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ECONOMIC MODELLING OF SUSTAINABLE STRUCTURES IN PRIVATE CONSUMPTION

AN ANALYSIS OF HEATING AND TRANSPORT

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Study by the Austrian Institute of Economic Research commissioned by the Federal Ministry for Agriculture and Forestry, Environment and Water Management and the Federal Ministry for Transport, Innovation and Technology

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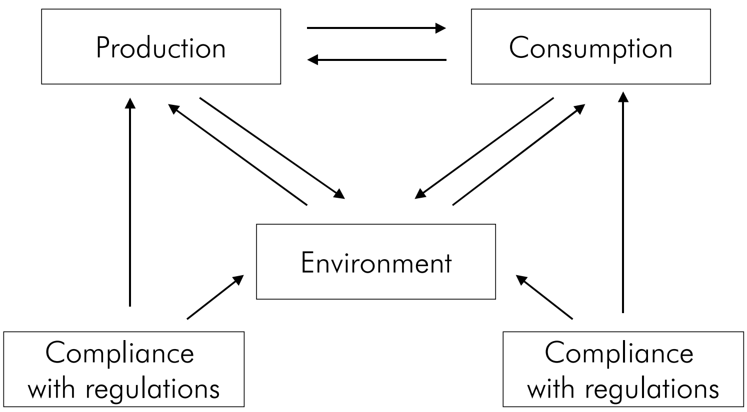
1. Introduction

Increasing awareness with respect to environmental problems is being reflected in the search for production and consumption patterns which are less damaging to the environment. Technological Innovation as well as changes in social and institutional arrangements are seen as central elements on the path towards sustainable development. Such innovation affects not merely the ecological aspects of sustainable development but also its economic and social dimensions. The concept of sustainable development has been a guiding principle in environmental discussion since publication of the Brundtland Report in 1987, or at the latest since the 1992 UNCED Conference in Rio de Janeiro. In terms of ecology, the guiding principle of sustainable development has focussed strongly on the need to adopt a precautionary stance in environmental policy, i.e. it focuses on damage prevention or avoidance. Despite this, in practice most environmental decision making still adopts an end of pipe approach in policy design. The redirection of policy away from reaction towards more pro-action and prevention tends to be very hesitant, even though new scientific knowledge and evidence stress the necessity of a reorientation from an ecological point of view.

One aspect of such a reorientation involves a stronger focus on patterns of consumption. Traditionally, environmental concerns largely dealt with regulating and modifying production processes so as to reduce environmental damage. An essential starting point in this respect, apart from the use of command and control procedures, was the promotion of research and development so as to speed up innovation of environmentally friendly technologies and products. In other words, it was a supply side approach. Now, in addition to production processes, the growing importance of consumption behaviour in achieving sustainable development is increasingly being recognised.

Figure 1: Interactions between environment, politics and the economy



Consumption behaviour has a significant impact on production processes and largely determines the use of energy and other resources. As global private consumption increases, there is an ever-increasing negative impact on the environment, since on the one hand an ever-larger amount of inputs are required in production, and on the other, the amounts of waste produced increase too. A counter-tendency has, however, also been observed, i.e. rising consumption is also accompanied by an increased demand for environmentally friendly products and for a cleaner environment. Given the interactions between consumption and the environment, household consumption takes on a central role in any attempt to redirect economic activity towards more sustainability.

To a certain extent, looked at from the point of view of sustainable development, environmental processes are now being seen in a more systemic light, since more consideration is being given to the interactions between the various levels of economic activity (production, consumption etc.) and the ecosystem. The idea of "sustainable development" has moved beyond the pure ecological dimension to become an integrative concept encapsulating economic, ecological and social targets. Sustainable development entails a global approach aimed at generating both economic and social change.

The ecological dimension of sustainable development aims at sustaining the following basic functions of the environment:

- Resource supply
- Assimilation and absorption
- Provision of environmental services (for leisure activities, basic function of life support etc.)

In terms of social aspects, sustainable development revolves around the idea of social equity. This involves social welfare concepts, and concerns such matters as inter- and intra-generational welfare (income distribution, access to education and health services etc.).

The economic dimension of sustainable development centres largely on the question of capital, i.e. the extent to which natural capital can be substituted by man-made capital. Assuming that substitution is possible, the question arises what direction must technology take, in order to ensure that the replacement of natural by man-made capital is in fact sustainable over the long-term.

As far as the economic system is concerned there are several factors which need to be considered when attempting to change to a more sustainable orientation. The nature of prevailing institutional arrangements and the application of incentive based policies are two crucial aspects in this respect. Regulatory arrangements have a major influence on the behaviour of economic agents in terms of both production and consumption. One aim of institutional development should be to provide more scope for the various agents in the decision making process and to allow greater participation.

Reduction of material flows must be seen as a primary target when attempting to avoid environmental problems arising directly from increasing quantities. Material flow reduction is one form of prevention. Closely related to this are other aspects such as the use of renewable resources, more efficient recycling, and improvements in integrated cycle. One further aspect is a potential move in general towards a more service-oriented focus in order to change consumer behaviour i.e.

the concept of use rather than possession should become more prevalent. To be able to assess whether production and consumption processes are at all compatible with the principle of sustainable development indicators have to be found which are capable of capturing interactions between the economic and ecological system. Such indicators allow for the operationalisation of the sustainable development concept by capturing the causal links between human activity and changes in the environment and by measuring the extent to which progress towards or away from the defined sustainability targets is being made. They thus provide the informational foundation upon which political and/or social criteria and decision making can be based.

The multidimensionality already visible in the sustainability targets mentioned above, is a clear indicator of the complexity to be faced when attempting integration of all three areas. In order to make the multidimensional nature of the problem more tangible it is imperative that sustainability targets be integrated across various areas of politics. Any de-linkage of ecological concerns from other areas of policy (e.g. from fiscal policy, R&D, regional, technology, transport, social or economic policy etc.) may tend to undermine the furtherance of environmental concerns in practice since they are likely to find themselves at the end of a chain of political activity and therefore subordinate. Any environmental policy interested in focussing on causes, and on finding solutions which are system-based and holistic in nature, requires as a matter of basic principle, wide-ranging integration and co-operation across various institutions and political establishments as well as an adequate focus on production and consumption activity.

Structure of Present Study

The present study, an analysis of sustainable structures of private consumption in the categories room heating (hereafter referred to as "heating") and transport, adopts a rather broad view. Apart from the empirical research on these two sectors in Austria and the respective modelling analysis, attention is also paid to international research on relevant information systems and to descriptive analyses of the interactions between economy and ecology. Further, a review of the literature on concepts and applications of sustainable consumption is also provided. The results on information systems as well as on the methodological problems in the various concepts of sustainable consumption both serve to highlight the complex nature of the topic.

The basic motive underlying the present research was provided by, amongst other things, the need to extend consumption modelling beyond the approach found in standard economic models, and in particular to integrate non-economic factors, in the sectors transport and heating, into an empirical model for Austria. This largely entails the assessment of the various technical options available as well as assessment of changes in lifestyle patterns and their impact on energy flows. To this end, attention was centred primarily on services and on depicting interactions between stocks and flows.

In chapter two, the study begins with an analysis of information systems relating to the interactions between economy and environment. This includes a description of the System of Integrated Environmental and Economic Accounting (SEEA). This comprises primarily satellite accounts from standard national accounting systems, and was originally made available by the United Nations in 1993. The information presented here is based on the provisional accounts, SEEA-Revision, available on the Internet.

Apart from the description of the SEEA, chapter two also outlines international research on the development of sustainability indicators. The link to "green" national accounts is on the one hand provided by the fact that the data necessary for indicator development is also contained in SEEA, and on the other, by the fact that SEEA contains guidelines on deriving indicators from satellite accounts. It is assumed that indicator development is closely related to the concept of green national accounting. In practice, however, research work on green national accounts and on developing indicators of environmental sustainability remain separated.

One important subsection deals with the various modelling approaches in integrating environment and economy. The approaches discussed here, as well as the references to results of empirical research, show that in practice, implementation of such integration concepts in model construction is still in its infancy.

Chapter three describes various concepts of sustainable structures in private consumption as well as relevant research activities. On the one hand prevailing consumption patterns are analysed, and on the other, the motives and incentives underlying consumption growth and the ensuing environmental impacts are described. The first part of the chapter is dedicated to aspects of theory and methodology. The second part provides an overview of various initiatives aiming to reform individual consumer behaviour.

Chapter four deals with the depiction and modelling of sustainable consumption structures in Austria. Beginning with a description of environmental awareness/concern among Austrian households, various approaches to consumption modelling are adapted and extended by the addition of different aspects of sustainable consumption. The data from the Austrian consumer survey 1999/2000 forms the basis for the identification of "sustainable" households and the modelling of demand shifts presented here. This analysis, together with a description of the underlying database, provides the necessary prerequisite for the general consumption model presented in this chapter.

In chapter five, econometric estimations using the model developed in chapter four are presented. Taking a predetermined sustainability target as a starting point, the impact of a change in demand structures in the sectors heating and transport is illustrated with the help of the general consumption model for Austria.

Chapter six presents the most important results and concludes the study.

2. Environmental Information Systems and Economic – Environmental Modelling

2.1 Environmental National Accounting

Several approaches have been used over the past few decades to assess and capture the impact of environmental factors and services. The primary motivation and aim of the diverse methods lay in an attempt to integrate environmental accounts into national accounts as completely as possible.

The United Nations made fundamental contributions to the development of essential concepts. The revision of the System of National Accounts (SNA) in 1993 resulted in the creation of the Integrated System of Environmental and Economic Accounting (SEEA).

The starting point for the attempt to integrate environmental concerns into national accounting procedures was the clear need to depict the interactions between the environment and the economy, not least in an effort to move towards sustainable development as a basic guiding principle. At the same time, the present methods to depict environmental factors within the SNA are sometimes misleading. For example, end of pipe measures taken to correct for environmental damage have a positive influence on GDP growth, while measures having a positive impact on the environment or environmental services without a market value, are not included in national accounting figures at all. A further problem lies in the treatment of man-made capital and natural capital. While a reduction of man-made capital is recorded in the national accounts via the process of depreciation, a decrease in the stocks of natural capital is treated positively in income accounts. Thus, non-sustainable use of natural resources creates a flow of income over a certain period, but the actual decline in the stock of natural capital goes unrecorded.

The interplay of economic and environmental forces is extremely complex. To capture these interactions adequately a comprehensive data network is essential. At the same time, policy makers are expressing the desire for a statistical measure or index which is as simple as possible to express and understand, something like a "green GDP", a summary indicator to cover all the diverse interactions between economy and environment.

It was with this background in mind, that a considerable number of countries began a comprehensive effort to collect statistical data on environmental impact. Hecht (1999) provides several examples of partial environmental accounting, e.g.:

- Resource accounts: these capture stocks of natural resources and changes therein. This may be expressed in terms of physical units or in monetary terms.
- Emission accounts: measurement and recording of emission data in various disaggregation levels.

- Environmental expenditure accounts: to capture public and private expenditure on environmental protection. Such accounts already enjoy a long tradition in most industrialised nations. Apart from the distinction between public and private spending a distinction is also made between investment and current expenditure. Capturing expenditure on environmental protection has so far proved relatively simple, since to date most steps taken to protect the environment have focussed on end of pipe activities. However, as more integrated procedures take hold, it will prove ever more difficult to distinguish between investment in environmental protection and other forms of investment. In addition, when the environmental expenditure accounts are seen in isolation, the conclusions drawn can be fallacious, e.g. to assume that high expenditure on environmental protection implies high environmental quality.

The diverse nature of the environmental accounting methods used by various countries, impaired cross-country comparison and led the United Nations Statistics Department to attempt to produce common guidelines for accounting procedures. In 1993, as an annex to the revisions of the SNA, the UN published a handbook on the System of Integrated Environmental and Economic Accounting (SEEA).

In the SEEA handbook, the UN statistics office departs from the idea of complete integration of environmental accounts into the national accounts system. Rather, the SEEA presents a system of satellite accounts which measure environmental factors in physical and monetary units.

The following sections adopt a more or less hierarchical form. First, the comprehensive nature of the SEEA is stated and described. Then, on the basis of the satellite system of accounts, the work of the EU and of Austria with respect to environmental national accounting is described and its integration in the SEEA discussed.

2.1.1 System of Integrated Environmental and Economic Accounting (SEEA)

The so-called "London Group" has been working on the SEEA over several years. The description of the SEEA principles presented in the following chapters draws on a summarised version of the interim revised handbook as published on the Internet[1].

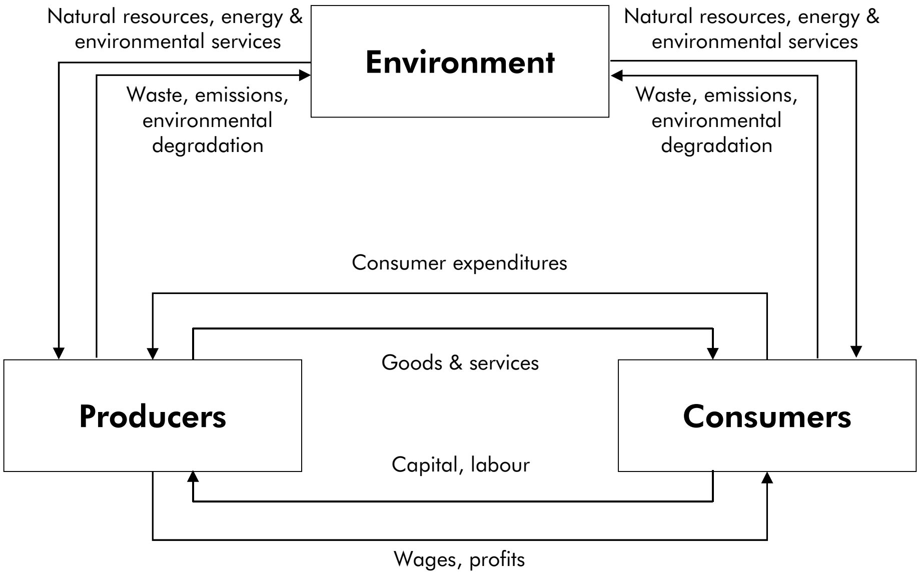
2.1.1.1 Interactions between National Accounts and Environmental Accounts

The need to draw up a system of internationally recognised standards on environmental accounting, derives to a large extend from the recognition that economic and/or environmental problems often stem from the impact of interactions between the two systems. Correct problem analysis depends therefore on sufficient knowledge of both systems, on knowledge of the interactions between the two, and on the possibility of a conceptual separation of the two realms. Two essential

[1] http://www4.statcan.ca/citygrp/london/london.htm.

characteristics of the economic system are, on the one hand the orientation towards market-based transactions, and on the other, the portrayal of stocks and flows in monetary units. Natural resources, energy and environmental services are all necessary in the production and consumption of goods. Figure 2.1 presents in simplified form, the various interactions which take place between the economic and environmental system. Included here are the monetary transactions described in national accounts, physical flows or environmental effects.

Figure 2.1 Links between environment and economy



S: http://www4.statcan.ca/citygrp/london/london.htm.

On the one hand, the flows of environmental inputs into the economic system, in the form of natural resources, energy and environmental services, are depicted, and on the other hand the cycle is closed with the production of waste material and the deterioration of environmental quality resulting from economic activity.

The interactions between economic and environmental systems outlined in Figure 2.1, can be found in the version of the SNA extended to include satellite accounts, the so-called System of Integrated Environmental Economic Accounting, which was developed as a result of the SNA revisions in 1993. By deciding in favour of the use of satellite accounts, as opposed to a more complete integration of environmental accounting in the national accounts, more leeway is made available in terms of choice of method and concepts. However, the more such flexibility is used, the greater the danger that the interfaces between national accounting and environmental accounting systems will no longer be appropriate. The SEEA needs to compromise between maintaining flexibility and ensuring that the basic categories and principles of the national accounts are not abandoned. Such qualitative features are better provided for by the inclusion of satellite environmental accounts in the national income statistics than would be possible by their full integration.

In national accounts, goods and services are recorded in terms of their market prices. In cases where environmental-economic interaction is described by resource flows (resource stocks to a limited extent), such a valuation scheme can also be used for environmental goods. In order to evaluate resource stocks (e.g. oil reserves), the stock of natural assets remaining needs to be discounted.

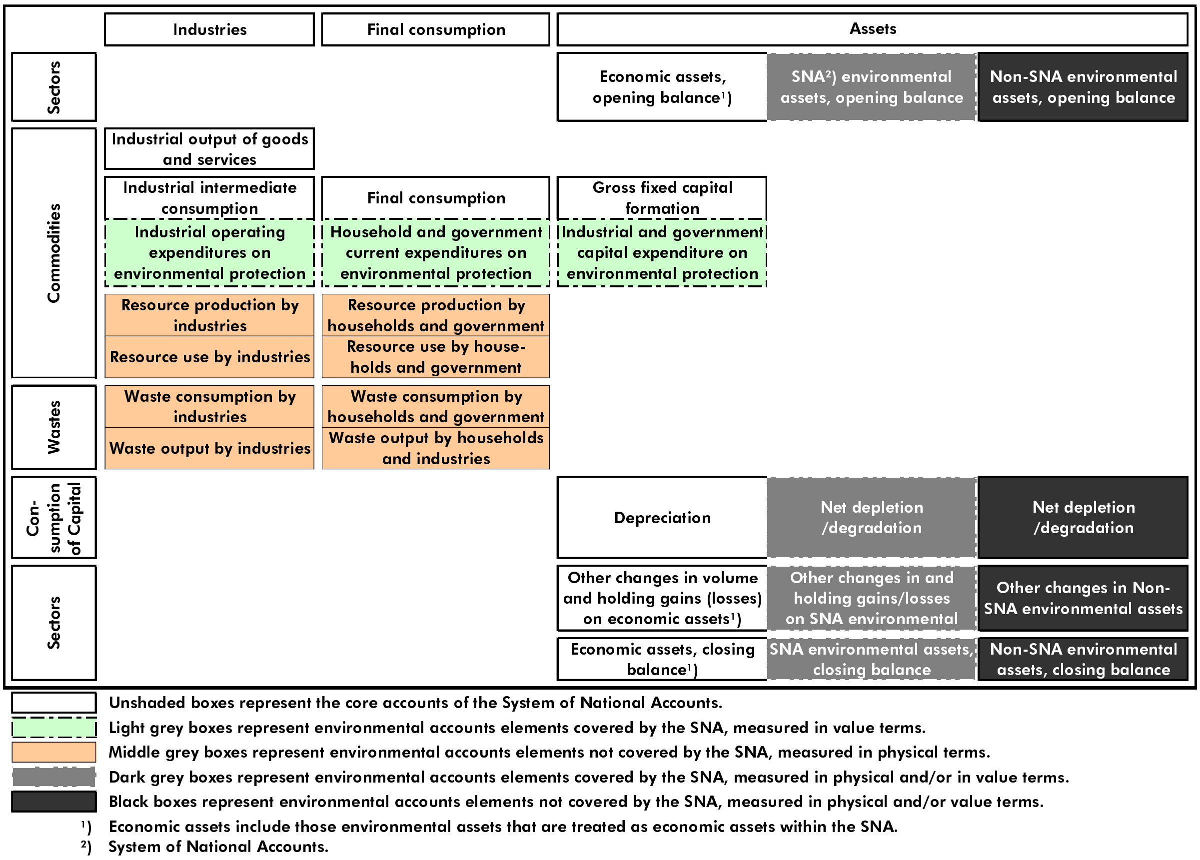
Apart from the market evaluation of environmental goods and services, there are other forms of interaction which require different valuation methods. One example here is the function of the environment as a sink for waste or damage arising from production and consumption activity. Two basic principles have been incorporated in the SEEA to deal with this[2]:

- Cost of emission abatement: this draws on economic agents' expenditures on environmental protection.
- Contingent valuation approach: this is an attempt to estimate the willingness of agents to pay for environmental goods and services. Hypothetical markets are created and specific surveying techniques are used to this end. Such methods attempt to put a value on environmental goods and services where no market transactions exist.

Figure 2.2 is a schematic presentation of the relation between environmental satellite accounts and national accounts. The core national accounts are shown, and these include output in goods and services, final demand and changes in asset levels. This core does not integrate environmental accounts consistently across its various components. Environmental protection figures (industry, households and the public sector) are completely integrated into the national accounts. Certain natural resource levels and their respective changes are also considered. These are largely resources used in production processes and given a monetary value. In addition to this there are also natural resources which only appear in the environmental satellite accounts, e.g. inputs expressed in physical units.

[2] In terms of both practical application and data requirements, both these evaluation approaches represent a considerable challenge. Important categories such as "life-support function" are not explicitly dealt with.

Figure 2.2: System of Environmental Accounts within the National Accounts



S: http://www4.statcan.ca/citygrp/london/london.htm.

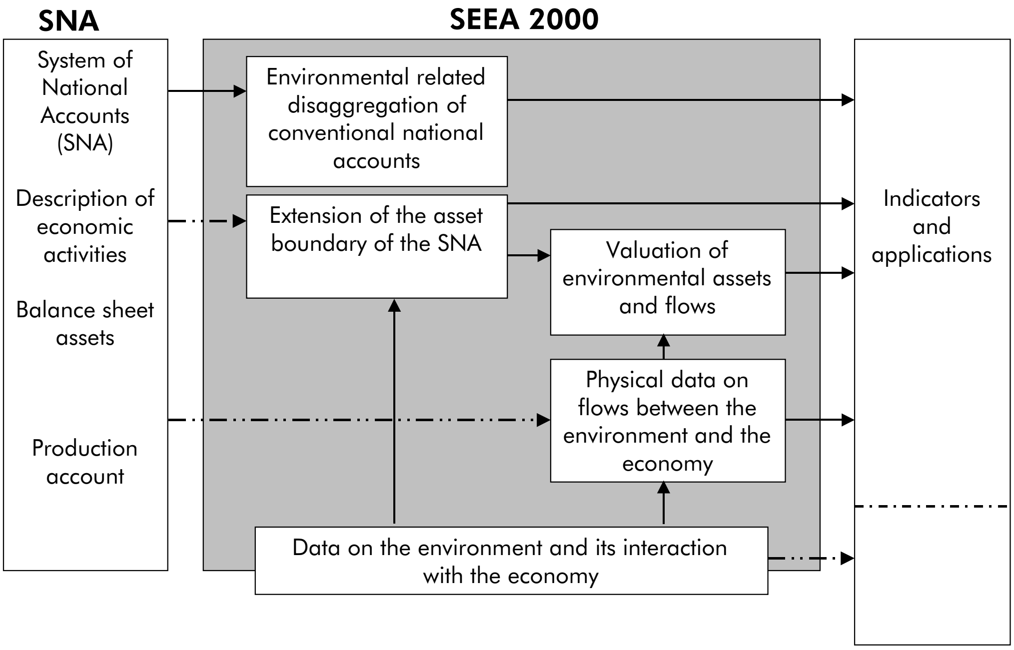
2.1.1.2 SEEA 2000 – Environmental Accounting Modules

In the revisions to the handbook of the System of Integrated Environmental and Economic Accounting four basic modules, which in turn comprise a series of sub-accounts, are presented. The four modules are:

- Asset accounts
- Physical flow accounts
- Environmental protection accounts, resource management and resource depletion
- Assessment of environmental degradation

Figure 2.3 shows how the individual modules can be incorporated in the SNA framework. The extent to which these modules are integrated into national accounts is not at all visible here. As in Figure 2.2, the respective level of integration is likely to vary across the different categories.

Figure 2.3: SEEA 2000 and links to SNA 1993



S: http://www4.statcan.ca/citygrp/london/london.htm.

Asset Accounts

Asset accounts include stocks of natural resources and environmental systems. The natural resource stocks are further broken down into renewable and non-renewable resources. Capturing natural capital involves on the one hand, taking account of the economic asset values, normally recorded as part of standard national accounting procedures anyway, and on the other hand, putting a value on natural capital which is not included in national accounts. The further classification of natural capital depends on how it is used in the economy, e.g. whether it is consumed during economic processes or whether it is employed only indirectly (e.g. land, surface water).

The above distinctions are reflected in the form date available. Natural resources used in economic processes are recorded in monetary terms. Accounting for environmental assets is more difficult, and frequently qualitative measures or changes in environmental quality are used.

Physical Flow Accounts

This environmental accounting module deals with flows of material resources and energy between the economy and the environment. These flows are largely related to the inputs used in production and consumption processes, and to waste and emissions entering the environment as a result of economic activity. This module depicts the physical economy, which is represented in terms of physical flows from the environment to the economy, material flows within the economy and material flows from the economy into the environment[3].

The basic objectives in describing physical flows are:

- To measure the changes in levels of natural stocks (in a specific time period) and to specify the connection to asset accounts
- To identify potential risks ensuing from the exploitation of natural resources and/or from the return of waste products to the environment
- To describe the physical economy
- To provide an information source for the development of environmental indicators, for example to measure decoupling of resource use and economic growth.

Physical flows in SEEA 2000 are structured on a modular basis. Full implementation can only be achieved at the expense of excessive effort. By means of a modular approach it is possible to concentrate attention on those areas of relatively high political significance. An example of such modular use – already being implemented in several countries – is that related to energy balances. On the one hand, energy balances provide good examples with respect to the use of scarce resources (in particular concerning the use of non-renewable resources), and on the other hand with respect to emission flows into the environment (various air pollutants such as CO_2 etc.).

The material flow categories proposed in the SEEA handbook distinguish between three groups:

Natural resources (renewable and non-renewable): these flows refer to natural resources which are physically consumed[4].

Products (material flows within the economic system): SNA 93 introduced a so-called Central Product Classification (CPC). In terms of identifying the physical flows of goods, it is necessary to check whether this system of classification is still generally valid, i.e. does it adequately reflect the potential for environmental damage of each product.

Residuals are physical flows from the economic to the environmental system. Waste products which are returned to the economic system via recycling activity are not included in this category. These then count as products.

The division and recording of material flows on the basis of the above categories is meant to ensure that material inputs and material outputs and/or accumulated materials balance out. This requires

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[3] The term material flow normally is used to refer to flows of minerals etc., while the term substance flow is used to described chemical substances such as cadmium etc.

[4] In contrast there are stocks in the natural capital accounts which are not consumed, i.e. they do not depend on prior use of natural capital. Examples might be the use of navigable rivers, the use of the atmosphere as a sink for air pollutants.

that common units of measurement be employed. The use of a single unit of measurement, however, say tonnes, does not provide information on the qualitative differences between the various environmental effects. In this respect, an additional weighting factor is required, in particular since mass and toxicity of material flows are often inversely proportional to each other.

Quantitative information on material flows is already recorded in several countries, including Austria. Such data are made public under the heading "physical flow accounting".

The fundamental identity, supply = demand, is just as valid in analysing material flows as it is in accounting for monetary flows and magnitudes. With respect to a single economy or a specific production process we have the following equation:

Total input = total output + changes in stock levels (net accumulation).

The following hypothetical case should help clarify the material flows and balances in the economic and environmental systems:

Table 2.1a: Physical flows and material balance for the economic system

Input in 1,000 tons		Output in 1,000 tons	
Import of products	149,530	Export of products	102,060
Natural resource extraction	403,693	Net output of residuals	355,364
		Net material accumulation in the economic sphere	95,799
Total	553,223	Total	553,223

Table 2.1b: Physical flows and material balance for the environmental system

Input in 1,000 tons		Output in 1,000 tons	
Net output of residuals	355,364	Natural resource extraction	403,693
Residual transfers from ROW	8,221	Residual transfers to ROW	3,929
		Material accumulation in the environmental sphere	-44,037
Total	363,585	Total	363,585

S: http://www4.statcan.ca/citygrp/london/london.htm.

Information on resource efficiency can be derived by examining the connections between physical material flows and relevant economic variables. Where such information is available in the form of time series data, it then becomes possible to comment on the development of resource efficiency in an economy and on changes in the prevailing economic structure. One project currently in implementation in several countries and with just such objectives in mind is the National Accounting Matrix Including Environmental Accounts, or NAMEA[5].

Environmental Protection Accounts and Resource Management

The environmental accounts described within this module are for the most part already included in the national accounting procedures. Such accounts are related to information on environmental protection with respect to firms, households and the public sector. Also included are data on environmental taxes, subsidies for environmental protection and for environmental technologies. Basically such data are presented in monetary terms and are already contained in the national accounts, albeit not in a form suitable for the isolation of specific environmental information. The composition of environmental and resource management accounts thus requires a new structure in order to facilitate the fulfilment of environmental objectives.

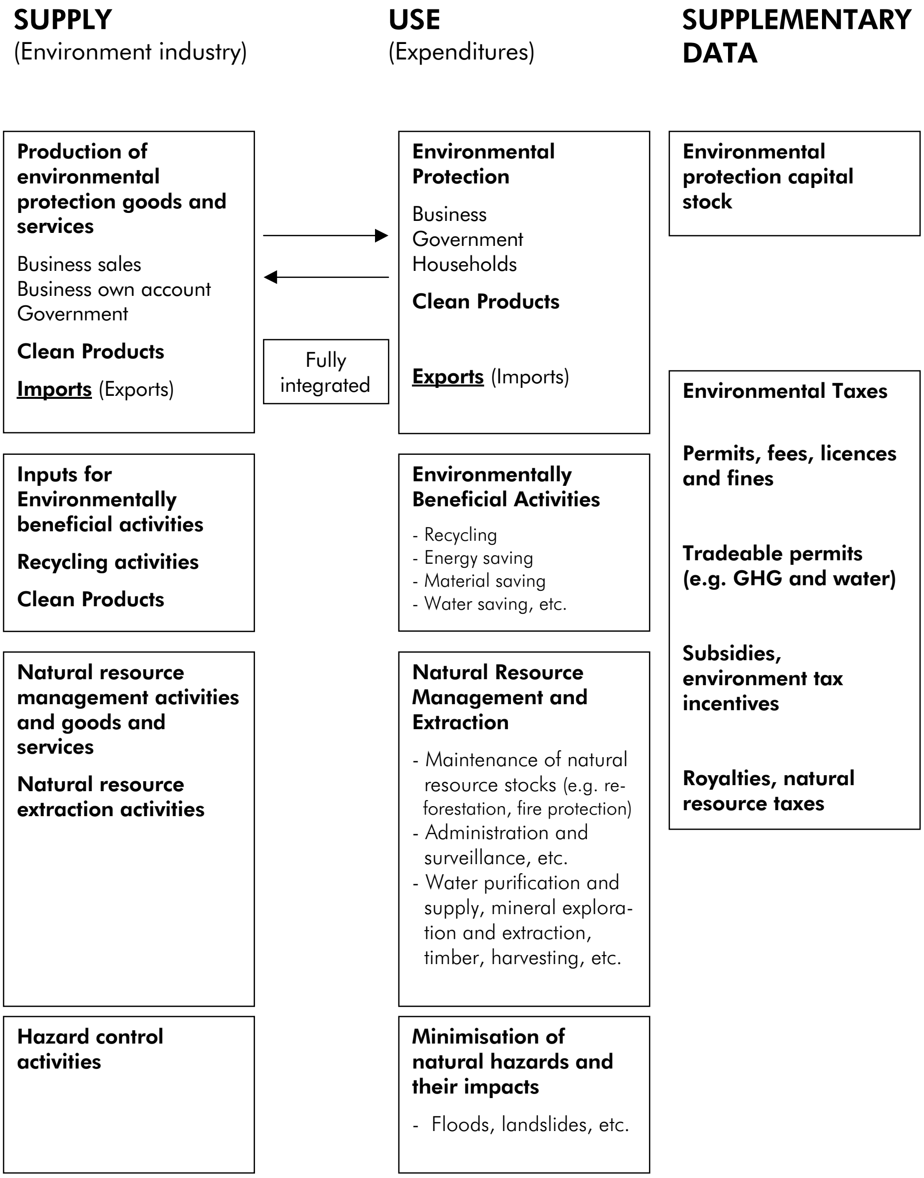
The major criteria to be observed in sorting accounts and data are as follows:

- Only actual environmental expenditure is to be included in the accounts
- Allocation is to occur on the basis of specific tasks to be fulfilled
- Environmental protection activity and "clean" products are included
- Evaluation on the basis of national accounting standards
- Funding of environmental protection activity is also to be included

Figure 2.4 presents an overview of the sub-accounts which are included in the present module. Environmental activities are arranged in two basic columns, one referring to supply activities and the other to areas of use. A further column captures complementary accounts, used for example, to record information on environmental taxes.

[5] On NAMEA in Austria see section 2.1.3.

Figure 2.4: Environmental protection accounts and resource management



S: http://www4.statcan.ca/citigrp/london/london.htm.

The basic objective is to capture all activities which are primarily concerned with environmental protection. The classification framework proposed for this is the Classification of Environmental Protection Activities (CEPA). Environmental activities are thus classified according to the following headings:

- Protection of ambient air and climate
- Waste water management
- Waste management
- Protection of soil and ground water
- Noise and vibration abatement
- Protection of biodiversity and landscape
- Protection against radiation
- Research and development
- Other environmental protection activities (e.g. education, training, information etc.)

Environmental protection measures are then broken down further in terms of type (e.g. prevention, reduction etc.).

On the basis of a definition given by Eurostat and the OECD, the environmental goods and services industry was included in the SEEA 2000. Industry activities correspond closely to those contained in the supply block of the module. The industry was defined by Eurostat and the OECD as follows:

"*The environmental goods and services industry consists of activities which produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air and soil, as well as problems related to waste, noise and ecosystems.*

This includes cleaner technologies, products and services which reduce environmental risk and minimise pollution and resource use."[6]

This is a very broad definition. Clean technologies are accounted for, but at the same time it is made clear that the recording of such activity is by no means unproblematic. The inclusion of technologies and services which help reduce resource use allows for clean energy technologies to be classified as part of the environmental goods and services industry.

In establishing a framework for capturing activities of the environmental industry, the working group drew on the following two principles:

- Goods and services which contribute unambiguously to the environment (the environmental industry). This is intended to distinguish clearly between environmental goods and multi-purpose goods.
- Ease of data set compilation: This refers to the effort involved in data collection. Clean technology, is one area named as an example involving excessive effort in data collection.

[6] *Eurostat* (1998), S. 8; *OECD* (1999A).

The environmental industry is divided into three groups:

- Pollution management (the core sector): This includes goods and services which are clearly targeted towards reducing environmental burdens and which are statistically easy to identify, e.g. so-called end-of-pipe technologies.
- Cleaner technology and product group: goods and services which help reduce or avoid environmental burdens but which may not be supplied for this reason, and which are difficult to define and identify in statistical terms.
- Resource management group: goods and services whose primary purpose is not that of environmental protection, but which have a positive environmental impact nevertheless, e.g. paper recycling activities, renewable energy etc.

These groups are differentiated according to their major activities (production of environmental products, supply of environmental services, construction work). A further division is made with reference to environmental media (air pollution control, wastewater management, solid waste management, remediation and clean-up of soil, surface water and groundwater, noise and vibration abatement, environmental monitoring, analysis and assessment).

This division of the environmental industry into its various sectors indicates the complexity to be expected in data compilation and highlights the need for a multi-faceted approach. Which statistical procedure is actually chosen depends on the specific task at hand and/or on the given political targets. However, in order to ensure international comparability of industry figures, domestic data collection should proceed according to OECD and Eurostat guidelines and should provide figures on the following items:

- Turnover
- Employment
- Investment
- Exports
- R & D expenditure

<u>Capturing environmental activities</u>

Account construction here is based on the split "supply – use – financing"(for firms, the public sector, and households). Environmental measures are divided into external activities and internal activities. The former are already included in traditional national accounting data, while the latter comprise those activities provided for self-use. Specific products providing environmental protection include clean products and environmental services. In terms of expenditures, a distinction is made between current and capital expenditure. The latter is further broken down into expenditure on end of pipe environmental protection and on integrated environmental technologies.

As seen in Figure 2.4, a number of indicators can be derived from the environmental protection and resource management accounts. These include:

- Indicators on the demand for environmental products and technologies and financial burdens through environmental protection
- Indicators on environmental protection expenditure according to specific measures, sectors, and regions
- Indicators on the production of goods and services contributing to environmental protection.

Assessing environmental degradation

The interim version of the SEEA 2000 also contains a chapter dealing with the assessment of environmental degradation. Essentially this is a question of establishing values for environmental goods and services which have no market price. The chapter provides an overview of the various valuation methods and makes a general distinction between cost-based pricing techniques and cost-benefit analysis.

- Cost-based techniques: such methods attempt to estimate the costs involved in combating or removing the loss in environmental quality
- Cost-benefit analysis: these methods attempt to estimate the value arising from the impact of negative externalities or from environmental damage or degradation.

The underlying principle here is that costs and benefits be treated as if they were actually being paid for by producers and consumers. The GDP figures are then recalculated under these assumptions. In this way indicators for Environmentally Adjusted Net Domestic Product (EDP) or for Genuine Saving can be derived. These indicators can then be compared with the standard macroeconomic data such as net national product in order to assess whether or not the economy is on course towards sustainable development.

Another concept assumes that the inclusion of costs, benefits and externalities in the evaluation process will lead to a change in the behaviour of producers and consumers. On modelling such behavioural changes it is possible to obtain a "green GDP" which once again can be compared with the traditional macroeconomic indicators.

Whichever conceptual approach is chosen, it must allow for consistency and coherency when dealing with the environmental asset and physical flow accounts.

2.1.1.3 Implementing SEEA

The planning and design of a system of environmental national accounts is a very extensive project. The organisers explicitly recognise that not all aspects of every account module can be operationalised. It lies within the remit of each individual state to decide upon the relative urgency of specific environmental account data.

For several reasons SEEA work is to be seen from a general development perspective. For example:

- Only a few countries have so far managed to develop appropriate environmental accounting systems and even here the accounts are far from complete. That is to say, potential interconnections between the disparate sectors and their relevance in practice still need to be checked through. Therefore at present, gaining practical experience with a whole series of environmental accounts must be seen as being of top priority.
- Environmental accounting is by its very nature never complete. Continuous scientific research means that there are always new questions demanding attention, and the new knowledge has to be incorporated into environmental national accounts. The increasing understanding with respect to the evaluation of environmental costs and damage is a case in point.

2.1.2. Environmental Accounting in the EU

EU work on environmental national accounts is closely related to the SEEA. The basis for EU research in this area is provided by the internal communication "Directions for the EU on Environmental Indicators and Green National Accounting - Integration of Environmental and Economic Information Systems" (COM(94)670). In recent years several pilot projects have been undertaken in member countries in order to gain better data sets for the implementation of environmental accounts. Environmental national accounting in the EU focuses on the following points (Steurer, 2000):

- Natural asset accounts (forests, water resources, soil, natural resources).
- NAMEA[7] emission accounts: air emissions and energy use, water consumption and water pollution, waste.
- Physical flow accounts and material balances.
- Environmental economic data: expenditures on environmental protection activities, environmental industry data, environmental taxes.
- Evaluation/modelling procedures: research on modelling and statistical compilation.
- Handbooks: co-operation with SEEA developments on the one hand, and on the other, the support and provision of internal work, e.g. the handbook on data collection for the environmental industry, developed jointly by Eurostat and the OECD.

[7] National Accounting Matrix Including Environmental Accounts

The above list of focal points clearly shows how interwoven EU and SEEA work already are. This comes as no surprise, since Eurostat is actively engaged in work on the revision of the SEEA. SEEA 2000 is to be published jointly by Eurostat, OECD, and the World Bank.

EU research on environmental national accounts is carried out in close co-operation with member states. For one thing, several members are working on pilot projects related to specific themes, and for another, representatives from member countries are meeting in task forces to concentrate on the implementation of certain focal points.

The progress made in these specific areas varies considerably. A few key points and results are described below.

Natural Asset Accounts

The EU has produced two publications concerning forestry in environmental accounting, "The European Framework for Integrated Environmental and Economic Accounting for Forests" and "Valuation of European Forests". The first provides a framework for comprehensive capital accounting in monetary and physical terms, and covers stock and flow concepts. The second publication presents valuation methods for land and forests. Case studies covering several countries are dealt with and these show that the use of different valuation methods can lead to enormous divergencies in the results.

The recording of data on natural resources is a further focal point, in particular on data relating to oil and natural gas. This involves problems of reserve definition and data compilation, valuation of reserves, their future availability, questions of property rights etc. Proposed methods were tested in pilot studies and these are to be used to provide a set of basic Tables for regular registration and recording of the relevant physical and monetary data in the fields of oil and natural gas.

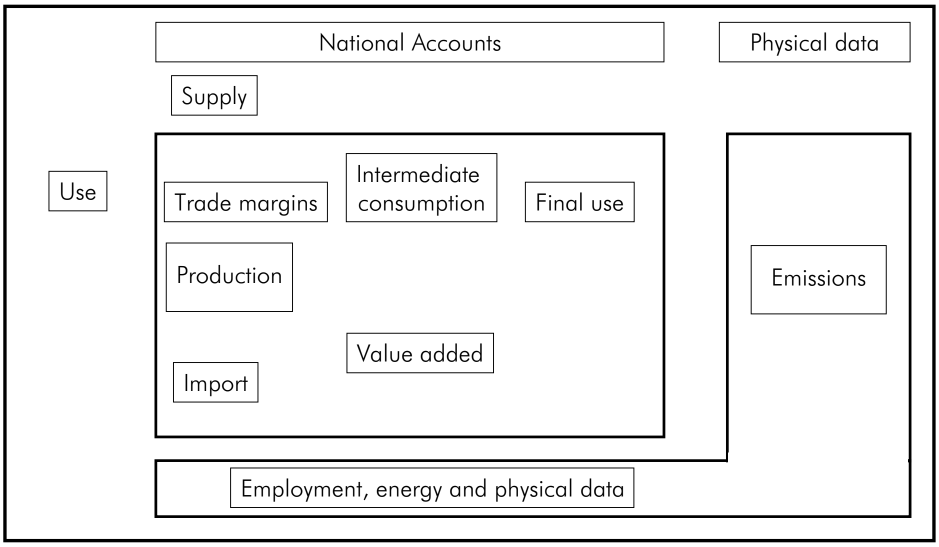
In the area of land, attempts are being made to devise information systems relevant for land use and land cover. Initial results for these accounts are expected in 2000/2001.

Eurostat also established a task force to deal with drawing up account information for water resources. The task force has proposed 13 Tables to be used in the respective satellite accounts. Basically, these should clarify the nature of water flows between the economy and nature, and should also include relevant monetary data as well as data on environmental pollution. Here, the connection to the national accounts with respect to costs of water use and waste water treatment, should be exploited on as wide a basis as possible.

NAMEA

NAMEA accounts include economic and emission data for economic sectors and households. According to Steurer (2000), such accounts are already widely used in most member states. The EU system for NAMEA can be represented schematically, thus:

Figure 2.5: NAMEA – EU System



S: Steurer, 2000.

The system is designed to capture time series information such that it becomes possible to carry out research at different levels of analysis, e.g. inter-sectoral analysis, intra-sectoral analysis over time, cross-country analysis at and over time, etc. Table 2.2 below, clarifies the varied extent to which the NAMEA system is or is not in place in member states. Several gaps in implementation are clearly visible.

Table 2.2: Overview of existing NAMEA systems in the EU

	Air emissions	Energy	Use of water	Waste-water	Solid waste	Resources
Belgium	+			f		
Denmark	+	+	+	f		+
Germany	+	+	+		+	
Greece	+	+	+			+
Spain	p		+	p	p	
France	+	f		p/f		f
Ireland	+	+		+	+	+
Italy	+					+
Luxembourg	+		f	f	f	
Netherlands	+	+	+	+	+	+
Austria	+		p	+	+	
Portugal	+		p		p	
Finland	+	+		+	+	+
Sweden	+	+	+			+
Great Britain	+	+		p		+

\+ NAMEA-System p planned f feasibility study.
S: Eurostat, 2000.

Physical Flow Accounts and Material Balances

Physical flow accounts record the total of all entities entering, processed within, or leaving a system in a certain time period (see IFF, 2000). The material stock account shows the physical stocks existing within a socio-economic system. Eurostat is hoping to have the relevant methodological guidelines ready by the end of the year 2000. This would provide a coherent and consistent system for recording material flows across the EU. Physical flow accounts allow for the derivation of several useful indicators, e.g. an indicator of resource productivity in a particular economy.

Environmental Economic Information (SERIEE): Environmental protection expenditure[8], Environmental industry, Environmental taxes

The methodological framework for environmental protection expenditure accounting was published by Eurostat in 1994 and has already been tested in practice by a number of member states. In parallel with implementation by member states, it is also intended to check the proposed break down of environmental protection activity. In addition, recording of environmental protection data is to be facilitated by carrying out revision of other statistical procedures and classifications such as NACE.

The EU system for environmental economic data is called SERIEE and comprises a system of satellite accounts for the compilation of the relevant information. For recording data on protection activity, the satellite account EPEA (Environmental Protection Expenditure Account) was set up. This deals with all measures and activities which aim to avoid, reduce or remove environmental damage. An activity is said to be environmentally protective when it involves the combination of various resources (e.g. equipment, labour, technology or products) in the supply of environmental services[9]. This includes activities which are clearly intended to provide environmental protection. It does not encompass activities which merely result in positive environmental effects, where such an effect was not the primary objective.

The EPEA includes the unified system of statistical procedures on environmental protection activities employed in the CEPA, where environmental services are allocated to their respective sector (air quality and climate protection, water pollution control etc.).

Information on environmental taxes[10] and the environmental industry is also collected. The method used for the compilation of environmental tax data was worked out in co-operation with the OECD. The same is true of defining the scope and classification of the environmental industry[11].

[8] For more on the system of environmental protection expenditure accounting see "Environmental accounts in Austria" in section 2.1.3.

[9] See Milota - Aichinger (1999B), Umweltschutzausgabenrechung in Österreich 1995/96, Ansätze zur Implementierung von SERIEE.

[10] For closer definition of the nature of environmental taxes, see section 2.1.3.

[11] Even the interim version of SEEA 2000 refers to the work of Eurostat and OECD on environmental industry definition.

Progress in Implementing Green National Accounting in the EU

As mentioned above, varying progress has been made in different sectors of environmental accounting. In some areas concepts are so well developed that data can be recorded on a regular basis. This includes the NAMEA categories air, environmental expenditure accounts, environmental taxes and physical flow accounts. In contrast to this, further conceptual and methodological work still has to be done in areas such as NAMEA water resources, and water resource accounts.

2.1.3 Environmental Accounting in Austria

Austrian activity with respect to environmental national accounting needs to be seen in an international context, i.e. on the one hand Austrian sub-accounts in the national environmental accounting procedures orient themselves on the basis of the concepts outlined in the SEEA, and on the other hand they are designed to comply with Eurostat developments.

Of all Austrian activities in this area, that enjoying the longest history is environmental protection expenditure accounting (even though changes in compilation procedures have produced gaps in relevant time series data).

SERIEE provides the basis for the present system of environmental protection accounts in Austria. This represents a collection of environmental protection expenditure data for the public and private sector. Such expenditures in the public sector cover national, regional and communal activities, as well as those of public and semi-public organisations specialising in environmental protection. Double counting of transfers payments among political subdivisions is not allowed. The following types of data are collected:

- Output in public environmental activity
- Revenues from environmental activities
- Gross fixed capital formation
- Public sector employees engaged in environmental protection

As in the public sector, there is also an account framework for the compilation of environmental protection data in the private sector. Data allocation is based on the following divisions:

- Investments (end of pipe and integrated technologies)
- Current expenditure
- Employees

Statistics Austria first presented sets of environmental protection expenditure accounts based on SERIEE for the years 1995 and 1996. The subsequent adoption of EU statistical conventions for the preparation of such accounts means that the data now available can no longer be compared with that from earlier years.

Three different levels are used in recording Austrian statistics on environmental protection expenditure:

- National environmental protection expenditures by use (Table A)
- Production of environmental services (Table B)
- Financing of national expenditure on environmental protection (Table C)

The data provided in Table A, "National environmental protection expenditures by use" for the most part corresponds to the definition of environmental protection expenditure used in earlier calculations.

National environmental protection expenditures reached a total of € 5.5 billion in 1995, and € 5.8 billion in 1996. Expressed as a share of GDP, these figures correspond to 3.4% and 3.3% respectively.

Figures on "environmental industries" are closely related to data on environmental protection expenditure. The procedure used by Statistics Austria borrows from the OECD and Eurostat methods, and apart from data on capital equipment and machinery, it includes environmental services such as waste disposal and construction services (see Gerhold - Petrovic, 1999). This method differs to the supply-side based data used in WIFO statistics which focuses exclusively on producers of environmental technology, defined in a rather narrow sense[12]. Statistics on the environmental industry are produced yearly by Statistics Austria.

As previously mentioned, a common method for the calculation of environmental taxes[13] was developed by the EU and OECD. The basic idea relies on the identification of taxes whose underlying tax bases have a negative impact on the environment. The Austrian compilation method for environmental taxes employs such an approach and a working group has been able to identify relevant taxes on a national level. Environmental taxes are published by using the methodology of the OECD/EU-working group.

As part of a pilot study and in co-operation with the Boku (University of Agricultural Sciences, Vienna), Statistics Austria produced compilation procedures for the evaluation of forests and land areas. Five different methods of evaluation were studied. The evaluation procedures were tested on the years 1993-1998, and showed that considerable differences in the asset valuation results are achieved depending on the specific method used (Sekot, 1999).

One further area covered in the development of asset accounts is that of evaluating natural resources. In co-operation with the Geologischen Bundesanstalt (Geological Survey of Austria), the

[12] See Köppl - Pichl (1995), Köppl (2000).

[13] Environmental taxes are classified under the headings, energy taxes, transport taxes, pollution taxes and resource taxes.

Statistics Austria is collecting data on physical quantities of reserves, and changes in reserves, for oil, natural gas and brown coal[14].

Work related to NAMEA, i.e. the linking of emission and economic data, is carried out in co-operation with the Environmental Agency. The most advanced data is available for the NAMEA field concerned with air monitoring, where a time series for the years 1980-1997 has been made available. Eight types of pollutant are included, and these are disaggregated according to the NACE classification as well as private consumption. In the sectoral classifications these emission statistics are complemented by economic data such as gross production figures, value added and employment data. As a result of revisions to certain data sets underlying NAMEA compilations (e.g. energy balances, production statistics, national accounting figures), NAMEA time series data is also in need of revision.

NAMEA Tables have been made available for the areas waste and water resources only for one single year.

With respect to physical flows, a time series data set exists for the period 1960 – 1997 (Schandl – Weisz - Petrovic, 2000). Such data depicts the exchange which takes place between nature and society in terms of material inputs. Such material flow data is calculated yearly for the Austrian economy. The data includes materials which are taken from the domestic environment and imported materials. In terms of material use , the following distinctions are made:

- Biomass
- Mineral material
- Fossil material

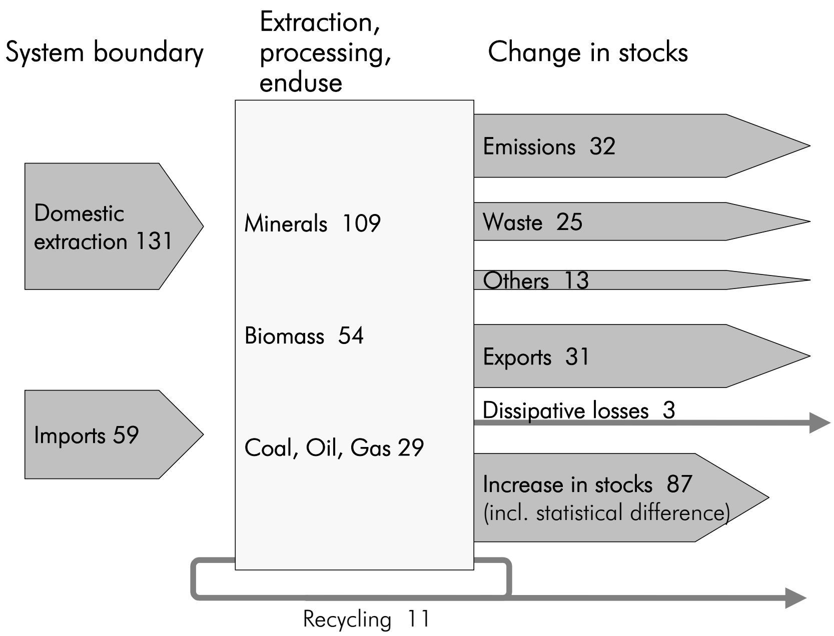
While existing statistical material is adapted for dealing with these areas, care is taken that the methods used to calculate physical flows are compatible with national accounting procedures. Physical flow accounts provides an important source of information for research on the development of resource productivity and resource efficiency. When time series data are available it becomes possible to state whether increases in efficiency have or have not been offset by growth effects. For example, the information on Austria shows that while physical efficiency has increased by 30% since the 1960s, the absolute level of material use has continued to increase as a result of general economic growth.

Material balance data, is not limited to input figures alone , it includes output information too. Use of materials leads either to an increase in stock levels or subsequent to consumption, results in the passing on of waste or emissions to the environment. The most recent material balance (excluding water and air data) available for Austria covers the year 1997.

[14] For the results see Fuchs (2000).

Figure 2.6: Material flow Austria 1997: Material balance (excluding water & air)

In Million tons



S: Statistics Austria.

Looking at the environmental national account data for Austria, one can see a wide accordance with the working areas focussed on in Eurostat. To no small extent this is due to the fact that Austria was actively engaged in relevant pilot studies on statistical compilation of environmental data.

A whole series of developments have taken place in the methodological and conceptual preparation of environmental satellite accounts in and outside Austria, at EU and also wider international levels. These advances in methodology now mean that data is not always available in time series (e.g. environmental protection expenditure) which restricts analysing development over time.

2.2 Indicators of Sustainable Development

The increasing significance of sustainable development as a general policy objective reinforces the need to develop an indicator capable of expressing progress in this direction. It is widely accepted that standard measures of welfare such as GDP are too restrictive in scope since they fail to take account of environmental services and damage and also largely ignore social aspects. A more suitable measure for evaluating sustainable development must therefore be sufficiently broad in scope so as to capture all the relevant economic, social, environmental and institutional factors. In addition it should be capable of capturing all the burdens placed on various parts of the system as well as any reactions to such burdens (Moldan – Billharz, 1997). The greatest attention should be placed on identifying the various interdependencies between the subsystems and on the impact of human activity. In order to make the concept of sustainable development operational and to make progress in this direction visible, several indicators and indicator systems have been and are being developed. These indicators use a multitude of different approaches. Some indicators are used on an international scale (for example those developed by the UN or OECD, etc.), others are more appropriate for use within a specific framework in individual states, regions or localities. Indicators also differ in how they treat economic, social and environmental aspects and the interrelationships between these sub-systems. To date, coherence and consistency between these various approaches is still largely lacking. However, as described in the previous section, environmental national accounting can be used to provide the data necessary for the development of economic and environmental indicators for various approaches. In the following section a brief description is given of the relevance of sustainability indicators and the criteria that may be used in their creation. In conclusion, illustrative examples are provided of approaches that have been developed at international level (UN, OECD, EU).

2.2.1 The Role of Indicators

Indicators are supposed to illustrate the complex nature of sustainable development, in a way that is clear, simple and understandable to the general public. Indicators should be capable of simplifying the various interdependencies between the components of the system in such a way that it becomes possible to ascertain whether progress is being made or not. The development of sustainability indicators must meet a number of demands (Bossel, 1999, Gallopin, 1997):

- They must provide a basis for political decision making at all levels - local, regional, national, global (policy relevance).
- They should include all relevant concerns and interactions of systems and their environment systematic way.
- Indicator sets should be comprehensive and at the same time compact, i.e. the number of indicators should be kept as low a possible but as large as necessary.
- All important stakeholders need to be involved in their development to ensure that they take account of the various values and ideas prevailing (participatory approach).
- Indicators need to be clearly defined, measurable, reproducible (standardised methods), unambiguous, comprehensible and operational (data, time series availability etc).
- Indicators should facilitate comparison between possible alternative development paths as well as evaluate the level of sustainability of current developments.

In preparing sets of indicators, a trade off arises between the demands involved in doing justice to the complex material that has to be presented, and the need for simplicity in employing them to inform the public and policy makers. In contrast to the scientific community which places great emphasis on the need for exact detail and comprehensiveness in data preparation, other groups, mostly political, would prefer to be confronted with a limited number of indicators or if possible with a single indicator of sustainable development (Sustainable Development Index). Similar to the single figure for GDP, the aggregation of several indicators into a single sustainability measure should provide an index of general national welfare capable of stating the existing welfare level as well as of indicating whether a society is moving closer to or further away from the sustainability goal. In developing such aggregate indices, it is important to take care that essential information is properly taken account of and/or that it is not lost altogether. The problem of weighting also has to be dealt with, i.e. what specific weights are to be attached to the various components making up the aggregate index.

At an international meeting in 1996, a set of expert guidelines was drawn up to aid the harmonisation of practices used in developing sets of indicators. These guidelines, the so-called "Bellagio Principles"[15], are designed to help assess progress towards sustainability. They comprise ten basic principles covering the whole evaluation process from indicator selection and design , interpretation, and on to communication of indicator results. The following requirements are included:

- Formation of a clear concept of sustainability with corresponding targets.
- Evaluation procedure must include all relevant sectors and establish areas of priority.
- Evaluation procedure should be target oriented and undertaken as openly as possible so as to ensure wide participation and effective communication.
- The possibility for continuous updating of evaluation results must be arranged, with methods and indicators being flexible enough to be capable of adapting to changing conditions and objectives.

2.2.2 Categorising Indicators

As already mentioned, several approaches exist in the development of indicators. Based on a rough dichotomy, we can distinguish the following types: Indicators which represent complex linkages and interactions between systems in simplified form, from which it is then possible to see the effects of economic activities and political measures (Guinomet, 1999), and a second type, namely, indices compiled by the aggregation of several indicators describing a similar effect[16].

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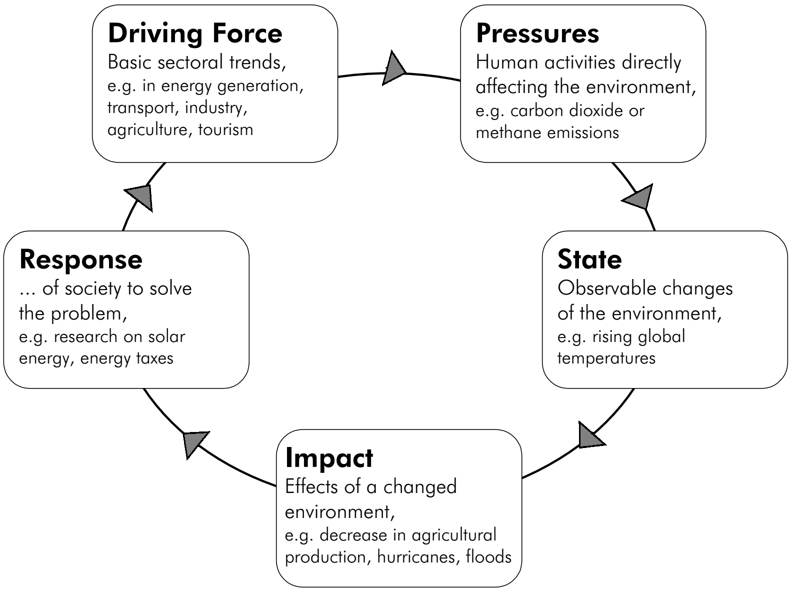
[15] Details of guideline and case studies can be found in Hardi - Zdan (1997).

[16] For example, based on respective global warming potential, the impact of individual greenhouse gases on climate change can be summarised in one index .

The approaches used in developing green national accounting procedures[17] belong to the first category, as do "pressure-state-response" sets of indicators and their model derivatives which are used in various international projects (Eurostat, OECD, UN CSD). Here, indicators are divided into specific categories so as to achieve as broad a view as possible of the interdependencies between the economic, social and environmental systems. As an example, a brief description of the "Driving Force-Pressure-State-Impact-Response" model, or DPSIR[18], is given in he following section. This model is used by Eurostat (Jesinghaus, 1999).

Figure 2.7: The Driving Force-Pressure-State-Impact-Response model



S: Eurostat, 1999.

Driving forces are basic factors or trends (social, economic etc.), which act upon a number of significant variables. Examples are the rate of population growth, energy consumption levels, emissions etc. Driving forces represent phenomena which react relatively slowly and are therefore difficult to influence. They serve primarily to deduce pressure indicators (e.g. passenger transport emission), indicating where corrections are needed if future problems are to be avoided.

Pressure indicators are variables which are influenced by driving forces and indicate directly where environmental problems (may) arise. For instance, pollutant emission figures, data on natural resource use, etc. Pressure indicators reveal the causes of environmental problems. Such problems

[17] see explanations in section 2.1.

[18] The DPSIR model is an extended version of the PSR (pressure-state-response) model developed in the 1970s and subsequently adopted by the State of the Environment (SOE) Group in the OECD.

can be influenced by specific policy measures and pressure indicators can be used to assess the effectiveness of such measures.

State indicators represent the current state of the environment or of sustainable development. They include indicators such as urban pollutant concentration levels, population densities, average increase in global temperature etc. State indicators are used to provide a picture of the current state, which is actually a result of past developments. They also provide information on where abatement measures are best applied.

Impact indicators describe the social and economic effects of changes in the state of the environment, and include for example an increase in the incidence of natural catastrophes, the frequency of specific (pollutant-induced) illnesses etc. They should provide a scientific foundation for decision making and if possible indicate causal chains of events.

Response indicators show what policies or measures are being undertaken by society's decision makers in attempting to combat problems or redirect behaviour in a certain direction. This involves factors such as environmental protection expenditure[19], eco-taxes, education and research expenditures, imposition of quality standards, etc. While response indicators may be observed over a short-term period, it is only possible to assess their effectiveness via the long-term development of pressure and state indicators.

For aggregated indicators or indices, it is assumed that the various component elements do not contribute equally to the impact of a specific phenomenon. These indicators concentrate information on particular pressures into index numbers of a similar nature, as is the case with economic indicators, thus making them more appropriate for public use. The disadvantage of this approach lies in the need to put a weight on heterogeneous elements, which entails the use of specific value judgements. Examples of such aggregate indicators are the "index of sustainable economic welfare" (ISEW), the "ecological footprint" and the "dashboard of sustainability".

2.2.3 Examples of Indicators Sets

2.2.3.1 Eurostat: A European System of Environmental Pressure Indices (ESEPI)

The fifth EU environmental action program, "Towards Sustainability" (1993), emphasised the importance of extending information systems so as to provide a basis for formulating sustainability strategies (Jesinghaus, 1999). In the Communication from the Commission to the Council and the European Parliament on "Directions for the EU on Environmental Indicators and Green National Accounting" (COM(94)670) two proposals were made for creating a comprehensive environmental information system, i.e. the development of satellite accounts (physical and monetary) which would

[19] Environmental protection expenditure accounts are one part of the environmental national accounting system and a core area in environmental economic data (see section 2.1).

complement standard national accounts, and in addition, the generation of physical indicators and indices which would provide information on the impact of human activities on the environment. With these objectives in mind, the initiative "A European System of Environmental Pressure Indices" (ESEPI) was launched in 1995. This is a multi-year project carried out by Eurostat and financed by the DG Environment, which is intended to provide a comprehensive description of those human activities (pressures) most damaging to the environment.

So-called "policy fields", derived from the themes established in the fifth Environmental Action Program, form the basis for the development of indicators. The ten policy fields are clusters corresponding to the structure of EU environmental policy and in which indicators are grouped according to specific topics. These include: air pollution, climate change, loss of biodiversity, marine environment and coastal zones, ozone layer depletion, of resource depletion, dispersion of toxic substances, urban environmental problems, waste, water pollution and water resources. The method used here is the Driving Force-Pressure-State-Impact-Response model described in section 2.2.2 above.

Eurostat is responsible for indicators relating to pressures, driving forces (particularly those describing trends in sectors such as energy, transport, agriculture etc.), and responses (e.g. environmental protection expenditure accounts based on SERIEE). The European Environmental Agency (EEA) is responsible for producing state and impact indicators.

At the beginning of the project it was assumed that between 50 to 100 pressure indicators would be necessary in order to capture all relevant environmental variables in the ten policy fields. A multi-stage consultation process was carried out involving ten specialist institutes in order to determine the structure and content of the project[20]. In total, approximately 2,300 environmental experts from all 15 EU-member states (Scientific Advisory Groups, or SAG), were asked, by means of questionnaires, to provide their opinion on the most important environmental indicators. The more than 2,000 suggestions thus received were condensed to form a list of 30 indicators for each policy field, and these in turn subjected to expert evaluation based on the criteria policy relevance, analytical foundations and responsiveness. From the results of this investigation, a "core ranking" of indicators was developed. Preliminary results (see Figure 2.8), i.e. the list of 60 pressure indicators derived from the consultation process, were published in the report "Towards Environmental Pressure Indices" (Eurostat, 1999). The indicators are listed from left to right, according to the frequency in which they are named by the SAGs.

[20] For details on this consultation process see Jesinghaus (1999) und http://www.e-m-a-l-l.nu/tepi/.

Figure 2.8: List of 60 pressure indicators

Air pollution	Emissions of nitrogen oxides (NO_X)	Emissions of NMVOC	Emissions of Sulphur dioxide (SO_2)	Emissions of particles	Consumption of gasoline & diesel oil by road vehicles	Primary energy consumption
Climate change	Emissions of carbon dioxide (CO_2)	Emissions of methane (CH_4)	Emissions of nitrous oxide (N_2O)	Emissions of chloro-fluoro-carbons	Emissions of nitrogen oxides (NO_X)	Emissions of sulphur oxides (SO_X)
Loss of biodiversity	Protected area loss, damage & fragmentation	Wetland loss through drainage	Agriculture intensity, area used for intensive agriculture	Fragmentation of forest & landscapes	Clearance of natural & semi-natural forest	Change in traditional land-use practice
Marine environment and coastal zones	Eutrophication	Fishing pressure	Development along shore	Discharges of heavy metals	Oil pollution at coast & at sea	Discharges of halogenated organic compounds
Ozone layer depletion	Emissions of bromo-fluoro-carbons	Emissions of chloro-fluoro-carbons	Emissions of hydro-chloro-fluoro-carbons	Emissions of nitrogen oxides(NO_X)	Emissions of chlorinated carbons	Emissions of methyl bromide (CH_3Br)
Resource depletion	Water consumption per capita	Use of energy per capita	Increase in territory permanently occupied	Nutrient balance of the soil	Electricity production from fossil fuels	Timber balance (new growth/ harvest)
Dispersion of toxic substances	Consumption of pesticides	Emissions of persistant organic pollutants	Consumption of toxic chemicals	Index of heavy metal emissions to water	Index of heavy metal emissions to air	Emissions of radioactive material
Urban environmental problems	Energy consumption	Non-recycled municipal waste	Non-treated waste water	Share of private car transport	People endangered by noise emissions	Land use (Change from natural to built up..)
Waste	Waste landfilled	Waste incinerated	Hazardous waste	Municipal waste	Waste per product	Waste recycled/ material recovered
Water pollution and water resources	Nutrient use (nitrogen & phosphorus)	Ground water abstraction	Pesticides used per hectare of agriculture area	Nitrogen used per hectare of agriculture area	Water treated/ water collected	Emissions of organic matter as BOD

S: Eurostat, 1999, Jesinghaus, 1999.

The list provided here is simply an initial step in an ongoing process. The indicator set is to be extended and improved in future, in particular with respect to data availability. There are also several other projects dealing with work on pressure indices (http://www.e-m-a-i-l.nu/tepi/).

One example is provided by the Sectoral Infrastructure Projects (SIP) which record the relative contributions of the various sectors of the economy to total environmental burdens[21]. Sectors considered include energy, agriculture, transport, industry, tourism and waste. Categorising pressure indicators on a sectoral basis should allow for more efficient measurement of the integration of environmental concerns in the corresponding areas of policy.

[21] Detailed information on Sectoral Infrastructure Projects can be found under http://esl.jrc.it/envind/hm_sips.htm.

The aggregation process can then be developed further on the basis of the pressure indicators. The six indicators in each policy field can be weighted to form one summary indicator (similar to the procedure used to calculated global warming potential). As a further step, it should be possible to aggregate the resulting ten indices into a single European environmental index. This would require, however, the use of weighting procedures within each policy field as well as across the ten policy fields.

The next phase of the project has set itself the aim of integrating environmental indicators with economic and social indicators so as to develop a Sustainable Development Index. Eurostat undertook a pilot study on this in 1997, employing the UN CSD methodology for the evaluation of progress towards sustainable development.

2.2.3.2 UN Commission on Sustainable Development (UN CSD)

The UN Commission on Sustainable Development (UN CSD) was founded after the Rio Earth Summit in 1992. At the third meeting in 1995, a work program was agreed upon which set out to provide a set of sustainability indicators for national policy makers by the year 2000. International research projects were the basis for the development of such indicators and more than 30 international organisations began co-operating on the theme. The indicators were chosen on the basis of specific criteria such as relevance to Agenda 21 targets, clarity, feasibility with respect to data availability, time, etc. (Mortensen, 1997). The result of the co-operation was a "working-list" of 134 indicators designed to incorporate economic, environmental, social and institutional aspects of sustainable development, which at the same time lent on the chapters of Agenda 21 (see Table 2.3).

The framework used for categorising the indicators is the "Driving Force – State – Response" model. This is an adaptation of the PSR approach. In contrast to the pressures described in the Eurostat model, driving forces (i.e. the impact of human activity on sustainable development), can here be considered in both a positive and negative sense.

Methodology sheets were developed for every single indicator in order to facilitate their use and analysis. These sheets contain information on the underlying concepts, the significance, and the potential areas of application (based on methodology used and data availability) of the respective indicator[22].

An illustration of the economic indicators from the working-list is found in Table 2.3.

[22] The list of indicators as well as the individual methodology sheets can be found under http://www.un.org/esa/sustdev/isd.htm.

Table 2.3: UN CSD Economic Indicators

Chapters of Agenda 21	Driving Force	State	Response
Chapter 2: International co-operation to accelerate sustainable development in countries and related domestic policies	- GDP per capita - Net investment share in GDP - Sum of exports and imports as a percent of GDP	- Environmentally adjusted Net Domestic Product - Share of manufactured goods in total merchandise exports	
Chapter 4: Changing consumption patterns	- Annual energy consumption- Share of natural-resource intensive industries in manufacturing value-added	- Proven mineral reserves - Proven fossil fuel energy reserves - Lifetime of proven energy reserves - Intensity of material use - Share of manufacturing value-added in GDP - Share of consumption of renewable energy resources	
Chapter 33: Financial resources and mechanisms	- Net resources transfer / GNP - Total ODA given or received as a percentage of GNP	- Debt / GNP - Debt service / export	- Environmental protection expenditures as a percent of GDP - Amount of new or additional funding for sustainable development
Chapter 34: Transfer of environmentally sound technology, co-operation and capacity-building	- Capital goods imports - Foreign direct investments	- Share of environmentally sound capital goods imports	- Technical co-operation grants

Q: http://www.un.org/esa/sustdev/indisd/english/worklist.htm.

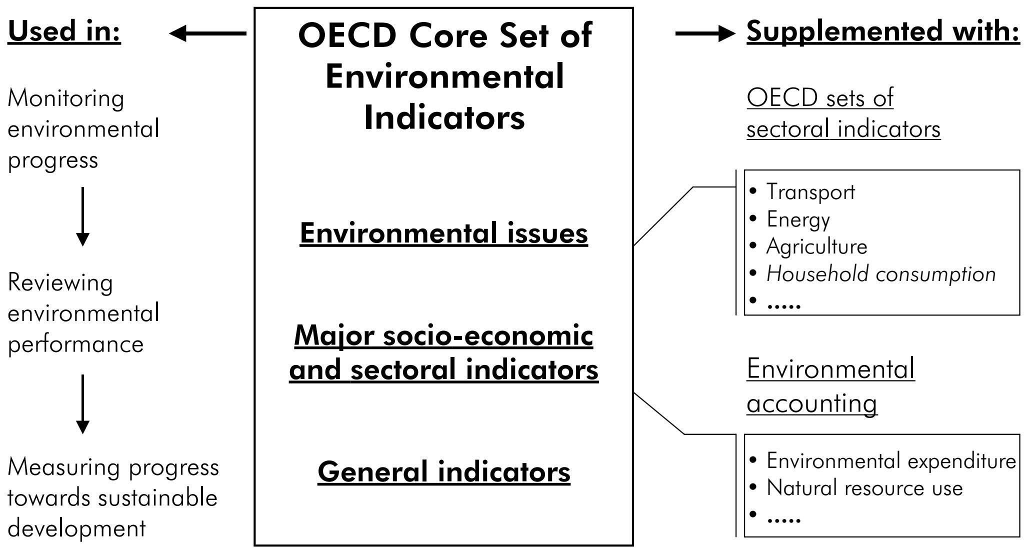
After the preliminary working list was published at the end of 1996, 21 states around the world (including Austria) said they would be willing to test the indicators in connection with their own priorities and targets until 2001. Not all indicators listed are suitable for all countries, and individual states can choose for themselves what indicators they deem most appropriate for their national targets. The test phase guidelines supplied by the CSD were designed to aid indicator implementation and to ensure that the test results would be comparable across different countries. As becomes clear from viewing the above Table, the process of indicator development has by no means been completed, particularly in the area of institutional indicators. To complete the list, further knowledge is needed on indicator interdependencies and on the impact of various activities on sustainable development. While national tests continue, further initiatives are also underway to develop additional sectoral indicators (e.g. to measure changes in patterns of consumption and production). The results are to be integrated into indicator development in future.

2.2.3.3 OECD

The OECD has been involved in the development of environmental indicators since 1990. Such indicators are used to assess the existing state of the environment and environmental performance, and to help ascertain whether progress towards sustainability is being made or not. There are now several set of indicators in use which have been specifically adapted for particular applications and which are closely connected with each other. The indicators are used in OECD analysis, for example in Environmental Performance Reviews, to assess environmental policies, etc., and are also part of the program on the development of sustainability indicators. The indicator sets include (see Figure 2.9):

- the core set of OECD environmental indicators (see OECD, 1998B), which serve to monitor environmental progress,
- sets of sectoral indicators (for agriculture, transport, private consumption, etc.), which are designed to aid integration of environmental concerns into sectoral policies,
- indicators derived from environmental accounting.

Figure 2.9: OECD indicator sets



S: OECD, 1999B.

The theme "Sustainable Consumption", is one of the focal points in the development of sectoral indicators. Since 1994, the OECD has been analysing consumption and production patterns and their significance for sustainable development. As part of the research program "Sustainable Consumption", a conceptual framework for research on consumption patterns[23] is being developed, and case studies are being carried out which deal with, on the one hand, policy measures which influence consumer demand, and on the other hand, the structure of private consumption and the connections between globalisation and consumption patterns (OECD, 1999B). The research is being carried out in close co-operation with other institutions (e.g. UN CSD).

Indicators on sustainable consumption act as the underlying basis for this work. These serve to identify interfaces between consumption patterns and environmental problems and to aid the integration of concerns on sustainability and the environment into the decision making process.

The indicators[24] are organised on the basis of a modified version of the "Pressure – State – Response" framework (see Table 2.4), thus:

- Environmentally significant consumption patterns and trends correspond here to the driving forces and indirect pressures. They take account of economic and socio-demographic trends, and of household consumption trends;
- Interactions between consumption and environment correspond to direct pressures on the environment and on natural resources and the related impacts. The indicators measure the impact of consumption on resource use, waste and pollution levels, and thus the significance of such consumption for the environment. Indicators are arranged according to environmental topics;
- Economic and political themes deal with the analysis of social and political reactions. Indicators are organised in terms of economic instruments (public expenditure, taxes etc.), informational and/or social instruments (eco-labelling, information campaigns etc.), and topics relating to international trade (e.g. the ratio of imported to domestic goods).

[23] Considered here is the consumption of private households as final users

[24] For details of calculation methods used (indicator sheets) and the indicators measured see OECD (1999B).

Table 2.4: Proposed set of indicators: Summary Table by major consumption activity

Environmentally significant trends	Interactions with the environment	Economic and policy aspects
General trends		
ECONOMIC TRENDS - Consumption expenditure shares of GDP - Saving rates (genuine savings) - Government consumption: public final consumption expenditure - Household consumption: private final consumption expenditure SOCIO-DEMOGRAPHIC TRENDS - Household size - Population structure	LAND RESOURCES - Urbanisation: land covered by urban development	REGULATORY INSTRUMENTS - To be further developed ECONOMIC INSTRUMENTS - Consumer price index - PAC expenditure (public, households) INFORMATION/SOCIAL INSTRUMENTS - Consumer attitudes - Public expenditure on environmental information and education - Public support to green NGOs
Key household consumption activities		
Transport and communication		
- Passenger transport - Passenger car stocks and ownership - Energy consumption by transport, consumption of road fuels - Communication tools	AIR - Air emissions from (passenger) transport NOISE - Population exposed to road traffic noise	ECONOMIC INSTRUMENTS - Subsidies for transport - Road fuel prices and taxes TRADE ASPECTS (see below)
Consumption of durable and non-durable goods		
- Household consumption expenditure by type of good - Ownership of selected household commodities - Average length of product life - Paper consumption - Food consumption	WASTE - Generation of household waste - Waste recycling rates NOISE - Population exposed to neighbourhood noise from various sources	ECONOMIC INSTRUMENTS - Tax rates on natural resource use vs. Services TRADE ASPRECTS - Composition of internationally traded goods - Ratio between imported and domestically produced goods in domestic consumption INFORMATION/SOCIAL INSTRUMENTS - Eco-labelled products
Recreation and tourism		
- Trends in international tourism: international tourist receipts - Household consumption expenditure on recreation - Leisure travel	LAND RESOURCES - Land use patterns & conversions in sensitive areas - Land used for recreation - Access to green areas in cities BIODIVERSITY - Protected areas	- to be further developed
Housing related energy and water use		
ENERGY - Total final energy consumption - Residential energy consumption WATER - Household water consumption	AIR - Air emissions from residential energy use WATER - Water abstractions for public supply - Waste water discharges by households - Population connected to waste water treatment plants	ECONOMIC INSTRUMENTS - Household energy prices & taxes - Subsidies for efficient building technologies & practices - Subsides for energy saving devices ECONOMIC INSTRUMENTS - Prices for public water supply - Charges for waste water treatment - Subsides for water saving devices

S: OECD, 1999B.

The indicator set (OECD, 1999B) was evaluated on the basis of three criteria: policy relevance, analytical soundness, and measurability. The list comprises short-term indicators, which are easy to measure since the necessary data is easily available in most OECD countries, and (medium and long-term) indicators which are deemed desirable from a political point of view but which for one reason or another, e.g. methodological problems, or problems of data availability, it has not been possible to compile to date. The indicators must be seen as of a preliminary nature, since continuous attempts are being made to improve their development, the underlying data and the general consistency with other international work in this field (above all, with the UN CSD).

2.2.3.4 Index of Sustainable Economic Welfare (ISEW)

Since the 1970s, GDP has been increasingly criticised as a measure of economic welfare. In order to highlight its inadequacies with respect to environmental and social concerns, and to show that economic growth is not necessarily related to increasing welfare, Herman Daly, John Cobb and Clifford Cobb developed the "Index of Sustainable Economic Welfare"(ISEW), which was first published in 1989. The ISEW is designed to provide the basis for empirical criticism of GDP as a measure of welfare and to act as a counterweight to it in matters of policy decision making, and to present a measure of economic development which is also capable of taking account of environmental sustainability and social equity over time.

In addition to the standard national accounts data, the following aspects are also to be considered when measuring sustainable development (Stockhammer et al., 1997):

- non-market production,
- defensive costs, i.e. those parts of production which are no longer disposable for consumption since they are used to repair damages caused by the economic system or to prevent potential damage being done (e.g. end-of-pipe technology, clean technologies);
- environmental damage (that is not repaired);
- reduction of future welfare as a result of present production and consumption activities;
- the effort required to attain present levels of welfare (e.g. labour duration and intensity);
- questions of income distribution.

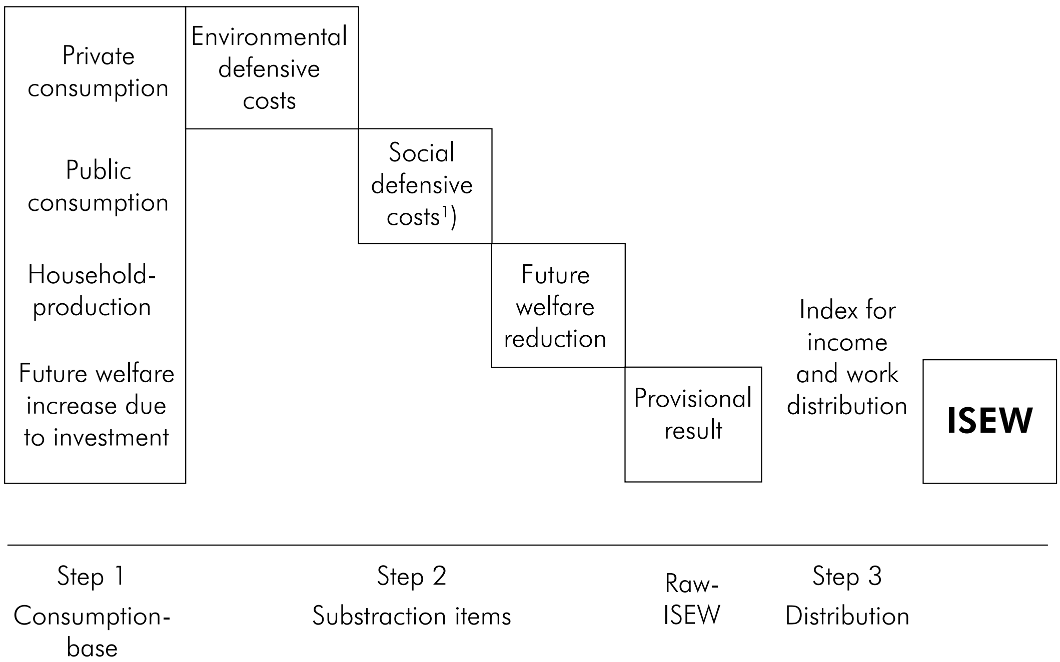
The ISEW is a one-dimensional indicator. As a result of uncertainties and a lack of data , for instance concerning the extent of future welfare loss , it can only provide a rough estimate of the development of sustainable economic welfare. Moreover, discussion of the concept and related methodologies is continually updated, with the result that several different ISEW[25] models have been

[25] For instance, a slightly adapted version, the Genuine Progress Indicator (GPI) developed in 1994 by C. Cobb. Details can be found under http://www.rprogress.org/projects/gpi/.

developed. Practical applications undertaken in several countries (see for instance Guenno – Tiezzi, 1998, on Italian ISEW usage), have always to be based on respective data sets available.

The ISEW is calculated in three steps (see Figure 2.10)[26]:

Figure 2.10: Scheme for ISEW Estimation



¹) "Social defensive costs" include for example cost related to urbanisation, car accidents etc.
S: Stockhammer et al., 1997.

1. Calculation of Consumption Base

This measures the level of possible and/or actual consumption on the basis of current production. Most of the elements needed for this are found in the system of national accounts (SNA). Figures for public consumption are taken over directly, while data on private consumption and investment

[26] Presentation is based on Stockhammer et al. (1997), who estimated the ISEW for Austria for the period 1955 – 1992.

needs to be slightly modified[27]. The value of unpaid housework is the only figure not available from the national accounts and must therefore be estimated.

2. Estimating of subtraction items

In order to calculate sustainable welfare, those economic activities which are necessary for the maintenance of standards and damage repair, but do not contribute to welfare, must be deducted from consumption. These are the so-called defensive costs of environmental and social nature. The monetary value used to record such costs does not correspond directly to the value of the damage incurred (e.g. through pollutant emissions, loss of natural areas, etc.), but represents the reaction of society to such damage (e.g. use of filtering equipment, or the costs of increasing urbanisation, etc.).

Additional deductions from the consumption base include items representing the potential future loss of welfare arising as a result of today's production and consumption activities. This includes, for example, the impacts of the greenhouse effect or of current resource depletion[28].

The subtraction of the above items from the consumption base provides a provisional result, the so-called raw-ISEW.

3. Index weighting of raw-ISEW to account for unequal distribution of labour and income.

Income inequalities are calculated by taking the respective differences in income between employees and employers, women and men, and employed and unemployed, dividing these by average income and then weighting them in terms of their corresponding shares in the population as a whole[29].

The division of labour takes account of the unequal distribution of paid and unpaid work , i.e. the division of wage and household labour among men and women. Large inequality is visible here, particularly with respect to household labour.

The Index of Sustainable Economic Welfare for a country is obtained by multiplying the raw-ISEW with the distribution index. The results for Austria, estimated by Stockhammer et al. (1997), are comparable to those obtained in other industrialised nations (e.g. Guenno – Tiezzi, 1998, Neumayer, 2000). The figures reveal that up to approximately 1970, GDP figures were marginally

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[27] In order to depict actual consumption of durable goods and not mere purchase, expenditure Figures are not used. Instead an annual stream of services estimated at 20% of total value is used (similar to depreciation procedures).

[28] The data used in estimating the costs of climate change was taken from relevant international studies. To estimate the costs of depleting non-renewables, either the value of the resources extracted is taken, or their replacement value. For information and criticism of such methods see Neumayer (2000).

[29] In the original ISEW the basis for estimation is the Gini coefficient for personal income. This was not possible for Austria owing to non-avalability of data.

above ISEW data, and the two data sets more or less moved in parallel. In later years the gap between the two indicators increased. While GDP continues to show an increase, ISEW estimates stagnated between 1980 and 1990.

2.2.3.5 The Ecological Footprint

A further one-dimensional indicator used to measure progress towards or distance from sustainable development is the "ecological footprint", published in Wackernagel – Rees (1996). It represents an attempt to indicate the impact of all consumption and production activities on the environment in the form of a single unit. Resource and energy flows in an economy are translated into the biologically productive area (land and water) necessary for the provision of resources and for the absorption of the waste materials and pollutants produced. The ecological footprint thus expresses the amount of natural capital a society needs in terms of biologically productive area. The size of this area depends on population size, prevailing living standards, technology used, and ecological productivity in the given country. The calculation of the footprint is based on the assumption that it possible to estimate resource use and waste production and to transform such flow estimates into the number of hectares necessary to support the respective tasks, such as the provision of food and fossil fuels, the assimilation of pollutants etc. The data necessary for this is normally available from national statistics offices. It thus becomes possible to compare the ecological footprint with the biological capacity available to a society. Calculations carried out for 52 countries show that most industrialised nations "consume" an area greater than their own size, and thus produce a "national ecological deficit" (Wackernagel et al., 1999).

In calculating the ecological footprint, the consumption of food (this includes wood), of other natural products (tobacco, wool etc.), manufactured (consumption) goods and energy, are all measured (with domestic production figures being corrected for imports and exports), then expressed in terms of area used for their production (arable land, pasture, forest, sea area) and then by means of equivalence factors, which take account of the differences in area productivities, are finally translated into common units[30] (area of average biological productivity). The footprint can then be compared with the area available in order to ascertain how much of the total land area of the country is needed to support production and consumption activities. Table 2.5 presents such comparisons for fourteen European countries.

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[30] A detailed description of the calculation procedure can be found in Wackernagel et al. (1999). Practical examples for Italy can be found under http://www.iclei.org/iclei/efcalcs.htm .

Table 2.5: The Ecological Footprint of 14 European Countries

	Population	Ecological footprint	Available bio-capacity	Ecological deficit (if negative)
	Persons		ha / cap	
Austria	8,053,000	4.1	3.1	-1.0
Belgium	10,174,000	5.0	1.2	-3.8
Denmark	5,194,000	5.9	5.2	-0.7
Finland	5,149,000	6.0	8.6	2.6
France	58,433,000	4.1	4.2	0.1
Germany	81,845,000	5.3	1.9	-3.4
Great Britain	58,587,000	5.2	1.7	-3.5
Greece	10,512,000	4.1	1.5	-2.6
Ireland	3,577,000	5.9	6.5	0.6
Italy	57,247,000	4.2	1.3	-2.9
Netherlands	15,697,000	5.3	1.7	-3.6
Portugal	9,814,000	3.8	2.9	-0.9
Spain	39,729,000	3.8	2.2	-1.6
Sweden	8,862,000	5.9	7.0	1.1

S: Wackernagel et al., 1999.

By comparing human demand for natural resources with available supply, the ecological footprint can be seen as a relatively simple method of expressing the impact of consumption on the environment. Such a comparison is an indication of the ecological sustainability of a society. Despite the wide area of application found for this indicator, work on its development is by no means complete. For example, depiction of human use of natural resources is to be improved in future by incorporating measures to reflect the consumption of drinking water and to calculate the area needed for the absorption of various hazardous materials so far neglected.

2.2.3.6 Dashboard of Sustainability

Developed by the "Consultative Group on Sustainable Development Indicators" (CGSDI)[31], the "dashboard of sustainability" represents a relatively new approach to measuring progress towards sustainability. The basic rules for the concept were established in May 1999 at a Bellagio-Forum meeting. The final version has not yet been complete, but a description of a draft version can be found in Hardi – AtKisson (1999). The dashboard has been conceived that it can function as an

[31] The CGSDI is part of the International Institute for Sustainable Development (ISD).

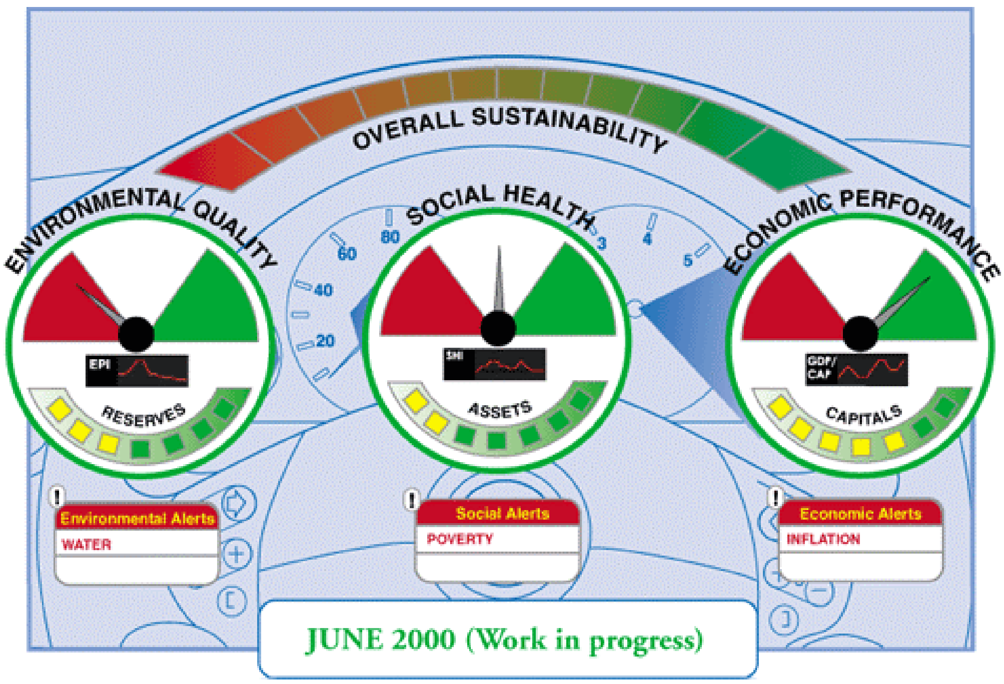
instrument of public information and as the basis for political decision making. Sustainability is presented in the form of three aggregates (environmental, economic and social), each of which is based on a cluster of a maximum of seven indicators. The dashboard shows the levels of crucial stocks and the related flows, which either impact on these stocks or are influenced by them. In addition, problems of a persistent or urgent nature are dealt with separately.

As the name suggests, the indicator has a form similar to a car dashboard, with an indicator display for each of the three aggregates (see Figure 2.11). Each display shows three indicators:

- An indicator needle, to show current system performance,
- A graph, to indicate changes in the performance over time,
- A "gauge", to show the amount of certain critical stocks.

Below each display there is a warning light which serves to indicate potential problems, the surpassing of critical threshold levels etc. This is an important component of the dashboard since it serves to point out problems of an urgent or chronic nature which would otherwise remain unnoticed or hidden in the aggregate data.

Figure 2.11: Dashboard of Sustainability



Q: http://iisd.ca/cgsdi/dashboard.htm.

The indicators upon which the aggregates are based were selected according to the following criteria: methodological soundness, policy relevance, simplicity, wide acceptance, data availability and consistency with indicators in other international initiatives.

The state of the environment and its development is represented by the Environmental Quality Index (EQ) which is an aggregate figure derived from seven pressure indicators. These indicators are based on the EU pressure – index program, the UN CSD indicator-set and the "Environmental Performance Indicators" used in the Netherlands[32]. Actual pressures observed are greenhouse gas emissions, water and air quality, dispersion of toxic substances, soil degradation, waste disposal and urban sprawl. The "Living Planet Index" (LPI) of the WWF is used to show resource reserves. This index is an aggregate measure for stocks of renewable resources (e.g. forest stock, species, etc.). Non-renewable resources are not included in this index as they are considered to be part of economic capital.

Economic performance is represented by gross GDP growth rate and the change of GDP per capita over time, complemented by six indicators: total material throughput, per capital energy consumption, international trade (the sum of imports and exports as a percentage of GDP), the ratio of debt service to export earnings, labour productivity and inflation. Reserves, in this case capital, are represented by the World Bank indicator "Produced Assets plus Sub-Soil Assets".

The social dimension of sustainability is shown by the Social Health Index (SHI). The SHI is a performance indicator made up of seven factors: population growth, unemployment, poverty gap index, crime rate, housing affordability, child nutrition status and democratic participation. The reserves in the environmental quality display, and the assets in the social health display are combined in the "Human Well-Being Index" (HWI). The HWI is based on the same data as the "Human Development Index" used by the UN, excluding those components connected to the GDP figures since these are included elsewhere in the dashboard.

2.2.3.7 Significance of Private Consumption in Indicator Systems

Private consumption is one of the main determinants of sustainable development. It determines the composition as well as the extent of production and therefore also the demand for natural resources. Attaining a clear assessment of private consumption or its development is no simple matter. On the one hand, increasing consumption leads to greater use of resources, creates more waste and induces more traffic etc., but on the other hand, increased consumption can also lead to greater demands for greener products and an intact environment. In order to assess whether a particular development path is sustainable or not, it is therefore important to take account of the diverse economic, environmental and social impacts of private consumption.

[32] More information on this approach can be found in Adriaanse (1993).

Within the indicator systems so far presented, the significance given to private consumption tends to vary. In the OECD framework on the development of sectoral indicators, private consumption occupies a central role. It is also a basic starting point in the ISEW and "ecological footprint" research. In the other approaches (UN CSD, Eurostat, Dashboard), the area of consumption remains more in the background, and greater attention is paid to its specific impacts expressed in the form of environmental pressures (e.g. private car transport, energy and water use per capita, etc.). Nevertheless, the key role of consumption in the attainment of sustainable development is still well recognised here, as is evident from the ongoing work on indicator improvement. One example in this respect, is the co-operation between the UN CSD and the OECD on the completion of indicators to represent changing patterns of consumption.

2.3 The Construction of Economic- Ecological Models

The environmental information systems described in the preceding pages provide the "accounting framework" for a descriptive analysis of economic-ecological interactions. It now remains to be shown, to what extent the results of such descriptive analysis are taken account of in the construction of economic-ecological models. No attempt is made, however, to provide a complete overview of all such models.

Research on the concept of sustainability, understood in a broad sense, tends to range over a very wide area and to deal with paradigms of a rather disparate nature. Examples of this are given in Gijsel – Gerlach – Glombowski (1997). Van den Bergh (1996) classifies the different approaches in terms of various schools or "perspectives", supplying comprehensive bibliographies for each. On the basis of his classification he ends up with the following 12 perspectives:

- Equilibrium – neoclassical
- Neo-Austrian – temporal
- Ecological – evolutionary
- Evolutionary – technological
- Physico – economic
- Biophysical – energy
- Systems ecological
- Ecological – engineering
- Human ecological
- Socio biological
- Historical – institutional
- Ethical – utopian

Assuming that this classification if found to be acceptable, then in terms of the present study, it can be stated that the various perspectives are sometimes more and sometimes less appropriate in depicting economic-ecological interactions. Present discussion in the literature varies for example on the extent to which the approaches based on relating economic-ecological interactions with physical databases (material balances, material flows etc.) might contradict traditional neo-classical environmental economics or might in fact complement it (see Hinterberger – Luks – Stewen, 1999; van den Bergh, 1996). Several perspectives do present extensions in the form of input-output and general equilibrium models. The basic idea is that traditional input-output and general equilibrium models adopt a rather limited perspective, which needs to be broadened by factoring in economic-ecological interactions. The first step in this direction involves extending input-output and general equilibrium models by the inclusion of material balance equations and energy flows. This was first done theoretically by Ayres – Kneese (1969), and illustrative empirical examples for Austria were later provided by Katterl – Kratena (1990). The pure input-output model or the extended version of a general equilibrium model are of central importance in such an approach, which involves extending the basic economic model to account for ecological factors such as food chains, material balances and natural energy flows (see Hannon, 1995). Such extensions of the original equilibrium approach, involve changing the mathematical functions used to describe agent behaviour.

The "neo-Austrian – temporal", "ecological – evolutionary" and the "evolutionary – technological" perspectives all deal with very specific aspects, but by focussing heavily on either economic or ecological concerns they largely fail to represent system interactions. Similarly, the "human ecological", "socio-biological", and "historical-institutional" approaches lend themselves well to the analysis of specific areas of sustainability, but they tend to hide economic-ecological interactions, as they are understood here.

The remaining perspectives, "physico – economic", "biophysical – energy" and "systems ecological", are therefore of particular interest. With the term "physico – economic", van den Bergh (1996) is referring to an economic model in which the two laws of thermodynamics are integrated. Using physical units, the model depicts material balances and energy flows which are linked to the economic system ("industrial metabolism"). In order that clear statements can be made with this approach, the crucial point to remember is that certain basic concepts in thermodynamics (equilibrium) cannot be unambiguously transferred to economic processes. Most ecosystems, and their adjoining economic systems, are not closed in a thermodynamic sense. They are open systems, and this means that from the perspective of sustainability defining the limits of economic activity is by no means unproblematic. As is shown by van den Bergh (1996) with reference to the work of Prigogine, a certain amount of progress has been made possible in this respect with the development of "disequilibrium thermodynamics".

The limit to economic and ecological activity in the "biophysical – energy" approach is given by the availability of high grade energy. Once again, use is made here of the second law of thermodynamics. To a certain extent, energy also functions as a form of currency for measuring ecological processes. Some authors in this area employ "system-dynamics" models in order to present energy flow paths. Other authors concentrate on an "energy theory of value". Here, all direct and indirect energy inputs in the economic and ecological systems are recorded in an input-output model. By using energy as a common unit of account, transactions in ecological and economic systems become directly comparable. In some cases, a complete mapping of ecological systems in terms of economic input-output analysis has been suggested and even theoretically derived (see Hannon – Costanza – Herendeen, 1986). So far, not much attention in the literature has been paid to this seemingly strange notion of deriving "ecological prices". Much more attention has been concentrated on establishing the extent to which it is possible to devise a complete and consistent energy theory of value, and here, as in the Marxist labour theory of value, this is largely a question of establishing the value of capital. Van den Bergh (1996) refers to some pure ecological studies when describing this approach (e.g. Odum, 1983), and does not confine himself to work in the field of energy economics.

As is to be expected, ecological modelling also occupies a central position in the "systems ecological" perspective. This approach depicts the impact of economic activity on ecological processes (e.g. the effect of pollutant concentration levels in air and soil, eutrophication of water systems, etc.). This facilitates the formation of ecological stress indicators which can be directly linked to the corresponding economic forces upon which they are based. A very promising approach in this respect, which according to van den Bergh is still only infrequently found in the literature, is that of integrated economic-ecological models, which are capable of describing both ecological and economic components to some considerable extent. The major difficulty here lies in sufficiently reducing complexity so that the model becomes operational, while at the same time ensuring that all the necessary variables are still taken into account when examining specific problem areas. Van den Bergh (1996) contains several examples of such models, including modelling of sustainable forest use in the Netherlands, a regional model depicting interactions between nature and agriculture, and a model to evaluate development strategies on the Sporades, a group of Greek islands. All these approaches appear promising in that they open up possible paths for operationalising the concept of sustainability in the construction of economic models. In addition, they also reveal the essential multi-dimensional nature of the problem. Even for models applied on a relatively small, local scale which capture only a subsection of the total ecosystem, manifold interdependencies and interactions immediately arise and these all need to be dealt with.

The examples of integrated ecological-economic models given here show further that the significance of sustainability can by no means be reduced to technical description alone. Of rather more significance are the social and political interactions which arise, e.g. as seen in the traditional policy approach where social welfare functions may come into play. Were political economy to be understood in terms less restrictive than those currently in use, conflicts of interest with respect to the economic-ecological system could be dealt with by employing various weighting criteria. Be that as it may, there are always political processes which massively impinge on the operationalisation of sustainability, thus making technical reductionism completely impractical.

We now turn to a few new, concrete examples involving different levels of sustainability modelling. These illustrate the value of the "physico – economic", "biophysical – energy", and "systems ecological" approaches in the case of Austria. The examples have been chosen to illustrate how different levels of requirements can be catered for in the modelling process.

2.3.1 Integrating Environmental National Accounting into Models

The first step in the incorporation of economic-ecological interactions involves adding the information from the environmental satellite accounts to the normal data set of the model. This can be done in the form of macro-models, input-output models or general equilibrium models.

In principle, all economic models dealing with emission reduction policies act as a link to the ecosystem. In most models, e.g. those depicting energy and CO_2 emissions (where for instance emission reduction policies are simulated by means of energy and carbon taxes, or CO_2 emission permits), the emission side of the model is simply appended but left open ended. This means that no feedback effects are present, and sustainability is introduced into the model via predetermined political objectives. In the E3ME model (a disaggregated, multi-regional macroeconomic model for the EU), the possibility of capturing feedback via environmental damage costs and sustainability indicators has been built into the model but not yet implemented.

A relatively recent example of a more advanced approach is the work by Meyer – Bockermann – Ewerhart (1998). Here, a multi-sectoral macro-model of the German economy (the German INFORUM-Model INFORGE), is extended by adding data from the NAMEA of the German statistical office. The resulting model, "PANTA RHEI", focuses on an analysis of physical flows of energy and air emissions. Not only physical data are tied to the model. Data on environmental protection expenditure is also integrated. In other words, the model incorporates the latest data on empirical applications of green national accounting in Germany. However, this simultaneously represents the limitation of the approach. In those areas where environmental national accounting data is missing, essentially data related to the Eurostat SERIEE concept, the model is incapable of establishing the necessary linkages. Nevertheless, the model is still helpful in carrying out analyses on the impact of policies aiming at air pollution reduction.

One significant disadvantage of the model is the fact that it lacks explanatory power concerning emissions which cannot be reduced by "end-of-pipe" technologies.

With regard to the link between economy and ecology, the "PANTA RHEI" model is in principle applicable to Austria, since the requisite data sets, i.e. information on environmental expenditure and a "NAMEA – air" are both available. What is more likely to represent a problem in Austria, is application of the economic side of the model. Several attempts have been made at WIFO to construct a more elaborate multi-sectoral model. Certain approaches to energy modelling also exist (Kratena, 1999). However, as a result of insufficient resources, the construction of a fully consistent, multi-sectoral model with an energy/emissions component must be left to future research.

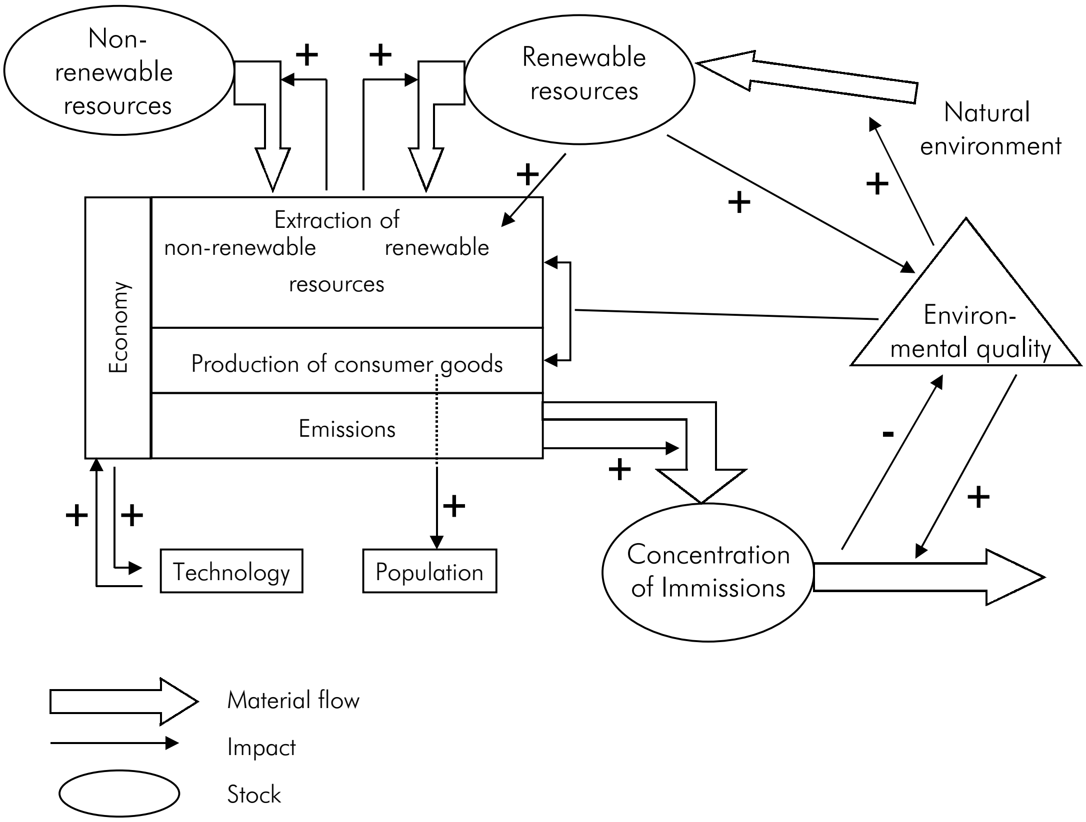
A conceptually more advanced approach for integrating environmental national accounts in economic models is found in Atkinson et al. (1997). Using a UNO SEEA scheme a formal system of macro-economic behavioural/definitional equations is derived. Such a system can be considered a starting point in integrating environmental national accounts into a macro-economic model. The focus here is on deriving welfare indicators for a variety of environmental problems (living systems, non-renewable resources, emissions with end-of-pipe technologies, and emissions without end-of-pipe technologies). Atkinson et al. (1997) provide further examples of practical application of the approach in different countries and also derive values for indicators. One possible means of advance, as far as improving the economic-ecological modelling character of this approach is concerned, might be to integrate the formal derivation of welfare indicators into an empirical macro-economic model.

2.3.2 Integrating Sustainability into Economic Models

The second stage of modelling sustainability via economic-ecological interactions entails including concepts of ecological sustainability directly in theoretical formulation of the model. The focus here is then on the integration of concepts such as carrying capacity of ecosystems, material balances, and service functions of ecosystems in production and consumption. A second important point of focus is the theoretical and empirical integration of sustainability indicators into models. This provides a mechanism for integrating "sustainable development feedback" between the political sphere and the natural environment.

Examples for both approaches are to be found in van den Bergh (1996). In chapter six he presents a physical growth model employing six different production sectors (consumption goods, investment goods, use of renewable resources, use of non-renewable resources, recycling, and disposal). Two crucial characteristics of the model are used to express the concept of sustainability: (i) full capture of all material flows in the economy while simultaneously taking account of any changes in stock levels in the economic and ecological system (pollutant concentrations), and (ii) the impact of all flows on the state of the environment and the respective feedback effects on the economy.

Figure 2.12: Ecological-Economic Interactions in a Physical Growth Model



S: van den Bergh, 1996.

Materials balance equations and functions describing the state of the natural environment are incorporated at all levels of the model. The basic structure of the model is based on the supply-side of a two-sector growth model (consumption, investment) and uses explicit modelling of technical progress. This is modelled on the economic side by being made dependent on the speed of embodied technical change, public expenditure on research and development and on a Kaldor / Verdoorn mechanism[33].

For example, by introducing sustainability into economic activity we arrive at the following production function for the consumption goods sector:

[33] Here the rate of productivity growth itself is dependent on output growth as a result of scale economies and learning by doing.

(2.1) $Q = MIN \{F_Q (K_Q, E) R_{sup} / c_Q (T_{rd})\}$

Q output of consumption goods

K_Q capital stock for the production of consumption goods q

E environmental quality

R_{sup} resource stocks (upper production limit)

T_{rd} technological state of the art

c_Q resource input per unit of output (in physical terms); $c_Q (T_{rd}) > 1$.

For a given level of capital stock there is thus a positive feedback effect from the environment to the production process, and production is limited to that level possible with the resources available. The influence of the second law of thermodynamics is recognised in the term for resource efficiency since this shows that more resources are used than the amount of physical output produced ($c_Q (T_{rd}) > 1$). This relationship varies according to the given state of technology, which itself is subject to change as a result of environmental feedback (a "sustainable environmental feedback" mechanism).

With respect to integrating sustainability, the heart of the model is represented by the block of equations (2.2). This serves to explain the following basic characteristics of an ecological system: regeneration, emission uptake, ability to act as a source of production inputs, sink capacity for waste, and provision of services relating to private consumption processes. In a fashion similar to that shown above in the production of consumer goods, feedback loops are also included for each area of economic activity. In this way, it becomes possible to represent environmental quality as a function of the three properties, i.e. N (natural resources), P (pollution assimilation) and B (state of the environment). Own stock levels and level of environmental quality serve as explanatory variables for all these dynamic processes. In addition, minimum levels, i.e. levels representing no anthropogenic impacts (G and –A), are also accounted for in the equations. N is a declining function of renewable resource extraction, R_N, and P is an increasing function of emissions W_{em} . The state of the environment, B, contains various environmental stress factors, i.e. population growth, (Pop), capital accumulation, (K), and the rate of extraction of renewable (R_N)and non-renewable resources, (R_S):

(2.2) $E = H (N, P, B)$

$dN/dt = G (N, E) - R_N$

$dP/dt = -A (P, E) + W_{em}$

$dB/dt = [b_1(E) - b_2(dK/dt) - b_3(dPop/dt) - b_4(R_N) - b_5(R_S)] * B$

The materials balance identities serve to close the model and to derive waste emissions levels as the difference between total waste produced and waste recycled or disposed of. The level of resource extraction from the natural environment is given by a materials balance equation.

Feedback from the sustainable development processes to the economic system is contained within the indicators, since it is here that the maximum allowable levels of resource extraction (renewable and non-renewable) and the maximum allowable emission quantities are defined. This is achieved by setting the determinants of environmental quality, N, P and B described above, in relation to their own determining factors R_N; R_S; and W_{em} . Processes may arrive at a minimum position such that no influence on environmental quality exists. In such a position, the respective indicator takes a value of 1, with this value approaching 0 as the impact on the natural environment increases. To ensure that the system remains well-defined, once the maximum allowable level of extraction is reached it is necessary to introduce a price index mechanism. This contains an implicit discount rate and functions, as van den Bergh puts it, as a measure of "ethical concern", with respect to future generations.

The target function for the indicators derives from the various definitions of sustainability. Here, van den Bergh (1996) posits two conditions for the attainment of sustainability, i.e. a basic minimum subsistence level of welfare must be achieved, and the level of welfare must also be maintained.

The model was calibrated using realistic parameter values and solved for different scenarios over a 25-period time frame where it was assumed that in the long-term the economy would be facing enormous environmental problems. The baseline scenario describes an initial starting position which combines high environmental quality and ethical concern for future generations with high levels of capital stocks. This makes it possible to maintain the initial level of welfare over the long-term. The other eight scenarios vary the initial levels of ethical concern and initial stock levels. The most important result appears to be the negative impact of declining environmental quality on the level of consumption goods, i.e. environmental problems may impose constraints on the level of consumption over the long-term. To some extent this is a result of reallocation of capital from consumption to investment in the waste disposal and recycling sector. Other feedback effects arise between environmental quality and technical progress. It was found for example, that the scenario generating the highest level of technological growth had as an initial starting position, a high level of ethical concern for future generations and a low level of environmental quality.

As van den Bergh (1996) himself concedes, although the model does not allow for the making of realistic forecasts with respect to future paths of development, it does indicate in a consistent manner the workings of the manifold economic-environment interrelationships arising directly out of the given objectives and definitions with respect to sustainability. The model can thus be understood as a general source of support, whose basic approach can be adapted to meet specific needs, and may still therefore prove valuable in operationalising the concept of sustainability. In its most general form, the model is not suited to empirical application owing to its complexity and size, and also owing to problems of data availability. Van den Bergh therefore calls for the use of smaller, partial models.

In chapter 7 of his book, van den Bergh (1996) presents a partial equilibrium model dealing with the empirical study of cadmium cycles. All relevant material flows were built into the model. In addition, a direct connection between material flows and the state of the ecological system and sustainability is established. This is done by means of a sustainability indicator derived directly on the basis of pollution accumulation level in the environment, which is itself an endogenous variable in the material balance equation. Based on the studies available, Van den Bergh (1996) builds on work on a dynamic material flow model for cadmium in the Netherlands. As in the Austrian material flow accounts, this model includes international trade, domestic resources and those sectors and products in which cadmium is employed. A further section of the material flow account is given over to the representation of flows from the economic system into the "waste/emissions" system, and another section depicts flows into the natural environment. In total, three large accounts are used to illustrate cadmium flows. In drawing up these accounts, van den Bergh (1996) is also able to show once again the inadequacies in existing data. Data were available for two base years (1980, 1985), and exhibited, in some areas, considerable differences in input and output information. The accounting system itself is not a model, since it merely serves to portray the identities given by the material balance. Nonetheless, it still represents an important advance on traditional national accounts in that it captures stock variables. Stock balances can thus be derived by examining flow data. The stock-flow relationship for the material flow can be given by:

(2.3) $$I_e + I_w + I_n = \Sigma \Delta E_i + \Sigma \Delta W_j + \Sigma \Delta N_k$$

with

I net additions of cadmium, with subscripts e, w, and n, representing the economic, the waste/emissions, and the natural environment systems respectively.

ΔE_i , ΔW_j , ΔN_k net change in the stock of cadmium in the system (the economic, waste/emissions, and natural environment systems

One further possible extension of the above, might be the formulation of a related input-output model which could then in turn act as a framework for the development of a dynamic model, e.g. a multi-sectoral macro-model.

Although the model merely reflects a series of identities, by deriving sustainability indicators from material flows, van den Bergh (1996) still succeeds in establishing a basic link to the concept of sustainability. There is no reason, at least in principle, why it should not prove possible to develop practical sustainability indicators: e.g. cadmium intensity indicators to show the impact of specific economic processes, cadmium response indicators (related perhaps to the effectiveness of available cadmium collection systems), cadmium pressure indicators to monitor levels of cadmium emissions in various environmental media, and cadmium impact indicators to check on accumulation of cadmium across the environment. Once more, as van den Bergh (1996) shows, it becomes clear that the development of sustainability indicators and the operationalisation of sustainability itself are only possible when technical data are linked to political objectives. The ministry for the environment in the Netherlands defines and regulates the nature of sustainable cadmium use explicitly. For instance:

(i) cadmium flows into the soil have to be compensated by cadmium removal or losses, so that net accumulation in the soil does not occur,

(ii) the measurable cadmium concentration in the soil should be lower than the commonly used standard of 0.8 mg cadmium per kilo dry weight of soil.

The first, relatively weak condition for sustainability, was complemented by the second condition in order to give more weight to the state of the natural environment. In the light of both these criteria, van den Bergh (1996) succeeds in deriving two sustainability indicators which provide a direct link to material flow accounts. The indicator corresponding to the first condition takes the form:

(2.1) $ND_t = -(A_t - L_t)$

This describes the net deficit of cadmium, ND_t , in tonnes per year (t). It represents the difference between material removal or losses, L_t , and the total additions to the soil stemming from economic and waste/emission systems, A_t . A positive value for this indicator implies that, in terms of the first criterion, the sustainability target has been exceeded.

The second sustainability criterion with respect to the accumulation of cadmium, the "soil quality index" (SQI), is expressed thus:

(2.5) $SQI = (S_t / S_{st} - 1)$

S_t represents the actual stock of cadmium present in the soil in mg/kg, and S_{st} is the standard of 0.8 mg cadmium per kg dry soil. This index thus incorporates a measure of environmental quality. Where sustainability in terms of the second criterion is attained, the index has a value of 0, for conditions of non-sustainability, the index has a positive value.

Van den Bergh (1996) also describes the historical development of both indicators from material flow accounts for 1980 and 1985. Both are developed from material flow account data. Their use of stock-flow relationships is regarded as being of particular significance.

3. Sustainability in Private Consumption – the Search for New Concepts

The debate and analysis on the environmental impact of private consumption have led to an increase in related research activity in recent years. Common to much of this research work is the problem of how to organise social and economic developments in such a way that negative impact on the environment is reduced.

One manifestation of the focus on private consumption patterns is given by the numerous theoretical approaches now available for an analysis of the interactions between consumption and environment. A further manifestation lies in the ongoing international and national initiatives aiming at an analysis of consumption trends and the derivation of policy recommendations for a basic reorientation in consumption behaviour towards greater sustainability.

In Agenda 21, both existing consumption patterns as well as growth in the level of consumption itself, are taken to be central causes of environmental damage. It is the responsibility of the industrialised countries to counteract these damaging patterns and to design and implement policies which are capable of pushing given consumption patterns in the direction of sustainable development. Agenda 21 deals explicitly with the negative environmental impact of consumption activity. In the years prior to this, the production sector[34] was taken to be the main culprit as far as environmental damage was concerned. To a certain extent there has thus been an increased demand for an extension of environmental policies so as to cover demand based approaches and not merely limit the focus to the more traditional supply side concepts.

Before prevailing consumption behaviour and life styles can be changed, however, it is essential to obtain a thorough understanding of both the motives and incentives underlying increasing consumption activity as well as of the ensuing environmental impact. The following section describes how the theme of sustainable consumption structures is dealt with in the literature (covering theoretical as well as empirical research).

The first section provides a summary of the relevant theories and methods employed. The second section offers an overview of national and international initiatives aiming at a reorientation of individual consumption behaviour.

- The research activities and concepts described here are to be seen as initial steps in an analysis of sustainable patterns of private consumption. More with a view to highlighting potential areas of research than intending to imply criticism, we mention the following points which have not received sufficient attention so far:

[34] Interactions between the supply side and demand side are analysed in Jolivet – Haake (2001).

- Definition and delineation of the term "sustainable consumption". In most of the research in this area it is assumed that prevailing consumption and life styles are not sustainable, but exact specification of what sustainable consumption means is waived.

- Consumption can not be seen in isolation from production. This idea is touched on briefly in a number of papers, but not systematically analysed. Of central importance here is the need to focus on services and utility that are incorporated in products[35]. This aspect receives a great deal of attention in the present study, in terms of both model design and empirical analysis.

- Multi-disciplinarity – The inclusion of various disciplines such as sociology, psychology or anthropology in the analysis would enrich understanding of consumer behaviour[36]. The development of a coherent theory has thus not yet been attained.

- Incentive based policies have been called into question in some papers since they are geared to the assumption of rational consumer behaviour. From our point of view, the question in need of explanation is: how do incentive based environmental policies have to be formulated, in the face of the rising significance of other explanatory approaches to consumption?

3.1 Concepts and Perspectives for Sustainable Consumption Structures

As can be gleaned from a glimpse of recent articles published in the journal "Ecological Economics", there is a great variety of concepts and approaches currently employed in the field of sustainable consumption. The primary focus is on the sociological and psychological explanations of consumer behaviour. The common themes covered include:

a) environmental effects of private consumption

b) basic motives underlying private consumption

c) relationship between consumption and quality of life

d) possible starting points in changing consumer behaviour

e) criticism and extension of the concept of a utility maximising consumer.

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[35] In the past decade the main focus was on improving product design in order to make goods more environmentally friendly (eco-design). It has increasingly been recognised, however, that in order to attain sustainable consumption patterns, greater emphasis needs to be placed on eco-efficient services and product service systems. See Brezet et al. (2001) and Mont (2001).

[36] The conference series produced by the research team "Consumption, Everyday Life and Sustainability" adopts an inderdisciplinary approach aiming at furthering understanding of consumption patterns. This is part of a programme on "Tackling Environmental Resource Management", financed by the European Science Foundation. Information and papers can be found under http://www.comp.lancs.ac.uk/sociology/esf/.

In the following survey, questions relating to the above points are dealt with under three headings:

1) criticism and extension of the concept "homo economicus" (d, e)
2) consumer motives (b, c)
3) modelling consumption behaviour in ecological–economic models (a, d)

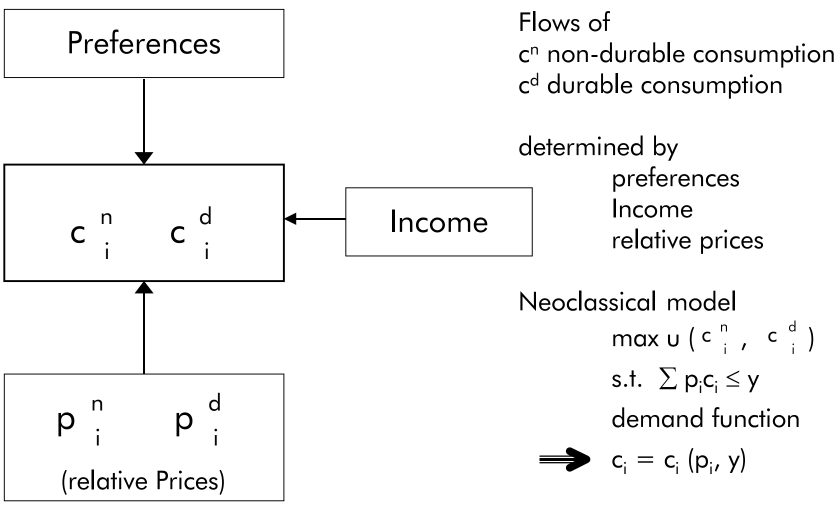
The above classification is not to be taken as a rigid demarcation of research areas since overlap occurs in many fields, particularly with respect to (1) and (2). It does allow, however, for greater clarity of focus.

3.1.1 Criticism and Extension of the Concept Homo Economicus

Several studies on sustainable consumption have criticised the neoclassical concept of homo economicus as being too restrictive for a proper explanation of consumption behaviour. The authors of such studies call for a more interdisciplinary approach and welcome the incorporation of sociological and psychological research.

Figure 3.1 provides a schematic of the neoclassical model of consumption. The central point of neoclassical theory is given by a representative utility maximising consumer. One of the advantages of modelling representative consumer behaviour on the micro level is that results then lend themselves to aggregation. However, the assumption of identical preferences means that differences in individual consumer behaviour can not be depicted, and that the constraints at the level of the individual consumer are carried over to the aggregate level.

Figure 3.1: Neoclassical derivation of consumption



Siebenhüner (2000) has suggested the concept of "homo sustinens" as an alternative to the modelling of representative consumers[37], since this would place the individual firmly in a social context.

Siebenhüner (2000) sees the assumptions underlying utility maximising consumption behaviour as constraining factors in analysis, i.e. the assumptions of:

- Rational behaviour
- Self-interested behaviour
- Methodological individualism

While the focus on a representative consumer does tend to be rather limiting when analysing differences in consumption patterns, several of the other points of criticism need to be further qualified. Even when aspects such as altruistic behaviour or environmental motives are missing, as is normally the case when use is made of the concept of utility, in principle the concept of homo economicus still allows for the inclusion of such characteristics in the mapping of tastes and in utility functions[38].

Sen, in particular, has long been a critic of the assumption of rational consumers, interested only in maximising their own welfare[39]. He emphasises instead the existence of altruistic (and environmental) tastes, which influence individual decision making within a social context and which are significant for the attainment of an overall social optimum. He also sees values, norms and basic principles playing an important role: first, in that they influence the process of taste formation, and second, in that they lead to the rejection of certain patterns of behaviour – even when they might be beneficial for the individual – as they are considered to be socially unacceptable.

In the economic theory of consumption, the problems stemming from the focus on a representative consumer are overcome to some extent by distinguishing between specific groups of consumers exhibiting different forms of consumption or social behaviour etc. The acquisition of data on consumption patterns of individuals or individual households and the definition of specific lifestyles is an approach propagated by Duchin (see Duchin, 1998). Employing the term "structural economics", she envisages an extension of input-output analysis which includes more detailed depiction and integration of the household and environmental sectors. By incorporating the various lifestyles into the input-output structure, it becomes possible to investigate what economic and environmental

[37] An overview of developments in consumer theory which attempt to overcome the narrowness of neoclassical approaches can be found in Roth (1998).

[38] On this point see Robin (1998). Robin discusses the relevance of findings from behavioural research for economic decision making.

[39] On this see Sen (1973) and Sen (1985).

effects might arise from lifestyle changes. Duchin considers this to be analogous to the cross-sectoral impacts resulting from changes in technology in production processes.

According to Siebenhüner the consumption behaviour of homo sustinens is oriented towards complying with the requirements of sustainable development, i.e. the connection between man and nature is essential in influencing behaviour. However, what the exact characteristics of a sustainable lifestyle are, remains an open question. The core making up the concept of homo sustinens is based on a bundle of theoretical principles drawn from a diverse number of disciplines such as evolutionary biology, neurobiology and psychology. Homo sustinens is characterised by social and emotional skills and attitudes and by nature-related behaviour.

The interdisciplinary nature of the research results employed in devising a concept of sustainable consumption behaviour indicates the complexity involved in the factors influencing individual and social behaviour. The paper by Siebenhüner outlines the characteristics of homo sustinens. The type of institutional arrangements, policies and general conditions that such characteristics would require is not analysed.

As in Siebenhüner (2000), van den Bergh et al. (2000) also adopt a critical stance with respect to the neoclassical, utility or profit-maximising individual. Van den Bergh et al. (2000) provide an overview of explanatory models of consumer behaviour and preference formation which move beyond the economic theory of utility. Included in such approaches, which either conflict with or complement the neoclassical model, is the concept of bounded rationality developed by Simon (1957). The core premise in the model of bounded rationality is that the ability of people to solve complex problems is limited. This cognitive limitation, together with the diverse nature of problems that people are confronted with, rules out the possibility of objective rational choice.

An alternative to utility maximisation is a behavioural model based on the concept of "satisficing". This term refers to situations where agents strive to attain a satisfactory level of welfare while still complying with certain cost or efficiency constraints. Transaction costs and the effort involved in necessary information gathering play a decisive role in deciding where such a satisfactory level of welfare might be.

One further approach questions the appropriateness of accepting the substitutability of consumption goods and assumes that individual needs are ordered hierarchically. It is assumed here that needs occupying a higher level of the hierarchy only become effective when lower level needs have been satisfied and not before. This rules out the possibility of substitution. Lexicographic and Leontief preferences are used to model such situations of non-substitutability among certain needs and goods.

Further approaches focus on problems of uncertainty and risk which may prevail at the time of consumer decision making. Such situations are analysed by means of the concept of expected utility.

Other models see the determining factors underlying consumer choice to be habits or differential evaluation of expected losses and returns (losses are valued more highly[40]).

Based on the various models of consumer behaviour which move beyond the neoclassical approach, van den Bergh et al. (2000) derive the possible consequences for economic policy formation. While in traditional environmental economics priority is clearly given to incentive based policies such as taxes and emission trading, based on the behavioural models of consumption van den Bergh et al. reach different conclusions. They argue that the rejection of utility maximisation as a guiding principle in explaining consumer behaviour implies radically different policy recommendations. In particular, they doubt the effectiveness of policies based on achieving behavioural change through induced changes in relative prices.

Once the calculus of utility maximisation is replaced by the assumption of a lexicographic preference order or by habit-based behaviour, policies focussing on information, education, social and behavioural analysis, and analysis of preference formation become much more significant.

3.1.2 Consumer Motives

Closely related to the above discussion of behavioural models, is the question of the underlying motives leading to the growth in consumption levels and thus the question of which policies might be appropriate in inducing change.

Røpke (1999) adopted a rather broad approach in explaining consumption patterns and the development of consumer behaviour. The starting point for the analysis centred on the following questions:

- Why are gains from increased productivity passed on in the form of an increase in income instead of an increase in leisure?
- Why are increases in income used to demand products and services[41] which are material-intensive and not used for alternatives which are less material-intensive?

Røpke classifies explanations in terms of the following three categories:

- Economic explanations – focussing on the macro level
- Socio-psychological explanations – the social context is the focus of attention here
- Historical and socio-technical explanations – an analysis of various aspects of everyday life

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[40] See Rabin (1998).

[41] In Røpke (2001B) the role played by services in sustainable consumption is analysed.

Røpke identifies the economic driving forces as: increased productivity as a result of economic competition, and the stimulation of new consumer needs through the increase in product variety and the impact of advertising.

The fact that the gains from increased productivity are passed on in the form of wage increases instead of an increase in free time[42] is seen by Røpke to be the result of prevailing institutional arrangements in the labour market. An example of such institutional constraints is seen in the increasing importance of time-independent components in labour costs that has occurred over the course of time. Similarly, for reasons of capital efficiency, productivity gains are also likely to be passed on to workers in the form of wage increases rather than increased time off. Further, increases in income are a major force in stimulating consumption demand. That such demand is primarily expressed in the form of demand for material-intensive goods results from the prevailing structure of relative prices whereby cheaper mass-produced goods are preferred to more expensive labour intensive goods and services.

Socio-psychological explanations emphasise that consumption processes and behaviour are determined by social relationships. Here, Røpke draws on an analysis of social structure developed by Douglas – Isherwood (1980) who assumed that:

1) societies may vary considerably, but they always have some form of hierarchical structure. Within a society there are different classes and groups. Consumption behaviour is important in determining group formation and a sense of belonging[43].

2) social relations depend on a form of consensus attaining legitimacy for (at least) a certain minimum period of time.

Consumption is an important factor in society, since apart from satisfaction of needs, goods and services perform an additional significant function in that they act as information providers and thus help determine the relative status of individuals within a society. Consumption processes occur within a social context[44]. They change over time and lead to redefinition of social and cultural structures.

For any one individual, increased consumption is obviously meaningful since it contributes to greater acceptance and participation within social processes. Since within a hierarchically structured

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[42] The implications of time allocation for the use of environmental resources is described in Cogoy (1999). Cogoy emphasises the importance of human skills and human capital in structuring the allocation of time and in the organisation of consumption.

[43] Consumption patterns, for example, relating to lighting or heating, can vary considerably across cultures (see Wilhite et al., 1996). Nevertheless, the desire to demonstrate status or group membership through the possession of certain goods is an important factor in all industrialised countries

[44] On the social importance of consumption and its determinants see Wilhite – Lutzenhiser (1997) and Shove – Warde (1997).

society a person's social position is (more or less) defined via consumption, greater individual consumption in such a setting implies more enjoyment and quality of life.

In the socio-psychological approach the growth in consumption demand also derives from the trend towards greater individuality. First, in a society in which traditional social roles are losing their significance, and in which individuals find it ever easier to move between different groups and lifestyles[45], there is a greater need for processes which help define individual identity. Second, the increased focus on the needs of the individual has direct implications for consumption demand, since it results in, for instance, increased demand for flats with the requisite fixtures and fittings.

The third category identified by Røpke comprises historical and socio-technical motives. Increased consumption is associated with the desire to leave behind the confinement and restrictions imposed by historical circumstances. Consumption activities are regarded as a suitable means of escape. In this respect, the acquisition of more living space (house construction) plays a central role in consumption, as it allows people to break free from confined or unhealthy living arrangements. Consumption is closely connected with the desire for and realisation of an increase in the quality of life. The striving for more quality is also reflected in the acquisition of household labour saving machinery. Empirical research has shown, however, that ultimately such acquisitions do not lead to any (significant) reduction in housework, since new devices and equipment are accompanied by new demands, standards and desires.

Social standards and prevailing technical arrangements exert a mutual impact on each other, and they both influence consumption behaviour and are influenced by it. Individual consumer choice is therefore limited by the impact of socio-technical conditions on daily life[46]. For example, social habits, infrastructural arrangements etc. have largely transformed the car into a necessity. Examples of further structural arrangements which influence the formation of daily life and consumption activity and which act as a basis for an increase in the standard of living include electricity supply systems, communication systems, and the school system, etc.

Table 3.1 provides a summary of the driving forces underlying consumption growth. The various approaches are not meant to be seen as mutually exclusive but as complementary explanations of a complex reality.

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[45] Reusswig employed a typology of social groups and lifestyles in his work and looked at the related consumption patterns and their impact on environment and sustainability.

[46] On the relation between infrastructure and/or public utility systems (e.g. water, electricity) and private consumption see for example van Vliet – Chappells (1999). The research described was carried out as part of the EU-sponsored project DOMUS (Domestic Consumers and Utility Systems). See also http://www.sls.wau.nl/es/DomusTotal.pdf.

Table 3.1: Driving Forces in Consumption Demand

	Abstract theoretical	Historically concrete
(Macro-) economic	Competition: - new products, new variants - diversification - advertising	+ increasing pace + commercial television + commercialised public space
		credit facilities
		Labour market institutions: work and spend
	- reduce costs	The production of material goods easier industrialised
	Expansion of market relations	Sectoral shifts
(Micro-) sozio-psychological	Human beings need goods to make sense of the world In combination with the hierarchial organisation of society	Ideals of the period The consequences of late-modernity for the construction of self-identity
	Justification	Increasing interpersonal independence, individualisation
(Meso-) everyday life	The importance of desires and emotions in relation to social relations	Home-building
		The duality of the ideal family
	Sturcture-actor interplay	The paradox of time-saving
	The inertia of established socio-technical systems	The momentum of socio-technical systems

S: Røpke, 1999.

The manifold nature of consumption behaviour has negative implications for the individual as well as for society (time pressures, insufficient recuperation, social impairment, environmental damage etc.). The negative effects of increasing consumption and of the prevailing consumption lifestyle are the driving force behind the search for alternative possibilities or for policies leading to a change in consumption behaviour. The simple sketch of the driving forces in consumption given in Table 3.1 is in itself a clear indication of the need to approach the problem of change orchestration at many different levels of policy.

This definitely includes the use of economic policy. In contrast with the approach taken by van den Bergh et al. (see above), Røpke does not question the effectiveness of economic instruments. She does, however, see the need for a bundle of various instruments, which includes information provision and education as well as an analysis of social structures[47].

Brown – Cameron (2000) focus on the problem of how to curb the consumption of natural resources. For them, the main determinant of excessive resource use is the prevailing value system. The motives for consumption, similar to the analysis by Røpke, are seen to derive from economic, social and psychological factors. They conclude that policy intended to change resource use must begin at the level of cultural values. Policies which focus on changing specific attitudes or consumption patterns cannot be expected to be effective in bringing about a reduction of resources. Research has shown for example that evidence of environmentally friendly behaviour in connection with the purchase of a specific product or product group cannot be taken to imply that an individual is more environmentally friendly in his/her overall consumption behaviour. At this general level, it is the overarching world view or social value system which dominates and determines behaviour.

According to Brown – Cameron a reduction in the use of resources requires a fundamental reorientation in prevailing values. The preconditions for such a value reorientation are:

- Refutation of the prevailing consumer value system which posits a connection between the consumption of goods and the level of happiness or well-being.
- Promotion of an alternative value set, which sees well-being in connection with environmental quality, social relations, satisfying employment relations etc.

The greatest challenge lies in establishing how such a fundamental reorientation of values is to be achieved. There is still a considerable lack of empirical knowledge concerning which precise instruments or strategies might be capable of bringing about such value change. Here, the authors see considerable scope for further research, both theoretical and empirical, and requiring the co-operation of various disciplines. Questions concerning how excessive consumption is to be defined are just as significant as those aiming at the identification of methods necessary for value change and/or the identification of social norms which hinder resource reduction. Economic questions relate to issues such as the analysis of institutional or procedural settings etc. in order to ascertain which arrangements or policies might be most useful in facilitating a reduction of resource use.

3.1.3 Modelling Consumption Behaviour in Ecological-Economic Models

A further direction of research is found in the use of simulation models. These are intended to portray the social processes occurring between interacting agents. Such models simulate behavioural heterogeneity, e.g. with respect to preferences, skills or informational access. The

[47] It is argued here that the possibility of using economic policy to change consumption behaviour depends on how deeply given practices and routines are anchored within the culture. Such cultural or local characteristics should be taken into consideration when policy measures are chosen (economic instruments, changes in infrastructure, information campaigns etc.). See also Wilk, 2001, Hedtke, 1999.

purpose is to incorporate individual behaviour within an economic-ecological model. One approach which has proved suitable for such purposes is that provided by experimental economics. Gintis (2000) provides a summary of the various types of experiments (single players, repetitive games etc.) involved in such an approach. These experiments do not provide support for the neoclassical assumptions of rational behaviour (focus on the individual, constant time preference, etc.). In fact, experiments point out that in many cases economic agents develop co-operative patterns of behaviour. Experimental economics is appropriate for testing which behavioural decisions are made by individuals under specific (controlled) conditions. As Gintis suggests, the results of such experiments can provide valuable input for the formulation of regulations in environmental policy.

Bossel (2000) uses so-called "orientors"[48] to analyse the normative value orientation that economic agents exhibit with respect to issues of the environment. The analysis is then used to derive behavioural rules, which depending on the respective weightings used for the individual orientors, result in different lifestyles. Bassel argues that orientor analysis can also be employed to derive suitable sustainability indicators since it can check the extent to which basic orientor requirements are met.

Jager et al. (2000) developed a model for simulating the behaviour of several agents based on the conceptual analysis of cognitive consumer decision making processes[49]. The model investigates how the individual agent decisions on a micro level influence results on a macro level. A variety of behavioural processes (situations involving rational deliberation (à la homo economicus), imitation, repetition, social comparison) and their impact on consumption behaviour are simulated (in this case the "extent of fishing and mining"), all the time allowing for possible overexploitation of natural resources. Pollution and the extent of fishing activity are essential factors, and by means of the simulation model, can be calculated on the basis of the observed behavioural processes. By simulating different behavioural processes it is possible to distinguish between the resulting types of interrelations between man and environment. The simulation results allow conclusions to be drawn with respect to regulating the management of natural resources.

3.2 National and International Initiatives

Several national and international initiatives have been started with the aim of altering consumer behaviour and changing the predominance of the prevailing consumer lifestyle. These programmes run in parallel to the conceptual and theoretical work on sustainable structures in private consumption. In addition to the national and international projects, there are many more programmes being undertaken as part of local Agenda 21 activities which are not described here.

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[48] Orientors represent fundamental variables which are significant in indicating the overall viability of a system, as well as the properties necessary for survival and success within the system.

[49] An overview of applications of computer simulations aimed at explaining consumer behaviour can be found in Jager et al. (2001).

3.2.1 The OECD Programme on Sustainable Consumption

In 1993 the OECD began a long-term work programme on sustainable consumption patterns. This was to focus on three main points:

- Developing a conceptual framework
- Identifying trends and policy instruments
- Evaluation and monitoring of progress

Several different areas were looked at within the programme. Starting from a basic conceptual framework and an analysis of existing conditions in member countries, specific areas were then chosen for more concrete analysis such as how to improve the environmental performance of the public sector, an investigation of the impact of globalisation on the environment and consumption, plus various case studies in the individual member states on food consumption and transport and tourism.

A workshop in 1995[50]was organised to promote a clarifying of concepts. The background for the workshop was provided by a paper describing the essential concept dealing with interactions between the environment and the economy and/or consumption activities. The concepts discussed were:

- Carrying Capacity: this concept deals with the limits of the natural environment with respect to population and economic growth.
- Use of environmental space: this concept is related to the carrying capacity approach. The difference is that it employs a dynamic perspective. The limits of the system are not given by the prevailing biophysical constraints since it is assumed that societies can influence the use of environmental space, for instance, through technological progress.
- Steady state economics: this idea stems largely from the work of the American economist Herman Daly. The basic assumption is that as a result of the "non-reproducibility" of the ecological system unlimited economic growth is not possible. The connection between stocks and services is a central point in this approach, i.e. the level of services obtainable from a given amount of capital stock (natural and economic) is to be maximised[51].
- Ecological footprint and ecological rucksack: see chapter 2 of the present study for more on these concepts.

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[50] OECD (1997).

[51] The relationship between stocks and flows is a central aspect in the present study of sustainable consumption patterns in the areas heating and transport (mobility).

- Environmental accounting: this issue was discussed thoroughly in chapter 2.
- Eco-efficiency: this aims at a reduction of material throughput, i.e. an increase in energy and material productivity with a simultaneous decrease in resource consumption and the accompanying amounts of waste, at least in relative terms. The rebound effect can lead to an increase in absolute quantities. From an economic perspective an increase in resource productivity contributes to greater competitiveness and a lower use of the environment.

The various concepts contain several similarities, e.g. with respect to the limits of the eco-sphere and the subsequent need to reduce environmental exploitation. Increased efficiency with respect to the use of the environment and a reorientation towards the service function of products are key factors in stimulating change in consumption patterns. The emphasis placed on these in the concepts mentioned above varies considerably.

On the basis of the conceptual framework and its focus on ecological issues, a need for informational systems was derived. These systems would help integrate the interactions between economy and environment and also serve to indicate the impact of policy measures in both areas. The OECD believes that a basic precondition for change in consumption structures is a process of social discourse on sustainable consumption and production, and that such discourse needs to be initiated at a political level.

Reports on initiatives in OECD member countries are part of the process of evaluating and monitoring progress towards sustainable development, one of the three focal points mentioned above. These reports provide summaries of measures used to change the consumption activities of households or small and medium-sized businesses. Such measures encompass regulatory and economic instruments as well as intervention in institutional or social arrangements (awareness raising, information campaigns, eco-labelling etc.).

Based on the feedback from individual member states, the OECD reaches the following conclusions:

There are isolated initiatives in most member countries, but a coherent overall strategy for changing consumption behaviour towards more sustainability is still lacking.

Informational and educational measures only help to a rather limited extent, since they only lead to changes in consumption behaviour as long as this is not associated with extra consumer costs or loss of consumer convenience.

Member countries report that economic and regulatory measures are successful.

Comprehensive evaluation of national measures is difficult since the approaches used are relatively new and there is as yet little measurable evidence available. However, those initiatives which are built up on the basis of implementing a package of policy measures simultaneously, appear to be the most promising.

The OECD report "Globalisation, Consumption and the Environment"[52] discusses the major trends in household consumption patterns at national, OECD, and global levels. It also looks at the potential impact of globalisation on such consumption patterns and how this might affect the environment.

Particular emphasis is placed on an analysis of the following four areas:

- Housing
- Leisure
- Agriculture
- Transport

The examination of basic trends and of specific developments in the above sectors reveals that it is not possible to come to any general conclusions with respect to the impact of globalisation on household consumption and environmental quality.

The Commoner–Erlich equation is used as the analytical framework. This shows the relation between environmental impact (I), population growth (P), per capita consumption (C), and environmental impact per unit of consumption (T).

$I = P \cdot C \cdot T$

The environmental impact per unit of consumption is interpreted as "technology", i.e. it covers which product inputs and production or consumption processes are used, which production and consumption structures prevail, and which waste flows result. The OECD report looks at three channels to affect T:

- Technical effects: depict changes in the production processes of relevance for the environment.
- Product mix effect: includes the environmental impact of changes in the bundle of products consumed.
- Structural effects: covers changes in economic structures.

The variables P and C can be interpreted roughly as scale effects, and they show the impact of growth on the environment.

[52] OECD (1999C).

Table 3.2: Expected Environmental Impact of Globalisation on Individual Sectors

	Scale effect	Technical effect	Structural effect	Product effect
Housing	negative	positive	insignificant	negative
Leisure	negative	insignificant[1])	positive[2])	insignificant[2])
Agriculture	negative	insignificant	uncertain - positive[3])	mainly negative
Transport	negative	positive	negative	negative

[1]) Except tourism - positive.
[2]) Except tourism - negative.
[3]) Uncertain between countries, positive between sectors.
S: OECD, 1999.

The sectoral trends then are analysed on the basis of the above effects. As seen in Table 3.2, the environmental impact of globalisation varies across the individual sectors. The scale effect alone, is estimated to be negative in all sectors. It is assumed that further moves to trade liberalisation will result in an increase in economic growth, and that this will be accompanied by negative environmental impacts.

Globalisation has the lowest direct impact on the housing sector. The developments in this area are, however, characterised by global trends such as increasing urbanisation, the tendency towards smaller housing units with more floor area per person, and increasing reliance on private cars to satisfy mobility needs. The negative scale effects result on the one hand from population growth, and on the other hand from increasing welfare levels. Both these factors lead to an increase in demand for better equipped and larger dwellings. Globalisation could exert a positive effect on technological progress in the housing sector.

Based on the increase in leisure activity a negative scale effect is derived for this sector. The other effects, however, exert a positive or negligible impact in this area. In the sub-section tourism, negative environmental effects are found to stem from structural impacts on the one hand – tourist activity is growing faster than GDP – and on the other hand from changes in demand patterns, e.g. shorter and more frequent holidays, and longer travel distances.

Negative scale effects are also felt in food production. The product mix effect is largely negative as a result of both an increase in demand for meat and for foodstuffs requiring longer transport distances. An increase in the demand for organic foods could have a positive impact here.

In the transport sector the negative scale effect is accompanied by a negative structural effect resulting from transport growing faster than GDP. For the most part, the technical improvements which have led to greater fuel efficiencies and thus a reduction of CO_2 emissions have been offset by product effects (moves to larger, more powerful cars). Technical improvements only led to absolute reductions in the levels of other air pollutants.

In total, the results of the analysis show that the scale effects are crucial, and that they are difficult to offset via the impact of other effects.

In November 2000, two further components of the work programme on "Sustainable Consumption" were completed, dealing with case studies in "Household Food Consumption Patterns"[53] and in "Household Tourism Travel Patterns"[54]. The purpose in both cases was to identify the forces in both sectors which determined consumption patterns and related environmental impacts.

The OECD food consumption report was based on information from four country case studies (Austria[55], Poland, Sweden and the USA).

From the case study results and from additional information sources it was possible to identify some general trends in OECD food consumption patterns. These included:

- An increase in per capita consumption of meat.
- For dairy products: a decline in the consumption of milk with a simultaneous increase in the consumption of cheese.
- An increase in consumption of fresh fruit and vegetables as a result of greater public health consciousness.
- A large rise in the consumption of bottled and canned drinks. Owing to the often low rates of recycling this leads to higher amounts of waste. For example, the recycling rate for plastic packaging in the United States is about 5%.
- Demand for food items in OECD countries is expected to increase by 7% by the year 2002, with expected further increases in demand for greater food variety and a rise in the share of imported foodstuffs.
- A probable increase in the demand for meals out
- In food distribution, there is a continuing decline in the number of outlets and at the same time an increase in outlet size.

The most important factors and forces influencing consumption patterns were determined with the aid of the NOA-model (Needs-Opportunities-Abilities Model). The model identifies specific factors

[53] OECD (2000A).

[54] OECD (2000C).

[55] Payer et al. (2000).

which have a bearing on individual as well as aggregate consumption behaviour. Table 3.3 gives a summary of the model structure with respect to the food sector.

Table 3.3: The Needs-Opportunities-Abilities Model (NOA) and Household Food Consumption

Needs	**Opportunities**	**Abilities**
Nutrition and health	Food price	Per capita disposable income
Convenience	Food products and services available	Education: nutrition, exposure to food and food preparation skills, environmental awareness
Variety	Advertising	

Technology (food production, preparation and conservation), Policy (regulations, information), Demographics (household size, employment), Culture (gender, religion, age).
[1]) Needs-Opportunities-Abilities.
Q: OECD 2000 (A).

Health and safety aspects, as well as variety and convenience are relevant for satisfying needs (this is true even concerning the availability of convenience foods).

Need satisfaction depends on sufficient knowledge of alternatives available in terms of both product price and product variety. Advertising plays a central role in both cases. The ability to satisfy needs is related to variables like income, education and information. Increasing income allows for an increase in the demand for higher quality foodstuffs and for more meals out. Education and information are important in contributing to healthier food consumption patterns.

In its report, the OECD discusses the environmental impacts of energy use, transport volume, and waste, and their relation to food sector activity or more indirectly, as affected by food consumption activity. It is concluded that attempts to influence the environmental impacts of food consumption need to be seen in a broad perspective. While the environmental impacts of food consumption itself are not to be neglected, attempts to change consumption behaviour are more likely to be effective at a different level, e.g. by focussing on policies dealing with aggregate energy use or aggregate household transport demand.

The last area to be investigated as part of an OECD sectoral study was travel behaviour in tourism (OECD, 2000C). This report looks at international developments in the tourist industry and their impact on the environment. It also describes the household demand for tourism services and discusses policies which might be used to influence the environmental impact of tourist activity. The impact of leisure activity on the environment was already described in the report "Globalisation, Consumption and the Environment" (OECD, 1999C). However, in the later case study on travel behaviour, some areas are looked at in more detail.

The environmental impact of tourism-related transport becomes particularly significant when seen in connection with the corresponding growth forecasts. A major factor is the increasing number of long-distance flights and the corresponding increase in energy requirements. Travel patterns, in terms of frequency and destination, are determined at the household level, but the actual choice made depends to a large extent on the information available and given knowledge of alternatives. One possible means of influencing consumers in this area, would be the provision of information concerning the environmental impact of the choices available. If such information is presented to consumers, it might lead to changes in travel habits. Giving present economic, social and demographic trends, however, such a policy is only expected to exert a marginal impact on travel behaviour. What is important, is that the negative environmental impact of travel behaviour be reflected in the costs and in the price of the journey. This is a question concerning the regulatory competence of governments. Clearly, in the case of international travel, a co-ordinated, cross-country policy approach is of necessity. At the same time, the tourist sector represents an important economic factor, particularly for less developed countries, and restrictions on travel access are not likely to be in the latter's interest.

3.2.2 The Oxford Commission on Sustainable Development

The Oxford Commission on Sustainable Consumption (OCSC) was launched at the seventh session of the United Nations Commission on Sustainable Development in April 1999. The OCSC was set up by Mansfield College, Oxford, with research work being carried out at the Oxford Centre for the Environment, Ethics & Society (OCEES).The Commission aims to promote activities and policy measures by citizens, government bodies, the media and businesses, which contribute to the achievement of sustainable patterns of consumption. The interdisciplinary approach employed by the OCSC in drawing up sustainability policies for consumption focuses heavily on the role of social and cultural processes in the formation of consumption patterns and their relation to economic and technical mechanisms (OCSC, 1999B). The research agenda is based on five steps (OCSC, 1999A):

1. Developing criteria for sustainable consumption, which cover objectives for the environment, the economy, and society, and which are relevant for institutional and cultural issues.

2. Evaluation of processes in the past which led to large scale changes in consumption behaviour (e.g. housing construction, transport).

3. Development of case studies concerning existing initiatives aiming for sustainable consumption (e.g. the local Agenda 21 activities etc.) in order to identify promising approaches, and the key factors and individuals/institutions involved.

4. Developing the Action Plan, in order to identify the types of policies necessary, as well as the role of the media and education system.

5. Dissemination of research results in workshops, conferences, publications etc.

The priorities of the OCSC work programme are set on areas of consumption which are of particular significance for the environment such as food, transport, energy, housing and the impact of consumption on climate change. Four projects have been initiated so far:

- Action plans for sustainable consumption (for further information see http://www.mansfield.ox.ac.uk/ocees/pages/csc/Action.pdf, OCSC, 2000B).

This series of projects represents the core of the OCSC work programme. In co-operation with the International Institute for the Environment and Development (IIED) action plans on sustainable consumption in six countries, focussing on the local level, are to be developed. The projects concentrate either on one of the three critical focal points of consumption (food, transport, housing), or on the use of important resources (energy, water, soil). Individual projects are carried out in four stages: The first stage deals with the preparation of a report on the respective consumption patterns and trends, the related driving forces and their effects, and the attitudes of local populations towards consumption and the environment. In the second stage, action plans are prepared together with local stakeholders and institutions. The first thing that has to be done here is to establish concrete targets for sustainable consumption and to identify the social, economic and technological changes necessary to achieve them. It is then necessary to assess the contributions that can be made by existing initiatives in achieving the set targets. In the third stage of the project, action plans are implemented, any progress made is monitored and evaluated over a period of at least 18 months, and if necessary adjustments are made to keep the project on course. In the final project phase, the results of implementation are made public and disseminated via reports, Internet and other suitable channels. So far three projects have been initiated. These deal with private transport patterns in Hampshire, Great Britain, water use in Kathmandu, Nepal, and food consumption, housing and transport in Brazil.

- Sustainable Food Consumption (for more information see http://www.mansfield.ox.ac.uk/ocees/pages/csc/FoodProj.pdf).

In co-operation with the OECD (see section 3.2.1) the following factors are to be investigated in four to six countries: the existing patterns of food consumption and their development, underlying driving forces (demographic, technological, cultural factors) and the effects of such forces. The focal points here are the impact of population growth and economic development on consumption, the effects of different consumption patterns and trends on environmental and social sustainability, and the role played by the various factors which influence the formation of consumption patterns. On the basis of this information and the experience derived from existing initiatives, options are then to be developed for the achievement of more sustainability in food consumption, and concrete recommendations are to be formulated for political, economic, and consumer institutions etc.

- Media and Consumption (for more information see http://www.mansfield.ox.ac.uk/ocees/pages/csc/MediaProj.pdf).

This project is designed to investigate the role played by the media in influencing consumption behaviour, in order to obtain knowledge useful in the development of information and communication strategies for sustainable consumption. The influence of advertising on the formation of consumption patterns is not the only factor to be investigated. The impact of lifestyles and images as projected through film and entertainment media is also the subject of analysis.

A workshop for scientists, media representatives and representatives of industry was organised on the above theme in Oxford, in January 2001. The following topics were discussed: the contribution made by the media in the formation of consumption patterns and consumer culture, the part played by the media in creating public awareness of social and environmental problems, the potential of the media to change norms and values relating to consumption processes[56].

- Youth and Sustainable Consumption (for more information see http://www.mansfield.ox.ac.uk/ocees/pages/csc/YouthProj.pdf).

Together with the UNEP Youth Advisory Council this project looks at the consumption patterns of young people between the ages of 16 and 24 years. Their underlying motives, values, and potential role in achieving sustainable consumption are all investigated. By establishing discussion groups in six to eight cities in different countries, background knowledge on the environmental impact of concrete consumption patterns is to be collected and strategies towards more sustainability developed. In addition, a study of youth consumption patterns and their related effects is being carried out in order to derive consumption sustainability indicators and policy recommendations for the respective cities.

Apart from the projects described above, the OCSC also carries out research on the ethics of consumption. In a paper on this theme (OCSC, 2000A) the following questions were examined:

- What are the central components of an ethics of consumption? What are the underlying attitudes with respect to human needs, the "good life", and nature, on which sustainable development could be based? How are these related to (materialistic) consumption?
- What factors determine consumption growth and diversity in Western societies? What contributions can be made by the values and norms of other cultures, the trend towards globalisation, and scientific progress, to attaining the objective of sustainability?

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[56] In preparation for the workshop the OCSC published a theme paper (OCSC, 2000C). A summary of the workshop can be found in OCSC (2001).

Within this context, issues relating to consumption are considered which lie outside the normal scope of the rational, welfare maximising approach taken in traditional economic theory[57]. Particular emphasis is placed on the significance of social and cultural aspects in the formation of consumption behaviour. Thus, consumption which exceeds that necessary for the satisfaction of material needs (e.g. conspicuous consumption) still serves to raise utility, albeit indirectly, in that it allows the individual to demonstrate social status and to belong to certain social groups.

3.2.3 The Green Household Budget

The Norwegian "National Institute for Consumer Research" (SIFO) is engaged in research on questions of consumption, consumption policy and the testing of consumer products. For several years, one of the focal points of its research has been the area "consumption and environment". As part of this research, the institute has prepared studies on the sustainability of consumption in Norway[58], and has also developed the concept of a green household budget, which is designed to serve as information source and guide for households wishing to change their consumption habits towards greater sustainability. The budget takes both the environmental effects of consumption into account, as well as the economic consequences of the various consumption possibilities (Stø – Vittersø – Strandbakken, 2000).

The basis for the Green Household Budget was provided by the "Standard Budget for Consumption Expenditure" developed by the SIFO. This represents the costs associated with maintaining reasonable consumption expenditures for different types of household, adjusted for household size and household composition. (Vittersø – Strandbakken – Stø, 1999).With the exception of housing costs, the budget takes all the main areas of consumption into account. These include:

1. Food and beverage
2. Clothing and shoes
3. Health and hygiene products
4. Sport and leisure articles
5. Travel expenditure
6. Groceries

[57] For more on this, see section 3.1.

[58] Project reports have only been published in Norwegian. The main results of empirical studies are summarised on the homepage of the institute (http://www.sifo.no/english/publications/environment/1-95.htm, http://www.sifo.no/english/publications/environment/8-00.htm). Here, it can be seen that about half of the population considers itself to be environmentally conscious, although this is not reflected in all areas of consumption. Waste separation, recycling and the purchase of environmentally friendly detergents and cleaning products are practised by a large proportion of the population, but environmental awareness in food consumption and personal transport plays only a relatively minor role. Behaviour also varies according to age and sex. Apart from personal attitudes and beliefs, the most important determinant of eco-friendly consumption was found to be state and social support .

7. Household products
8. Furniture
9. Telephone, newspapers, television, repairs
10. Car expenses
11. Kindergarten

The Standard Budget represents the "reasonable consumption expenditure"[59] on goods and services of an average Norwegian household. Such expenditure, however, does lie below the actual levels recorded for most Norwegian households.

The Green Household Budget was developed on the basis of the Standard Budget. It is devised to function as an advisory tool for those households wishing to make their consumption behaviour more sustainable, without defining any "correct" level of consumption. Apart from the consumption categories already mentioned above, the Green Household Budget also includes housing expenditure. Considerations on the "greening" of consumption do, however, focus on the three areas of food, transport, and housing / energy, since these are the most environmentally relevant areas of consumption and together make up 80% of household energy consumption. According to this guide, changes in consumption can be achieved by following a three point strategy:

1. The product level
2. The service level or level of organisation
3. The reduced consumption level

On the first level conventional products are replaced by corresponding eco-products. Such change has financial implications, but does not demand a drastic change in lifestyle.

The basic idea behind the second level is the redefinition of consumer needs in terms of the services (heating, availability of hot water, clean clothing, mobility etc.) rendered by products, instead of the possession of products themselves. Such services can be purchased on the market or made available in collective arrangements, and are not necessarily dependent on product possession.

On the third level the actual level of material welfare and consumption is reduced. This requires major re-organisation of daily life and of consumption behaviour.

Table 3.4 shows several suggestions from the Green Household Budget for changing consumption patterns in transport, housing and food (Vittersø – Strandbakken – Stø, 1999):

[59] Reasonable consumption is defined as "...an expenditure level on which families and their members have the opportunity to maintain physical and mental health, to be culturally integrated and to participate in basic social activities." (*Vittersø – Strandbakken – Stø,* 1999, S. 266).

Table 3.4: Suggestions for changing behaviour in the areas transport, housing and food

	Transport	Housing	Food
Level 1: Product substitution	purchase of fuel efficient cars	exchange oil for electricity, alternative energies	purchase of organic food
Level 2: Service level/ organisation	maintenance, catalytic converters,...... organisation of travel behaviour (public transport, car pools, car sharing)	purchase of energy efficient appliances, use instead of purchase	transition to a more vegetarian diet, homegrown vegetables
Level 3: Reduced consumption	reduction of number of travels and / or kilometres travelled	lowering indoor temperature by 1° C	

S: Vittersø – Strandbakken – Stø, 1999.

The individual levels are not of equal importance for all areas of consumption. For example, little alternatives are available for households with respect to the replacement of fossil fuels. The possibility of obtaining electricity derived from non-fossil production is very small, and apart from that, fossil fuels only make up 8% of household energy needs (Vittersø – Strandbakken – Stø, 1999). Seen as a whole, however, the budget does offer the possibility of estimating the relative impact of the various behavioural changes, especially those occurring beyond the product level.

There is a separate budget section devoted to each area of consumption. First the respective expenditures in the Standard Budget are compared to averages found in national consumer statistics and the environmental impact of the consumption area is calculated. Based on this, suggestions are then made for potential changes in consumption behaviour on the different levels, and their financial impact is calculated.

In order to show what type of information is significant for specific areas of consumption and how the Green Household Budget works, the area "food and drink" was explained in more detail (Vittersø – Strandbakken – Stø, 1999). This areas accounts for more than 20% of consumption expenditure, is responsible for a considerable share of direct and indirect energy consumption and other environmental impacts (volume of waste, environmental impact of production etc.). Here, in particular, there are several possibilities for strengthening sustainability, for example: increased use of organic food, substitution of vegetables for meat, self-production or the use of locally produced products, and changes in food storage and preparation as well as waste disposal.

First the cost of replacing conventional food products with organic foods was calculated for a family of four. From the 110 products listed in the Standard Budget, a maximum of 33 can be replaced by organic alternatives. If all 33 are replaced, monthly food expenditure increases by 28%. Since it appears unrealistic that all organic products would be purchased on a regular basis, two other alternatives were estimated in which only easily available products were taken into consideration: either organic vegetables, or organic milk. The latter two possibilities still led to an increase in monthly expenditure of 5%.

The financial impact of more vegetarian diet was not calculated in detail. It is simply assumed that the substitution of vegetables for meat does not lead to an increase in costs. The same applies to the purchase of locally produced foodstuffs, waste separation and composting. Potential savings are possible , however, through self-production. Were households themselves to produce all the vegetables, fruit and fish they needed, 28% of food expenditure could be saved[60].

Whether and to what extent the measures listed can be carried out, depends on the one hand on household economic and time constraints, and on the other hand, on where households are located. For example, the supply of organic foods is probably greater in cities, while households situated in the country will find it easier to produce their own food or buy directly from farmers. Product substitution is likely to be the most practical strategy for the majority of households, since it entails relatively low effort in terms of time or labour, and does not call for great changes in lifestyle.

The application of the Green Household Budget at the European level, is being supported by funds from the Fifth Framework Programme of the EU. The project "The involvement of stakeholders to develop and implement tools for sustainable households in the city of tomorrow (ToolSust)"[61]is being carried out by research bodies and universities in one city[62] in each of the following countries: Norway (SIFO), the Netherlands (IVEM), Italy (University of Padua), Great Britain (University of Surrey), and Sweden (Environmental strategies Research Group, ESRG). The project also includes, in co-operation with local stakeholders, the development of targets and policies for achieving sustainable consumption and the testing of their application in daily life.

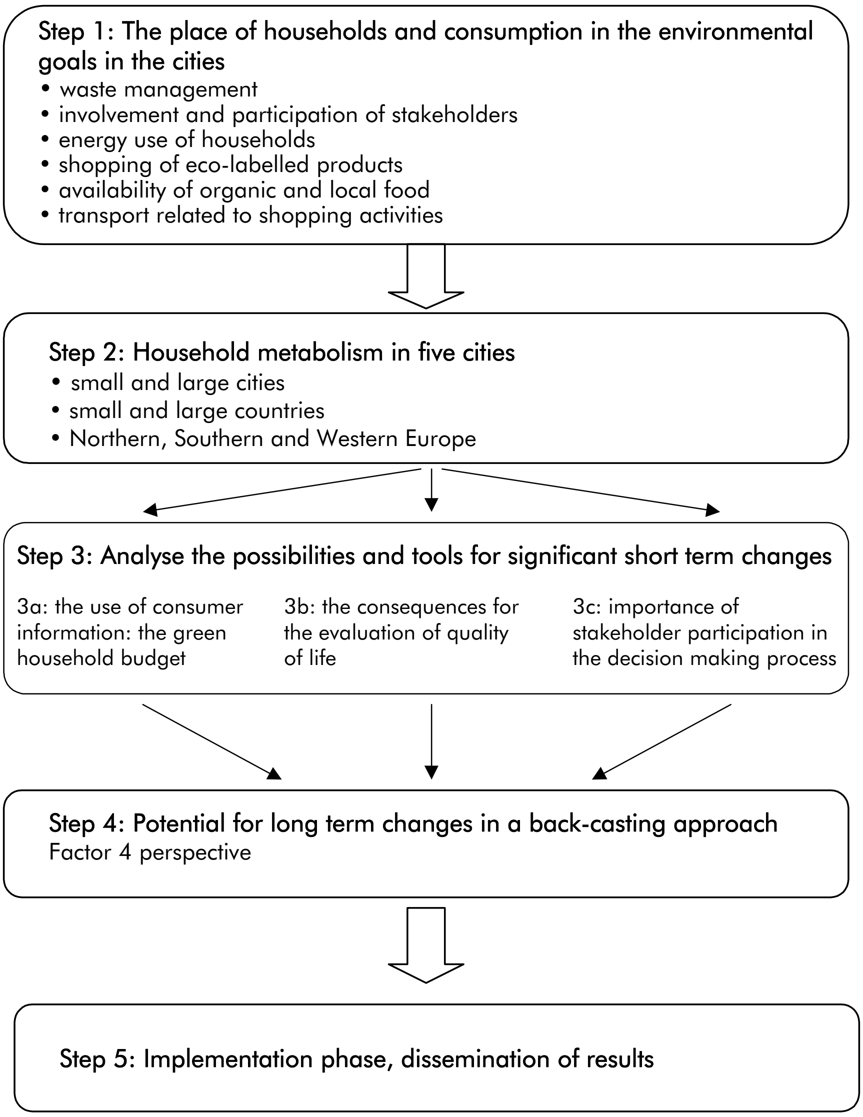
With the co-operation of social and natural scientists five research and work stages are to be carried out (see Figure 3.2).

[60] However, other expenditure incurred are not considered here, for example, for tools, equipment, transport, time etc.

[61] Further information on the project is available on the homepage (http://www.toolsust.org).

[62] Cities participating are Fredrikstad (Norway), Groningen (Netherlands), Padua (Italy), Guildford (GB) and Stockholm (Sweden).

Figure 3.2: ToolSust work programme in five research steps



S: Vittersø – Strandbakken – Stø, 1999.

Step 1: Clarification of the institutional and economic framework; description of the part played by households and consumption in the environmental policy objectives of the respective city.

Step 2: Examination of household metabolism in the five cities.

Step 3: An analysis of the possibilities for achieving important changes in the short-term, such as through the application of the Green Household Budget, evaluation of impacts on life quality, and assessment of the importance of stakeholder co-operation in decision making.

Step 4: Ascertaining the potential for long-term change (factor four etc.).

Step 5: Integration of stakeholders in implementation and dissemination

Within the scope of the project work, the Green Household Budget is to be tested on strategic groups of consumers. The purpose is to estimate how sustainable consumption can become when households are prepared to accept change, when the necessary information is provided, and when the local environment is geared to support such change (by administration, consumer groups, environmental organisations etc.). The primary focus in the project is on the following consumption activities:

- Purchase of durable and non-durable goods
- Durability of household equipment
- Purchase of organic and local foods
- Connection between purchase behaviour and ecolabels
- Waste disposal behaviour of households and neighbourhoods
- Energy consumption
- Transport induced through purchase activities.

As well as being of considerable importance for the environment, these consumption activities are also open to direction through (local) policy measures. Not only potential changes in behaviour are analysed, however, but also the ensuing economic impacts on the households and on the retail business. Special attention is paid in the dissemination of project results to adapt information to the different needs and preferences of the various consumer groups and stakeholders concerned.

3.2.4 The Perspective Project

The project "Perspective" was commissioned by the Ministry for Housing, Spatial Planning and Environment in the Netherlands, and was begun in 1995 and carried out by NOVEM (the Dutch Agency for Energy and Environment). The background motivation for the project was given by the observed steady increase in energy consumption. Between 1990 and 1997 this increased by an average of 1.2% per annum, and could be largely attributed to the increasing household demand for electricity (+2.5% p.a.) (Brand, 1999). The higher levels of disposable income available had raised household consumption expenditure, in particular leading to greater purchase of electrical appliances.

By means of empirical research on Dutch households, the project "Perspective" aimed to clarify the extent to which differential consumption patterns lead to a reduction in energy use, even when income is increasing. The results were to provide the basis for a definition of an "energy efficient" lifestyle and its respective advantages and disadvantages. The research focussed on the ways and means of influencing indirect energy consumption, i.e. energy consumed in the production, transport and marketing of consumption goods. The share of indirect energy consumption in terms of total energy consumption of an average household amounts to 63%[63].

Twelve households, of varying size, and with different levels of income, took part in the project. Mostly households exhibiting relatively low levels of direct energy use were selected. The households were set the task of purchasing products with the lowest possible energy intensity[64] since this would thus reduce indirect energy use. For this, participant households received a payment equivalent to 20% of their net income, and this premium had to be spent completely. The aim was to reduce energy consumption to 40% below the level of a "normal" household with the same income.

Each household was obliged to keep its "energy accounts" on a computer so that based on information such as country of origin, weight, price etc., the energy components of the goods and services could be calculated , i.e. in the areas food, clothing, transport, leisure and personal care. Apart from receiving continual information on their energy budgets, energy counsellors were also made available to help households gain more energy awareness.

Compared with figures recorded before the start of the project, a considerable reduction in household total energy consumption was achieved (-31%). Of this, 88% came from reductions in indirect energy use, and 12% from the impact of greater consumption awareness and the replacement of old equipment. (Brand, 1999). The following changes in consumption patterns were observed:

- Increased acquisition of more labour intensive products (e.g. hand made furniture),
- Improvements in the quality or durability of products,
- Changes in eating habits (more organic food, less meat),
- Changes and reductions in mobility (fewer car journeys and flights),
- Increased use of personal services (household help, restaurant visits, educational courses),
- More efficient use of goods (repair instead of purchase).

The participants had quite a positive view of their new lifestyle and saw it as an improvement in their quality of life. The explicit benefits mentioned were the acquisition of higher quality and more durable goods and the increased use of personal services. Energy efficient consumption was seen to

[63] Data on indirect energy use in the consumption of goods and services is from the Universities of Groningen and Utrecht, and from the Netherlands Research Centre.

[64] Energy intensity is calculated by dividing the energy used in the production of a good or service by its price.

be selective consumption, and not as a limitation on life quality or convenience. The main problem arose at the beginning of the project as it was at first difficult for the households to change their consumption behaviour and to deliberate over every purchase. Limitations on mobility were felt to be a further problem, particularly in households with several children. The majority of households was convinced that at least part of the new consumption behaviour would be continued after the end of the project, even without external guidance. To test this aspect of consumption sustainability, a follow up study was carried out on 11 of the 12 households eighteen months later. Most of the households were still quite happy with the energy efficient lifestyle, and this was mainly evident in patterns of food consumption, leisure activities and the purchase of household equipment. Retention of the new lifestyle is probably partly due to increased awareness on the part of the participants and their willingness to adapt behaviour and accept change. In areas such as small purchases, personal services, and in particular in transport and travel patterns, energy efficient behaviour had diminished. The reasons given for this were the conflict between energy efficient behaviour and general trends (e.g. towards greater mobility), and the lack of social acceptance. After the end of the project average energy consumption had again risen by 7.8% on average (Brand, 1999).

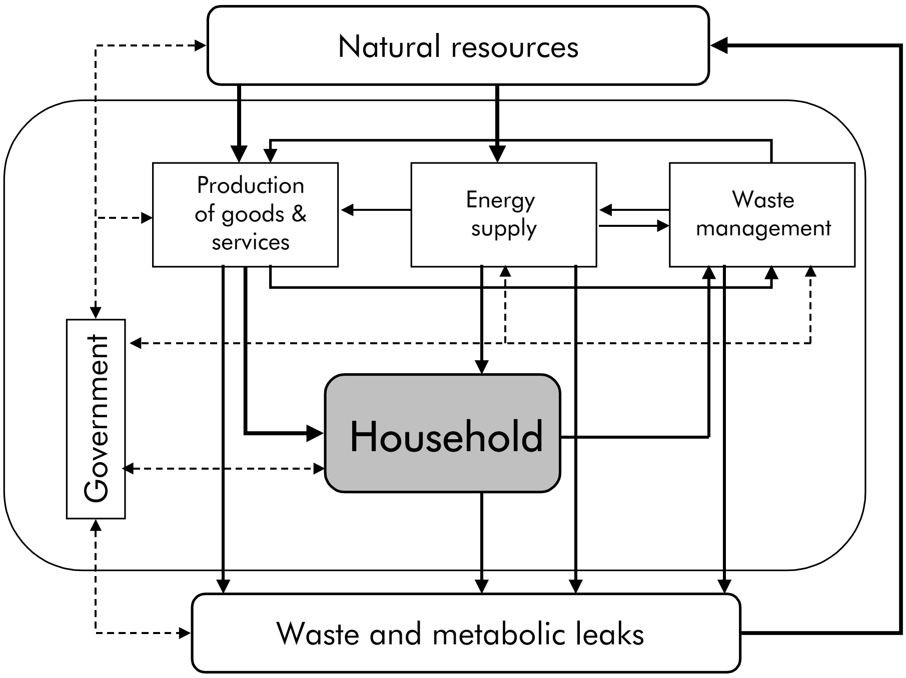
One factor which supported the continued use of energy efficient consumption patterns, was for instance the opinion that organic food or cycling were not only energy efficient but also good for personal health. The main difficulty with respect to continued energy efficiency was seen to be the loss of the additional project income. This meant that several products were no longer affordable. The end of external advice and the general lack of information about products made it sometimes difficult for households to choose the most durable or higher quality item. For some of the households, owing to the high fares and poor service, public transport was not seen as a realistic alternative to private car transport.

3.2.5 Household Metabolism Effectively Sustainable (HOMES)

HOMES is an interdisciplinary, applied environmental research programme being carried out by the Universities of Groningen and Twente in the Netherlands. It is aimed at developing concepts, operational approaches and policies which can be used to diagnose and evaluate the household metabolism of a Western society, taking the Netherlands as an example. It also investigates the changes necessary for achieving sustainable consumption patterns.

The concept of household metabolism focuses on the flows of energy, resources and waste passing through households. The direct household use of energy and resources is captured, as is their indirect use in the production of the necessary flows of goods and services. Several factors influence household metabolism, including technical, economic, spatial, administrative and behavioural variables. In order to develop effective instruments for achieving greater sustainability of the household metabolism it is necessary to understand the determinants of household consumption and their interdependencies (Noorman–Biesiot–Schoot Uiterkamp, 1998). Figure 3.3 depicts metabolism flows related to household consumption activities. Natural resources are extracted from the environment in order to produce goods and services. This, and the subsequent consumption activities require energy. As a result of production and consumption waste is produced, only a very small part of which is recycled. A necessary condition for the sustainable use of natural resources is the reduction of material and energy flows and the closure of the related cycles.

Figure 3.3: Metabolic relations between household, other sectors, and the environment.



S: Noorman – Biesiot – Schoot Uiterkamp, 1998.

The first phase of the HOMES project (diagnosis) examines which characteristics and factors determined metabolic flows through Dutch households in the past (1950 - 1970), in the present (since 1990), as well as in the near (up to 2015) and distant (up to 2050) future.

The second phase, evaluation, is to test whether household metabolism and operational concepts such as sustainability and environmental quality are compatible.

In the third phase, the conditions allowing for sustainability are to be analysed, as are the mechanisms, instruments and strategies available or needed to achieve a sustainable household metabolism.

The results of the diagnosis on the Dutch household metabolism were summarised in "Green Households? Domestic Consumers, Environment and Sustainability" (Noorman - Schoot Uiterkamp, 1998). Relevant research questions dealt with relate to the analysis of consumption trends over the past few decades and the related impacts on the environment. Further, the factors determining such trends were identified and conclusions about future developments in resource use for household consumption were determined.

In order to capture the majority of material and energy flows, the most important household functions in three consumption categories were examined, i.e.:

- Heating and mobility (from the category infrastructure and housing),
- Household appliances (from the category durable household goods),
- Consumption of water, gas and electricity (from the category non-durable goods).

The results for energy consumption in housing (electricity, gas) and transport are now briefly outlined below.

The household metabolism diagnosis revealed that there has been a strong rise in direct and indirect energy consumption since 1950. This development can be broken down into three broad stages. In the post-war years, 1950-1965, the focus lay on reconstruction, with little attention being paid to aspects of resource efficiency or environment. The development of large gas reserves signalled the beginning of the second period. This ended in 1980, following the second oil crisis. This second stage was marked by a strong increase in household wealth and the spread of the welfare state. An increasing number of consumption goods became affordable for large numbers of households. In addition, owing to the widespread extension of infrastructure systems (e.g. gas networks) supply conditions for the population were improved. In the third stage (1980 to the present) the growth in consumption has slowed. This is the result of concerns about the future scarcity of fossil fuels, increasing social awareness about environmental issues, and the existence of large-scale market saturation in households goods.

Changes in household metabolism are clearly reflected in energy use. Between 1950 and 1979 the demand for energy in heating increased by an average of 5% p.a. (from 130 PJ to 550 PJ). After the second oil crisis the demand for gas[65] for heating purposes fell (1995: 375 PJ) as a result of the (nominal) rise in prices and the introduction of energy saving measures (van der Wal–Noorman, 1998). In contrast, the demand for electricity has continued to rise in the same period, from about 550 kWh in 1950, to more than 3,000 kWh in 1995. This trend is likely to continue in future, as more and more households become equipped with a growing number of electrical devices. The increasing energy efficiency of such devices is being outweighed by the rise in quantity.

[65] Until the middle of the 1960s coal was the most important fuel source for heating. Since then the importance of gas has rapidly increased. At present 99% of heating is produced using gas.

A similar picture can be seen in transport. Between 1960 and 1995, the number of kilometres travelled as well as the number of private vehicles increased rapidly. Fuel consumption in private car transport rose on average by 10% per year, from 10 PJ in 1960, to 196 PJ in 1993 (van der Wal– Noorman, 1998). Here too, greater fuel efficiency is largely offset by the increasing number of vehicles and their increase in weight.

One major determinant of energy demand is price. In the period considered, there was a nominal increase in energy prices due to higher tax rates (an increase in value added tax and the introduction of various ecotaxes), but in real terms the 1995 prices for gas, electricity and fuel were at the same level as in 1960[66]. This hardly represents an incentive to use energy efficiently.

The analysis of total energy use in Dutch households for the period 1969 to 1988 shows that the share of indirect energy use was at all times higher than the share of direct energy use, comprising between 56% – 61% (Wilting – Biesiot, 1998). The increase in total energy use in this period by about 30% was caused by an increase in consumption (mainly in the area of electrical appliances) and by an increase in the number of households (and simultaneously a fall in household size). Following the second oil crisis energy saving measures were implemented in production processes and in households. However, the subsequent pick up in the growth of consumption together with the increase in the number of households have cancelled out the improvements in energy efficiency.

At the level of the individual household, energy use is determined by consumption expenditure, which itself is dependent on factors such as income level, household size, age structure etc. There is an almost linear relationship between consumption expenditure and energy use. A comparison of households from different income groups clearly revealed differences in energy intensity both between and within the individual groups (Wilting – Biesiot, 1998). This is explained by the presence of differing consumption patterns among households. It also points to the potential energy savings that can be achieved in the short term.

Apart from the demographic trends already described above, development of income and prices, technological innovations and policy measures also influence household metabolism. A number of policies, primarily designed to achieve quite different objectives, had the unintended side effect of leading to an increase in consumption and to negative environmental impacts. For example, public provision of dwellings, infrastructure development, social and tax policies, to name but a few. It was only in the last 20 years that the Dutch government began to embark on definite policies aimed at limiting specific aspects of household metabolism. These include energy saving measures (subsidy programmes for heating insulation, solar power etc.), the introduction of eco-taxes on fuels, transport policy (management schemes for parking, car pooling initiatives), and information campaigns (Ligteringen, 1998).

[66] Details on tariff structure and energy taxation levels can be found in Linderhof – Kooreman (1998).

The comprehensive diagnosis of Dutch household metabolism carried out in the HOMES project showed that in terms of consumption and environmental impact, driving forces exerted a stronger influence than the dampening factors. Thus, in general, prevailing consumption patterns cannot be described as sustainable. In order to assess further developments and the possibilities for a reorientation in energy use, scenario analysis was carried out for the period up to 2015. It was found that given complete implementation of all technical measures to save energy in production and consumption, a 50% reduction in direct and indirect household energy consumption could be achieved by the year 2015 (Biesiot – Noorman, 1999). The result in practice, however, is heavily dependent on whether the growth in consumption activity continues or whether it begins to slow or stabilise. Changes in lifestyles and consumption patterns could lead to a significant reduction in energy use. Households, however, can only influence part of their energy consumption. Changes in institutional arrangements and the creation of new incentive systems for producers and consumers are also necessary if a truly sustainable household metabolism is to be achieved.

A socio-psychological part of the HOMES project examined the social sustainability of environmentally sustainable consumption patterns and how such sustainability might be achieved. Environmentally sustainable consumption was defined in terms of an upper household limit on energy consumption (direct and indirect), with the long-term goal being 1kW per person by 2050. Social sustainability was assessed using 16 quality of life indicators (Gatersleben, 2001).

A field study involving 393 Dutch households in Groningen and Leiden was carried out in 1997 in order to examine the impact of sustainable consumption patterns on quality of life and to assess the necessary energy savings. The participants were divided into three income levels (high, middle, and low), and into six different household categories: young singles (under 45), young couples, couples with young children (under 12), couples with older children (over 12), older couples (over 45), and older singles. Interviews were carried out with household members covering (amongst other things) the following topics: ownership and use of household goods, expected expenditure in the next five years (for durable goods, travel etc.), changes in behaviour or adoption of measures to save energy they were considering to adopt in the next five years (39 choices were offered), assessment of sustainable consumption based on the 16 indicators, and evaluation of ten different consumer policy measures (e.g. information, energy price rises, energy rationing, subsidy programmes etc.)[67].

Direct and indirect household energy use and its future development were estimated on the basis of replies to questions on ownership of goods, planned expenditure, and energy saving measures. From these estimates, the size of the reduction in energy use needed to attain sustainable consumption was then derived[68].

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[67] For details on questionnaire design and evaluation of data see Gatersleben – Vlek, 1998.

[68] This Figure was arrived at by comparing the difference between expected energy use and the given sustainability limit for 2050. The difference was divided by 55(years) and multiplied by 5, in order to find the energy savings necessary over the next five years. Of these, 50% were to be reached through changes in behaviour or measures applied by households.

The results show (Gatersleben, 2001) that energy use increases with household size and with income. An average increase in energy use of about one third was expected in the next five years (largely due to increases in long-distance travel and expected second cars). The expected reductions were about 10%. 37% of households (mainly families and low income households) already showed patterns of energy use at sustainable levels. The remaining households would have to save between 12% and 14% of expected future energy use in order to reach the set target values.

With respect to the impact of sustainable consumption on quality of life, on average the households questioned expected there to be a negative effect on comfort and independence, with slightly negative impact on social relationships, leisure and private life. Positive effects were expected for environmental quality, natural resources, and to a lesser extent on income levels. The respondents assumed that overall the average reduction in energy use would not have much impact on their quality of life. Where large energy savings were necessary, the willingness to change behaviour fell. This implies that reductions in energy consumption are acceptable for households as long as the benefits lost remain marginal.

3.2.6 A Household Exploration of Conditions, Opportunities and Limitations pertaining to Sustainable Consumer Behaviour

In order to place the vision of sustainable consumption on amore concrete footing and to identify approaches which might lead to a reorientation of the prevailing consumer lifestyle, a large scale project was commissioned by the Federal Environment Agency in Berlin ("Demonstrationsvorhaben zur Fundierung und Evaluierung nachhaltiger Konsummuster und Verhaltenstile"). This sustainable consumption project comprises four sub-projects. For one sub-project, the Institute of Social-Ecological Research (ISOE) carried out a "Household Exploration of Conditions, Opportunities and Limitations pertaining to Sustainable Consumer Behaviour". This aimed to provide empirical social research on the development of environmental strategies for differential target groups. The results of this research are briefly discussed below.

The project focuses on the key consumption categories of food, heating/energy, laundry and cleaning. Additional topics dealt with are housing and mobility, and the characteristics of household equipment (Empacher – Götz – Schultz, 2000A). In order to clarify the nature of the framework conditions surrounding consumption behaviour, general and environmentally relevant consumption trends are taken as a starting point. Five "mega trends" were seen to be of fundamental relevance with respect to their impact on the environment and on consumption behaviour:

- Population growth as a result of immigration (impact on type of goods available, distribution networks and the globalisation of consumption),
- Trend towards smaller households (strong increase in single households, need for residential space and equipment),

- Ageing of the population (growing expenditure on health, age related services and products),
- Increasing participation of women in the workforce (direct implication for the consumption of convenience foods and purchases of household appliances),
- Increasing polarisation (barriers to consumption through to greater differences in income, and differentiation on the consumer goods market).

Several general trends were found on comparing consumption expenditure and consumption behaviour patterns over the last 30 years. Total expenditure for an average household increased fivefold in this period, largely due to an absolute growth of consumption. As a result of falling prices over this period, the expenditure shares of food, drink, clothing and footwear all fell considerably. In addition, noticeable changes in consumption patterns for food also occurred (increase in the consumption of meat till the mid-1990s, increases in low-fat and low-sugar products, in environmentally friendly products and in frozen products). In contrast, expenditures on housing, energy, leisure, transport and telecommunications all increased. Transport expenditure in particular, was found to occupy a key position. Between 1960 and 1990 private car travel increased sixfold, and air traffic threefold. In the category of housing too, both the total area devoted to dwellings as well as the area per person increased considerably. Expenditure on health and personal hygiene only began to increase noticeably after about 1993. There has also been an increase in the use of electrical appliances such as washing machines, electric dryers, and dishwashers. Here, the improvements in energy efficiencies have been cancelled out by the increase in the number of units used.

The environmental behaviour of German households has been recorded since 1985[69] and can be summarised in six basic trends:

- The share of environmentally concerned consumers rose quickly up to 1990, fell slightly after that, and then began to climb again slowly after 1996.
- Environmental concerns are still an important factor in policies of product positioning.
- There is clear evidence from a comparison of the consumption behaviour of those interested in the environment and those who are not that environmental discussion and information provision have a marked effect on purchasing habits (e.g. purchases of detergent).
- The increase in the purchase of certain products, e.g. canned drinks, clearly shows that environmental education has its limits.

[69] The Society for Consumption, Distribution and Market Research collects data on 7,000 households in both the old (West) and new (East) federal states for its household panel.

- Population age structure results in a "cohort effect". The 45-50 year old age group exhibits the largest decrease in environmental concern.
- Household analysis shows that in the past few years there has been an increase in the proportion of households with children under six years of age among those displaying environmental concern.

Based on the above trends and the results of an empirical survey, ISOE derived the motives lying behind consumption behaviour and developed a typology of consumer lifestyles. "This facilitates typological collation of consumer orientations so as to make behaviour understandable and interpretable in terms of social setting" (translated from Empacher – Götz – Schultz, 2000A, p.22). The consumer groups thus identified serve as reference characteristics for the development of differential social and environmental strategies.

Interviews with 100 households were carried out concerning attitudes and consumer orientation. The households varied in terms of geography (urban/country), size, age structure, and socio-economic characteristics (occupation etc.). In addition, a standardised survey was employed to capture the main characteristics of household equipment and consumption behaviour70. Interview analysis led to the identification of 14 consumer model elements (consumer orientations) which determine real household consumption behaviour. These include household orientation towards such factors as convenience, quality, environment, health, price, status, material possessions, adventure etc.

Ten consumer styles and their related inhibiting and encouraging factors with respect to sustainable consumption were identified:

1. Fully-managed Eco-Families – These families are geared towards equality of family members and receptiveness to new things. Consumption is largely directed according to principles of health and environmental soundness, the desire to mould or diversify consumption activity conflicts with the desire to save time in family organisation, thus making car ownership indispensable. The families have a minimum of one child, both parents work, are mostly well-educated and enjoy relatively high income levels. This type of consumers is highly informed about the environmental impact of products and personal behaviour, environmental labels and sources of consumer advice are also well known and accepted. The largest impediment to further "greening" of consumption is the lack of time stemming from the double pressures of organising home and work life.
2. Childless Professionals – These singles or couples concentrate largely on their careers, are successful and enjoy a high income level. Consumption is oriented towards convenience and status/possession (high quality, exclusive hobbies, long distance travels). Concern for the

[70] Data collection focussed on the consumption of food, laundry/cleaning, heating and transport, and covered consumption scope (number of certain products) as well as consumption level (household income, holiday behaviour, price of certain goods).

environment is partly rejected out of unwillingness to accept what is regarded as "green lifestyle". The desire for high quality possessions can make energy saving devices and "ecological" services (laundry or delivery services) attractive for such consumers. Ideas such as "use don't buy", car sharing or recycled products are not acceptable. Knowledge of the environmental significance of consumption behaviour is high, as is knowledge of consumer advice centres, but this only plays a relatively minor role in purchasing decisions.

3. Self-interested Youngsters – This type of consumer is young (up to 25 years old), lives alone and has a low income. Price is therefore a key variable in purchase choice. There is almost no interest in environmental, social or political issues. Consumption is strongly oriented towards leisure and adventure, convenience and short-lived or fashion products. Consumer or environmental advice programmes make almost no impact on such consumers and they are not interested in practising a more conscious consumption lifestyle (paying more attention to environmental labels etc.).

4. Everyday Life-Creatives – Are young to middle aged consumers and can be found in all household sizes. They are mostly female, but also include men who work in occupations requiring a high amount of creativity or social skills. Such consumers exhibit a high degree of environmental awareness and also enjoyment in consumption. Health, ethical consumption, and social equality are all important issues. The orientation towards creating and shaping consumption means that ideas such as "use don't buy", exchange of goods and services, repair and maintenance as well as organic or locally produces food are all considered attractive. Such consumers are very well informed about the environmental relevance of products, and consumer advice is both well received and sought after. Inhibiting factors for more sustainable consumption are for example the small choice and high prices of organic food or Fair Trade products.

5. People fed up with Consumption – This comprises mainly middle aged men, who despite enjoying a relatively high income level, are often extremely displeased or annoyed about the general circumstances of life. Consumption is seen as an annoying chore. Cars are regarded as important and valuable items, other consumption goods have to be practical and moderately priced. Environmental and health concerns are completely absent. Consumer advice centres or other sources of information (e.g. quality labels) are regarded with suspicion, Socially or environmentally aware shopping is felt to be too much effort. Cost savings are likely to be the only possible incentive for more energy conscious behaviour. In order to reach such people at all, consumer advisors must primarily draw attention to their function as suppliers of consumer protection, strengthen their perceived competence and take steps to improve their credibility.

6. Rural Traditionals – This consumer group is comprised mainly of the older, more traditionally organised families with children. They are homeowners with an average level of education. Consumption behaviour is strongly oriented towards quality, possession and security. Car ownership is important. Environmental concern is shown mainly in decisions to purchase locally

produced goods of known origin (directly from farmers etc.). Higher prices are willingly paid in return for higher quality. The importance given to possession and high quality means that high durability and the repair and maintenance of products is quite welcome as well as energy saving renovation. Knowledge about the environmental impact of goods is not always given, but basic interest is generally present as is (sometimes) the willingness to become informed.

7. Underprivileged who can't cope – A low income, poorly educated group, exhibiting a traditional family division of labour, lack of competence in daily life and lack of social resources. Crucial determinants in purchase decisions are the need to save money and an orientation towards short-lived consumption. Lack of knowledge about both products and sources of relevant product information is an expression of the low level of general competence in daily life. Environmental issues are of no interest or are rejected as they are seen to be too much of a burden. Interest is expressed in strategies which can combine environmental friendliness with saving money. For cost considerations repair and the use of second-hand products are practised. Special offers are sought in an effort to compensate for frustrated consumption desires. Consumer advice centres are partly treated with suspicion, and partly accepted as "advisors to the poor".

8. Run-of-the-Mill Families – This consumer type is made up of families from all age groups with children, with average education levels, average income and partly traditional division of labour. Consumption behaviour is conservative and traditional and based on price. Environmental issues are not determining factors, but neither are they rejected. Cars, cleanliness/hygiene and child health are very important aspects. Their lifestyle is unspectacular, extremes are avoided. Moderate awareness of environmental concerns is present, but a certain amount of suspicion exists with respect to labels such as "biological" or "eco". Strategies involving energy or water savings are considered acceptable, as are repair services. Sources of information are mostly of a traditional nature (church, clubs and associations) and official consumer advice centres are hardly seen to be relevant.

9. Active Seniors – This group comprises mostly couples over 55 years of age, with average to above average education, average to above average income, and lots of free time. They are open to new ideas and like to travel. Consumption is oriented towards quality, health and relation to the local region or area. Such consumers are responsive to offers of high quality and organic goods. Repairs and customer service are seen to be part of their understanding of quality. The orientation towards travel and adventure interferes with other tendencies towards sustainable consumption. The level of knowledge concerning the environmental impact of products or types of behaviour is not very high. There is, however, a certain sense of openness and interest in becoming better informed. Consumer advice bodies have a good image but are rarely used.

10. Status-orientated privileged Families – This group is characterised by high levels of income, home ownership, traditional family organisation, very high level of consumption, and strong

integration in the respective social circles. Consumption is strongly oriented towards status and possessions, frequently expensive hobbies and long-distance trips are often undertaken. Characteristics such as status seeking and the importance of ownership, might be used to help induce a positive response to services and service-based product offerings, although in general, their consumption orientation tends to act as impediment in achieving more sustainable consumption. Such consumers are accustomed to using large amounts of resources and thus very much prefer to isolate themselves from environmentally friendly lifestyles and groups suggesting the adoption of an alternative lifestyle. The use of recycled goods, car sharing and the like, are not considered acceptable. Information on the environmental impact of products is only considered to be of interest as far as food and nutrition are concerned. Consumer advice bodies and other sources of information are not used.

As a result of the similar motives and orientation factors involved, the above ten categories can be condensed into four target groups (see Table 3.5).

Table 3.5: Summary Table of Target Groups

Target group 1: **Environmentally orientated People**	Target Group 2: **People who can't cope**	Target Group 3: **Traditional People**	Target Group 4: **Privileged People**
Fully managed eco-families Everyday life-creatives	Self-interested youngsters People fed up with consumption Underprivileged who can't cope	Rural traditionals Run-of-the-mill families Active seniors	Childless professionals Status-orientated privileged families

S: Empacher – Götz – Schultz, 2000.

Target group specific consumer advice strategies were developed on the basis of the summary target groups.

Target Group 1 –Environmentally orientated People

In principle, all strategies promoting sustainable consumption behaviour which are linked to environmental concern are worthy of consideration for target group 1 (the purchase of organic, biological, energy saving products, use of eco-efficient services and public transport, resource preservation and conservation measures at home etc.). Inhibiting factors are found to be family time constraints and to some extent price barriers.

Target Group 2 – People who can't cope

For target group 2 strategies involving second-hand goods, barter or exchange groups, and recycling are of special interest, since existing needs could thus be met economically. It is also important to try to raise the level of knowledge and competence of this group. This requires the use of informational material specifically designed for this target group, in order to overcome feelings of stress and to break through barriers resulting from poor education etc. A promising strategy would appear to be a combination of environmental behaviour with economy measures, or to use specific approaches in the media, such as programmes offering consumer advice, or the provision of consumer advice via telephone call centres.

Target Group 3 –Traditional People

Target group three could be easily motivated to buy more products from the local region, as such goods are associated with freshness and healthiness. There is a lack of knowledge concerning ethical issues of consumption, environmental labelling and organic food. Raising labelling credibility is therefore essential. Strategies involving the idea of "use don't buy" or car sharing are accepted and implemented by this group. Specialised informational material could be used to reinforce various strategies, such as the preparation of a guidebook containing useful addresses of relevant rental or repair companies.

Target Group 4 –Privileged People

Persons in target group 4 are primarily interested in strategies which are related to product durability (e.g. with respect to clothing or electric equipment). This derives from the desire for high quality and from the wishes of group members to shut themselves off from the consumption behaviour of other social groups. Eco-efficient services which are (coincidentally) environmentally beneficial(cleaning services, delivery service, repair service) are also of interest to this group. However, to be attractive, and since most things "eco" are viewed in a rather negative fashion, such offerings have to be couched in terms of their high quality, with environmental impact only being mentioned as a secondary additional benefit. While investing in energy saving technology and other such measures is easily affordable for this group, in order to increase motivation it is necessary to raise the group's awareness concerning the benefits of such investments.

In summary, the analysis of consumer behaviour reveals that not all potential measures aiming at a reorientation of consumption towards sustainability have been used up. One important conclusion of the project is that blanket policies are not likely to succeed. However, it proved possible to identify a whole range of environmental strategies targeted at specific groups which appear promising. The core result is that underlying motives in the various areas of consumer behaviour have to be targeted explicitly in policy design.

4. Modelling and Capturing of New Sustainable Consumption Patterns

For any economy, private household consumption expenditure represents the largest component in aggregate demand. In Austria the contribution of private consumption to GDP amounts to 57%. In view of consumption's economic importance, changes in consumption patterns are clearly of great significance for the attainment of sustainable development.

As in other industrialised countries, the level of consumption expenditure in Austria is already very high and continues to rise. This high level of consumption is marked by high resource use and a continuous increase in the number of chemical substances in the eco-sphere. It therefore appears urgently necessary to place a limit on substance flows by developing new patterns of consumption which are less material and product intensive and which allow for more environmental product innovation[71]. This was one of the reasons why the concept of sustainability was adopted as a guiding vision in international environmental policy at the Rio conference in 1992. In the meantime the process thus begun has also led to the EU Commission issuing a communication "A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development" (COM(2001)264 final). Austria has also presented national Strategy for sustainable development in early 2002.

In the following pages we first describe an important factor in sustainable consumption, the development of environmental awareness in Austria on the basis of data collected by GfK (the Association of Market Research). Following this, suitable consumption models are then developed which are to be used in econometric simulations. The purpose of the simulations is to examine the consequences of sustainable consumption for those consumption categories where a linkage of economic and technical data is possible. To do this, the traditional approaches, which are based on a purely economic calculus, need to be modified.

4.1 Development of Environmental Awareness in Austria on the Basis of GfK Household Panel Data

Environmentally conscious consumption behaviour depends on consumers being aware that every purchase decision has ramifications for issues of production and for issues of waste disposal. Further, the environmental consequences of the whole range of processes related to the purchase decision must be sufficiently clear to the consumer such that he/she is in a position to evaluate alternatives available. This knowledge also has to be combined with a willingness of the individual to contribute to the protection of the environment. The changes in behaviour resulting from all this

[71] This requires a learning process in society, based on developing individual responsibility and emotional ties to nature as well as feelings for the value of others (Meppem – Gill, 1998). Learning to communicate and co-operate are essential in attempts to improve the social and natural environment (Siebenhüner, 2000). See also Chapter 3 in the present report.

can be manifold. The spectrum ranges from simple willingness to spend more money for environmentally friendly products to more radical steps such as complete refusal to consume (Wenke, 1993).

The larger the potential for bandwagon effects, the greater the impact of environmental awareness on demand, i.e. households less interested in environmental issues may begin to copy the trends set by the environmentally conscious consumers.

Several studies have been carried out on the development of environmental awareness and the consequences for consumption behaviour. Between 1985 and 1995 a representative sample of some 2.800 households in Austria were surveyed by the GfK with respect to environmental attitude. This household panel supplies data on regular weekly purchases of a diverse number of goods. At the end of every year a special survey was conducted with panel participants on the topic of environmental awareness. This involved a questionnaire comprising 21 questions whereby participants could make their various environmental attitudes known on the basis of responses organised on a five point scale (1 – I disagree completely….5 – I agree completely). By means of cluster analysis the households were then classified in five types according to their attitudes towards environmental issues:

- Active greens
- Passive greens
- No opinion
- Disinterested
- Rejecters

The active greens comprise those who are actively engaged in protecting the environment, who react negatively to environmentally harmful products, and who, not least because of their good economic position, are also prepared and able to pay higher prices for environmentally friendly goods.

Passive greens are not actively engaged in protecting the environment, but are aware of the necessity for more environmentally friendly behaviour. However, they prefer to pass the responsibility for this on to official bodies or to industry.

The "no opinion" households mainly comprise older families, with low income levels, for whom the issue of the environment is almost completely irrelevant.

The disinterested includes those households which are not prepared to subordinate their economic concerns to those of the environment. Questions of environmental protection are sometimes perceived, but the issues are only of minor concern.

Rejecters are mostly families in a weak social position, whose main concern is self-protection and who are worried that too strong a commitment to environmental considerations would be a financial burden.

According to the data collected by the GfK, the proportion of the environmentally concerned (active and passive greens) rose from 46% in 1985 to 59% in 1990, and then fell to 54% in 1995. In the same period, the proportion of the core target group of environmentally concerned went from 20% to 31%, and then fell back to 24%, with a low point of 21% occurring in 1993.

According to GfK data, in some product groups considerable differences in purchase intensity can be found between environmentally aware households and other groups of consumers; this is true in terms of quantity and value purchased (Wüger, 1992). No general tendency is observable, however. Above and below average purchase intensities among the environmentally concerned vary according to specific product group. Thus, active greens buy 2% less universal washing detergents, and 17% more specialised detergents than the average Austrian household[72]. Greater environmental awareness does not always imply foregoing consumption, but rather a change in consumption patterns.

More recent data is not available for Austria, since owing to the lack of interest at the time, the Gfk survey was ended in 1996.

In Germany, the GfK has been carrying out surveys of environmental awareness since 1985. These studies are quite comparable to those in Austria and they provide results going beyond the year 1995. The surveys show that in Germany too, the proportion of environmentally concerned rose quickly up to 1990. A turning point then occurred, with the proportion falling slightly up to 1995. The year 1996 witnessed a further rise. According to a study commissioned by the Federal Environment Agency in 2000 (Kuckartz, 2000), it would appear that the downward trend in environmental awareness in Germany has come to an end.

According to a German study (Empacher – Götz – Schultz, 2000A), orientation towards the environment is an important factor in product positioning on the market. Environmentally concerned consumers purchase significantly less of those household products which are a topic of public discussion on the environment (e.g. fabric softeners, universal detergents, bathroom cleaners etc.). For some products (cereals, vinegar based cleaners, etc.) clear ups and downs in patterns of environmental awareness can be observed for the last few years. Regarding the purchasing behaviour of environmentally concerned and non-concerned consumers, for some products there has been a gradual move towards convergence over the years, i.e. differences in purchase patterns between the two have narrowed in favour of greater emphasis on environmentally friendly

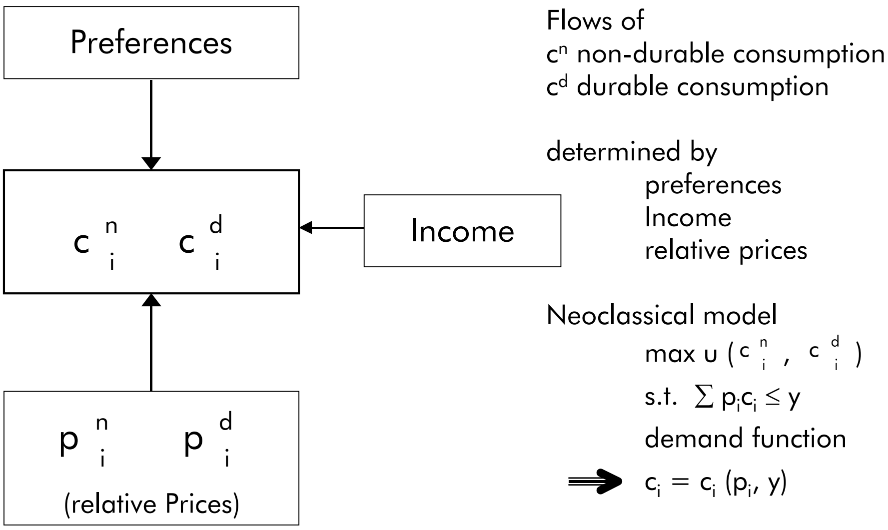
[72] In contrast, the rejectors spend 5% more than the average household on universal detergents, and 10% less on specialised detergents.

products[73]. While the study counts the discussion surrounding the use of fabric softeners as an environmental success story, it also points out that there are limits to environmental campaigns (e.g. the increasing use of cans in beer packaging), and emphasises the importance of strategies designed for specific target groups[74] in contributing to the attainment of sustainable consumption patterns.

4.2 Developing Suitable Consumption Models

There are many different explanatory models available dealing with consumer behaviour. The starting point for the mainstream economic approach is the notion of "homo economicus", an economic agent who, subject to certain constraints, strives to maximise utility, or what is the same thing, to minimise costs in order to attain a certain level of utility. As can be seen in Figure 4.1, on the basis of factors such as preferences, income, and relative prices, consumers demand flows of durable and non-durable goods[75].

Figure 4.1 Consumption Model of Mainstream Economics



[73] This might be due to the impact of bandwagon effects, with the result that in general environmental concern has become more visible and/or that more environmentally oriented supply has led to greater demand.

[74] The study identifies ten relevant consumer styles (see chapter 3 above) and the respective inhibiting and encouraging motivational factors for sustainable consumption.

[75] For a discussion on the advantages and disadvantages of this approach see for example Siebenhüner (2000) and the bibliography cited therein, and see also the comments in chapter 3 of the present study.

Particularly problematic, and therefore requiring modification[76], is the fixed relationship between goods consumed and the satisfaction of needs. The consumer demands specific features or services which can in fact be satisfied by various bundles of goods or technologies (the Lancaster approach[77]). In terms of nutrition for example, there is primarily a need to cover a certain calorie intake. This can be met by means of various bundles of goods which may be more or less healthy. In the category of heating, energy services are demanded which can be provided by various types of technologies (insulation, different heating systems, different types of fuels etc.), and these may result in more or less resource conservation, which ought to be of particular concern for environmentally aware consumers. In the category of transport there is a demand for mobility, which can be met through public or private (cars) means. Here, sustainable consumption patterns could lead to greater use of public transport, an extension of car sharing systems, and for those who must buy a car, they could be persuaded to purchase a fuel efficient vehicle instead of a "gas guzzler" (and thus display environmental concern rather than status or standard of living).

The purchase of a car (a decision relating to a stock variable) is in fact the acquisition of potential benefits and services which are to be consumed over the period of the vehicle's life. It also involves the determination of future utility to a certain extent since it is related to decisions on average vehicle fuel consumption, housing location, potential use of free time etc. The purchase decision also incurs further costs such as vehicle maintenance costs, tax and insurance costs, running costs etc. Thus, the purchase decision depends not only on the market price of the car but also to a large extent on the follow up costs incurred. For a given level of comfort, the price of fuel together with other relevant factors determines actual vehicle usage (kilometres driven). This illustrates that there is an interdependence of stocks and flows, of durable and non-durable goods, and that a broad or integrated perspective needs to be adopted to capture all aspects[78]. Journeys can be voluntarily foregone (e.g. out of concern for the environment) or substituted for by the use of other technological options (e.g. telebanking or telecommuting).

The acquisition of a consumption good is accompanied by potential environmental effects whose extent depends on the use of the good in question. This highlights the significance of consumption style in matters of environmental concern (Wenke, 1993). This becomes particularly evident in the case of household production. Just as age and structure of the capital stock influence environmental impacts, so too does economic activity in the home (e.g. processing of primary or semi-finished goods), in particular where technical skills are involved (Cogoy, 1999). In addition, in household

[76] As alternatives to the standard neoclassical approach, a good collection of models of individual behaviour is given in van den Bergh et al. (2000). Cogoy (1999) attempts to portray the consumer as a social and environmentally aware agent. For an overview of alternative models see chapter 3 of the present study.

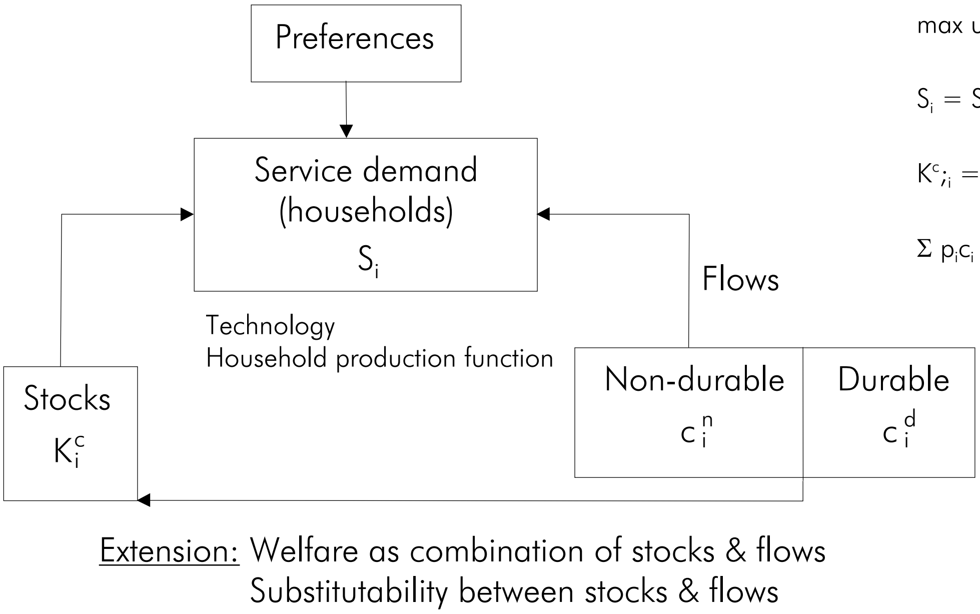
[77] This perspective was first emphasised by Lancaster (1971).

[78] This is made clear by the relationship between fuel consumption and car purchase. Consumption depends on the stock, the fixed technical component (litres used per 100km) and on variable factors such as maintenance or driving style, which may vary according to the level of environmental awareness present.

production there are several options available for substitution on the input side (substitution of time or labour for consumer goods).

How the various modifications and extensions (discussed above) of the mainstream economics model (Figure 4.1) can be used to move closer to sustainability is shown in Figure 4.2. Here the utility derived from household services is maximised subject to the constraints imposed (by preferences). The services are produced by means of capital, depreciated at an appropriate rate, and by means of consumption goods employing various technologies, with for instance, environmental and social concerns also being allowed to play a part (Cogoy, 1999, Siebenhüner, 2000). A further novelty of this approach, is the fact that welfare can be derived from stock as well as from flow variables, and the fact that stocks and flows can be substituted for each other.

Figure 4.2: Consumption Model: "Sustainability (1)": Extension of the Mainstream Model



$$\max u\,(S_i)$$

$$S_i = S_i\,(K^c{}_{;i},\ c^n{}_{;i})$$

$$K^c{}_{;i} = \delta * K^c{}_{;i;\,t-1} + c^d{}_{;i}$$

$$\Sigma\, p_i c_i \leq y$$

4.2.1 *Formal Presentation of Extended Consumption Models*

The modelling of consumption so as to allow for the simulation of sustainable consumer behaviour must – as already mentioned several times above – consider more than the incorporation of purely economic factors. Three suitable modelling approaches are presented below.

The first approach is that of Wenke (1993), which represents an attempt to integrate economic and sociological/psychological components. The second approach is based on the work of Conrad –

Schröder (1991), and portrays an integrated perspective on the demand for durable and non-durable goods. The stock-flow relationship is modelled separately and by taking costs instead of market prices into account it becomes possible to incorporate follow up costs into the decision making process. This approach can also be extended to capture demand shifts, for example, as might result from the adoption of sustainable consumption patterns. The third approach presents the household production function, derived originally by Becker (1965). Deaton –Muellbauer (1980) said of this approach: "*the household production approach is not merely a clever or elegant way for looking at household decisions but the only appropriate way.*"

4.2.1.1 The Wenke Approach

Economic analysis sees behaviour primarily as the result of constraints on human action. Pecuniary and non-pecuniary constraints are explained theoretically and operationalised. One step that appears particularly necessary, is the endogenisation of preference structures, since these are normally treated as exogenous. That changes in preferences can be integrated into a theoretical model of demand based on the neoclassical principle of utility maximisation is shown by Etzioni (1985). In this approach, apart from goods (X,Y), the optimisation rule includes the parameters (a, b) which are designed to capture the changes in consumer preferences. Thus:

(4.1) $\max_{a,b} U(X,Y;a,b)$

A further determinant of consumer behaviour is introduced into the optimisation procedure in the form of a so-called "emotive factor", (E). This establishes a link between changes in preferences and changes in demand, since the utility derived from a good (e.g. X), is influenced by the emotive factor (E). We then have:

(4.2) $X = X(E,I,P_x,P_y)$

(4.3) $E = E(a,b)$

with

I = income

P_x = price of good X

P_y = price of good Y

Apart from making use of the approach undertaken by Etzioni, Wenke also turns to models based on concepts of utility which have been extended to incorporate psychological factors. These are then used by Wenke to explain sustainable (i.e. environmental) consumption behaviour. Here, Wenke relies on the Antonides model which integrates economic and psychological aspects of consumption, and which depends on the separability of the combinations of goods demanded into their constituent elements. This procedure is chosen by Wenke on the grounds that "the psychological determinants of consumer behaviour are normally examined in connection with specific decisions being taken with respect to individual goods, where these merely differ in terms of a single definite characteristic (e.g. environmental friendliness)" (Wenke, 1993). Apart from product and household characteristics, the consumption decision also depends on the attitudes and expectations of the consumer (e.g. attitude towards sustainability). The part utility h_x thus becomes a function of the specific attitudinal parameters (A), giving

(4.4) $h_x = g(A)$

where attitudes and expectations are linear functions of "weighted stimuli", or they are represented by means of expressions of attitudes.

In this approach, then, utility in consumption is not solely determined on the basis of quantity of goods, but also by additional components, which are related to a certain behaviour, like sustainable consumption patterns. In this way, shifts in preference structures can be depicted.

Since it was not possible to break down the household decision making process on the basis of the data available, Wenke (1993) approximated the influence of the parameters a and b, and of the emotive factor E on demand behaviour via environmental awareness, UB, and arrived at an estimated macroeconomic consumption function of the form[79]:

(4.5) $C = C(UB,I,P)$

(4.6) $UB = UB(a,b,Z)$

with

C consumption expenditure

UB household environmental awareness

Z other determinants of environmental concern or sustainability

Wenke has used this consumption model to evaluate the macroeconomic effects of environmentally aware purchasing behaviour with respect to the demand for household chemicals. According to his empirically based model estimates for Germany, it can be assumed that market sales (in volume terms) of products containing household chemicals have fallen as the number of households declaring themselves in surveys to be environmentally concerned or aware has increased. To date, no comparable model estimates have been made available for Austria.

Wenke considers both his model and its application to macroeconomic questions to be nothing more than a trial run, since the problem of data adequacy in terms of the relationship between the "content" of the theoretical variables and the statistical material available was only partly resolved.

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[79] In a second approach Wenke modelled propensity to consume additionally as a function of environmental concern

4.2.1.2 The Conrad-Schröder Approach

The Conrad-Schröder approach takes a variable expenditure function e, as its starting point. This expresses the minimal expenditure on non-durable consumption goods as a function of a given level of utility (u), prevailing prices (p), and a (quasi-fixed) stock of durable consumer goods (z).

(4.7) $e = e(u,p,z)$

(4.8) $x = \delta e/\delta p$

(4.9) $\delta e/\delta z < 0$

In (4.8) the demand (x) is derived on the basis of the optimisation condition, taking into account that the purchase of high quality, durable consumption goods will lead to the reduction of expenditure on non-durable goods (4.9).

A distinction is made between the demand for durable consumer goods (cars, electrical appliances,…) and the services that such goods provide over their lifetime[82]. The optimal level of capital stock, which results when the shadow prices[83] correspond to actual prices, is derived on the basis of an intertemporal expenditure minimisation problem which takes adjustment costs into account.

In such a world, the consumer strives to minimise the present value of variable expenditures, expenditure on durable consumption goods, and also the adjustment costs arising from the fact that changes in levels of durable goods[84] are accompanied by changes in the standard of living. Account is also taken of the fact that the acquisition of durable consumer goods involves follow up costs (for example in car acquisition, these are fuel costs, repair and maintenance, insurance, taxes,….), and a distinction is made between fixed components (e.g. normal fuel consumption per km) and variable components (which depend on individual driving style, e.g. a tendency towards speeding or racing). In the Conrad-Schröder model the fixed components influence decision making via costs, and not via preferences, thus only the variable components are incorporated into the utility function.

The Conrad-Schröder approach uses an AIDS model (Almost Ideal Demand System) which pays particular attention to the interactions between durable and non-durable consumer goods. As already shown in the work of Alston et al. (2001), such models can be used to capture demand shifts, resulting for example from a move towards greater sustainability in consumption behaviour. Parsons (1986) applied such a model to explain the demand for specific housing characteristics.

[82]On purchasing a durable consumer good the consumer acquires a level of potential services that is to be consumed over the life time of the product.

[83]The shadow price indicates the savings made by raising the capital stock by one unit.

[84]Investment results from the adjustment of actual stock levels to optimal stock levels.

This indicates that the approach is quite capable of being extended to accommodate features beyond those purely related to costs.

Sustainable consumption ought to make itself felt not only with respect to stock decisions (e.g. the decision to use more fuel efficient vehicles) but also with respect to use behaviour. The Conrad – Schröder model[85]can be modified to accommodate sustainability in that various forms of stock are employed (e.g. improved housing insulation, more fuel efficient vehicles, improved public transport infrastructure,…) which exert an impact on the other areas of demand (stock-flow relationship). In addition, the model accounts for a direct impact of sustainability on the demand for non-durable consumption goods via the corresponding shifts in demand.

4.2.1.3 Household Production Functions

A very broad approach to the modelling of household behaviour is provided by the theory of the household production function (Becker, 1965, Lancaster, 1966). In this approach, it is assumed that households derive utility, not from goods demanded on the market but from commodities which the household itself produces through the employment of market goods and leisure time[86].

The theory of household production establishes a link between the theory of consumption and the theory of the firm (Roth, 1998). Decision making is seen to occur in two stages, with stocks and technologies playing important roles. Particular attention is devoted to the treatment of non-market activity, time, and the state of consumer knowledge (human capital). Modelling focuses specifically on the conversion of purchasable goods into so-called "commodities", which serve to provide utility and satisfy demands. While in traditional economic theory consumption analysis focuses on the demand for goods, in the theory of household production it is "commodities" which are demanded. These incorporate additional characteristics or benefits (comfort, entertainment, nourishment, etc.), and are produced subject to the prevailing consumption technology constraints, which are included in the household production function.

Utility (U) is maximised

(4.10) $U = U(Z_1, Z_2, \dots Z_n)$

[85] Conrad – Schröder use their model to capture environmental policy effects (tax increases, with or without refunds; elimination of fixed car taxes compensated by an increase in fuel taxes) and to show their impact on consumer welfare and on income distribution. This is made possible by starting from a cost function and by using data differentiated according to household type (for more detail see Kletzan et al., 2000).

[86] In this way Stigler – Becker (1977) can explain phenomena which are normally not subject to economic analysis or are simply attributed to changes in consumer tastes. For example preferences can be explained in terms of the accumulation of specialised human capital, habits in terms of the costs arising from non-habitual behaviour, and the influence of advertising and fashions in terms of a process of social transmission and emulation.

"Commodities" (Z_i) are produced by employing market goods (X_i) and time (t_i) under the environmental conditions (E), giving a household production function.

(4.11) $Z_i = Z_i (X_i, t_i \mid E)$

Various technical parameters are subsumed under E: stocks, human capital, household characteristics etc. Optimisation is subject to time and income constraints (proper full-time income is assumed).

This approach was used by Willet – Naghshpour (1987) in an attempt to explain the demand for energy, and by Bollino et al. (2000) to account for the impact of demographic factors in complete systems of demand (since the model allows preferences to be explained as a function of demographic variables). A further application was provided by Kutty (2000) who used the approach to depict "functionality". Functionality was defined as "the ease with which physical activity can be carried out", and was assumed by Kutty to be explicable in terms of education and genetic factors. Kutty also attempts to model shifts in tastes and in technology.

Different types of production functions may be used in the household production function approach since they enable greater flexibility. Types used include Cobb–Douglas production functions, Diewert cost functions and AIDS models.

4.2.2 Modifying Consumption Models to Include Sustainability

Based on the various approaches above we now derive a consumer demand model which incorporates elements of sustainability for the categories heating and transport, both significant in terms of their energy relevance. This encompasses the following adaptations:

- A consideration of stock-flow relations

The categories heating and transport (mobility) are characterised by a substitutive relationship between energy flows and capital stocks employed to produce the desired energy services (as emphasised by the household production function approach). In clear contrast to the neo-classical notion of a household production function, a model of sustainable consumption structures should not depict stock – flow relations merely as a result of changes in price. Decisions with respect to both stock levels and levels of demand for services are based on a multitude of economic and non-economic factors, and not on changes in relative prices alone. The nature of the infrastructure available, for instance, road networks, public transport systems, housing location characteristics etc., has a significant impact on the demand for energy services and energy flows. This leads to the substitution of technologies with specific inputs of capital and energy (public transport, private transport). In terms of the original work on household production functions, the only concept our study makes use of is the notion of the transformation of energy flows into services (thus moving attention away from flows towards services, these being seen as more relevant).

- Costs of adapting capital stock

Conrad – Schröder (1991) only deal with the stock-flow relations mentioned above in a narrow neoclassical sense, i.e. capital stock is optimised in strictly economic terms (cost minimisation). However, in modelling sustainable consumption structures a large number of possible adjustment costs in capital stock need to be taken into account. These include e.g. a move to more fuel efficient vehicles, the use of better thermal insulation technologies in construction and also effects on flow demand, e.g. through a change in driving style. At the same time, attention has to be paid to the connection between the processes of capital stock adjustment and the consumption of non-energy goods and services. The process of substituting capital for energy flows lowers the consumption of energy and has to be paid for by reducing consumption for non-energy goods. This implies that a more flexible approach than that adopted by Conrad – Schröder (1991) is needed.

- The incorporation of possible (exogenous) changes in preferences through demand shifts

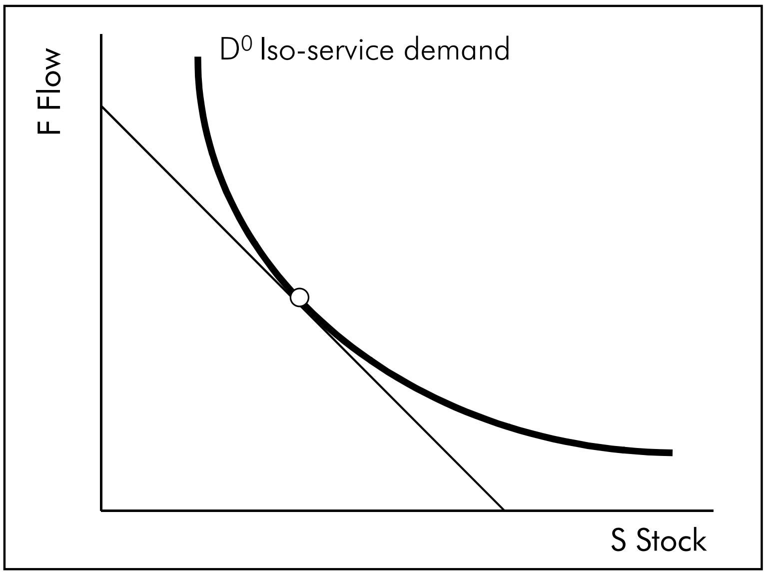
The development of sustainable consumption patterns may come about as the result of changes in preference structures, which lead to shifts in demand. In what he himself saw as a very rough approximation Wenke (1993) attempted to illustrate such demand shifts by incorporating an environmental awareness indicator in macroeconomic consumption functions. However, to facilitate the incorporation of demand shifts in consumption, the development of a separate module is called for. This requires either the development and implementation of special surveys, or the appropriate adaptation of existing methods in order to identify sustainable consumption lifestyles and to allow for their comparison with the more traditional ways of life. Shifts in the level of services demanded can also be taken account of via changes in aggregate variables (e.g. relative population densities).

In terms of extending conventional modelling approaches to allow for appropriate accommodation of sustainable consumption patterns, three distinct stages can be pointed out.

4.2.2.1 Neoclassical Stock-Flow Relationships

The first stage of model extension involves the consideration of stock-flow relationships. The emphasis here is on the possibility of substituting flows (energy and other raw materials) by an increase in capital stock. See Figure 4.3. In order to meet a certain desired level of transport services (e.g. passenger km per year) a consumer will have to decide which type of car, at what rate of fuel efficiency should be chosen. This decision making process is governed by the relative prices of stocks and flows. Thus, for a given price ratio (represented by the tangent to the curve in Figure 4.3) a specific input mix will be chosen. This simple relationship can be considerably extended and made far more flexible (as in Conrad – Schröder, 1991). However, in terms of decisions on the consumption of durable and non-durable goods, the relative market prices remain the determining factors, and thus become the only means available for any attempt aiming to produce a reorientation in consumption behaviour towards more sustainability.

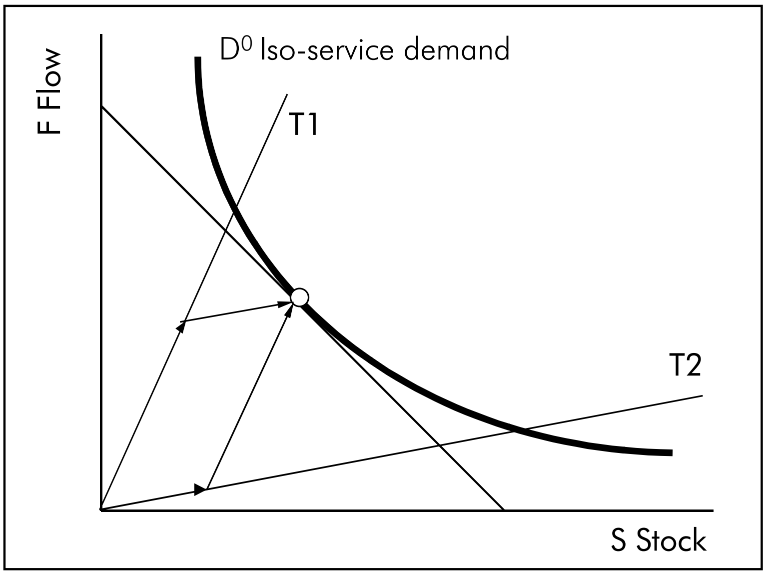
Figure 4.3: Neoclassical Stock-Flow Relationships



4.2.2.2 Flexible Stock-Flow Relationships and Consumption Technologies

The next step in extending the model lies in dealing explicitly with the choice of input mix and its relationship to various stocks (infrastructure) and the types of technology incorporated within them. Expenditure on certain types of stock, which may not be induced by individual consumer decisions (e.g. public transport infrastructure, bicycle infrastructure etc.) may impact on efficiency (measured in terms of expenditure on stocks per unit of service). As seen in Figure 4.4, various levels of stocks in combination with the respective flows represent different technologies (T1, T2) which can be used to consume identical levels of services. Taking transport as an example, we can see that for a desired level of service (demand for mobility) a choice is made between the various possible consumption technologies, (e.g. the mix of public and private transport). The rays depicting technologies show the respective stock-flow relations and their slope may be influenced by market prices, as in the neoclassical model, or by other factors, such as infrastructure availability, life style, spatial planning etc. A central aspect of this approach is the part played by induced technological change, which again may depend on infrastructure, life style, planning, and other factors subject to the influence of public policy. This includes infrastructure in its broadest sense, e.g. the design and acceptance of local transport systems, or transport regulations dealing with car-free zones, car-sharing, research programmes etc.

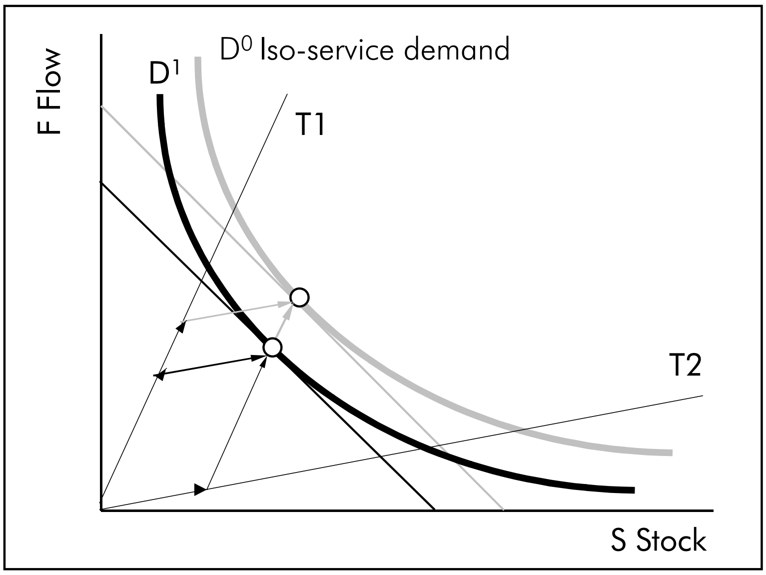
Figure 4.4: Flexible Stock-Flow Relationships and Consumption Technologies



4.2.2.3 Demand Shifts and Consumption Services

The last step in attempting to extend the model, is based on the fact that the level of consumer demand for services is not fixed. A shift in the iso-service curve as depicted in Figure 4.5, could be seen as an improvement in technology. In principle such a shift might arise as a result of a change in any of the underlying parameters deemed to exert an impact on the demand for services. This could again involve changes in market prices, or in any of the infrastructural factors mentioned in section 4.2.2.2 above. Of particular interest are those shifts in demand which do not involve higher cost levels and which therefore do not reduce levels of consumer welfare. This leads us to the idea of redundancy in service demand, i.e. there may be redundant elements in the demand for services which become visible after background conditions change. In conventional models, with respect to the highest level of demand flows actually manifest, such changes are represented in the form of shifts in tastes. For example, in terms of mobility, this would mean that changes in background policy conditions, perhaps influenced by spatial planning considerations, could lead to a reduction in the desire for mobility with no loss of economic welfare (since the policy change helps eliminate the redundant "excess" demand by creating conditions under which the initial higher level of mobility is no longer felt to be necessary).

Figure 4.5: Demand Shifts and Consumption Services



4.3 Empirical Application of Sustainable Consumption Models

4.3.1 Developments in Expenditures on Heating and Transport

The purpose of the empirical analysis is to develop a model of private consumption with which it will be possible to simulate the impact of various sustainable development policy measures. Sustainable consumption entails changes in production processes and in resource use and also influences well-being and the levels of emissions and waste. Therefore, a disaggregated consumption model needs to be sought which provides linkages to the environmentally significant data sets in consumption and the related physical flows.

Linking economic data with technical data is feasible in the categories of heating and transport. In this way, it becomes possible to depict the service components and material flows which lie behind demand. It is for these reasons that these two areas were made the focus of attention in the present study on the empirical analysis of sustainable consumption. Both sectors can be reasonably portrayed in terms of stocks and flows (e.g. vehicle stocks – fuel demand; housing stock – energy demand), and the demand for material flows occurring in activities which are of environmental significance can be represented as the result of specific "technologies" which households employ in an attempt to satisfy their demand for goods and services.

In the category "heating", it is possible to represent the necessary material flow (energy input and the related CO_2 emissions) as the result of a household production process which combines inputs of capital with a certain type of technology. The capital stock is calculated on the basis of national accounting figures for housing construction using the "perpetual inventory" method. Further data is also taken into consideration which allows total housing investment to be divided into "new construction" and "renovation". Housing statistics enable calculation of the total floor space which needs to be heated, and this figure serves as an indicator of required or expected energy services. This assumes that for a given floor area, households demand a room temperature which offers a certain level of comfort. The figure for total floor space is arrived at by multiplying average floor space by the cumulative figure for housing stock. Three different housing categories are distinguished based on year of construction (pre-1945, 1945-1980, post 1980). The different quality levels of the capital stock used (buildings erected in different periods, renovated/non-renovated buildings) are taken to represent differences in technology, and are measured in terms of necessary (minimal) energy input per unit of area. Relevant figures are available to WIFO for multi-storey dwellings and for one-family houses.

For the category "transport", official statistics contain highly detailed information on vehicle fleets, and this is split up on the basis of various vehicle and fuel consumption characteristics. A major additional data source, to which WIFO has access, is the database used for modelling transport at the Technical University, Graz. This data set records information on the stock of infrastructure capital, classified in terms of "individual" and "public" distances travelled on the primary road network, the railway system and on public transport networks. For the assessment of energy service levels, information is available on passenger kilometres travelled for the respective transport modes, for car traffic additional data on car kilometres is available, and for public transport (part) information is available on numbers of passengers conveyed. The average fuel consumption of the car fleet can be calculated on the basis of kilometres travelled and total fuel consumption figures.

To explain the demand for energy services, aggregate economic data such as household disposable income (taken from the national accounts) and total population figures are used, as are regional population statistics. The latter were calculated by interpolating county population data for the years between national census counts on the assumption of fixed elasticities for growth in federal state populations and growth in county populations. The time series data already available for federal state populations was used to construct time series population data for counties for the period 1971 to 2001.

The following trends in energy consumption in Austria can be identified. Between the reference years 1990 and 1998, total final energy consumption (excluding fuels), rose by 1.5% per annum on average. Energy consumption for private households (excluding fuels), which in 1998 made up 36% of total energy consumption, rose by 1.4% on average in the same time period. The slight decline in the category of heating was clearly offset by increasing use in other areas of energy consumption. This is particularly true for electrical appliances. Dishwashers, washing machines and fridges have all become more energy efficient. However, this has been more than cancelled out by the so-called rebound effect, i.e. an increase in the absolute level of existing equipment together with an increase in the types of equipment used (computers, second TVs, more telecommunications devices). In this segment of the market, it appears particularly difficult to convey to consumers information on alternative (energy saving) consumption habits (Empacher – Götz – Schultz, 2000A). It will become increasingly important in future to offer appliances which contains integrated or automatic energy saving functions (e.g. stand-by functions for a computer) or to introduce energy saving devices on the market which are simple and easy to use.

Private car use is a crucial indicator of consumption, and individual motorised transport is by far the most significant means available for achieving mobility. Over the course of time, total distances travelled have increased dramatically, largely as a result of the rise in the number of vehicles on the road (individual vehicle mileage is declining). As a general rule, increasing wealth leads to the purchase of larger and more powerful vehicles. At the same time, there has been a considerable increase in engine efficiency[80]. Air traffic has also increased rapidly in recent years. The final energy consumption of fuels rose by an average of 2% per annum between 1990 and 1998. This was far greater than total final energy consumption, or final energy consumption for households (excluding fuels).

Changing individual transport behaviour counts as one of the most difficult problems for environmental policy, not merely because of the economic factors involved (e.g. commuter traffic) but also because of the deeply personal aspects involved, which may end in irrational forms of individual or social action (e.g. in some cases cars may achieve the status of sacred objects). However, some policies have proved successful in containing the advance of motorised private transport and in advancing the causes of public transport and bicycle travel, and thus indicate that changing consumer behaviour may not be as difficult as it appears at first sight. This is also evident from the figures for trends in kilometres travelled by vehicle type for the 1990s. Here, total distances travelled between 1990 and 1998 rose from 93.2 bn km to 98.9 bn km, with the share of individual traffic (car, motorbike, moped km) falling from 68.5% to 64.4%.

A major challenge appears to be motorised traffic, particular within large cities, since this can be a significant impediment with respect to the quality of life. Car sharing agencies appear to offer a partial solution[88]. However, it will also prove necessary to develop more specific targeting methods, in order to achieve greater harmony between the desires of the individual for private transport and the needs of the community at large (City Mobile).

Table 4.1 and 4.2 clarify the significance of the sectors housing and heating, and transport. Their importance both in absolute levels, and in terms of their share of total consumption expenditures in the national accounts is clearly visible. At present, Austrians spend about € 22.8 bn for housing and

[80] According to German surveys (Empacher – Götz – Schultz, 2000A) average fuel consumption per 100 km was about 10,2 litres in 1978 and fell to 8,8 litres in 1997 (a reduction by 14%).

[88] On the potential of car-sharing see Prettenthaler – Steininger (1999).

heating, and about € 13.8 bn for transport, 20% and 12% of total consumption expenditure respectively.

Table 4.1: Value and pattern of the private consumer expenditure for housing, water and energy

Current prices

	1996		1997		1998		1999		2000	
	Million €	Percentage shares	Million €	Percentage shares	Million €	Percentage shares	Million €	Percentage shares	Million €	Percentage shares
Actual rent (excluding running costs)	2,044	10.3	2,255	10.9	2,263	10.8	2,296	10.6	2,392	10.5
Imputed rent (excluding running costs)	7,485	37.8	7,937	38.4	8,114	38.8	8,512	39.1	8,887	39.1
Products for the regular maintenance and repair of the dwelling	407	2.1	394	1.9	400	1.9	426	2.0	443	1.9
Services for the regular maintenance and repair of the dwelling	847	4.3	849	4.1	854	4.1	908	4.2	955	4.2
Water supply and other services for the dwelling	5,174	26.1	5,307	25.7	5,417	25.9	5,703	26.2	5,953	26.2
Electricity	1,880	9.5	1,883	9.1	1,889	9.0	1,910	8.8	1,982	8.7
Gas	450	2.3	490	2.4	480	2.3	492	2.3	513	2.3
Liquid fuels (excluding motor fuels)	598	3.0	632	3.1	518	2.5	516	2.4	652	2.9
Coke	86	0.4	78	0.4	49	0.2	56	0.3	46	0.2
Coal	65	0.3	59	0.3	36	0.2	40	0.2	38	0.2
Biomass	285	1.4	286	1.4	403	1.9	403	1.9	407	1.8
District heating	489	2.5	498	2.4	490	2.3	495	2.3	481	2.1
Total	*19,810*	*100.0*	*20,669*	*100.0*	*20,914*	*100.0*	*21,756*	*100.0*	*22,748*	*100.0*

Source: Statistics Austria.

Apart from the national account figures, there are several other consumer surveys which provide information on Austrian spending patterns. Consumer data are based on cross-sectional surveys which have been carried out in Austria every 5 to 10 years by Statistics Austria. The purpose was to devise a weighting scheme for the consumer price index so that consumption behaviour could not only be collected in detail, but also be depicted in terms of demographic and socio-economic characteristics. The last survey was carried out in 1999/2000 and covered 7.098 households in Austria. Survey samples were taken over a whole year, and dealt not only with standard questions of consumption expenditure, income, household equipment etc., but also with questions of social circumstances, and for the first time, environmental awareness.

Table 4.2: Value and pattern of the private consumer expenditure for transport

Current prices

	1996		1997		1998		1999		2000	
	Million €	Percentage shares	Million €	Percentage shares	Million €	Percentage shares	Million €	Percentage shares	Million €	Percentage shares
Passenger cars	4,229	35.0	3,793	31.6	3,833	31.0	4,400	33.3	4,319	31.4
Passenger car-operatingleasing	268	2.2	275	2.3	297	2.4	323	2.4	343	2.5
Motorcycles, mopeds	200	1.7	212	1.8	269	2.2	292	2.2	258	1.9
Bicycles	127	1.1	127	1.1	134	1.1	158	1.2	182	1.3
Replacement parts and fittings for private vehicles	256	2.1	263	2.2	270	2.2	296	2.2	302	2.2
Fuels and grease for private vehicles	2,105	17.4	2,118	17.6	2,108	17.1	2,132	16.1	2,511	18.2
Maintenance, repair of passenger cars	2,751	22.8	2,888	24.0	2,873	23.3	2,884	21.8	2,972	21.6
Maintenance, repair of motorcycles and mopeds	163	1.3	175	1.5	191	1.5	208	1.6	223	1.6
Car park, garage	67	0.6	72	0.6	71	0.6	73	0.6	77	0.6
Charges for bridges, tunnels, motorways	93	0.8	159	1.3	165	1.3	163	1.2	174	1.3
Services of driving schools	126	1.0	130	1.1	147	1.2	163	1.2	176	1.3
Passenger transport by rail traffic	310	2.6	325	2.7	377	3.1	386	2.9	404	2.9
Tram, trolley bus	262	2.2	274	2.3	275	2.2	304	2.3	305	2.2
Taxi and rented cars	263	2.2	267	2.2	260	2.1	266	2.0	271	2.0
Bus	192	1.6	202	1.7	210	1.7	241	1.8	229	1.7
Passenger transport in the air	595	4.9	661	5.5	784	6.3	846	6.4	940	6.8
Passenger transport on the waterways	11	0.1	12	0.1	12	0.1	14	0.1	15	0.1
Freight transport on the road	53	0.4	56	0.5	64	0.5	67	0.5	70	0.5
Freight handling	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0
Total	*12,075*	*100.0*	*12,015*	*100.0*	*12,347*	*100.0*	*13,220*	*100.0*	*13,776*	*100.0*

Source: Statistics Austria.

4.3.2 Model Results for the Consumer Survey 1999/2000

The model needs to depict price effects in combination with diverse constraints and conditions. Particular attention is to be paid to stock-flow relationships and to shifts in demand arising from the adoption of sustainable consumption patterns. These demand shifts are to be captured by employing data from the 1999/2000 consumer survey and integrating this in the time series model of consumption (based on figures from the national accounts).

In integrating the concept of sustainability into empirical models of consumption, the economic, environmental and social aspects of sustainability all need to be considered. The economic side can be captured by using household income data from the consumption survey, the environmental aspect is reflected by means of the statements made by specifically chosen consumer groups with regard to environmental actions, the social aspects through e.g. statements concerning relevant donation activity. Survey data can also be used to provide information on household types of particular interest, for example by identifying various groups on the basis of their consumption sustainability, e.g. "exemplary households", might be taken as those exhibiting below average expenditure on energy per square meter, above average investment in energy saving devices, and above average use of public transport, etc.

An important component of sustainability is environmental awareness. Micro-studies have repeatedly shown that consumer statements and consumer actions with respect to the environment diverge considerably (see for example Wenke 1993, and the literature referred to therein). A rough estimation concerning differences in behaviour between environmentally aware and environmentally unaware/indifferent groups can be obtained by combining the results of the 1994 environmental micro-census and those of the 1993/94 consumer survey. The process of statistical matching necessary for combining such data sets is, however, subject to certain limitations, since differences in consumer behaviour stemming from different levels of income can only be captured indirectly via other characteristics such as sex, age, occupation, education, etc. (for more on this see Kletzan et al., 2000).

The results show that environmentally concerned households spend relatively less on heating and transport activities, i.e. those categories upon which our study focuses, and that the environmentally indifferent or unconcerned spend relatively more. For environmentally aware households purchase intensity in these consumption areas is lower than that for consumption activity overall, for the environmentally unconcerned, it is higher.

The results of the consumer survey for 1999/2000 should provide the basis for a more sound analysis. Apart from detailed questions on income and consumption expenditure, questions were asked concerning socio-economic and demographic factors, and environmental awareness[89]. By asking households whether they react to the environmental friendliness of a product (e.g. eco-labelling etc.) when making purchasing decisions, a better estimation of the impact of environmental concern on purchase decisions should be obtained and thus help alleviate the problems of data adequacy.

Based on the data set of the 1999/2000 consumer survey econometric functions are to be used to depict shifts in preferences between environmentally concerned and non-concerned households and related demand shifts. In particular, the connection between preferences and numerous economic

[89] Households are asked whether they take any notice of the environmental friendliness of certain products such as food, cleaning materials, paints and varnishes, electrical equipment and furniture when making purchasing decisions.

variables needs to be clarified and depicted (e.g. the effect of income level, age group, household size and composition, and of regional factors such as population density).

In general, preferences can be expressed in terms of income elasticity. The higher the income elasticity for a particular consumer good, the greater the impact of a rise in income on demand. Elasticity figures need to be derived econometrically, whereby all essential factors need to be considered. Apart from the factors already mentioned above, dwelling size and vehicle size (measured in terms of vehicle tax[90]) were also used in deriving elasticity figures for heating and transport expenditures respectively.

Demand shifts can be captured by standardising expenditure data. This entails estimating econometric functions for environmentally concerned and non-concerned households and calculating what they spend on heating[91] and transport[92] given equal income, household composition and regional origin[93]. As the two types of households can mainly be distinguished according to their concern for the environment, the differences in expenditure derived from the statistical analysis can thus be interpreted as being the result of demand shifts occurring on the basis of such environmental concern.

However, the calculations are impaired by the fact that at a disaggregated level, estimations of heating and lighting expenditure can only be carried out subject to certain restrictions, since survey data has to cope with various time scales, including both monthly and bi-monthly payments for energy, as well as annual fuel bills (Kletzan – Köppl, 2001). Similar difficulties apply to expenditure for public transport (annual travel passes) and vehicle purchases[94]. For the latter, survey questions focussed on the period of the previous twelve months.

With respect to heating expenditure, the results obtained from the econometric estimates reveal a figure for income elasticity of 0.25 for environmentally concerned households. This is less than half that obtained for non-concerned households (0.55), and indicates the presence of clear differences in preferences. For environmentally concerned households, income elasticity was also found to be lower for private transport (fuel expenditure), and higher for public transport. These results provide evidence of more sustainable consumption patterns in the case of environmentally concerned households. It was not possible to obtain meaningful estimates of income elasticities for vehicle

[90] It was necessary to estimate a large number of equations here since the number of determinants had to be varied successively in order to overcome problems of multicollinearity, different econometric specifications had to be tested to check various elasticities, and a variety of aggregation procedures had to be undertaken in order to alleviate deficiencies in the existing survey data.

[91] Dwelling size is also considered here as a determinant of heating expenditure.

[92] Motor capacity measured in terms of vehicle tax bracket is also used here in explaining transport expenditure.

[93] Average Figures for all households were taken as reference values for the exogenous variables such as income, age, etc.

[94] Purchase data had to be converted into corresponding monthly Figures, not always a satisfactory procedure.

purchasing behaviour, on the one hand owing to the above mentioned difficulties of matching data sets, and on the other, as a result of a certain amount of consumer irrationality in this area.

Demand shifts between environmentally concerned and non-concerned households can then be determined by standardisation of expenditure data as explained above. The results show that compared with the non-concerned households, and under otherwise equal conditions, environmentally concerned households spend 7.5%[95] and 13.5%[96] less on heating/lighting, 6% and 13% less on fuel, and 5% more on public transport.

As only a very small number of households provided information on their donation activities, it was not possible to capture the social aspects of sustainability in these terms. As the calculations were not able to capture all the aspects of sustainability previously mentioned above, an alternative attempt was made to define sustainability in terms of those households exhibiting "exemplary behaviour". These are households which, after taking account of housing density, dwelling size and year of construction, in terms of income and/or total consumption spend relatively little on energy, and which after taking account of purchase intensity (measured in terms of vehicle tax) and housing density, spend relatively little on fuel. To this end, taking account of housing density, dwelling size (year of construction), and consumption intensity, households were ordered in terms of relative expenditure (measured as a proportion of total consumption and/or income) in the consumer sectors relevant for this study, i.e. heating/lighting, fuel, public transport. When ranked in ascending order in terms of relative expenditure on heating/lighting, and in descending order in terms of fuel expenditure the "more sustainable" households are deemed to be those found in the first 50%[97]. Once again, demand shifts are determined by standardising expenditure data as explained above. The results show that the more sustainable households spend only 40% of the amount spent by other households on heating and lighting, and about 45% of the amount spent on fuel. In contrast, the amount spent by the less sustainable households on public transport corresponds to only 20% of the amount spent by the more sustainable households. The analysis indicates that in order to achieve a 20% reduction in fuel expenditure, it would be necessary for the proportion of more sustainable households to rise to 76%.

Assuming that the demand shifts derived on the basis of the consumer surveys are valid over the long term, they can then be transferred to the time series models. This is likely to be the case when consumer survey data are taken to reflect (more or less) a situation of equilibrium. This is a normal assumption underlying cross-sectional and longitudinal surveys[98].

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[95] When environmental concern is measured in terms of the average for all consumer groups.

[96] When environmental concern is measured solely in terms of purchases of large items of household equipment.

[97] There are 2 basic reasons for this division: First, the share of environmentally concerned households is roughly of this size; second, for technical reasons inherent in estimation procedures, i.e. equal population sizes are thus available which is a help in estimating the required consumption functions.

[98] The requisite ceteris paribus condition of constant prices is satisfied in the consumer survey. In addition , in estimating the demand shifts proxy variables for capital stock (e.g. engine capacity) were used.

4.3.3 General Model for Sustainable Private Consumption

In the following section the overall model for private consumption is presented. This model, in which demand shifts are to be integrated, is based on time series data (see section 4.3.1). Consumption data for the overall model largely derives from national accounting figures. The data is complemented by information from energy statistics, from the transport databank at the Technical University in Graz, and from other relevant sources.

Drawing on the various model approaches described above, it would appear that all models of sustainable consumption used in analysing energy patterns in heating and transport, must include the following two points:

- Taking account of stock-flow relations
- Feedbacks from adjustments in capital stock to energy and/or non-energy consumption

The first point, stock-flow relations, serves to emphasise that a relation of substitutability must prevail between energy flows and real capital with respect to the relevant energy services. The second point implies that a substitution of energy flows by capital will lead on the one hand to a fall in energy consumption in the mid-term, but on the other hand to a short term decrease of consumption in the non-energy sector. This relationship is depicted consistently in the simultaneous model described in Conrad-Schröder (1991).

In section 4.2, three graphs were depicted to show how the demand for energy services and their "production" can be altered by the use of energy and capital in such a way that a move towards more sustainable structures is produced. In the case where energy services are narrowly defined only capital (in the form of better building insulation) can be substituted for energy (heating) (see Figure 4.3). In the purely neoclassical model this is given by the tangent of the price line (capital/energy) on the "iso-service curve". In a broader and more flexible version of this model, capital stock may be influenced by factors external to private consumption and prices and thus merely have an impact on energy use. In cases where the "production" of energy services in household demand (mobility measured in passenger km) is rather broadly defined it is possible to formulate a model in which technologies involving specific levels of capital and energy use (public and private transport) become substitutes for each other (see Figure 4.4). Energy use is determined by both the procedures necessary in the "production" of energy services as well as by the level of energy services demanded. Factors which induce a shift in the level of demand for energy services are thus also of interest there (see Figure 4.5).

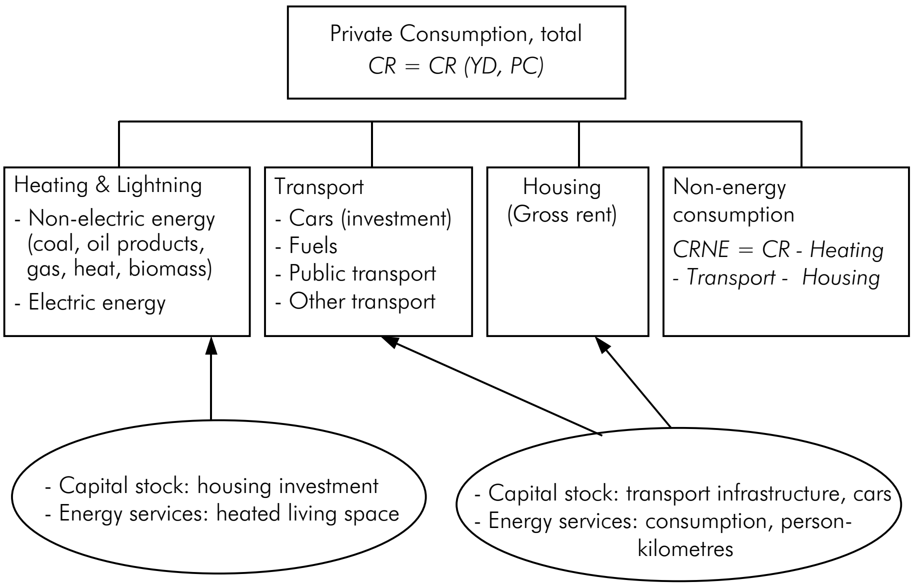
The dynamics of energy efficiency are determined by developments in technology. In this respect, the present model takes as a starting point the concept of embodied technical change, i.e. substitution of energy by capital is here equivalent to an increase in energy efficiency based on the application of more capital stock input.

On the basis of the above considerations, it proved possible to construct a model for analysing consumption activities in the categories heating and transport which could be integrated into the overall model for private consumption. Total real private consumption is first treated as a function of real household disposable income, with YD as nominal income and PC as total consumption deflator:

(4.12) $\Delta\ln(CR) = CR\ \{\Delta\ln(YD/PC), ECM\}$

A dynamic specification with error correction mechanism (ECM) was chosen.

Figure 4.6 Overall Consumption Model



CR ….. private consumption, total
YD ….. household disposable income (nominal)
PC ….. price index for private consumption, total
CRNE .private consumption, non-energy

As a first step total private consumption was split up into the following categories (see Figure 4.6):

- Housing
- Heating/lighting
- Transport
- Non-energy consumption

It is assumed that no substitution takes place between these categories. For any given levels of total consumption, and given levels of expenditure for housing, heating/lighting and transport, non-energy consumption is treated as a residual element.

The introduction of the relevant capital stocks must be accompanied by the formation of linkages to the respective consumption activities. For example, the variable real housing stock was chosen in the case of heating. The consumption category "housing" was then linked to this stock variable to provide a connection to private consumption. The corresponding variable for transport is vehicle stock or vehicle fleet. This arrangement means that for the above variables, the substitution of energy flows by "units" of capital can only be achieved at the expense of short-term non-energy consumption. In this respect, however, there is no direct linkage for transport infrastructure capital (roads, public transport networks). This could to some extent be achieved by the adoption of a public sector budget constraint, such that higher investment in transport infrastructure might partly be financed by reductions in disposable income (e.g. through extra taxation or cuts in other areas of public spending), and would thus impact on non-energy spending. As a first step, however, it would appear sufficient merely to describe the extra costs resulting from higher transport infrastructure expenditure without giving any consideration to the feedback effect on consumption. This would then show to what extent an increase in private welfare, as a result of transport infrastructure expenditure, occurs at the expense of public financing.

Several theoretical approaches were presented in section 4.2.1, all of which allow for the integration of elements needed in sustainable consumption structures. However, the majority of the studies referred to still retain the rather restrictive corset of neoclassical consumption theory. The theoretical background chosen here for the empirical application of the model on heating and transport was that of the household production function. It is assumed here that a certain level of energy services is "produced" with capital and energy or with capital/energy technologies. The demand for energy services is modelled separately, securing the integration of demand shifts within the household (via results of consumer surveys).

A CES-production function was chosen to describe the "production" of energy services. Thus:

$$(4.13) \quad SE_t = \left(d_E EN^{(\sigma_E - 1)/\sigma_E} + d_K K^{(\sigma_E - 1)/\sigma_E}\right)^{\frac{\sigma_E}{\sigma_E - 1}}$$

where EN represents energy flows, K is capital input, d_E and d_K are the respective factor shares in the production of energy services and σ_E is the elasticity of substitution. In this case energy flows are made up of market demand for goods, energy services, which are in fact the real source of utility, and household capital stock inputs. The strictly neo-classical approach of the household production function (Willett – Naghspour, 1987) combines (4.13) with an equation to explain the factor K. In our case the equation describes capital accumulation. We thus have:

$$(4.14) \quad K_t = K_{t-1} + I_t - \delta K_{t-1}$$

where I_t represents gross fixed capital formation and δ is the rate of depreciation. In addition, a household budget constraint is introduced which makes income Y equivalent to total expenditure plus savings. If at the same time K represents the total relevant stock of capital and assuming that in equilibrium the savings investment identity is valid (I = S), we then have a system of equations from which it is possible to derive the "optimal" demand for market goods. This also includes the "optimal" level of demand for capital goods, given that an additional unit of capital provides utility in the form of lower energy expenditures, with respect to market prices for capital (and analogous to the concept of a shadow price for capital), all this being discounted over the life of the capital goods.

In our case, as a result of embedding heating and transport in the overall model of private consumption (see Figure 4.6) the budget constraint is removed and K does not represent the total capital stock in the economy. In addition to this, the cost benefits of the variable factor (energy), discounted over their lifetime, do not determine the demand for capital. This depends on other economic factors. Nevertheless, in analogy to the household production function model, a system of simultaneous equations is produced comprising a production function and an equation describing capital stock accumulation.

The demand for market goods EN can thus be derived directly from the CES function and combined with the equation for capital. In the pure neo-classical model this would produce the following input demand function for energy flows:

(4.15) $$\frac{EN_t}{K_t} = \left(\frac{d_E p_K}{d_K p_{EN}}\right)^{\sigma_E}$$

where p_K and p_{EN} are factor prices. Demand thus depends on relative prices and on the capital stock.

We are assuming here that capital is a quasi fixed factor and that in general the substitutability between K/SE and EN/SE as depicted in Figure 4.3, is given. This allows us to derive the following equation for the input demand for energy goods:

(4.16) $$\frac{EN_t}{K_t} = \left(\frac{d_E (SE_t/K_t)}{d_K p_{EN}}\right)^{\sigma_E}$$

In the case of transport, the equation incorporates the relation between both capital stocks (public and private transport), the relative price of both types of transport, plus population density, this latter serving as a general variable for infrastructure. Once again, the theoretical background is that of an input demand equation derived from a CES function:

(4.17) $$\frac{EN_t}{K_t} = F\left(\frac{SE_t/K_{p,t}}{SE_t/K_{o,t}}, \frac{p_{o,t}}{p_{EN,t}}, \frac{POP_t}{A}\right)$$

As in Figure 4.4, the above equation shows that a certain level of SE_1 can be produced with various bundles of capital and energy, or "technologies".

Capital accumulation is given by stock adjustment equations which determine capital stocks for housing, vehicles and transport infrastructure, thus:

(4.18) $\Delta \ln K_t = F\{Z_t, \alpha_1 \ln K_{t-1}, \alpha_2 \Delta \ln K_{t-1}\}$

Here, $\alpha_1 < 0$ and α_2 are adjustment terms.

The overall variable Z includes variables which exert a positive influence on capital accumulation, i.e. mainly population and real disposable income, and in the case of transport also fuel prices. In cases where capital accumulation is affected by prices of energy goods, it is possible to analyse to what extent "optimal adjustments" of capital take place, as is to be expected in a neoclassical model. Infrastructure investments were not taken into consideration. Which combinations of capital and energy are used to produce energy services is thus a question which depends on factors lying outside the consumption model, i.e. those relating to the availability of real infrastructure. With respect to car transport the impact of prices and taxes on average fuel consumption for the vehicle fleet were also tested and taken into account.

As a matter of empirical measurement, in practice energy services are only approximately captured by specific variables (e.g. floor area for heating, passenger kilometres for mobility). Nevertheless, the attempt should be made to embody the relevant beneficial activities actually demanded by households within the factor energy services in as pure a form as possible. The total demand for energy goods then results by combining the input demand equations ((4.16) and (4.17)) with the energy services SE.

In the case of heating, housing stock floor area is the indicator used to capture services. This is calculated as the product of the average housing stock floor area and the figure for housing stock resulting from application of the stock adjustment equation (4.18). Here, Z includes population and real disposable income.

(4.19) $\Delta \ln DW_t = F\{Z_t, \alpha_1 \ln DW_{t-1}, \alpha_2 \Delta \ln DW_{t-1}\}$

The expression for housing stock, DW (expressed in physical units), measures energy services for heating, and the accumulated housing investment (measured in constant prices with respect to a base year) is intended to measure capital stock. In such a case, an increase in the relation K/SE implies an increase in the quality of the capital stock, e.g. as a result of improvements in building insulation.

For the category transport, energy service is represented by total mobility, i.e. the sum of passenger kilometres for all forms of transport. This is determined by macroeconomic factors such as real disposable income, as well as by relative prices, with $p_{SE,t}$ being the national accounts figure for current transport expenditure (i.e. excluding vehicle purchases). A further variable, "relative population density" was also introduced. This is simply the ratio of population in areas surrounding cities to respective city population. In the formula this acts to stimulate transport levels.

(4.20) $\ln SE_t = F\,\{\ln(YD_t/PC_t), \ln(p_{SE,t}/PC_t), \ln(POP_t/A)\}$

Here, an increase in the K/SE ratio implies that as real income rises the transport infrastructure necessary for the satisfaction of mobility needs to grow faster than the demand for mobility itself, so that capital intensive technologies can begin to replace or squeeze out energy intensive technologies.

As depicted in Figure 4.5, a shift in service demand can only result from changes in the underlying, determining variables. For heating these are for example changes in population which impact on floor space, or social changes such as an increasing trend towards single-person households, which in turn would be reflected as an increase in total floor space. The most relevant variable with respect to mobility is likely to be "relative population density". Here, historical changes reflect the formation of specific lifestyles. Such lifestyles involve the development of non-sustainable consumption patterns, and are accompanied by matching changes in the demand for passenger kilometres. Thus, in such a case, any shift in the demand for services (Figure 4.5), presupposes requisite changes in existing life styles, and these in turn depend on appropriate adaptation of political institutions and procedures, primarily in the area of spatial and regional planning.

The model above can be described in simplified matrix form thus:

(4.21) $EN = A_{SE}\,SE + A_K\,K + A_{p,EN}\,p$

(4.22) $SE = A_{Z,SE}\,Z + A_{p,SE}\,p$

(4.23) $K = A_{Z,K}\,Z + A_{p,K}\,p$

The variables EN, SE and K are 1x2 vectors for energy demand, energy services and capital stock with i elements and i = heating, transport. All matrices A contain the estimated equation parameters. The exogenous variables are given by matrix Z comprising the relevant macro-variables such as income, population, relative population density, and by the vector p with the prices for energy demand. The two elements of vector EN, heating and transport, are linked to CO_2 emission levels by means of fixed emission coefficients. In model simulations designed to estimate a specific reduction in CO_2 emissions, as an initial step a target value for EN can be determined directly. The requisite changes in exogenous variables can then be obtained directly through inversion of the equation system (4.12) to (4.23). Relevant here are mainly alterations to p, and partly also changes in Z (e.g. relative population density). Simultaneous calculation with respect to CO_2 emission reduction targets for heating and transport is also worthy of consideration. In contrast, in the model application described in the next section, a trial and error procedure was used to explore changes in exogenous variables up to target levels, and the reduction targets for heating and transport were treated separately.

For the integration of demand shifts in the model, however, the inverted demand system, (4.21) to (4.23), is used. The assumption made here is that the energy demand (EN) given in national accounting figures represents the average for various household types, and that these types also vary in terms of their consumption sustainability. Quantification of these differences in household consumption patterns is achieved by evaluating consumer survey data (see section 4.3.2). Households are ranked in terms of energy expenditure, taking criteria such as population density, date of house construction, and fuel consumption (derived from vehicle tax rates) into account, and the two types of household, "sustainable" and "normal" are then determined. "Sustainable households" exhibit values for expenditure on heating, lighting and fuel below the median, while for "normal households" such expenditures are above the median. Extra rankings were calculated in terms of energy expenditure per sq. meter floor space, public transport expenditure, and fuel expenditure. Total expenses on a macro level are then given by:

(4.24) $EN = x_1 \, EN_{NH} + (1 - x_1) \, EN_{KV}$

where EN_{NH} and EN_{KV} are averages for the sums Fehler! and Fehler!.

For the initial median cut off, the value of x_1 was exactly 0.5. On implementing demand shifts, and based on the target values set for EN, the relevant weights x_1 and $(1 - x_1)$ are recalculated, i.e. it is calculated how many of the "normal" households must change to "sustainable" households. Next, the inverse demand system ((4.21) and (4.22)) is used to calculate changes in energy services. Any additional effects can be estimated for total consumption, when the distribution used in (4.24) for energy services is also used for total consumption expenditure, thus:

(4.25) $CR = x_1 \, CR_{NH} + (1 - x_1) \, CR_{KV}$

5. Empirical results on Sustainable Consumption

In section 4 the theoretical background for modelling sustainable consumption was developed and the data underlying the empirical estimations was described. We now move on to the presentation of sustainable consumption structures in empirical applications for Austria. The following is divided into two sections. In section 5.1 the econometric estimates of the theoretical analysis (the derived equations) are presented and discussed. Section 5.2 contains the core of the empirical analysis of the study with respect to the consequences of the various sustainability scenarios for private consumption in Austria. Econometric simulations are carried out with the model developed specifically for this purpose, and apart from standard policy instruments, the impact of aggregate changes in economic and social conditions is also analysed (e.g. shifts from one type of household to another, changes in lifestyles).

A pragmatic approach to defining sustainability targets is taken as the basic starting point of the model simulations. Within the present study consumption patterns for heating and transport (mobility) are defined as sustainable when they allow for a reduction in CO_2 emissions to 13% below 1990 levels over a ten year period. While this approach is thought to provide a practical criterion in terms of sustainability and indicators (emissions), it obviously is not adequate in reflecting the whole range of sustainable structures in consumption. Nevertheless, it does represent a considerable contribution to the depiction and operationalisation of sustainable consumption structures in econometric modelling. The model simulations indicate which changes in individual factors have to be made in order to move towards more sustainable consumption over the period of about a decade. Such changes may be achieved in a variety of ways, e.g. by policy interventions or by establishing new social norms and values. Technological innovation is just as likely to contribute to such change, as are policies of demand management.

5.1 Econometric Estimates of Consumption Model Equations

The theory outlined in section 4 provides the basis for the econometric estimates. A major consideration here is the interaction of stocks and flows, their substitutability, and the depiction of service demand. Demand shifts from less to more sustainable consumption patterns have already been discussed in the description of consumer survey data in section 4.3.2.

To model stock – flow relations in the category of heating a suitable form of capital stock needs to be chosen. In this case, based on the perpetual inventory method, housing stock investment was selected. Initial stock levels and parameters for perpetual inventory modelling (rate of depreciation, ratio of active capital stock to reserve capital stock) were derived from earlier WIFO studies. However, this type of stock can only provide an approximate measure of the thermal quality of buildings, this latter in fact being the more suitable variable for the model under consideration. The development of the capital stock depends largely on trends in the housing population. Econometric estimates of a flexible stock adjustment model were carried out (equation 4.7). The results are shown in the first column of Table 5.1. The measure for capital stock includes new construction as well as investment for renovation work. The equation residual may be altered for simulation purposes. In the present case this corresponds to the assumption of higher renovation investments for a constant level of new construction (as a result of identical developments in population).

The energy service of interest to us in modelling heating is approximated by using the figure for total housing floor space. Thus, it is assumed that for a given floor area, all households strive to achieve a certain level of room temperature. Total floor space is given by the cumulative figure for housing stock multiplied by the average figure for floor space. Three classes of buildings are distinguished depending on year of construction (those built before 1945, 1945 to 1980, and those built after 1980). Floor space is used to represent energy service. Changes in this factor are explained econometrically by means of household disposable real income and by a stock adjustment term (column 3 in Table 5.1).

For the category "transport" an exogenous stock of infrastructure capital covering road networks and public transport networks is assumed. The private car fleet is assumed to be the appropriate stock figure for motorised private traffic, and once again is determined by means of a stock adjustment model. Changes in car stock are explained econometrically via real household disposable income, the price index for fuel, car fixed costs (repairs, vehicle tax etc.) and by means of a stock adjustment figure (column 2 in Table 5.1).

An approximate measure of the energy service of interest, "mobility", is found by using the total number of kilometres travelled in private motorised transport and public transport. Distinguishing journeys travelled in terms of length would actually be something well worth aiming for in analysing transport[99]. The demand for mobility is a function of real household disposable income, relative price of transport consumption expenditure (compared to the price of total consumption), and relative population density of cities (equation 4.9). The last variable relates the population density in the area surrounding Austrian cities to the population densities in the cities themselves and is designed to test the impact of housing location structures, induced by local and regional planning policies, on the demand for mobility. The results are given in the fourth column in Table 5.1. They reveal, amongst other things, that over-development and housing dispersion has a significant positive impact on the demand for mobility.

The transferral of energy services into observable consumption demand data is achieved via the demand functions obtained on the basis of household production function theory. This involved estimating the input coefficient for energy per unit of service (EN/SE), and this can be seen as an approximation of factor intensity (EN/K derived from the CES function), previously presented in section 4.

[99] In BMLFUW, 2000, an average distance of 23.2km per inhabitant per day is stated. It would be important to know, however, how many journeys are needed to reach this average distance and for what purpose they are undertaken (shopping, commuting etc.).

Table 5.1: Capital stock and energy services

	Captial stock		Energy services	
Dependent variable	Δlog(KWB)	Δlog(FA)	Δlog(DW)	log(PKM)
Independent variable				
log(POP)	0.064 (0.021)			
log(KWB_{-1})	–0.009 (0.004)			
Δlog(KWB_{-1})	0.593 (0.082)			
log(YD/PC)		0.177 (0.074)	0.095 (0.024)	0.094 (0.054)
log(PC42) + log(PC44)		–0.027 (0.016)		
log(FA_{-1})		–0.091 (0.073)		
log(DW_{-1})			–0.167 (0.053)	
log(PKM_{-1})				0.788 (0.052)
log(BEVD2/BEVD1)				0.111 (0.027)
log(PC/PC4)				0.344 (0.049)
Corrected R^2	0.892	0.577	0.703	0.998
Durbin-Watson	1.960	1.880	2.076	1.896

KWB Capital stock, housing
FA Passenger car stock
DW Housing stock
PKM Passenger km total
POP Population
YD Disposible income, current prices
PC Price index for private consumption
PC42 Price for fuel
PC44 Price of the fixed costs for passenger cars
BEVD2 Population density outside the metropolitan area
BEVD1 Population density in the metropolitan area
PC4 Price for transport

Values in brackets indicate the standard error.

For the category heating this approach is used to model non-electrical energy, such as coal, oil products, gas, district heating (exogenous) and biomass (exogenous). The input ratio of energy in the production of heating depends on the price of non-electrical energy, on the quasi-fixed factor in the form of the capital coefficient for "housing capital stock per unit of floor space", and on weather conditions measured in terms of heating degree days (Table 5.2). In contrast to the pure neo-classical model, capital stock is here given for the level of energy demand and not subject to a process of optimal adjustment on the basis of the price of capital. The capital coefficient "housing capital stock per unit of floor space" indicates the quality of the housing capital stock, and may for example be increased by thermal insulation or other thermal measures and thus reduce the energy consumption per unit of floor space (shown by a negative sign in column 1, Table 5.2).

Table 5.2: Energy demand of heating and private transport

	Heating, lighting		Transport by passenger cars			
	Non-electric energy	Electric energy	Passenger km by passenger cars		Passenger km by public transport	
			Excluding population density	Including population density	Excluding population density	Including population density
Dependent variable	log(CRENNEL/NFL)	log(CR81/NFL)	log(PkwKM/PKM)		log(PNVKM/PKM)	
Independent variable						
log(KWB/NFL)	–0.783 (0.689)					
log(HGT)	0.693 (0.221)	0.154 (0.081)				
log(1/PCENNEL)	0.499 (0.192)					
log(PCENNEL/PC81)		0.207 (0.087)				
T		0.014 (0.002)				
log(KPkw/KPNV)			0.344 (0.173)			
log(PC42/PC43)			–0.068 (0.031)	–0.105 (0.029)		
log($PkwKM_{-1}$/PKM_{-1})			0.486 (0.138)			
log(BEVD2/BEVD1)				0.173 (0.044)		–0.330 (0.086)
log(KPNV/KPkw)					0.457 (0.251)	
log(PC43/PC42)					–0.098 (0.045)	–0.215 (0.057)
log($PNVKM_{-1}$/PKM_{-1})					0.648 (0.089)	
Corrected R^2	0.539	0.850	0.874	0.911	0.931	0.911
Durbin-Watson	1.515	1.010	2.046	2.197	2.144	1.789

CRENNEL Non-electric energy
NFL Useable floor space
CR81 Electric energy
PkwKM Passenger km by passenger cars
PKM Passenger km total
PNVKM Passenger km by public transport
KWB Capital stock, housing
HGT Heating degree days
PCENNEL Price for non-electric energy
PC81 Price for electric energy
T Time
KPkw Road length in km
KPNV Railroad length in km
PC42 Price for fuel
PC43 Price for public transport
BEVD2 Population density outside the metropolitan area
BEVD1 Population density in the metropolitan area

Values in brackets indicate the standard error.

The demand for electrical energy per floor area does not depend directly on heating as electricity is primarily used in satisfying other household needs and is only seldom used as a primary source of heating. Electrical heating plays rather a secondary or additional role. The demand for electricity for heating purposes is determined by its own relative price (compared to the price of non-electrical energy), the number of heating degree days (this measures the need for secondary sources of heating, e.g. electric heaters) and trend factors (Table 5.2).

For the category "transport", total demand for transport services is split into private transport and public transport. These represent the two types of "technologies" which can be combined to achieve the desired level of mobility demand. Here, the term technology is understood differently to that used in the Environmentally Sustainable Transport (EST) Scenarios analysed in BMLFUW, 2000. In the latter, scenarios for alternatives to private motorised transport were looked at, such as fuel cells, or the substitution of fossil fuels by bio-fuels. Such alternative technologies are not modelled in the present project.

The input ratio of public transport to private transport depends on the relationship existing between the capital infrastructure networks (road network, public transport network) and on the relative prices of the two technologies. An additional calculation was made in order to specify the demand for both forms of technology as dependent on relative price and population density (ignoring the relationship between the infrastructure capital stocks)[100]. This alternative specification revealed that the relative population density in areas surrounding cities not only has an impact on the total demand for mobility services but also on the modal split.

After dividing the demand for mobility into these two types of technologies the fuel consumption for motorised private transport is calculated by multiplying kilometres travelled by the figure for average fuel consumption of the total vehicle fleet. The variable "conveyed persons per vehicle" links vehicle mileage with individual mileage. The figure for average fuel consumption is explained in terms of its dependence on effective vehicle tax rate, which itself is dependent on the given engine performance and capacity (prior to 1993) of the vehicle fleet. As can be seen in Table 5.3, vehicle tax exerts a dampening effect on average fuel consumption. The consumption category "car purchase" results directly from the changes in capital stock (vehicle fleet) and the rate of depreciation. Apart from the variable costs of private motorised transport, as in Conrad – Schröder (1991), we also look at, fixed costs, these being dependent on both capital stock (vehicle fleet) and the price index for fixed costs. Once again, the effective tax rate is an important variable in this index of fixed costs.

Based on the relevant energy services, the underlying consumption categories were then depicted in national accounting form. Further, by linking these categories to the aggregate energy balance the move to material flows of energy could be implemented in the model. On applying the official emission factors given in the Austrian Federal Environment Agency's CO_2 inventory, the direct CO_2 emissions stemming from private consumption can then be derived, and these serve as a sustainability indicator in the model simulations.

[100] One estimation using infrastructure capital stocks, prices and relative population density produced considerably worse results in terms of statistical significance than the two alternative versions.

Table 5.3: Purchase of passenger cars, fixed costs and average consumption of fuel

	Expenditures for passenger cars		
	Purchase of passenger cars	Fixed costs for passenger cars	Average consumption of motor fuel
Dependent variable	CR41	log(CR44)	log(AVBNDS)
Independent variable			
$FA - FA_{-1}$	0.163 (0.030)		
FA_{-1}	0.015 (0.001)		
log(FA)		1.318 (0.114)	
log(PC44)		–0.510 (0.082)	
log(FA_T)			–0.013 (0.010)
log($AVBNDS_{-1}$)			0.909 (0.073)
Corrected R^2	0.912	0.981	0.975
Durbin-Watson	1.973	1.599	2.265

CR41 Purchase of passenger cars
CR44 Fixed costs for passenger cars
AVBNDS Average consumption for motor fuel
FA Passenger car stock
PC44 Price of fixed costs for passenger cars
FA_T Implicit vehicle tax rate per passenger car

Values in brackets indicate the standard error.

5.2 Simulation of Sustainability Scenarios

The simulations of sustainability scenarios for Austria presented here employ the instruments and models described in the analysis above. Environmental accounts and sustainability indicators as discussed in section 2 are relevant for the evaluation of simulation results. The state of international research and debate in this area has been extensively discussed in the present study. It has been found that while agreement exists concerning the need for sustainability indicators, a large number of rather diverse approaches are in fact being pursued. While a very broad range of concepts relating to environmental accounting has been developed, their implementation has been relatively sparse. Interactions with the environment occur through direct and indirect resource extraction and through direct and indirect emission into the ecosystem. As an initial step, as seen in OECD research (Table 2.4), sustainability indicators can be formulated as emissions arising directly from specific activities (private motorised transport, heating etc.). The analysis of environmentally relevant consumption activities and the portrayal of their impact on the environment in the form of specific indicators provides the basis for the formation of policy objectives. In view of the given institutional and social setting, and the focus of the present study on consumption in the categories of heating and transport, the "likely acceptable indicator for sustainability" is taken to be a reduction of CO_2 emissions in private consumption by 13%. The next logical step towards achieving a more holistic and macroeconomic perspective and analysis of sustainability would be the embedding of the consumption model in a model of the aggregate economy. This is, however, beyond the scope of the present research.

The concepts and cases described in section 3 provide a framework for the determination of "types of sustainable households" and for a consideration of where and how political intervention might be necessary and/or which shifts in demand might be required in order to attain more sustainable household demand patterns in Austria. With respect to empirical applications, this implies the need to depict interactions between the formation of policy objectives (definition of sustainability) and their actual implementation via concrete policy instruments, reactions in aggregate consumption, and interpretation in terms of emission data and respective feedback effects (operationalisation of sustainability), as shown in Figure 5.1. By bringing all the parts together in a dynamic model the picture of sustainable consumption is completed. The interactions between the level of consumers and the level of political agents become visible via the formation of policy instruments and their resulting impact on consumption. This helps avoid a naïve understanding of politics whereby political agents are regarded in isolation from consumption agents and taken to be the sole determinants of policy.

The complex nature of sustainable consumption described in section 3, i.e. the multitude of factors influencing the formation of consumption patterns (economic considerations, socio-psychological aspects, technological and infrastructural conditions etc.) and the forces of change to which these factors are permanently subject, make it necessary to adopt a wide-ranging, integrated approach when dealing with such issues, i.e. a bundle of diverse policy instruments is needed. Roughly speaking, available policy instruments, some of which were used in the simulations described below, can be divided into three categories (UNEP, 2001; OECD, 2000D):

- Economic instruments – this comprises measures which aim to induce a move toward sustainable behaviour via price changes. This might include resource, product or emission taxes, direct or indirect subsidies for specific activities, or the removal of environmentally counter-productive support measures. Employed on a wide scale such measures are in fact equivalent to a policy of environmental tax reform. A further type of instrument in this category is tradable emission permits. These are similar to many other economic instruments in that they also serve to promote the internalisation of external costs.
- Regulatory instruments – here legislation is introduced bring about a specific desired individual or societal behaviour. Such measures include the typical command and control methods, whereby emission standards are set, energy efficiency levels or specific technologies are

prescribed by law, certain products are forbidden or the responsibility of producers is extended to cover social or environmental concerns.

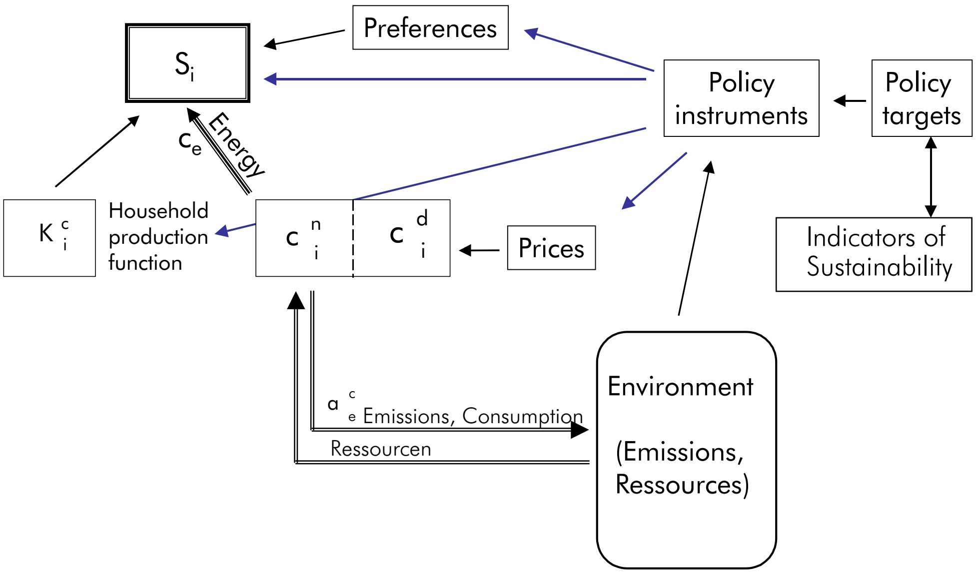
- Social instruments – a category of "soft" measures designed to redirect consumer activity through communication or awareness raising programmes. Such measures include (target group oriented) training, educational or informational campaigns, identification of environmentally friendly products (e.g. ecolabelling), environmental awards, encouraging participation in decision making processes, the development of pilot projects etc.

Above and beyond all these measures, there is still the responsibility of the relevant political authorities to establish a suitable framework for sustainable consumption by ensuring that sufficient investment in infrastructure takes place, that regional and local planning procedures are appropriate, and that the requisite institutional changes are made (e.g. to encourage the supply of wide-ranging, integrated mobility services).

The private consumption CO_2 targets selected for the simulations below have been derived from the general climate policy objectives for Austria, and point to a reduction of CO_2 emissions by an average of 13% for the period 2008 to 2012 compared to the emissions of 1990, the base year. The simulations begin with the base year of 1990 and contrast actual historical developments with the emissions path that would have been necessary to achieve the set objectives. Results for the two categories heating and transport are shown separately. The emission paths reveal a clear need to reduce emission levels. In part (in the category heating) this can be attributed to the base year selected. The sustainable emission paths act as the target levels for the sustainability scenarios. The exogenous sustainability targets can be achieved in a variety of ways: first, through the direct application of policy instruments, and second by inducing changes at the general level of the economic and social system which impact on consumer preferences. In order to make the effects of these changes in the various simulations explicit, in each of them on individual (policy) intervention in the relevant category was applied such that it became possible to attain the target path set. Insisting that for every exogenous intervention the target path must be reached has the advantage that it makes the consequences of the individual scenarios comparable. In our simulation, the use of a common target path for all scenarios obviates the need for an extra indicator and the results of the economic simulation (the resulting costs and benefits) can be compared directly. When both economic and environmental changes occur, in particular when they are contrarily, other indicators from the environmental national accounts need to be applied.

Once again, as in section 4 and 5.1, a service orientation provides a basic starting point for the simulation. The channels taken by the interactions between politics, consumption and environment are shown in Figure 5.1, and the CO_2 paths for the categories transport and heating are depicted in Figures 5.2 and 5.3 respectively.

Figure 5.1: Sustainable Consumption Patterns



S_i	Service demand	C_{in}	Non-durable consumption
K_i	Capital stock	C_{id}	Durable consumption

Figure 5.2: CO_2 Emissions in Private Transport (1,000 tons): base level and target level

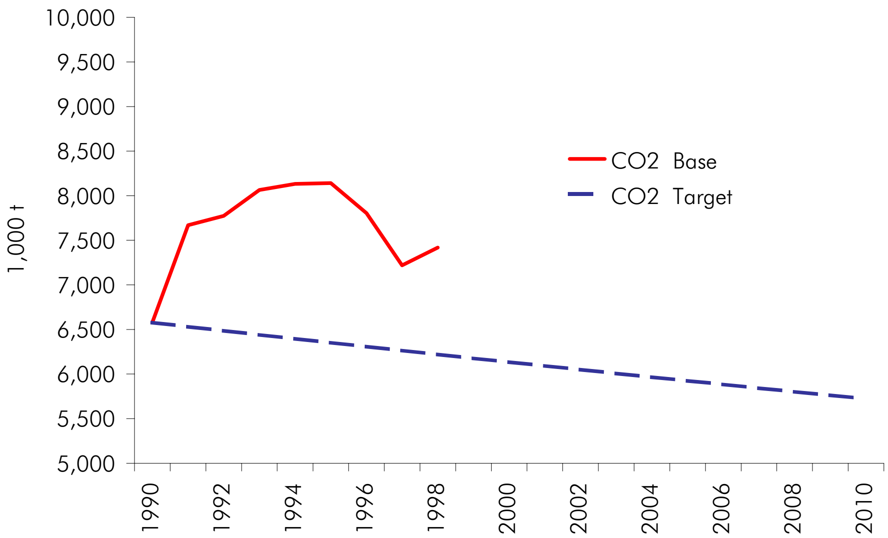
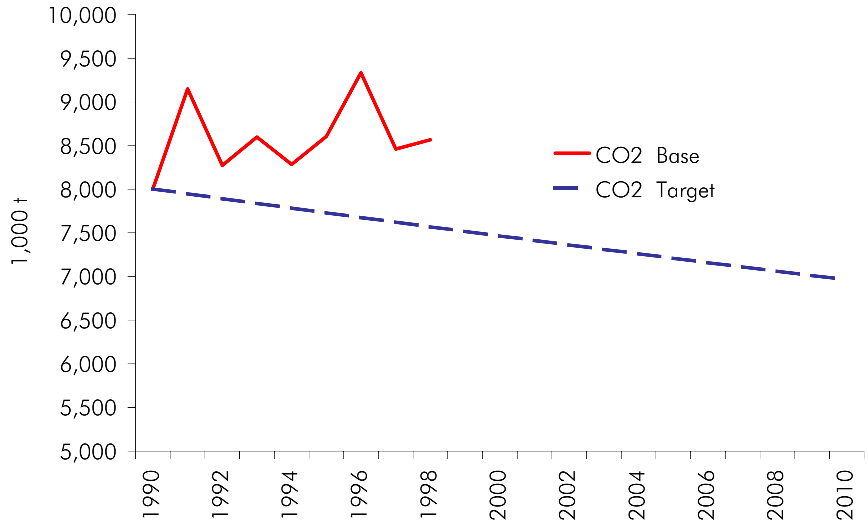


Figure 5.3: CO_2 Emissions in Heating (1,000 tons): base level and target level



The effects on private consumption are calculated for a total of eight simulations. Six of these are sustainability scenarios as defined above, and the other two serve as illustrative examples. The sustainability scenarios deal with changes in prices, capital stock, relative population density (as influenced by planning policy) and household structure ("sustainable" vs. "normal") and cover the following simulations:

Sustainability Scenarios for transport

- Road Pricing – a kilometre charge for cars is introduced and returned in the form of a lump sum transfer payment ("ecobonus").
- Zero Charge – the price for public transport is reduced, the fall in transport company revenues is offset by an increase in vehicle tax.
- Regional Planning – the population density of the cities rises in relation to that of the surrounding areas.
- Demand Shifts – the share of "normal" households falls and the share of "sustainable" households rises. This shift is achieved by introducing a variety of policy measures.

Sustainability Scenarios for Heating

- Building Regulations – energy certificates are introduced for all buildings requiring minimum thermal quality. This leads to an increase in investment in the renovation of buildings constructed between 1945 and 1980.

- Demand Shifts – the number of "normal" households falls, and that of "sustainable" households rises.

The two illustrative simulations test the impact of investment in transport infrastructure and the potential for renewable energy for the period 1990 to 1998. In this period the public transport network was subject to extensive change, more than the changes experienced in the road network, and this should have led to a shift to greater use of public transport.

A summary of the implications of the individual scenarios is given in Table 5.4. The figures given reflect the dynamic interactions of the variables in the model. For example, should consumption fall after tax measures are introduced, the ex post figure for tax revenue is lower than that calculated ex ante. All scenarios indicate that in order to have reached the emission path necessary to achieve the Kyoto objectives massive changes in the respective variables would have been necessary.

Table 5.4: Policy Instruments for Sustainability Scenarios (average 1990 – 1998)

Simulation Scenarios Transport	Road pricing	Zero charge	Regional planning	"Demand shift"
Changes in variables				
Road toll revenues	1.8 bn €			
Vehicle tax (fixed costs)		0.34 bn €		
Price of public transport		-29.6%		
City population density			41 inhabitants per km^2	
Change in shares of household types				14%points

Simulation Scenarios Heating	Regulations	"Demand shift"
Capital stock, dwellings	8.7 bn € [1])	
Change in shares of household types		12%points

[1]) of which only € 2,9 bn per year are due to investment in thermal improvement.

5.2.1 Sustainability Scenarios Transport

Sustainability Scenario "Road Pricing"

This scenario comes closest to representing a neo-classical environmental policy approach in that it targets emission prices. It proposes a revenue neutral tax on kilometres travelled. This could be implemented in the form of a toll fee for example, or in the form of a vehicle charge per kilometre – the technical or administrative details are not relevant for the simulation. Revenue neutrality means that the revenues so raised could be returned to the public on a households or per capita basis in the form of a lump sum payment ("ecobonus" model). Revenue neutrality is crucial in ensuring that no negative effects are triggered at the macro level .Ex post, i.e. after the desired change in demand has occurred, the road pricing policy produces revenues of (€ 1.8 bn) for the approximately 45 bn km driven (average 1990 – 1998). This represents an effective charge of about € 0.04 per kilometre.

By returning these extra revenues to households an increase in nominal disposable income is induced, and this has a corresponding effect on total real private consumption. No account was taken here of differences in consumption among the different income classes. This would only have been possible within a more detailed treatment encompassing the impact of income distribution.

The road charge raises consumer prices by about 1.7%, while the revenue recycling has an opposite effect so that the net impact is close to zero. As a result there is therefore hardly any change in real household disposable income. Thus, given the fall in real expenditure on individual motorised transport, we see a corresponding increase in expenditure on non-energy consumption. For the period 1990 to 1998 there is an average real increase in non-energy consumption of 2% and this has positive secondary effects on the macroeconomy (multiplier effects). These macroeconomic effects are not quantified since here only a partial model of private consumption is employed. The assumption, however, that such effects are positive is not unfounded.

Energy consumption, which declines, has a higher import share and includes demand for goods which are less labour intensive than those comprised in non-energy consumption, which increases. Clarification and proper quantification concerning this issue would, however, require the use of a disaggregated, macro-economic model.

Further, not only does fuel consumption fall by the 11.3% necessary to achieve the targeted CO_2 levels, all forms of expenditure on individual motorised transport fall too. This includes car purchases (approx. -15%) and real vehicle fixed costs (-7.5%) since, similar to an increase in fuel tax, the road charge raises the variable costs of car use. In addition, since public transport declines by only 0.9%, we also see a change in the demand structure for transport, with an alteration in the modal split between private and public transport. Summing up, the "road pricing" scenario, similar to many other studies on energy taxation, shows that with respect to the standard indicators employed in national accounts, sustainable development can indeed be combined with positive macroeconomic effects (double dividend). A prerequisite for such success, however, is that the necessary policies are implemented that bring about the shifts in the tax burden (see Table 5.5). The positive macroeconomic impacts are seen in the rise of non-energy consumption, though it also needs to be noted that depending on the prevailing structure of non-energy consumption patterns, an increase in the latter might lead to a rise in indirect energy consumption, i.e. that needed in the production of the consumption goods.

Sustainability Scenario – "Zero Charge "

The logic underlying this scenario is based on the assumption that the general acceptance of public transport will increase. The extent to which cost considerations affect such acceptance is also tested here. Thus, this scenario is also an example of neo-classical price regulation of emissions being used as an environmental policy instrument. The specific design of the scenario does, however, allow further additional aspects to be captured, but these are only dealt with qualitatively and not quantitatively. In this sustainability scenario, the price for public transport is reduced on average over the period 1990 to 1998 by 30%, and the resulting revenue loss experienced by the transport companies is offset by an increase in vehicle tax. This can be seen as the provision of a cross-subsidy for public transport financed by the vehicle tax. As a small proportion of vehicle tax (since 1993 an insurance tax based on engine size) is earmarked for developing the public transport network, cross-subsidisation of public transport operations would imply only a rather minor change in the system.

The required fall in fuel consumption of 11.3% is achieved on the one hand by the shift from private to public transport (+6.1%), and also by the manifold effects of the increase in vehicle tax on fuel consumption. The increase in effective vehicle tax rate, which (ex post) generates extra tax income to the value of € 363 million, has an impact on the average fuel consumption of the car fleet, and also greatly influences the real fixed costs of private transport, which in turn dampens vehicle purchases. I.e. fewer, and at the same time, more fuel-efficient vehicles are purchased in an effort to offset, at least partly, the increase in vehicle tax. At the same time, as a result of the increased transport costs there is an increase in the consumer price index of 1.3%, and despite the related subsidisation of public transport there is a decline in disposable income and in real private consumption. This represents a major difference to the scenario "road pricing". The combined price and income effects result in a real decline of car purchases by 15% and a real decline in fixed costs by 25% . In nominal terms, fixed costs rise by 15% since the impact of the increase in vehicle tax on fixed costs is greater than the quantity reactions occurring in response to the price change. The total effect on the price of the consumption category transport is positive, about 12% on average (for the period 1990 to 1998), in other words, the impact of the increase in vehicle fixed costs is greater than the reduced price of public transport. There is thus a decline in the overall demand for transport services, in particular with respect to private traffic as a result of the shift in the modal split. In total, we see here a smaller increase in non-energy consumption (+1.3%) than in the "road pricing" scenario. Thus, in this scenario too, positive effects on non-energy consumption and accompanying advantages for the macroeconomy are to be expected (see Table 5.5), and once again, these could only be quantified using a comprehensive, aggregate approach.

In this scenario the changes in fuel consumption stem both from the reduction in kilometres driven and from the lower average fuel consumption of the vehicle fleet arising as a result of the higher vehicle tax. In this scenario the higher vehicle tax and resulting reduction in car fuel consumption have just as much impact as the shift in modal split and due to lower prices in public transport. One can also see, that there is only a marginal increase (+0.7%) in the number of kilometres travelled in public transport.

These quantitative model estimates do not take account of the additional incentive effects that could be integrated into such a scenario. Intelligent mixing of vehicle tax schemes with reductions in the price of public transport could produce many such incentives. Direct coupling of the two measures for example could lead to an effective zero charge in public transport for all payers of vehicle tax, inducing a twofold impact and greater changes in the modal split than those quantified here. The same is true concerning the combination of public transport with other services to make it more attractive. These additional services are not depicted in the model. They include such things as imposition of constraints on road space for private motorised traffic in urban areas (e.g. bus lanes), car-sharing, promoting rented vehicles and taxis, parking schemes and improved passenger information. Co-ordination of activities between different suppliers of public transport would also increase overall transport attractiveness.

Such a scenario might prove more attractive to policy makers since it implies less interference in tax structures but still allows for the development of suitable incentives which increase the appeal of public transport by extending its scope and generally making it more flexible. On the other hand, the expected positive effects on the macroeconomy are likely to be less pronounced than in the scenario "road pricing" since there is no net reduction in the burden faced by the consumer. The dilemma arising with respect to major policies of environmental tax reform such as road pricing is that the burden of new taxes is instantly perceived by the pubic while the positive macroeconomic effects are not (or not to the same extent). Thus, this might lead to a preference for the – in terms of macroeconomic impact – relatively worse "zero charge" scenario, which involves less interference in tax regimes and also state-led redistribution of benefits (revenue recycling).

Sustainability Scenario – "Regional Planning"

The starting point for this scenario is provided by changes in lifestyle patterns occurring between 1990 and 1998 which led to an increase in traffic volume. The central variable in the model is the ratio of the density of the population in areas surrounding cities to that of the population in the cities. This ratio rose continuously throughout the period 1990–1998, reflecting a lifestyle of "work in the city and live in the country". The latter is related to company location policy and the availability of local job offers. Such a lifestyle also encompasses the development of large out-of-town shopping centres, a further factor in the increase in traffic.

In contrast to these historical and ongoing changes in consumer lifestyle, it was assumed for this sustainability scenario that population movement would lead to increased concentration of residential and work areas within the cities. This leads to a significant increase in city population density, with the respective figures going up by 40 persons per square kilometre (+29%). On looking at the long-term historical developments in the opposite direction, e.g. between the census years 1981 and 2001, it seems clear that such large shifts do not in fact occur even over longer periods of time.

From our point of view, this sustainability scenario is also important in that it illustrates the interface between transport and housing. In addition to the energy aspects and the impact on consumption behaviour depicted in the simulation, considerations of land use with respect to housing and transport are also relevant. Looking at the proportions of land used for public transport and road transport we find the following: public road network 88%, rail network 4%, airports 2%, ports and docks 1%, and parking spaces, petrol stations 6% (BMLFUW, 2000). The high proportion of space occupied by the public road network cannot be seen in isolation from developments in demand for dwellings and the increase in land used for housing development. The interactions between transport infrastructure and housing development are being strengthened over time by growing motorization, a rise in the number of households, the increase in living area per inhabitant and changes in housing densities. All these factors influence energy consumption and emission levels and attempts to control them through spatial and transport planning are thus important.

Regional shifts in the population have no impact on the total level of private consumption. This corresponds to the pattern of a fall in redundant energy services with no reduction in the level of economic welfare. Since, however, only the expenditure on fuel consumption falls and other transport related expenses remain almost constant, we witness merely a slight shift between energy and non-energy consumption. In this scenario the expected effect on the macroeconomy as a result of the rise in non-energy consumption is positive, but it still remains below that found in the scenarios "road pricing" and "zero charge" (see Table 5.5).

On the one hand, the variable relative population density in general reduces the total demand for mobility, but on the other hand it also more strongly tends to reduce the demand for car travel owing to its above mentioned influence on modal split. In the model, "population density" is treated as an exogenous variable in explaining the demand for mobility, and other factors and interdependencies are ignored. Where the factor "out-of-town-shopping" dominates in transport, and this was not considered in the model, increased urbanisation could just as easily lead to an increase in traffic volume. In addition, further urban concentration could, ceteris paribus, also lead to an increase in motorised traffic within urban areas. This phenomenon is in fact typical of rapidly growing cities in developing countries. In practice, it is highly probable that in order to reduce car traffic even in the presence of rising urban concentrations, either a much improved public transport service, or the various innovative mobility service combinations described above are required, or possibly both[101].

Sustainability Scenario "Demand Shifts" in Transport

This scenario is intended to analyse the effects of a shift in household types towards more sustainability, and as mentioned above, a multitude of factors have to be taken into consideration. In order to achieve the CO_2 target here, the two household types are no longer divided based on the median value (see section 4.3.3), but on the assumption that 64% of households must engage in more sustainable consumption, and only 36% may remain "normal". Seen in terms of the changes in environmental awareness achieved in the past (see section 4.1), this is no easy matter. This assumption results mainly in an expenditure shift between private and public transport with transport expenditure remaining constant. In total, this leads to a slight increase in kilometres travelled of 3% . The differences in total consumption expenditure for each household type were also taken into account. This showed that "sustainable" households tend to exhibit lower total consumption expenditure. The shift in the household structure thus leads to a decline in total real private consumption by about 2%, whereby non-energy consumption falls by 2.6% (see Table 5.5).

The resulting macroeconomic impact on GDP (not depicted here) is expected to be negative. In this scenario, a decline in energy flows is achieved by a reduction in the flow of goods in consumption. The positive environmental effect thus stands in contrast to a negative macroeconomic effect (as calculated on the basis of standard national accounting methods). In terms of the framework given here, in which it is intended to compare the economic consequences of scenarios exhibiting equal environmental impact (with respect to the given emission target), no overall assessment of the scenario is possible. Using traditional national accounting methods, this scenario appears to be less favourable than the other three. The results for this scenario thus show that in order to obtain a comprehensive assessment the model framework (i) would have to be extended to a disaggregated, macroeconomic model, and (ii) sustainability indicators derived on the basis of environmental accounting procedures have to be used since these enable overarching analysis of the interactions between and impact of economic and environmental changes.

[101] The potential of teleworking, delivery services, and part-time peripheral office work are also worthy of investigation.

Table 5.5: Simulation Results for the Sustainability Scenarios Transport (average 1990 - 1998)

	Road pricing	Zero charge	Regional planning	"Demand shift"
	Difference to baseline in %			
Consumer prices	1.7	1.3	-	-
Private consumption, total	0.1	-1.1	0.0	-1.9
Non-energy consumption	2.0	1.3	0.5	-2.6
Private consumption (P 95) Transport				
Cars	-14.6	-15.0	0.0	-
Fuels	-11.3	-11.3	-11.3	-11.4
Public transport	-0.9	6.1	-0.4	20.0
Other transport	-7.5	-24.7	0.0	-
Transport activities				
Person-kilometres, total	-12.7	-10.4	-12.5	2.8
Person-kilometres, cars	-17.9	-15.6	-17.9	-17.9
Person-kilometres, public transport	-1.7	0.7	-0.6	45.8

5.2.2 Sustainability Scenarios –Heating

Sustainability Scenario " Building Regulations"

In this scenario, the thermal quality of building stock constructed in the period 1945 to 1980 is increased to such an extent that achieving the targeted emission levels is possible. The need for upgrading in this area is largely accepted in Austria and discussion merely centres around what policies are to be used to provide suitable incentives. The simulation assumes that official proof for the achievement of minimum standards of energy efficiency would be required in building regulations, and that this would then trigger the necessary investment in renovation and improvement. This enables us to bypass any political controversy on the nature and form of public housing subsidies. This means that in the model, we assume that household investment in the necessary improvements has to be financed by an increase in expenditure on housing. Were public subsidies to be used to a greater extent in support of thermal upgrading, then the cost of such work to households could be correspondingly lower.

In terms of practical relevance, the scenario used here is not altogether appropriate for the simulation model used in testing proximity to the set target path (starting from 1990), since it relies on an instant shift in the level of capital stock. A more practical design would involve incremental increases in renovation investment expenditures which would exert a cumulative impact on capital stock over the mid-term and thus produce ever stronger impacts on emissions. The uniform simulation design was nevertheless chosen for all scenarios in order to allow for direct comparison of the instruments used.

To achieve the emission targets set for heating, real expenditure on heating/lighting has to decline by 11.7%. The scenario shows that the capital stock of housing (in terms of thermal quality) would have to increase by € 8.7 bn on average for the period 1990 to 1998 to achieve the emission target. This result was not calculated using the relevant capital coefficient (new capital stock per unit floor area) in the equation for non-electrical energy in heating (Table 5.2). The demand for non-electrical energy in heating depended rather on the use of a synthetic variable for floor area (related to period of construction) multiplied by the kWh/m^2 efficiency parameters (for the relevant construction period). The background information for the efficiency parameters is derived from the BUWOG database on multi-storey housing and from an energy saving association in Upper Austria (Energiesparverband Oberösterrreich für Einfamilienhäuser). With the alternative equation thus obtained, it became possible to calculate the extent to which the efficiency parameter for the housing stock constructed between 1945 to 1980 would have to fall in order for the target levels to be attained, and what this meant in terms of volume of housing stock in need of upgrading. The result indicates that about 12% of the housing stock (from 1945 to 1980) would have to renewed. This corresponds to a total of 16 million square meters. According to an analysis carried out by the BMLFUW, the costs of thermal upgrading amount to about € 181.68 per m^2, and this figure was used in the calculations. These reveal that an increase in housing capital stock to the value of € 2.9 bn would be needed. This only includes the costs of thermal upgrading. If we assume that on average these costs only represent approximately one third of total necessary renovation, we arrive at a total figure of € 8.72 bn for the whole period of the simulation. At first sight this may appear somewhat excessive, but it is placed in perspective when one realises that the average annual increase in housing capital stock amounts to € 8.5 bn.

In the simulation the least favourable case for households is used, i.e. it is assumed that households have to finance renovation themselves and also that all renovation costs contribute to emission reduction. In reality, one can assume that investment in renovation, by leading to an improvement in the quality of housing stock, will in fact also exert a positive effect on household welfare. In the model, thermal upgrading results solely in a reduction in fossil fuels since electrical energy is not considered relevant for heating. Expenditure on heating/lighting thus falls by a mere 3.5%. Financing renovation puts a considerable burden on households, leading to an increase in real expenditure on housing of 2.3%. With no change in total expenditure for private consumption, this in turn leads to a decline in non-energy consumption by 0.3%. This decline in non-energy consumption probably does induce some negative macroeconomic effects, but these are more than likely offset by the positive impact on the economy of the massive increase in building renovation and upgrading (see Table 5.6).

Sustainability Scenario "Demand Shifts" in Heating

As in the corresponding simulation in transport, this scenario leads to a shift in household types with respect to heating/lighting, such that 62% of households would have to consume in a more sustainable fashion, while 38% are allowed to remain "normal" in their consumption habits. Since the demand shifts apply to the total expenditure on heating/lighting, there is an 11.7% fall not only in fossil fuel consumption but also in electrical energy consumption. At the same time, the differences in total expenditures for the household types were also taken into account. The shift in household structure thus leads to a decline in total real private consumption by 1.9%, with non-energy consumption falling by 2.3% (Table 5.6). Once again, negative effects on GDP are to be expected. Thorough evaluation of this scenario, as was the case with the scenario covering demand shifts in transport, is only possible in an extended framework covering both macroeconomic and environmental accounting procedures.

Table 5.6: Simulation Results for the Sustainability Scenarios Heating (average 1990 - 1998)

	Regulations	"Demand shift"
	Difference to baseline in %	
Private consumption, total	0.0	-1.9
Non-energy consumption	-0.3	-2.3
Gross rent	2.3	-
Private consumption (P 95) Heating		
Heating & lightning, total	-3.5	-11.7
Electricity	0.0	-11.7
Coal	-11.7	-11.7
Oil products	-11.7	-11.7
Gas	-11.7	-11.7

5.2.3 Illustrative Simulation for Transport Infrastructure Investment (Road Network vs. Public Transport Network)

A quick look at the emission reductions necessary to reach the sustainability targets and the extent of past investment in the transport network shows that the targets are unlikely to be attained by mere diversion of investment funds towards public transport. Such a scenario would be far removed from the actual historical figures used in setting up the econometric estimates and would thus place the model under excessive strain. In fact, it is precisely with respect to transport infrastructure where we observe that desirable long-term effects are only obtainable when accompanied by measures designed to upgrade the attractiveness of public transport.

An illustrative ex-post simulation was carried out to underscore these points. It is designed to show the actual shifts in network developments between 1990 and 1998. In this period the public transport network actually grew considerably. However, in the simulation it was assumed that the public network remained at the level of 1990 and that the total increase in transport infrastructure took place in the road network. This simulation shows that transport emissions for the year 1998 would be 2.6% higher, the demand for mobility in total would not be affected, and there would be a shift from passenger travel on the public network to more private road travel. This would be accompanied by an increase in real expenditure for fuel of 1.6% and a decline in real expenditure for public transport of 2.3% (Table 5.7).

Table 5.7: Results of Investment Shifts in Transport Infrastructure (Network), 1998

	1998 Difference to baseline in %
CO_2, transport	2.6
Private consumption (P 95)	
Transport	
Cars	0.0
Fuels	1.6
Public transport	-2.3
Other transport	0.0
Transport activities	
Person-kilometres, total	0.0
Person-kilometres, cars	2.6
Person-kilometres, public transport	-4.8

5.2.4 Illustrative Simulation for the Potential of Renewable Energy

A second illustrative case was simulated in order to estimate the potential of renewable energy in private household heating for the period 1990 to 1998. This only focuses on the final energy consumption of households and thus leaves the use of renewable energy in the provision of electricity and heat to households unexplored (this is in fact no minor limitation since it considerably reduces the potential use of renewable energy forms, particularly over the short term). The simulation took as its starting point the data produced in the "ambitious" renewable energy scenario analysed by Haas – Berger – Kranzl (2001) up to the year 2010. We assume in our simulation that the potential achievable for renewable energy up to the year 2010 as stated in this study, is in fact achieved in the period 1990 to 1998. This includes an increase in the capacity of biomass plants by 18 PJ, of solar driven heating plant by 7.6 PJ, and of plants using ambient environmental energy (heat pumps etc.) by 4.3 PJ. This additional quantity of renewable energy was distributed in the form of linear growth over the period 1990 to 1998. In accordance with the model assumptions used here the additional renewable energy replaces only fossil fuels and not electricity. As Table 5.8

shows, the reductions in CO_2 emissions and fossil fuels revealed by this scenario for the period 1990 to 1998 are almost the same as those found in the sustainability scenarios "heating". No additional costs for implementing greater use of renewable energy sources were taken into account, since it was assumed, in accordance with the study by Haas – Berger – Kanzl (2001) that such costs (which are quite considerable) are financed through reallocation of existing public funding programmes and subsidies (e.g. housing grants, environmental subsidies etc.). Thus, there is no initial impact on income, and there are no effects on private consumption nor on non-energy consumption.

Table 5.8: Results of Renewable Energy Scenario

	Difference to baseline in %
CO_2, heating	-11.6
Private consumption, total	0.0
Non-energy consumption	0.0
Private consumption (P 95)	
Heating	
Heating & lightning, total	0.0
Electricity	0.0
Coal	-11.3
Oil products	-11.3
Gas	-11.3

6. Summary and Conclusions

6.1 Background

In much of the past few decades, environmental debate tended to concentrate largely on the negative environmental impacts of production processes. In 1992, the Rio Earth Summit led to a more holistic approach, with the concept of sustainable development becoming an accepted part of scientific and political discourse. Consumer behaviour and lifestyles are also increasingly recognised as determining factors for sustainable development. Consumption structures influence production processes and involve resource use. An increase in consumer demand places more pressure on the environment, since on the one hand, in order to satisfy demand more energy and other resources have to be used, and on the other hand, there is a related increase in the amount of waste produced.

Given the importance of private consumption in the economy, it is imperative that consumption patterns be changed in order for sustainable development to be reached. Although the necessary steps for such a reorientation have already been dealt with in the literature (see section 6.3), as have the specific methodological requirements of ecological-economic information systems (see section 6.2), so far the related quantitative assessments are still lacking.

With this in mind, the present study set as its target the economic modelling and quantification of changes in consumption behaviour in the categories of transport and heating. For both these categories sufficient amounts of suitable data are available. The study aims to evaluate a number of technical options and potential changes in lifestyles and their respective impacts on energy flows. Here it is intended to move well beyond the standard models of consumption by incorporating non-economic factors, particularly in the categories transport and heating, into empirical and model analysis. Important innovations include the focus on consumption services and the depiction of the interaction between stocks (capital) and flows (energy and other materials). Further, the study also attempts to illustrate the impact of shifts in demand resulting from changes in consumption patterns.

Both the development of the model, as well as the empirical analysis of the respective changes in consumption patterns are placed within the general debates concerning the need for information systems in sustainable development and the treatment of sustainable consumption found in the relevant economic literature.

6.2 Environmental Information Systems

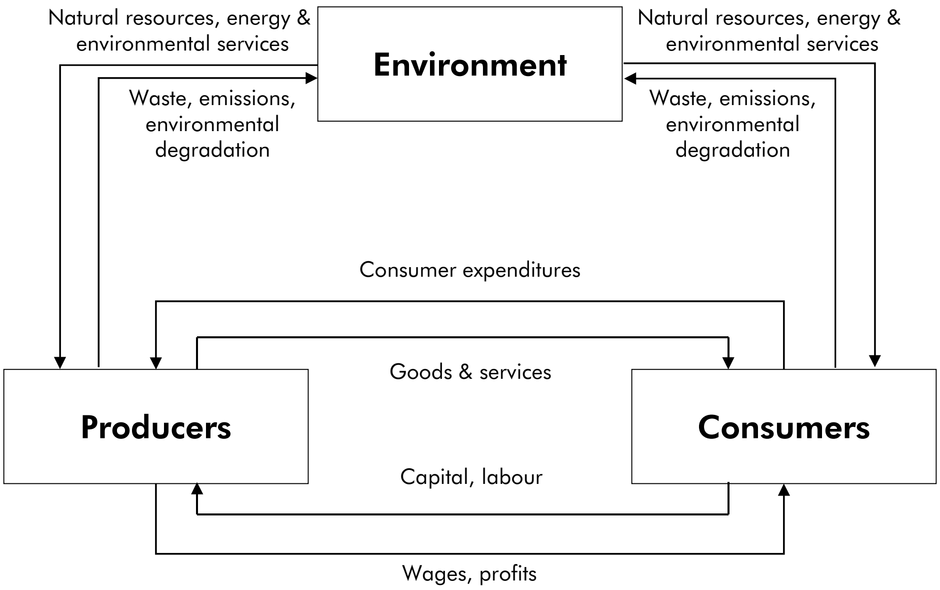
Suitable knowledge of the information systems which capture flows and interactions between environment and economy is a prerequisite for economic modelling of sustainable development.

Several methods for capturing and assessing environment and environmental services have been made available over the last few decades. The main motives and aims of these approaches derive from attempts to achieve the most comprehensive integration possible of environmental factors in national accounting systems.

As part of their revision of the System of National Accounts (SNA) in 1993, the United Nations devised and published the Integrated System of Environmental and Economic Accounting (SEEA). This and other work carried out at the UN, has been of fundamental benefit in this research area and has greatly influenced the design of the various strategies developed.

The underlying motives for producing a system capable of reflecting and securing internationally valid standards for environmental accounting derive mainly from the recognition that problems may indeed arise as a result of interactions between economic and/or ecological systems. Correct problem analysis depends therefore on sufficient knowledge of both systems, on knowledge of the interactions between the two, and on the possibility of a conceptual separation of the two realms. Two essential characteristics of the economic system are, on the one hand the orientation towards market-based transactions, and on the other, the representation of stocks and flows in terms of monetary units. Raw materials, energy and environmental services are all necessary in the production and consumption of goods. Figure 6.1 presents in simplified form, the various interactions which take place between the economic and environmental system. Included here are the normal transactions described in national accounts, physical flows or environmental effects.

Figure 6.1: Links between environment and economy



S: http://www4.statcan.ca/citygrp/london/london.htm.

On the one hand, the flows of environmental inputs into the economic system, in the form of raw materials, energy and environmental services, are depicted, and on the other hand the cycle is closed with the production of waste material and the deterioration of environmental quality resulting from economic activity.

6.3 Economic Modelling and Capturing of New Patterns of Consumption

In order to capture sustainable patterns of consumption, conventional economic models have to be adapted. In this respect, the approaches of *Wenke* (1993), *Conrad-Schröder* (1991), and the household production function approach derived from *Becker* (1965) and *Lancaster* (1966) all provide essential guidelines on the changes needed.

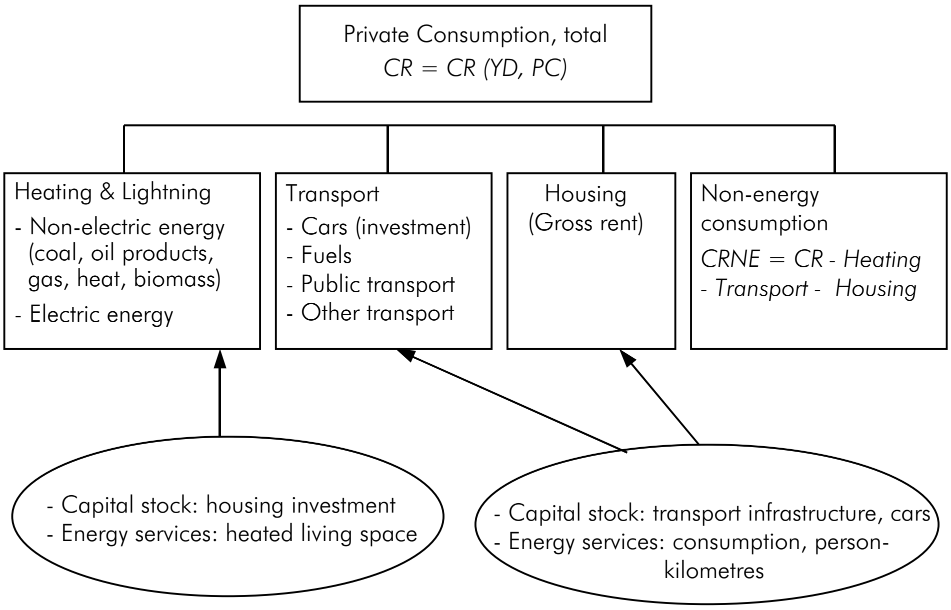
From these various approaches we derive a model of sustainable consumption in two categories of relevance for energy use, i.e. heating and transport. These were both categories where suitable basic data was readily available. The model elements thus derived include:

- Consideration of stock-flow relations
- Costs of adjustments in capital stock
- "Demand shifts" as possible (exogenous) changes in preferences.

A general model based on the above considerations (Figure 6.2) was then devised to depict sustainable consumption. The major components of this model are: Production functions for energy services (e.g. heating, mobility), an equation to describe capital accumulation (e.g. investment in improvements, purchase of vehicles), and demand functions for energy services. Demand functions for market goods are then derived from the production functions and expressed in terms of factor demand. Here, demand is not, as in the neo-classical approach, made solely dependent on relative prices, but adjusted in such a way as to reflect the stock of capital in infrastructure, which is treated as a quasi-fixed factor. The demand for energy services is modelled separately, where, in order to be consistent, the effects of demand shifts are considered[81]. By demand shifts, we are here referring to shifts in demand towards more sustainable patterns of consumption.

[81] Energy demand measured in national accounts data represents the average of different household types in terms of sustainability of consumption patterns. Thus, demand shifts are integrated directly into consumption demand.

Figure 6.2: Overall model



CR private consumption, total
YD household disposable income (nominal)
PC price index for private consumption, total
CRNE private consumption, non-energy

We thus obtain a model for consumption behaviour in the areas of heating and transport which is embedded in an overall model for aggregate private consumption. Total (real) private consumption is expressed as a function of real household disposable income. In the next step, in order to allow for more differentiation within this total, a distinction is made between the following categories: housing, heating/lighting, transport, and non-energy consumption. It is assumed that no explicit substitution takes place between these categories (i.e. none which can be derived from the theoretical relations described in the model), but rather, for the given levels of total consumption and expenditures for housing, heating/lighting and transport, non-energy consumption is treated as a residual.

"Ex post" simulations were carried out with the model for the period 1990 to 1998 in order to provide sustainability scenarios in terms of CO_2 emissions. In settling on a suitable definition for the sustainability target a rather pragmatic approach was chosen. Consumption in the categories of heating and transport was said to be sustainable when it led over a ten year period to CO_2 emission levels being 13% lower than the levels reached in 1990. The results of the ex post simulations reveal how much actual levels diverge from the target set. The gap between the two time paths shows that substantial intervention would be needed in order to redirect consumption patterns.

While the use of such a pragmatic criterion for assessing and defining sustainability obviously cannot capture the whole spectrum of sustainable consumption, it does make a significant contribution to the depiction and operationalisation of the structures that need to be considered in economic modelling. The simulations indicate in which specific areas changes would have to be made, in order to induce, in the period of about a decade, a move towards sustainable consumption patterns. Such changes may arise in many different ways, e.g. as a result of deliberate policy making or through alterations in social values. Technological innovation can contribute as well as demand management policy.

To aid comparison, "maximum settings" were used in the simulation runs, i.e. in each of the scenarios tested, and thus for every exogenous intervention, the sustainability target had to be reached (the above mentioned 13% reduction in CO_2 emission levels). This procedure is necessary in order to allow for direct comparison of the various simulation results. The effects of changes in technology, prices and behaviour are thus made visible. The results indicate that any attempt to achieve the 13% reduction in CO_2 emissions by concentrating on specific single measures would involve intense or excessive effort. It seems that moving prevailing consumption behaviour towards more sustainable patterns is only likely to succeed when a bundle of various policy instruments is used. This also includes non-quantifiable factors. Furthermore, the highly illustrative simulations carried out for the category of transport reveal that both the provision of infrastructure as well as its extent exhibit a traffic-inducing effect.

With respect to transport, the following sustainability scenarios were defined and calculated:

- "Road Pricing": a kilometre charge for cars is introduced and then returned to households in the form of a llump sum transfer payment ("ecobonus")
- "Zero charge": the price of public transport is reduced and offset by an increase in vehicle tax
- "Regional Planning": the density of city populations increases
- "Demand shifts": the proportion of "normal" households falls, that of sustainable households rises.

With respect to heating, the following sustainability scenarios were defined and calculated:

- "Building Regulations": minimum standards for thermal quality in construction induce investment in improving building stock (buildings constructed between 1945 –1980)
- "Demand shifts": the proportion of "normal" households falls, that of sustainable households rises.

To further aid understanding, additional simulations were carried out to assess the influence of infrastructure investment in public transport, and to test policies aiming at the promotion of biomass in household energy demand.

Table 6.1 presents information on the extent and impact of the measures used in the various scenarios. It can be seen in all cases that reaching the emission path for achieving the Kyoto targets in the period 1990 to 1998 would have demanded massive changes in the relevant variables.

Sustainability Scenario "Road Pricing"

This scenario comes closest to representing a neo-classical environmental policy approach in that it targets emission prices. It proposes a tax on kilometres travelled. This could be implemented in the form of a toll fee for example, or in the form of a vehicle charge per kilometre. The crucial aspect in this scenario is the intended revenue neutrality (i.e. in total, there are no new net revenues generated since tax revenues raised are returned). This is designed to prevent any negative macroeconomic impacts. Ex post, i.e. after the desired change in demand has occurred, the road pricing policy produces € 1.8 bn for the approximately 45 bn km driven (average 1990 – 1998). This represents an effective charge of about € 0.04 per kilometre.

The road charge raises consumer prices by about 1.7%, while the revenue recycling has an opposite effect so that the net impact is close to zero. As a result there is therefore hardly any change in real household disposable income. Thus, given the fall in real expenditure on individual motorised transport, we see a corresponding increase in expenditure on non-energy consumption. Further, not only has fuel consumption fallen by the 11.3% necessary to achieve the targeted CO_2 levels, all forms of expenditure on individual motorised transport fall too. This includes car purchases (approx. -15%) and real vehicle fixed costs (-7.5%) since, similar to an increase in fuel tax, the road charge raises the variable costs of car use. In addition, since public transport declines by a mere 0.9%, we also see a change in the demand structure for transport, with an alteration in the modal split between private and public transport. Summing up, the "road pricing" scenario, in correspondence with many other studies on energy taxation, shows that with respect to the standard indicators employed in national accounts, sustainable development can indeed be combined with positive macroeconomic effects (double dividend). However, this would demand substantial interventions regarding politically sensitive prices.

Sustainability Scenario "Zero Charge"

The logic underlying this scenario is based on the assumption that the general acceptance of public transport will increase. The extent to which cost considerations affect such acceptance is also tested here. Thus, this scenario is also an example of neo-classical price regulation of emissions being used as an environmental policy instrument. In this sustainability scenario, the price for public transport is reduced on average over the period 1990 to 1998 by 30%, and the resulting revenue loss experienced by the transport companies is offset by an increase in vehicle tax.

The required fall in fuel consumption of 11.3% is achieved on the one hand by the shift from private to public transport (+6.1%), and also by the manifold effects of the increase in vehicle tax on fuel consumption. The increase in effective vehicle tax, which (ex post) generates extra tax income to the value of € 363 million, has an impact on the average fuel consumption of the car fleet, and also greatly influences the real fixed costs of private transport, which in turn dampens vehicle purchases. I.e. fewer, and at the same time, more fuel-efficient vehicles are purchased in an effort to offset, at least partly, the increase in vehicle tax. The combined price and income effects result in a real decline of car purchases by 15% and a real decline in fixed costs by 25%. In total, we see a smaller increase in non-energy consumption (+1.3%) than in the "road pricing" scenario. Thus, in this scenario too, positive effects on non-energy consumption and related advantages for the macroeconomy are to be expected (see Table 6.2). The present scenario differs from "road pricing" in that compensatory payments in order to achieve a double dividend effect and to offset the increased tax are not made in the form of a general reimbursement. Here, on the other hand, a double steering effect is achieved by targeting compensation specifically at a lowering of public transport charges. It is not least because of this, that policy intervention – involving the politically sensitive issue of price rises– is able to be kept at a relatively low level. If, in order to raise the attractiveness of public transport, additional measures were used at the same time (e.g. schemes to promote co-operation with taxi operators), it would be possible to increase steering effects still further. In such a scenario it is also possible to make the idea of cost redistribution even more transparent for households by providing a direct link between the two cost elements. For example, the annual payment of vehicle tax could be automatically coupled with the provision of a public transport pass.

In this scenario, an increase in the average fuel efficiency of the car fleet and a decline in the distances travelled, both factors being a result of the increase in vehicle tax, lead to a fall in fuel consumption. Here, the reduction in car fuel consumption as a result of the raise in vehicle tax, is at least as great as that arising from the alterations in modal split due to the decline in public transport charges.

Sustainability Scenario "Regional Planning"

The starting point for this scenario is provided by changes in lifestyles occurring between 1990 and 1998 which led to an increase in traffic volume. The central variable in the model is the ratio of the density of the population in areas surrounding cities to that of the population in the cities. This ratio rose continuously throughout the period 1990–1998, reflecting a lifestyle of "work in the city and live in the country". In contrast to this consumer lifestyle, it was assumed in this scenario that population movement would have led to increased concentration of residential and work areas within the cities. This leads to a significant increase in city population density, with the respective figures going up by 40 persons per square kilometre (+29%). From our point of view, this sustainability scenario is important in that it illustrates the interface between transport and housing. Regional shifts in the population have no impact on the total level of private consumption. This corresponds to the pattern of a fall in redundant energy services with no reduction in the level of economic welfare. Since, however, only the expenditure on fuel consumption falls and other transport related expenses remain almost constant, we witness merely a slight shift between energy and non-energy consumption.

Sustainability Scenario "Demand Shifts" in Transport

This scenario is intended to analyse the effects of a shift in household types towards more sustainability. This is largely assumed to take place through changes in transport behaviour, and as mentioned above (see section 4.2.2), a multitude of factors have to be taken into consideration. In order to achieve the CO_2 target here, the two household types are no longer divided based on the median value, but on the assumption that 64% of households must engage in more sustainable consumption, and only 36% may remain "normal". The result is mainly an expenditure shift between private and public transport with transport costs remaining constant. In total, this leads to a slight increase in kilometres travelled of 3%. The differences in consumption expenditure for each household type were also taken into account. This showed that "sustainable" households tend to exhibit lower consumption expenditure. The shift in the household structure thus leads to a decline in total real private consumption by about 2%, whereby non-energy consumption falls by 2.6% (see Table 6.2). In this scenario, a decline in energy flows is achieved by a reduction of the flow of goods in total consumption.

Sustainability Scenario " Building Regulations"

In this scenario, the thermal quality of building stock constructed in the period 1945 to 1980 is increased to such an extent that achieving the targeted emission levels is possible. The simulation assumes that official proof for the achievement of minimum standards of energy efficiency would be required in building regulations, and that this would then trigger the necessary investment in renovation and improvement (a sum of € 2.9 bn). In the model, household investment in the necessary improvements has to be financed by an increase in expenditure on housing.

To achieve the emission targets set for heating, real expenditure on heating/lighting has to decline by 11.7%. The scenario shows that the capital stock of housing (in terms of thermal quality) would have to increase by € 8.7 bn on average for the period 1990 to 1998 to achieve the emission target. In the simulation the least favourable case for households is used, i.e. it is assumed that households have to finance renovation themselves and also that all renovation costs are ascribed to emission reduction. In reality, one can assume that investment in renovation, by leading to an improvement in the quality of housing stock, will in fact also exert a positive effect on household welfare. Financing renovation puts a considerable burden on households, leading to an increase in real expenditure on housing of 2.3%. With no change in total expenditure for private consumption, this in turn leads to a decline in non-energy consumption by 0.3%.

Sustainability Scenario "Demand Shifts" in Heating

As in the corresponding simulation in transport, this scenario leads to a shift in household types with respect to heating/lighting, such that 62% of households would have to consume in a more sustainable fashion, while 38% are allowed to remain "normal" in their consumption habits. At the same time, the differences in total consumption expenditures for the household types were also taken into account. The shift in household structure thus leads to a decline in total real private consumption by 1.9%, with non-energy consumption falling by 2.3% .

Table 6.1: Policy Instruments for Sustainability Scenarios (average 1990 - 1998)

Simulation Scenarios Transport	Road pricing	Zero charge	Regional planning	"Demand shift"
Changes in variables				
Road toll revenues	1.8 bn €			
Vehicle tax (fixed costs)		0.34 bn €		
Price of public transport		-29.6%		
City population density			41 inhabitants per km²	
Change in shares of household types				14%points

Simulation Scenarios Heating	Regulations	"Demand shift"
Capital stock, dwellings	8.7 bn € [1])	
Change in shares of household types		12%points

[1]) of which only 2,9 bn € per year are due to investment in thermal improvement

Table 6.2: Simulation Results for the Sustainability Scenarios "Transport" (average 1990 - 1998)

	Road pricing	Zero charge	Regional planning	"Demand shift"
		Difference to baseline in %		
Consumer prices	1.7	1.3	-	-
Private consumption, total	0.1	-1.1	0.0	-1.9
Non-energy consumption	2.0	1.3	0.5	-2.6
Private consumption (P 95) Transport				
Cars	-14.6	-15.0	0.0	-
Fuels	-11.3	-11.3	-11.3	-11.4
Public transport	-0.9	6.1	-0.4	20.0
Other transport	-7.5	-24.7	0.0	-
Transport activities				
Person-kilometres, total	-12.7	-10.4	-12.5	2.8
Person-kilometres, cars	-17.9	-15.6	-17.9	-17.9
Person-kilometres, public transport	-1.7	0.7	-0.6	45.8

Table 6.3: Simulation Results for the Sustainability Scenarios "Heating" (average 1990-1998)

	Regulations	"Demand shift"
	Difference to baseline in %	
Private consumption, total	0.0	-1.9
Non-energy consumption	-0.3	-2.3
Gross rent	2.3	-
Private consumption (P 95) Heating		
Heating & lightning, total	-3.5	-11.7
Electricity	0.0	-11.7
Coal	-11.7	-11.7
Oil products	-11.7	-11.7
Gas	-11.7	-11.7

6.4 Conclusions for Policy Making

- To date, implementing economic structures consistent with sustainable development has largely consisted in pointing to those restructuring measures considered desirable, i.e. measures where present levels of economic welfare can be maintained with lower material throughput (flows), and reducing the use of problem materials and substances, mainly fossil fuels.

- International research on sustainable consumption is mainly focused on conceptual analysis and/or project based work. A central point in theoretical and practical work is the focus on a reorientation of demand structures. In contrast, the integration and depiction of sustainable demand structures in empirical economic modelling is more or less new ground in research. The empirical study presented here for Austria, can be considered a major step towards the integration of sustainable consumption patterns (for heating and transport) in an overall consumption model (a partial model in the aggregate economy). For the first time in this context, an analysis of demand shifts was presented, a subject of central importance in the literature, and their respective impact was calculated within the overall consumption model for Austria.

- In the present project specific focal points in the field of consumption behaviour were chosen as a basis for analysis. The modelling procedure revealed the possibility of a new and extended method for the measurement of economic welfare. The role of welfare relevant consumption services generated by a combination of stocks and flows is to be analysed. This reveals the important result that calculations based on flows alone can be highly misleading, particularly in the field of consumption.

  The economic analysis of sustainable consumption patterns or structures attempts to clarify the extent to which it might be both possible or commendable to promote the substitution of flows by stocks (e.g. improvements in thermal quality of buildings, or more energy efficient transport systems). Relevant too, in this respect, is the role that can be played by technological innovation (improvements in the existing building or vehicle fleet stock, or the potential for introducing specific incentives to promote new technologies). Two crucial aspects thus determine the sustainability of consumption: the demand shifts concerning the consumer services desired, and the composition of the stock-flow mix necessary for the service provision.

  In accordance with the above considerations, the following adaptations were introduced to distinguish the present analysis from that found in conventional models:

  - Instead of an economic analysis of consumption flows, attention was focussed on the level of consumption service achieved through stock-flow combinations.

  - Stock-flow relations were explicitly modelled.

- The integration of technological innovation into the interplay of stocks and flows and the respective impact on consumption services affecting welfare.
- Demand shifts as a result of changes in lifestyle were taken into account.

- Thus, economic policy can influence consumption patterns in three principle ways:
  - by influencing shifts in demand (e.g. through campaigns to raise public awareness),
  - by acting on relative prices (e.g. those of stocks and flows) and
  - by creating incentives to promote suitable technological advances (e.g. investments in infrastructure, or specifically targeted R&D programs).

- The modelling of sustainable consumption patterns in the categories of heating and transport represents an important step towards operationalising sustainability. The present analysis clearly moves beyond the state of international research projects mentioned in the report. A major point that has to be emphasised is that an empirical assessment of specific aspects of sustainability for private consumption in Austria was achieved for the first time. The simulations carried out here offer several advantages. They point out the extent and the direction of the behavioural changes needed to achieve sustainable consumption patterns as well as the possible form that policy intervention might take (economic instruments, infrastructure investment, raising public awareness, provision of relevant information etc.). In addition, the economic impact of the various policy measures and the resulting alterations in the patterns of consumption were all quantified.

  It must be noted, however, that the wide dimension of sustainability cannot be properly captured in simulations based on the economic modelling procedures. Sustainability involves three dimensions, and to test it accurately would require a global, integrated model. Such an approach had to be dispensed with for simple reasons of practicality. In the current study, only the economic dimension was – as far as possible – taken as the subject of model analysis.

- The empirical evidence produced by the model reveals that economic instruments – in this case taxes and road pricing – can generate positive macroeconomic effects. This result is consistent with the evidence of several other studies that have been undertaken to test the effects of economic instruments in environmental policy. What is new in the present research is the strong focus on consumption services. It was found, and this deserves considerable stress, that consumption flows alone are not always relevant for economic welfare. The crucial point is that it is a combination of flows with a specific level of capital stock that leads to the achievement of the desired consumption service.

- Although the results appear positive for the macroeconomy, and despite theoretical confirmation of their potential efficiency, political realities lead to such policy measures being largely ignored. A prerequisite for successful implementation of such measures is the willingness to accept major changes in the existing economic framework. Macroeconomic effects are clearly only one part in the total assessment process. Other data found in the simulations would appear to be more important for political decision making. This includes: information on the starting points chosen for the policy interventions and the extent of possible effects on prices, tax rates, capital stock etc. In Overview 6.1, for example, the "zero charge" scenario for public transport demands an increase in vehicle tax of € 340 m. In comparison, the "road pricing" scenario for cars, has an equivalent ecological impact, but places an extra burden on the variable costs of private transport to the tune of approx. € 1.8 bn. In total the road pricing scenario has a greater positive economic impact (see Overview 6.2).

For the first time, the model framework makes it possible to assess the economic impact of shifts in demand. In the concrete case, this means that as far as the demand for energy in the categories heating and transport is concerned, the model is capable of determining how high the shift in the share of Austrian households towards more sustainable consumption would have to be, in order to reach the target set. The explanatory and predictive power of the model are largely exhausted when one begins to ask questions concerning how these shifts in demand are propagated or how high monetary expense needs to be in order to induce such changes in consumption behaviour. Looking at the issues in qualitative rather than quantitative terms, however, it can be assumed that apart from changes in consumption, the realisation of structural changes on the supply side should also prove possible. The existence of interactions between technology and changes in public awareness becomes clear. Such complexity makes it all the more necessary that political objectives are stated as explicitly as possible.

- A paradigm shift in society is of fundamental importance in achieving demand shifts, i.e. there has to be a move away from the belief that a rise in economic welfare can only be gained by more consumption or by the accumulation of material goods. To begin such a process of reorientation requires not only explicit clarification of priorities and targets in public policy, but also the simultaneous (co-ordinated) use of several different policy measures. In particular, the role of services on the supply side should be given much greater attention. This could be achieved on the one hand through measures in public administration (e.g. the public provision of transport infrastructure), and on the other hand there should be greater co-operation with private companies so that more integrated forms of product/service systems can be developed and made available. Apart from the influence of regulatory measures, companies should also recognise the possibility of occupying specific market niches through the supply of ecologically innovative offerings and the potential for creating long-term relations with customer groups interested in more comprehensive services in specific product areas. On the demand side, apart from the use of price related measures, strategies designed to inform and educate the public are of particular importance, and in recent years much greater emphasis has been placed on the need to design such programmes specifically for various target groups. Integrating consumers into the decision making process is also one clear means of influencing public awareness.

In conclusion, it can be stated that the comprehensive nature of the modelling and quantification of the economic impact of changes in consumption patterns carried out in the present study, has not been seen in international work before. In contrast to the analysis found in standard economic modelling, not only flows alone are considered as important important for demand satisfaction, but also stocks (e.g. infrastructure). Crucial here is the service element in demand which can be satisfied by combining different bundles of goods with input of time and know how. Thus, greater flexibility is achieved in the depiction of consumption patterns. Here, in contrast, to neo-classical analysis, relative prices alone are not sufficient to explain demand satisfaction. Additional important factors in this respect are the specific characteristics of goods and/or of stocks (e.g. vehicle fuel efficiency, improved housing insulation), as well as changes in consumer life style.

Data limitations prove to be a problem in the implementation of such a broad approach. This begins with attempts to capture the comprehensive nature of sustainability, which really would only be possible in a global, integrated model. The solution attempted, involved defining sustainability in terms of the behaviour of "exemplary" households. Although this makes the concept operational and quantifiable, it is not possible to ascertain how or at what cost such sustainable consumption patterns can be achieved. As it is only possible to link economic and technical data for the categories heating and transport, and since such data are needed to portray the service aspects, material flows and environmental effects underlying consumption, the present study restricts itself to these two areas in its empirical analysis of the consumer models employed. This means that other relevant categories of consumption, i.e. in the sense that the materials flows they involve are also relevant in terms of sustainability, are aggregated into the category "non-energy consumption" and thus remain hidden. A further limitation of the study is the use of CO_2 emissions as the sole indicator for sustainability. Furthermore, the simulation model used is a partial model, which takes private consumption (in total) to be the relevant factor for the aggregate economy. Thus, all indirect effects produced by consumption also remain hidden. Such indirect effects include on the one hand, impacts on aggregate economic data (e.g. GDP, employment rates, etc.), and on the other hand, ecological impacts in addition to those reflected by CO_2 emissions (e.g. general or specific material flows).

Future Analysis

Extending the existing model to cover the whole economy is worth considering as the next possible step in analysis. In practice, this means that the consumption model would have to be integrated into a currently existing aggregate economic model and an energy model (MULTIMAC and DAEDALUS). With regard to category definition and the more specific modelling of those activities currently subsumed under "non-energy consumption", a serious attempt should be made to clearly depict the consumption categories of relevance to sustainability (i.e. those consumption activities involving relevant material flows). The input-output interdependencies in the aggregate economic model would allow all indirect effects of consumption to be captured, the energy model would achieve the same for indirect energy effects. Only the use of such an aggregate model would enable comprehensive economic assessment of the impact of policy intervention in specific areas of consumption (e.g. regional policy) and would be able to include impact assessment of those areas only very indirectly affected (e.g. labour market impact disaggregated according to qualifications).

A further step would involve a much more detailed description of the relations between ecology and economy. Depicting such relations in a model can take manifold forms. One dimension that has already been integrated is the connection between energy consumption and CO_2 emissions. One extension to this might involve "attaching" additional emissions or material flows (NAMEA) at the level of consumption (directly affected) and at the level of other (indirectly affected) activities. A further extension would then be to improve the indicators used. It is conceivable, for example, that new indicators be derived from the material flow data available for Austria (e.g. on the carbon cycle).

Glossary

AIDS Model

The AIDS (Almost Ideal Demand System) model of private consumption was proposed by Deaton and Muelbauer in 1980, and has since been widely applied in empirical research. AIDS provides a complete demand system for a number of different goods. The starting point is the expenditure function (cost function) for a typical consumer. The demand system is obtained by minimisation of the cost function. The budget share of any one good is explained by the development of total expenditure and by goods' prices and is expressed in a semi-logarithmic function.

CES-Function

Unlike a Cobb-Douglas function, where elasticity of substitution is equal to 1, for a CES (constant elasticity of substitution) function, elasticity of substitution merely remains constant over the whole space of the production function. This can be taken as a less restrictive form of the production function.

Cobb-Douglas Function

The production function developed by Cobb and Douglas describes the relationship between input factors and output Q for a particular good. E.g. factors of production such as capital K and labour L (with F representing exogenous technical progress) can be expressed in the following form:

$Q = F\,L^{\alpha}\,K^{\beta}$

A Cobb-Douglas function is homogenous of degree 1, i.e. an increase in K and L by 1% results in an increase in Q by 1%. This is given by the fact that $\alpha + \beta = 1$ This restriction ensures that the elasticity of substitution between K and L, i.e. the possibility of replacing inputs of K with inputs of L and vice versa, is equal to one.

Assuming firms are profit maximising, it becomes possible to derive demand functions for the input factors K and L from the production function which will be dependent on their relative prices.

Double Dividend

This concept derives from the work of David Pearce (1990). He postulated that an environmental tax reform, i.e. the levying of a tax on resources coupled with a simultaneous reduction in other taxes, will have a double effect. There will be an improvement in environmental quality without any negative effect on income or welfare. In cases where at the same time a "distortionary" tax is reduced, e.g. wage dependent charges, which lead to misallocation in the labour market, one can even expect there to be an improvement in welfare levels.

Elasticity

This is a measure of the percentage change in one variable as a result of a percentage change in another variable, where the change in one is deemed to be caused by the change in the other. For example, the price elasticity of demand shows the percentage change in the quantity demanded of a good, when the price of this good increases by 1% .

Flow

The amount of some economic variable (e.g. income) measured per unit of time, expressed in monetary or physical terms. For example in national accounting, the flow of investment is measured by the amount of investment expenditure undertaken in a certain time period.

Multicollinearity

This refers to the problem in econometric analysis when two or more of the explanatory variables are highly correlated with each other. This makes it impossible to capture the exact effect of the explanatory (independent) variables is acting on the dependent variable. This may lead to errors in parameter estimation and/or may raise the variance of the estimated parameters.

Neoclassical School

Neoclassical economics began with the "marginal revolution" in 1871 (Jevons, Menger, Walras). Marginal utility analysis provided an elegant solution to centuries old paradoxes in value theory (e.g. the water-diamond paradox) and led to the use of indifference curve analysis (Edgeworth) in describing consumer behaviour. As a comprehensive theory, the central point of neoclassical analysis is the extension of the principle of counter trading to consumption and production which relies on the concepts of a utility maximising consumer and a profit maximising firm. Market behaviour is thus explainable in terms of individual optimisation. The formation of market equilibria with market clearing prices acts as the essential signal for consumers and firms. This partial analysis was extended by Walras and Pareto around 1900 to produce a (static) general theory of equilibrium.

Perpetual Inventory Method

This approach was derived from research undertaken by Almon. The method is used to estimate total capital stock, and takes as its starting point known historical levels of real investment, suitable rates of depreciation and data on gross fixed capital formation. The method focuses in particular on the difference between existing physical capital stock and/or potential output and capital stock in the economic sense. The capital depreciation of one year is added to a undisclosed reserves which are itself subject to depreciation. This splits capital stock into two component parts, an active and an undisclosed part, both of which can be determined simultaneously.

Statistical Matching

This method links data from different statistical sources using representative rather than real individuals. By using highly specific characteristics, it becomes possible to describe these representatives with such a degree of accuracy that conclusions on individual behaviour can still be drawn. In the present study, descriptive data from the micro-census (also found in consumption surveys) was used to describe household characteristics. Data on sex, age, occupation, education, place of origin, household composition (number of children), housing expenditure and running costs, can all be used to aid identification. The distributions on the basis of micro-census classifications are transferred to the consumer survey samples and the consumption expenditures are fitted to the respective representative agents.

Stock

The amount of some relevant variable at a specific point in time. Stocks may be measured in monetary or physical units (e.g. tons of inventory, number of unemployed at a particular cut-off date, existing level of consumer durables). In contrast to flows, stocks do not involve a time dimension.

Stock Adjustment Models

Such models derive originally from the work of Stone and Rowe (1957). In the extended version used here, it is assumed that actual capital stock K is adjusted to desired capital stock K* by means of a second order adjustment process, thus:

$$K_{i,t} / K_{i,t-1} = [K^*_{i,t} / K_{i,t-1}]^{\tau 1} [K_{i,t-1} / K_{i,t-2}]^{\tau 2}$$

This gives:

$$\ln(K_{i,t}) - \ln(K_{i,t-1}) = \tau_1 [\ln K^*_{i,t} - \ln K_{i,t-1}] + \tau_2 [\ln K_{i,t-1} - \ln K_{i,t-2}]$$

Closure of the model is achieved by the addition of an equation which explains capital stock K*. This latter is normally dependent on long term developments, e.g. output changes and other important variables.

References

Adriaanse, A., Environmental policy performance indicators: A study on the development of indicators for environmental policy in The Netherlands, The Hague: Netherlands Ministry of Housing, Spatial Planning and the Environment, 1993.

Alston, J. M., Chalfant, J. A., Piggott, N. E., "Incorporating demand shifters in the Almost Ideal demand system", Economics Letters, 2001, 70, S 73-78.

Atkinson, G., Dubourg, R., Hamilton, K., Munasinghe, M., Pearce, D., Young, C., Measuring Sustainable Development. Macroeconomics and the Environment, Edward Elgar, Cheltenham, 1997.

Ayres, R.U., Kneese, A.V., "Production, Consumption and Externalities", American Economic Review, (59), S. 282 – 297, 1969.

Becker, G. S., "A theory of the allocation of time", Economic Journal, 1965, 75, S 493-517.

Biesiot, W., Noorman, K.J., "Energy requirements of household consumption: a case study of The Netherlands", Ecological Economics, 1999, 28 (3), 367 – 383.

BMLFUW, EST Österreich, "Environmentally Sustainable Transport (EST) – Ausdehnung der Fallstudie EST Alpen auf Österreich, vorläufiger Projektbericht, Wien, 2000.

Bollino, C. A., Perali, F., Rossi, N., "Linear Household Technologies", Journal of Applied Econometrics, 2000, 15, S 275 - 287.

Bossel, H., Indicators for Sustainable Development: Theory, Method, Applications. A Report to the Balaton Group, IISD, 1999.

Bossel, H., "Policy assessment and simulation of actor orientation for sustainable development", Ecological Economics, 2000, 35 (3), 337 – 355.

Brand, I., "The Perspective Project Towards an energy-aware lifestyle", paper presented at the ProSus/CSTM Workshop on Sustainable Household Consumption: Impacts, Goals and Indicators for Energy-use, Transport and Food, University of Twente, November 17-19, 2000.

Brezet, J.C., Bijma, A.S., Ehrenfeld, J., Silvester, S., The Design of Eco-efficient Services, Method, tools and review or the case study based "Designing Eco-efficient services" project, Design for Sustainability Program, Delft University of Technology, 2001.

Brown, P. M., Cameron, L. D., "Survey: What can be done to reduce overconsumption?" Ecological Economics, 2000, 32 (1), 27 – 41.

Cogoy, M., "Analysis: The consumer as a social and environmental actor", Ecological Economics, 1999, 28 (3), 385 – 398.

Conrad, K., "Konsumnachfrage, Folgekosten und Kostenpreise", Zeitschrift für Wirtschafts- und Sozialwissenschaften, 104, 1984.

Conrad, K., Schröder, M., "Demand for durable and nondurable goods, environmental policy and consumer welfare", Journal of Applied Econometrics, 6, 1991.

Crocker, T., Tschirhart, J., "Ecosystems, Externalities and Economies", Environmental and Resource Economics, (2), S. 551 – 567, 1992.

de Gijsel P., Gerlach K. , Glombowski J. (Eds.), Nachhaltigkeit in der ökonomischen Theorie, Ökonomie und Gesellschaft Jahrbuch 12, Campus, Frankfurt, 1997.

Deaton, A, Muellbauer, J., Economics and consumer behavior, Cambridge, 1980.

Diekstra, R., Kroon, M., Cars and behaviour: psychological barriers to car restraint and sustainable urban transport, in: Tolley, R., (Eds), The Greening of Urban Transport: Planning for Walking and Cycling in Western Cities, John Wiley & Sons Ltd., 1997.

Diewert, E. W., Wales, J., "Flexible Functional Forms and Global Curvature Conditions", Econometrica, 55, S 43-68, 1987.

Douglas, M., Isherwood, B., The World of Goods, Towards an Anthropology of Consumption, London, 1980.

Duchin, F., "Population Change, Lifestyle, and Technology: How Much Difference Can They Make?", Population and Development Review, 1996, 22 (2), 321 - 330.

Duchin, F., Structural economics: measuring change in technology, lifestyles, and the environment, Island Press, 1998.

Empacher, C., Götz, K., Schultz, I., Haushaltsexploration der Bedingungen, Möglichkeiten und Grenzen nachhaltigen Konsumverhaltens, Teilprojekt 2 des Demonstrationsvorhabens zur Fundierung und Evaluierung nachhaltiger Konsummuster und Verhaltensstile, im Auftrag des Umweltbundesamtes Berlin, Endbericht (unveröffentlicht), Februar 2000A.

Empacher, C., Götz, K., Schultz, I., Results of the Study "A Household Exploration of the Conditions, Opportunities and Limitations Pertaining to Sustainable Consumer Behaviour", www.isoe.de/inhasta.htm, Juni 2000B.

Etzioni, A., "Opening the Preferences: A Socio-Economic Research Agenda", Journal of Behavioral Economics, 15, 1985.

European Commission, Directions for the EU on Environmental Indicators and Green National Accounting - Integration of Environmental and Economic Information Systems, COM (94) 670, 1994.

Eurostat, The Environment Industry Manual, Draft Report, Doc.Eco-Ind/98/1, Luxembourg, 1998.

Eurostat, Towards Environmental Pressure Indicators for the EU, First Edition, 1999.

Eurostat, Umweltgesamtrechnung 2000. Gegenwärtiger Stand und zukünftige Entwicklung, Eurostat B1, Brüssel, 2000.

Fuchs, I., "Naturvermögensrechnung Bodenschätze: Zur Bilanzierung der Vorräte", Statistische Nachrichten, Wien, (2), S. 117-128, 2000.

Gallopín, G. C., Indicators and their Use: Information for Decision-making, in: Moldan, B., Billharz, S. (Eds.), Sustainability Indicators, Report of the project on Indicators of Sustainable Development, SCOPE, 1997.

Gatersleben, B., Vlek, Ch., "Household Consumption, Quality of Life, and Environmental Impacts: A Psychological Perspective and Empirical Study", in: Noorman, K. J., Schoot Uiterkamp, T. (eds.), Green Households? Domestic Consumers, Environment, and Sustainability", Earthscan Publications Ltd., London, 1998.

Gatersleben, B., "Sustainable household consumption and quality of life: the acceptability of sustainable consumption patterns and consumer policy strategies", International Journal of Environment and Pollution, 15 (2), 2001, 200 – 216.

Gerhold, S., Petrovic, B., "Öko-Industrien 1996 und 1997", Statistische Nachrichten, Wien, (2), S. 122-128, 1999.

Gerhold, S., Petrovic, B., Materialflussrechnung: Bilanz 1997 und abgeleitete Indikatoren 1960-1997, Wien, mimeo.

Gintis, H., "Beyond Homo economicus: evidence from experimental economics", Ecological Economics, 2000, 35 (3), 311 – 322.

Guenno, G., Tiezzi, S., The Index of Sustainable Economic Welfare (ISEW) for Italy, Fondazione Eni Enrico Mattei, Nota di Lavoro 5.98, 1998.

Guinomet, I., The relationship between indicators of sustainable development, An overview of selected studies, 1999.

Hannon, B., Costanza, R., Herendeen, R. A., "Measures of Energy Costs and Value in Ecosystems", Journal of Environmental Economics and Management, (13), S. 391 – 401, 1986.

Hannon, B., "Input-Output Economics and Ecology", Structural Change and Economic Dynamics, (6), S. 331 – 333, 1995.

Hardi, P., AtKisson, A., The Dashboard of Sustainability, draft, 1999.

Hardi, P., Zdan, T., Assessing sustainable development: Principles in Practice, IISD, 1997.

Hecht, J. E., Environmental Accounting. Where we are now, where we are heading, Resources for the Future, 1999.

Hedtke, R., Nachhaltigkeit und Konsum. Sozialwissenschaftliche Konzepte und ihre Relevanz für die Lehrerausbildung, 1999.

Heiskanen, E., Pantzar, M., "Towards Sustainable Consumption: Two New Perspectives", Journal of Consumer Policy, Consumer Issues in Law, Economics and Behavioural Sciences, Kluwer Academic Publishers, 1997, 20, 409 – 442.

Hinterberger, F., Luks, F., Stewen, M., "Wie ökonomisch ist die Stoffstromökonomik. Eine Gegenkritik", Konjunkturpolitik (45), S. 358 – 375, 1999.

Jacobs, M., Røpke, I., "Special Section: Consumption and Environment – Perspectives from Ecological Economics", Ecological Economics, 1999, 28 (3), 363 – 364.

Jager, W., Janssen, M. A., De Vries, H. J. M., De Greef, J., Vlek, C. A. J., "Behaviour in commons dilemmas: Homo economicus and Homo psychologicus in an ecological-economic model", Ecological Economics, 2000, 35 (3), 357 - 379.

Jager, W., Janssen, M. A., Vlek, C., "Experimentation with household dynamics: the consumat approach.", Sustainable Development 2001, (1), 90-100.

Janssen, M. A., Jager, W., Preface: "the Human Actor in Ecological-Economic Models", Ecological Economics, 2000, 35 (3), 307 – 310.

Jesinghaus, J., A European System of Environmental Pressure Indices, First Volume of the Enviromental Pressure Indices Handbook: The Indicators, draft, 1999, http://esl.jrc.it/envind/theory/Handb_.htm.

Jolivet, P., Haake, J., "Some reflections on the link between production and consumption for sustainable development."

Katterl, A., Kratena, K., "Reale Input - Output Tabelle und ökologischer Kreislauf", Wirtschaftswissenschaftliche Beiträge 39, Physica, Heidelberg, 1990.

Kletzan, D., Köppl, A., Environmentally Counterproductive Support Measures im Bereich Energie, vorläufiger Endbericht, Studie im Auftrag des BM für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Dezember 2001.

Kletzan, D., Köppl, A., Kratena, K., Schleicher, St., Wüger, M., Nachhaltige Strukturen im privaten Konsum, unveröffentlichter Zwischenbericht, Studie im Auftrag der BM für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft sowie für Verkehr, Innovation und Technologie, Wien, November 2000.

Kletzan, D., Köppl, A., Kratena, K., Schleicher, St., Wüger, M., Nachhaltige Strukturen im privaten Konsum, Fortschrittsbericht, Studie im Auftrag der BM für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft sowie für Verkehr, Innovation und Technologie, Wien, April, 2001.

Köppl, A., Kratena, K., Pichl C., Schebeck, F., Schleicher, St., Wüger, M., Makroökonomische und sektorale Auswirkungen einer umweltorientierten Energiebesteuerung in Österreich, Studie im Auftrag der Bundesministerien für Umwelt, Jugend und Familie, für Wissenschaft und Forschung sowie für Land- und Forstwirtschaft, Wien, 1995.

Köppl, A., Pichl, C., Wachstumsmarkt Umwelttechnologien. Österreichisches Angebotsprofil, Studie des WIFO im Auftrag des Bundesministeriums für wirtschaftliche Angelegenheiten, Wien, 1995.

Köppl, A., Österreichische Umwelttechnikindustrie. Studie des WIFO im Auftrag des Bundesministeriums für wirtschaftliche Angelegenheiten, Wien, 2000.

Kratena, K., Energieverbrauch, CO_2-Emissionen und Energiebesteuerung. Simulationen mit dem Energiemodell DEDALUS , WIFO, Wien, 1999.

Kratena, K., Schleicher, S., Energieszenarien bis 2020, WIFO, Wien, 2001.

Kuckartz, U., Umweltbewusstsein in Deutschland, Studie im Auftrag des Umweltbundesamtes, Philipps-Universität Marburg, Berlin, 2000.

Kutty, N. K., "The production of functionality by the elderly: a household production function approach", Applied Economics, 2000, 32, S 1269-80.

Lancaster, K.J., "A new approach to consumer theory", Journal of Political Economy, 1966, 74, S 132-57.

Lancaster, K.J., Consumer demand – a new approach, Columbia University Press, 1971.

Ligteringen, J.J., "The Effects of Public Policies on Household Metabolism", in: Noorman, K. J., Schoot Uiterkamp, T. (eds.), Green Households? Domestic Consumers, Environment, and Sustainability", Earthscan Publications Ltd., London, 1998.

Linderhof, V.G.M., Kooreman, P., "Economic Aspects of Household Metabolism", in: Noorman, K. J., Schoot Uiterkamp, T. (eds.), Green Households? Domestic Consumers, Environment, and Sustainability", Earthscan Publications Ltd., London, 1998.

Lorek, S., Spangenberg, J.H., "Indicators for Environmentally Sustainable Household Consumption", International Journal on Sustainable Development, accepted for publication, 2000.

Mahmud, S., Robb, A., Scarth, W., "On Estimating Dynamic Factor Demands", Journal of Applied Econometrics, 2, S 69-75, 1987.

Meade, D., "The Relationship of Capital Investment and Capacity Utilisation with Prices and Labour Productivity", Paper Presented at the Twelfth International Conference on Input – Output Techniques, New York, 18 – 22 May 1998.

Meppem, T., Gill, R., "Planning for sustainability as a learning concept", Ecological Economics, 26(2), 1998.

Meyer B. , Bockermann A. , Ewerhart G. , Modellierung der Nachhaltigkeitslücke Eine umweltökonometrische Analyse, Physica: Umwelt und Ökonomie, Heidelberg, 1998.

Milota, E., Aichinger, A., "EU-konforme Umweltschutzausgabenrechnung des Produktionssektors 1995 und 1996", Statistische Nachrichten, Wien, (2), 1999A.

Milota, E., Aichinger, A., Umweltschutzausgaben in Österreich 1995/96, Ansätze zur Implementierung von SERIEE, Wien, 1999B.

Moldan, B., Billharz, S. , Introduction, in: Moldan, B., Billharz, S. (Eds.), Sustainability Indicators, Report of the project on Indicators of Sustainable Development, SCOPE, 1997.

Mont, O., Reaching Sustainable Consumption through the Concept of a Product-service System (PSS), Nordic Council of Ministers, TemaNord 2001:526, Kopenhagen, 2001.

Morrison, C. J., "Quasi-Fixed Inputs in U.S. and Japanese Manufacturing: A Generalized Leontief Restricted Cost Function Approach", The Review of Economics and Statistics, 70, S 275-287, 1989.

Morrison, C. J., "Decisions of Firms and Productivity Growth with Fixed Input Constraints on: An Empirical Comparison of U.S. and Japanese Manufacturing", in: Hulten, C., (Eds.), Productivity Growth in Japan and the United States, Chicago: University of Chicago Press, S 135-172, 1990.

Mortensen, L. F., The Driving Force – State – Response Framework used by CSD, in: Moldan, B., Billharz, S. (Eds.), Sustainability Indicators, Report of the project on Indicators of Sustainable Development, SCOPE, 1997.

Neumayer, E., "On the methodology of ISEW, GPI and related measures: some constructive suggestions and some doubt on the "threshold" hypothesis", Ecological Economics 34, 2000.

Noorman, K. J., Biesiot, W., Schoot Uiterkamp, A.J.M., "Household Metabolism in the Context of Sustainability and Environmental Quality", in: Noorman, K.J., Schoot Uiterkamp, T. (eds.), Green Households? Domestic Consumers, Environment, and Sustainability", Earthscan Publications Ltd., London, 1998.

Noorman, K.J., Schoot Uiterkamp, T. (eds.), Green Households? Domestic Consumers, Environment, and Sustainability", Earthscan Publications Ltd., London, 1998.

Norberg, J., "Linking Nature' s Services to Ecosystems: Some General Ecological Concepts", Ecological Economics, (29), S. 183 – 202, 1999.

Odum, E. P., Reichholf, J., Ökologie. Grundbegriffe Verknüpfungen Perspektiven, BLV, München, 1980.

Odum, H. T., Systems Ecology: An Introduction, Wiley, New York, 1983.

OECD, Sustainable Consumption and Production: Clarifying the Concepts, Workshop, Background Paper, Rosendal, Norway, 2 – 4 July 1995.

OECD, Programme on Sustainable Consumption and Production, Workshop on Improving the Environmental Performance of Government, Paris, 8 – 9 October 1996.

OECD, Sustainable Consumption and Production: Clarifying the Concepts, OECD Proceedings, 1997.

OECD, Towards Sustainable Consumption Patterns, a Progress Report on Member Country Initiatives, 1998A.

OECD, Towards sustainable development: Environmental indicators, 1998B.

OECD, The Environmental Goods and Services Industry. Manual for Data Collection and Analysis, Paris, ISBN 92-64-17109-6, 1999A.

OECD, Towards more sustainable household consumption patterns: indicators to measure progress, 1999B.

OECD, Globalisation, Consumption and the Environment, Working Party on Economic and Environmental Policy Integration, 1999C.

OECD, Sustainable Consumption: Sector Case Study Series, Draft Synthesis Report on Household Food Consumption Patterns, Working Party on Economic and Environmental Policy Integration, Paris, 14 – 15 November 2000A.

OECD, Sustainable Consumption: Sector Case Study Series, Household Food Consumption Patterns: Part B – Evaluation Methodologies and Indicators, Working Party on Economic and Environmental Policy Integration, Paris, 14 – 15 November 2000B.

OECD, Sustainable Consumption: Sector Case Study Series, Draft Final Report on Household Tourism Travel Patterns, Working Party on Economic and Environmental Policy Integration, Paris, 14 – 15 November 2000C.

OECD, Towards more Sustainable Consumption: An Economic Conceptual Framework, Working Party on Economic and Environmental Policy Integration, Paris, 14-15 November 2000D.

Orthofer, R., System Analytical Assessment of the Carbon Balance of Austria. Final Report Part 1: Carbon Balance for 1990. Austrian Research Center Seibersdorf Reserach Report OEFZS -A-4195, Dezember 1997.

Orthofer, R., et al., Austrian Carbon Balance Model, Austrian Research Centers OEFZS -S-0048, November 1999.

Oxford Commission on Sustainable Consumption (OCSC), Newsletter N° 1, Summer 1999(A).

Oxford Commission on Sustainable Consumption (OCSC), "Research Issues ", Document OCSC1.1, Oxford, September 1999(B).

Oxford Commission on Sustainable Consumption (OCSC), "The Ethics of Consumption", Document OCSC2.1, April 2000(A).

Oxford Commission on Sustainable Consumption (OCSC), Newsletter N° 4, August 2000(B).

Oxford Commission on Sustainable Consumption (OCSC), "The Media: a Resource for Sustainable Consumption", Issue Paper, December 2000(C).

Oxford Commission on Sustainable Consumption, "The Media: a Resource for Sustainable Consumption", Document OCSC3.2, Summary report on a workshop at New College Oxford, 8 – 9. January 2001.

Oxford Commission on Sustainable Consumption (OCSC), http://www.mansfield.ox.ac.uk/ocees/pages/csc/.

Parks, R. W., "Price Responsiveness of Factor Utilization in Swedish Manufacturing, 1870 – 1950", The Review of Economics and Statistics, 53, S 129-139, 1971.

Parsons, G. R., "An Almost Ideal Demand System for Housing Attributes", The Southern economic journal, 1986, 53, S 47-63.

Payer, H., Burger, P., Lorek, S., Food Consumption in Austria, Driving Forces and Environmental Impacts, National Case Study to the OECD Programme on Sustainable Consumption, 2000.

Prettenthaler, F. E., Steininger, K. W., "From ownership to service use lifestyle: the potential of car sharing", Ecological Economics, 28(3), 1999.

Princen, T., "Consumption and environment: some conceptual issues", Ecological Economics, 1999, 31 (3), 347 – 365.

Rabin,M., "Psychology and Economics", Journal of Economic Literature, 1998, XXXXVI (1), 11 – 46.

Robins, N., Roberts, S., "Making Sense of Sustainable Consumption", in: the Society for International Development, SAGE Publications, 1998.

Røpke, I., "Analysis: The dynamics of willingness to consume", Ecological Economics, 1999, 28 (3), 399 – 420.

Røpke, I., "The environmental impact of changing consumption patterns: a survey", Environment and Pollution, 2001A, 15 (2).

Røpke, I., "Is consumption becoming less material? The case of services.", Sustainable Development, 2001B, (1), 33-47.

Roth, T.P., The Present State of Consumer Theory. The Implications for Social Welfare Theory, Lanham, 1998, University Press of America.

Schandl, H., Weisz, H., Petrovic, B., "Materialflussrechnung für Österreich 1960-1997", Statistische Nachrichten, (2), S. 128-137, 2000

Schuster, G., Szeider, G., Wölfl, M., Wärmeschutzmaßnahmen an Wohngebäuden. Grundlagen für CO_2-Einsparungspotentiale des österreichischen Nachkriegswohnbestandes, Zentrum für Bauen und Umwelt, Donau-Universität Krems, 2000.

SEEA Handbuch, Vorläufige Version, http://www4.statcan.ca/citygrp/london/london.htm.

Sekot, W., "Naturvermögensrechnung für den österreichischen Wald", Statistische Nachrichten, Wien, (8), S. 693-700, 1999.

Sen, A., "Behaviour and the Concept of Preference", Economica 40, 1973, 241 – 259.

Sen, A., "Goals, Commitment, and Identity", Journal of Law, Economics and Organization, 1985, 1 (2), 341 – 355.

Shove, E., Warde, A., Noticing inconspicuous consumption, Paper presented at the ESF TERM Programme workshop on Consumption, Everyday Life and Sustainability, Lancaster University, April 1997.

Siebenhüner, B., "Commentary: Homo sustinens – towards a new conception of humans for the science of sustainability", Ecological Economics, 2000, 32(1), 15 – 25.

Steg, E. M., Brand, A. B., Rooijers, A. J., Vlek, C. A. J., Affective motives for car use, Center for Environmental and Traffic Psychology, University of Groningen, Groningen, 1998.

Steurer, A., Towards an environmental accounting framework for the EU, paper presented at the EVE workshop "Green National Accounting in Europe", Milan, 2000.

Stigler, G. J., Becker, G. S., "De Gustibus Non Est Disputandum", The American Economic Review, 1977, 67(2), S 76-90.

Stø, E., Vittersø, G., Strandbakken, P., "The tension between micro and macro strategies for short term changes in consumer behaviour: Introducing the green household budget", paper presented at the ProSus/CSTM Workshop on Sustainable Household Consumption: Impacts, Goals and Indicators for Energy-use, Transport and Food, University of Twente, November 17-19, 2000.

Stockhammer, E., Hochreiter, H., Obermayr, B., Steiner, K., "The index of sustainable economic welfare (ISEW) as an alternative to GDP in measuring economic welfare. The results of the Austrian (revised) ISEW calculation 1955-1992", Ecological Economics 21 (1), 1997.

UNEP, Consumption Opportunities, Strategies for change, A report for decision-makers, Genua, 2001.

United Nations, Vorläufige Version des SEEA Handbuchs, http://www4.statcan.ca/citygrp/london/london.htm.

van den Bergh, J.C.J.M., Ecological Economics and Sustainable Development. Theory, Methods and Applications, Edward Elgar, Cheltenham, 1996.

van den Bergh, J.C.J.M., Ferrer-i-Carbonell, A., Munda, G., "Methods: Alternative models of individual behaviour and implications for environmental policy", Ecological Economics, 2000, 32 (1), 43–61.

van der Wal, J., Noorman, K.J., "Analysis of Household Metabolic Flows", in: Noorman, K. J., Schoot Uiterkamp, T. (eds.), Green Households? Domestic Consumers, Environment, and Sustainability", Earthscan Publications Ltd., London, 1998.

van Vliet, B., Chappells, H., "The Co-provision of Utility Services: Resources, New Technologies & Consumers", paper from the Reader for the Consumption, Everyday Life and Sustainability Summer School, Lancaster University, 1999.

Vittersø, G., Strandbakken, P., Stø, E., "Sustainable consumption and the consumer: Introducing the green household budget", paper presented at the 2nd international Symposium on Sustainable Household Consumption, Household Metabolism: from concept to application, Groningen – Paterswolde, The Netherlands, June 3-4, 1999.

Voss, G., Das Leitbild der nachhaltigen Entwicklung – Darstellung und Kritik, Beiträge zur Wirtschafts- und Sozialpolitik, Institut der deutschen Wirtschaft Köln, 1997.

Wackernagel, M., Rees, W., Our Ecological Footprint: Reducing Human Impact on Earth, New Society Publishers, 1996.

Wackernagel, M. et al., "National natural capital accounting with the ecological footprint concept", Ecological Economics 29, 1999.

Weisz, H., et al., MFA und Umweltindikatoren, IFF-Soziale Ökologie, Wien, 2000.

Wenke, M., "Umweltbewusstsein und Konsumverhalten der privaten Haushalte – Theorie und Evidenz am Beispiel der Nachfrage nach Haushaltschemikalien", RWI Mitteilungen, 44(1), 1993.

Wilhite, H., Nakagami, H., Masuda, T., Yamaga, Y., Haneda, H., "A cross-cultural analysis of household energy-use behavior in Japan and Norway", Energy Policy 1996, 24(9),.795-803.

Wilhite, H., Lutzenhiser, L., Social Loading and Sustainable Consumption, Paper presented at the 1997 ECEEE Summer Study, Czech Republic, 1997.

Wilk, R., Culture and Energy Consumption, Indiana University, Bloomington, mimeo, 2001.

Willet, K. D, Naghshpour, S., "Residential demand for energy commodities: A Household Production Function Approach", Energy Economics, Oktober 1987, 9(4), S 251-56.

Wilting, H.C., Biesiot, W., "Household Energy Requirements", in: Noorman, K. J., Schoot Uiterkamp, T. (eds.), Green Households? Domestic Consumers, Environment, and Sustainability", Earthscan Publications Ltd., London, 1998.

Wolf, M. E., Hanauer, J., "NAMEA der Luftschadstoffe Österreichs 1980-1997", Statistische Nachrichten, Wien, (5), S. 401-417, 2000.

Woodland, A., "Substitution of Structures, Equipment and Labor in Canadian Production", International Economic Review, 16, S 171-187, 1975.

Wüger, M., "Günstige Konsumentwicklung bei rückläufiger Sparneigung", WIFO-Monatsberichte, November 1992.

Wüger, M., Die langfristige Entwicklung der Einkommensverteilung in Österreich – Der private Konsum als Indikator der Verteilung, WIFO-Studie im Auftrag des Bundesministeriums für Arbeit, Gesundheit und Soziales, Wien, 1998.

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