wasting	0.79	Variety in kind	1.19
Good for health	0.94	Can relax at home	1.00
Good nutrient balance	1.06	Good atmosphere	0.97
No need of cleaning	0.78	Can enjoy hand-made taste	0.68
Quick preparation	0.83	Fit my liking	1.11
Does not take much effort	0.91	Less garbage production	0.32
Safe	1.18	Can trust the shop/restaurant	0.60

In order to determine the correlation matrix of the alternatives versus secondary requirement items, at least five experts met and discussed on each correlation value. In this way, the values were determined rationally and based on the general consent among all the participating experts. The evaluation criteria of the secondary requirements vary, depending on scales of the characteristics, such as numerical, ordinal, and nominal measures. All the scales were converted to ordinal scale, and the correlation values were set including 0 being no correlation, 10 being mostly correlated, and any number between the two depending on the increments and relative correlations.

4. Results and Discussion

The actual matrix to determine the acceptability values for "how to enjoy dinner on holiday evening" is shown in Figure 2. The appropriateness of the suggested methodology was evaluated by comparing the calculated social acceptability values against the directly asked social acceptability from Q1 of the survey, using the correlation coefficient squared (r^2). In this particular example, the result shows $r^2 = 0.84$, which is a relatively high value.

		Economical		Healthy		Convenient			Safe	Comfortable						Env. Friendly	Reliable
		Low price	Less wasting	Good for health	Good nutrient balance	No need of cleaning	Quick preparation	Does not take much effort	Safe	Good taste	Variety in kind	Can relax at home	Good atmosphere	Can enjoy hand-made taste	Fit my liking	Less garbage production	Can trust the shop/resturan
Secondary Requirement from survey		1.43	0.79	0.94	1.06	0.78	0.83	0.91	1.18	2.21	1.19	1.00	0.97	0.68	1.11	0.32	0.60
Cook whatever available in the fridge	Physical Evaluation	10	5	7	5	0	2	1	5	5	0	10	5	10	5	5	5
Go grocery shopping and cook		6	5	10	5	0	0	0	5	5	10	10	5	10	10	0	5
Buy everyday dish		4	5	5	5	7	7	8	5	5	5	10	5	0	0	3	5
Order a house delivery		0	5	0	5	9	9	10	5	5	5	10	5	3	2	9	5
Eat Out		0	5	0	5	10	10	10	5	5	8	0	5	4	10	10	5
Cook whatever available in the fridge	Acceptability Value	14.28	3.96	6.61	5.28	0.00	1.66	0.91	5.92	11.03	0.00	9.95	4.85	6.80	5.55	1.60	3.00
Go grocery shopping and cook		8.57	3.96	9.44	5.28	0.00	0.00	0.00	5.92	11.03	11.90	9.95	4.85	6.80	11.10	0.00	3.00
Buy everyday dish		5.71	3.96	4.72	5.28	5.44	5.82	7.31	5.92	11.03	5.95	9.95	4.85	0.00	0.00	0.96	3.00
Order a house delivery		0.00	3.96	0.00	5.28	6.99	7.48	9.13	5.92	11.03	5.95	9.95	4.85	2.04	2.22	2.88	3.00
Eat Out		0.00	3.96	0.00	5.28	7.77	8.32	9.13	5.92	11.03	9.52	0.00	4.85	2.72	11.10	3.20	3.00

R= 0.9165
R*R= 0.8400

	Calculated	Ratio (%)	Actual (%)
Cook whatever available in the fridge	81.41	19.40	7.60
Go grocery shopping and cook	91.80	21.88	42.10
Buy everyday dish	79.90	19.04	3.40
Order a house delivery	80.69	19.23	6.60
Eat Out	85.80	20.45	40.30
Total	419.59	100	100

Figure 2 Calculation method for social acceptability in the case of "how to enjoy dinner on holiday evenings" using the expansion table of QFD.

For each of the 27 activities surveyed this time, the correlation coefficients between the two acceptability values are shown in Figure 3. The estimation was close to reality for some activities while there were cases where the suggested methodology did not estimate the reality properly. Improvement of the estimation power of suggested methodology is of great importance. The discussion on the potential rooms for improvements are: (1) determination of clusters and the elementary requirements specific to each cluster; (2) determination of correlations between the elementary and secondary requirement items; and (3) refinement of the characteristics evaluation of requirements with engineering scales. The detail discussions on the above issues are found elsewhere [3].

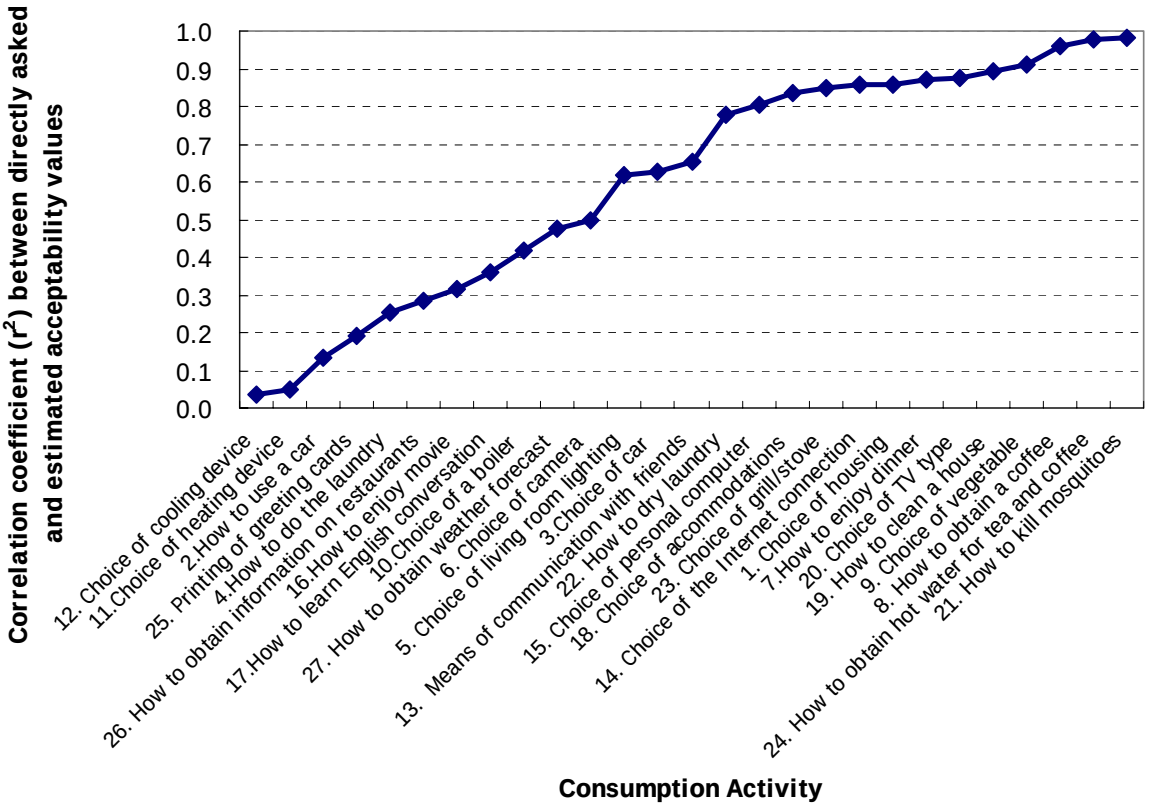

Figure 3 The result of the appropriateness of the suggested methodology expressed by correlation coefficient (r^2) between directly asked and estimated acceptability values.

5. The Potential Application of the Suggested Methodology

Suppose that there are three alternatives of products and services to achieve an "Objective Activity X." With using the suggested methodology, the user of this tool can predict quantitatively the social acceptability of each alternative. Combining the activity-based calculation of life cycle CO_2 emissions with using LCA and the results of the predicted social acceptability of the alternatives, total life cycle CO_2 emissions from a given population for the "Objective Activity X" can be calculated (See Table 4).

Table 4 The conceptual application of the suggested methodology before adopting a newly developed environment-friendly product.

Alternative	Social acceptability (% household)	CO_2 emission per function unit (kg CO_2/household)	Total CO_2 emission per objective activity (kg CO_2)
A	X_a	Y_a	$X_a \cdot Y_a$
B	X_b	Y_b	$X_b \cdot Y_b$
C	X_c	Y_c	$X_c \cdot Y_c$
Total			Total CO_2

Suppose that a new environment-friendly product or service (New Alternative D) has been developed to achieve the same "Objective Activity X" and put in the market in addition to the three alternatives of products and services. Using the suggested methodology, one can predict quantitatively the social acceptability of each alternative, based on the importance levels of consumer requirements. There is no need to obtain consumer preference data by conducting a survey because the importance levels of the secondary requirements are deployed from the elementary requirements specific to the cluster and the correlations between the two. In the same way as the first case, after obtaining the social acceptability of the alternatives including the New Alternative D, the total life cycle CO_2 emission from the same population for the "Objective Activity X" can be calculated together with LCA results (See Table 5).

Table 5 The conceptual application of the suggested methodology after adopting a newly developed environment-friendly product.

Alternative	Social acceptability (% household)	CO_2 emission per function unit (kg CO_2/household)	Total CO_2 emission per objective activity (kg CO_2)
A	$X_{a'}$	Y_a	$X_{a'}.Y_a$
B	$X_{b'}$	Y_b	$X_{b'}.Y_b$
C	$X_{c'}$	Y_c	$X_{c'}.Y_c$
D	$X_{d'}$	Y_d	$X_{d'}.Y_d$
Total			New total CO_2

Comparing the total CO_2 emissions for the "Objective Activity X" (kg CO_2/year) for the two cases, the user of this tool can evaluate the contribution of introducing the new technology (New Alternative D) to a society toward sustainability. However, potential obstacles also exist. For example, within a context of evaluating the social acceptability of a newly designed energy- or eco-efficient product, it was assumed that every respondent selects only one product among the alternatives. In the reality, however, consumers may or may not replace the old product along with the newly purchased product, depending on the situation or each household. Our methodology does not model the details of such short-term transition period.

6. Summary of Findings and Future Studies

The following are summary of findings resulting from this study:

- social acceptability of products and services are calculated based on the consumers' secondary requirements derived from empirically defined elementary requirements, thus, a conduct of consumer survey is not necessary every time a new technology is produced,
- total CO_2 emissions from the chosen products and services toward an objective activity can be calculated by combining the estimated social acceptability of given alternatives

and their life cycle CO_2 emissions per function unit using LCA, and

- within a frame of an objective activity, the effectiveness of introducing a new environment-friendly technology to a society in reduction of CO_2 emissions can be estimated.

7. Recommendations for Further Research

This study provided valuable information with respect to the development of the quantitative evaluation method of social acceptability of products and services. However, this work also generated a number of potential applications of this methodology that require further research. Among the potentials that should be addressed are:

- if a newly designed energy- or eco-efficient technology is predicted to be unpopular among the consumers despite its drastic reduction of CO_2 emission, one can re-design the technology based on consumers' secondary requirements in order to increase its popularity among the alternatives for the same objective activity,
- sustainable and un-sustainable objective activities can be identified by comparing the estimated total CO_2 emission considering the social acceptability and the CO_2 emission per function unit of alternatives,
- this methodology can assist decision-makers in the policy-development in taxation of unfavorable activity or incentives against activities with respect to CO_2 emissions. Details of how to pursue the policy development is our future task.
- It will also be possible to evaluate the geographical and demographical effects to social acceptability of products and services as well as the CO_2 emissions by comparing the results at different region, nation, culture, etc.

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Quantitative Evaluation Method of Social Acceptability of Products and Services for Activity-Based Calculation of Life Cycle CO_2 Emissions

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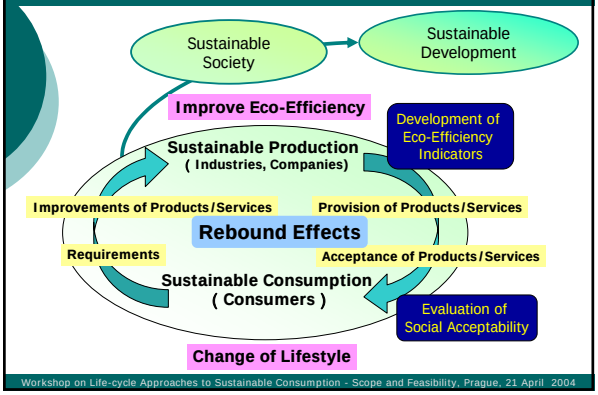
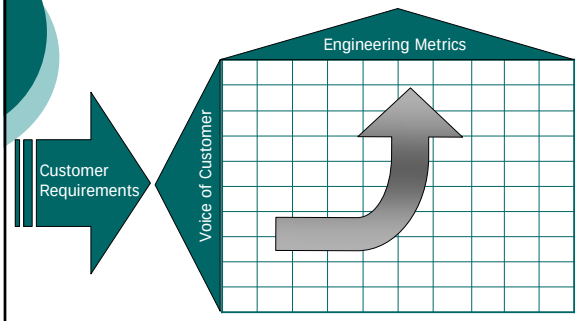
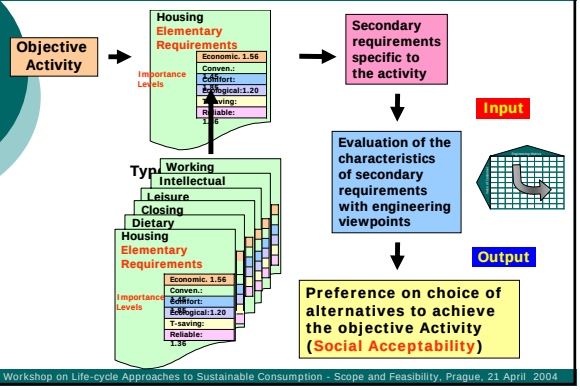
Introduction



Application of QFD Concept



The Concept of the Proposed Method



Flow of Tasks

- The Internet Survey
  - Samples:
    - 2,400 people in total
    - Mix of men and women
    - 20-69 yeas old
    - Registered with Nikkei Research, Inc. Internet Survey Panel
  - Questions:
    - Q1: preference of an alternative
    - Q2: ranking of the secondary requirements
    - Q3: frequency of each activity
- Calculation of social acceptability based on the importance levels of secondary requirement items obtained from the survey
- Evaluation of the appropriateness of this suggested method

Consumption Activities Used for this Study

Life Scenes	System / Product	Consumption Activities
Purchase of durable goods	System	1. Type of residence 2. How to use a vehicle for traveling purpose
	Product	3. Type of vehicle
Purchase of expendable supplies	System	4. How to do the laundry for white shirt
	Product	5. Lighting of living room 6. Type of Camera
Dining	System	7. How to enjoy dinners on weekday evenings 8. How to obtain coffee
	Product	9. Vegetable
Energy Consumption	System	10. Heating system
	Product	11. Type of heater 12. Type of cooling device
Information and Communication	System	13. How to communicate with friends
	Product	14. Type of Internet connection 15. Personal computer
		:
		27.How to obtain a weather forecast

Determination of Directly Asked Social Acceptability

Survey results - "how to enjoy dinner on holiday evenings"

Q1: Assume you are going to have dinner with your family or friends on holiday evening. Which of the following dinner will you pursue? Answer based on the assumption that all methods are available.	(%)
Cook whatever available in the house	7.60
Go grocery shopping and cook	42.10
Buy everyday dish	3.40
Order a house delivery	6.60
Eat out	40.30

Determination of the Importance Levels of Secondary Requirements

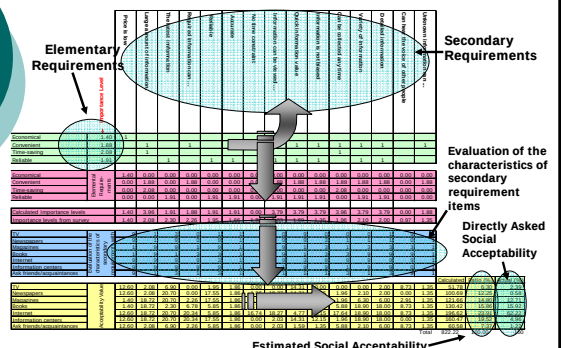
"How to enjoy dinners on holiday evenings"

Q2. If you choose an answer in Q1, to what extent do you place weight on the items below?

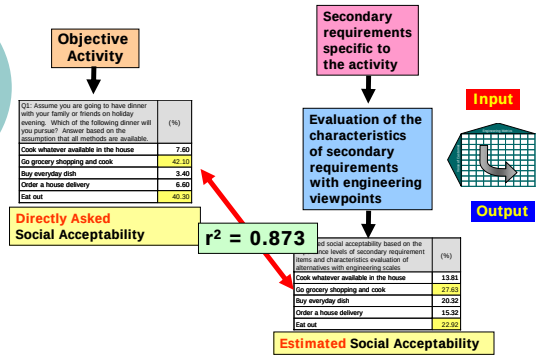
Secondary Requirement	Score	Secondary Requirement	Score
Low price	1.43	Good taste	2.21
No production of wastes	0.79	Variety in kind	1.19
Good for health	0.94	Can relax at home	1.00
Good nutrient balance	1.06	Good atmosphere	0.97
No need of cleaning	0.78	Can enjoy hand-made taste	0.68
Quick preparation	0.83	Fits my liking	1.11
Does not take much effort	0.91	Less garbage production	0.32
Safe	1.18	Reliable	0.60

Score: Ranking method was applied.

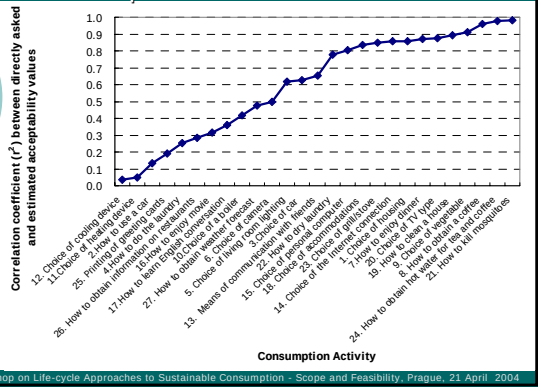
Development of the Proposed Method



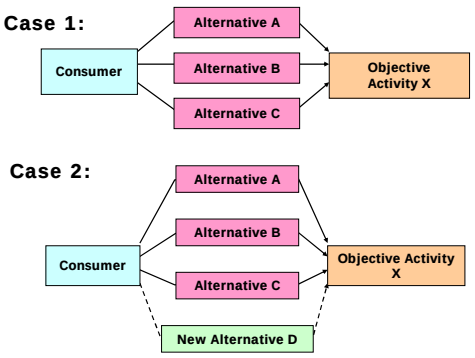
Evaluation of the Appropriateness of the Proposed Method



Evaluation of the Appropriateness of the Proposed Method: Results



Application of the Proposed Method (1)



Application of the Proposed Method (2)

Case 1:

Alternative	Social acceptability (% population)	CO_2 emission per function unit (kg CO_2/function)	Total CO_2 emission for the alternative (kg CO_2/function)
A	X_a	Y_a	$X_a \cdot Y_a$
B	X_b	Y_b	$X_b \cdot Y_b$
C	X_c	Y_c	$X_c \cdot Y_c$
Total	100%		$X_a \cdot Y_a + X_b \cdot Y_b + X_c \cdot Y_c$

Application of the Proposed Method (3)

Case 2:

Alternative	Social acceptability (% population)	CO_2 emission per function unit (kg CO_2/function)	Total CO_2 emission for the alternative (kg CO_2/function)
A	X_a	Y_a	$X_a \cdot Y_a$
B	X_b	Y_b	$X_b \cdot Y_b$
C	X_c	Y_c	$X_c \cdot Y_c$
D	X_d	Y_d	$X_d \cdot Y_d$
Total	100%		$X_a \cdot Y_a + X_b \cdot Y_b + X_c \cdot Y_c + X_d \cdot Y_d$

Potential of Proposed Method (1)

- Social acceptability of products and services are calculated based on the consumers' secondary requirements derived from empirically defined elementary requirements.
- Therefore, a conduct of consumer survey is not necessary every time a new technology is produced.
- Total CO_2 emissions from the combination of the chosen products and services toward an objective activity can be calculated (based on the estimated social acceptability of these alternatives and their CO_2 emissions per function unit with hybrid LCA).

Potential of Proposed Method (2)

- Within a frame of an objective activity, the effectiveness of introducing a new environment-friendly technology to a society can be estimated in reduction of CO_2 emissions.
- Sustainable and un-sustainable objective activities can be identified by comparing the estimated total CO_2 emission considering the social acceptability and the CO_2 emission per function unit of alternatives.

Current and Future Study

- Improvement of the proposed method's estimation power of social acceptability is of great importance.
  - Determination of life scenes and the elementary requirements specific to each life scene,
  - Determination of correlations between the elementary and secondary requirement items, and
  - Refinement of the characteristics evaluation of requirements with engineering scales.
- Further work is necessary in combining the social acceptability and the CO_2 emissions per function unit of alternatives.

The End

Thank you.

Workshop Questions and Answers

Speaker: Guido Sonnmann

Q: Asked for information on the Sustainable Procurement Programme. What is happening?
A: They are working on a database giving information on different schemes that different governments have set up. It is to be used as a reference for others. The database will be completed soon.
For information see:
http://www.un.org/esa/sustdev/sdissues/consumption/copenhagen.pdf
http://www.sustainableprocurement.net/
To be hosted at http://www.sustainableprocurement.net/

Speaker: Jessica Rodriguez

Q: Why do the lower class people show more concern about environment issues?
A: No proof, but hypothesis. The lower class people have a closer link to their indigenous communities and backgrounds and have learnt principles of conservation from a young age. Further, the survey shows that poor people are more aware of the health problems then the richer people.

Q: Is this same relationship true between rural and urban areas?
A: Yes

Q: As people ascent classes, do they show less concern towards the environment?
A: Personal opinion is that this is the case.

Speaker: Edgar Hertwich

Q: To what extent can you study changes in the IO coefficients coupled with changes in consumption over time?
A: In structural decomposition analysis you look at changes resulting from changing one variable over time. So if you change the final demand and keep the IO coefficients constant, then you can look at change in the outputs. Changes in consumption will lead to changes in the IO coefficient over time as industry adjusts to the changes in consumer behavior. Once consumers adjust to a given consumption behavior then the IO coefficients would again stabilize. You could look at how changes of the IO coefficients over time might affect given consumption behaviors. I think these types of studies are a low priority at this point in time.

Q: How do you define a functional unit?
A: Will probably use household consumption of one house.

Q: Would it be better to use a monetary unit. Consumers consume until they don't have anymore money. If someone reduces their expenditure by choosing a different consumption pattern, then they will spend the left over money on something else. I am concerned if you don't use the correct functional unit you may miss these problems.
A: This is an important secondary effect. We are looking at this problem. For instance, we are looking at a community that has agreed not to use cars. The members of the community will have a different consumption pattern then other community members that use cars.

Q: In demographic studies you can compare expenditure habits across age, sex, and so on. How do you compare against different cultural settings. For example, the Mediterranean way of consuming, with the Nordic way of consuming, and so on. What regional resolution does your study have?
A: We have used Norwegian data and so we have a national perspective. In our studies with Austria we use Austrian data and also have a national perspective. Before we start looking at more complex studies we need to learn how to solve the easier problems first, then later we can apply the studies to more complex issues.
C: You can look at lots of different scenarios. But the important thing is to look at is what makes change. What makes people adopt new lifestyles and so on? Small changes can have big effects, such as mobile telephones.
A: There are not many people making these links yet. We need to be able to learn how to anticipate changes and the resulting effects of change on the environment.

Speaker: Jacob Madsen

Q: Why is it so complex?
A: These are complex issues we are looking at.

Speaker: Olivier Jolliet

Q: How will this information be used?
A: The Swiss EPA plans to take up an information campaign on the key issues. They will take 4-5 examples of sustainable consumption linked to key issues. Then look at scenarios to see what could be sustainable behavior. The information will target key issues.
C: Many governments had targeted campaigns on recycling.
A: The aim is to determine what the key issues are. Then target these issues in campaigns. For example, not all recycling issues are important.

Speaker: Katarina Korytarova

No questions

Speaker: Toshisuke Ozawa

Q: Could not hear.
A: There are some difficulties in expressing preferences.
C: You might be able to link this sort of work in with the previous work on the car free village.
A: Perhaps my method is a more objective way because it narrows down choices to specific items.

Q: You choices are in simple product categories.
A: But they have many choices in each category. Each category covers most of the possible scenarios.

Q: How fast would people change preference over time? How often should you redo the survey?
A: Not sure what the answer is for that, but we have thought about it. My first task is to develop the model, then address those issues.

Q: Have you linked into with market research people to use some of their expertise?
A: We have obtained some help from these areas.

Q: Have you thought of doing a similar survey but not over the internet to remove any bias?
A: ?

List of Participants

Workshop: Life-cycle approaches to sustainable consumption: Scope and Feasibility
SETAC-Europe meeting, Prague Congress Centre
21 April 2004

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