Eva Heiskanen - Minna Halme - Mikko Jalas -
Anna Kärnä - Raimo Lovio

Dematerialization: The Potential of ICT and Services

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Foreword

Is it possible to reduce the consumption of natural resources significantly while maintaining economic growth and welfare? How can services contribute to dematerialization? What is the role of ICT in this development? These are topical questions in environmental policy, but until the present, there has been little critical and analytical research on them. The present report contributes to the currently emerging scientific and policy debate in the field, drawing on empirical evidence from Finland.

The report constitutes an ambitious effort to explore the prospects for dematerialization by investigating how emerging innovations in services and ICT could contribute to a significant reduction in natural resource use at the national level. It reviews the currently existing trends, as well as the potential of new ideas and innovations. It explores the practical obstacles to the adoption of potentially eco-efficient solutions, but also identifies "weak signals" of change. While the report points at significant uncertainties and data gaps, it also indicates where positive action can already be taken.

This report is based on a research project conducted at the Helsinki School of Economics (Organization and Management). The project was funded by the Academy of Finland, and it has also constituted part of the *Environmental Cluster Research Programme of the Ministry of Environment*. The present volume is the final report of the project, but not the final word on the issue. Instead, it points the way for new issues to monitor, new practical projects to undertake, and new items for the environmental policy and management agenda.

Contents

Dematerialization: The Potential of ICT and Services - Summary and Conclusions

Introduction

The aim of the present study has been to evaluate the potential of services and ICT to contribute to a substantial reduction of natural resource use. We have taken for granted the assumption that such a reduction would be desirable, even necessary, for a number of reasons.

Many studies have indicated that human-caused substance flows and environmental interventions are today so large in scale and speed that they interfere with the rest of nature. On the other hand, there are both social and economic pressures to increase consumption. Standards of living in the Third World are so low, that it is both probable and justified that their inhabitants claim an increasing amount of natural resources to fulfil their needs and desires. There are also pressures for continued economic growth in the well-to-do North; modern societies are built on the premise of continual growth and development.

Innovations have enabled changes in the resource-base of the economy throughout human history. The past few decades have witnessed the slow advent of a “service society” in mature economies. We have also just experienced a few hectic years of what is known as the “new economy” or the “information economy”. Many authors believe that these developments may lead to a much less natural-resource-dependent economy. The aim of the present study is to identify what new ways of wealth-creation can be identified in this context, how they are adopted, and with what consequences for natural resource use. The data for this study come from Finland, which has been a champion in some changes (e.g., development and adoption of ICT hardware), and very slow in others (transition to a service society).

The present report consists of three parts. The first is this summary, which also presents the conclusions of the entire study. The second is a set of conceptual papers exploring the concepts and discussions surrounding dematerialization, services and ICT (Part I). The third presents empirical studies from Finland, including both micro-level case studies and statistical analyses of the economy as a whole (Part II).

This summary will continue by first going through the background and the central premises of the entire study. Next, evidence for evaluating the future of dematerialization is presented. The relationship between developments at the micro-level (business activities) and the macro-level (the entire economy) is considered. Finally, we present our four main conclusions. A glossary of the terms used in this study is given at the end of the summary.

The topical discussion on dematerialization and new forms of wealth-creation

Two early inspirations for this study include the book, *Metabolism of the Anthroposphere*, by Baccini and Bruner (1989), and an article titled *Dematerialization* by Herman et al. (1989). The first is a study of how human activities influence natural substance cycles, which argues that the focus should be placed on decreasing the volume of these cycles, rather than on fruitlessly trying to establish the environmental risks of individual substances. The second is a discussion on the prospects for dematerialization in product design, including a suggestion that more radical reductions in materials use could be achieved by focusing on the function of the product. These authors recontextualized the work of pioneering materials-flow economists (e.g., Kneese et al. 1970; Ayres 1978; 1998), by placing it in the context of environmental policy and concrete, product-related decisions.

Schmidt-Bleek (e.g., 1994; 1998) and other researchers at the Wuppertal Institute have contributed significantly to the popularization of such ideas, as well to concrete suggestions for measuring and advancing dematerialization (see chapter 3). Perhaps their most significant input has been the introduction of *the factor 10 target*. It is based on a fairly simple argument: the top one-fifth of the world population (i.e., OECD countries) consumes four-fifths of the world's natural resources. By the next 40 years, if the rest of the world reaches the same consumption level (and almost doubles in population), natural resource use will grow eight-fold. On the other hand, knowledge on biospheric limits (e.g., climate stability) suggests that natural resource use should be halved. Hence, OECD countries should reduce their natural resource use to approximately one-tenth of current levels.

A number of other factor-targets have also been introduced. Von Weizsäcker et al. (1997) suggest a factor 4 improvement in natural resource productivity for near-term eco-efficiency. The slogan of their book is "doubling wealth, halving resource use". On the other hand, some Dutch analysts have suggested that improvements in a scale of factor 20 or more may be necessary (Weaver et al. 1998, see Rejinders 1998 for a review of the factor X debate).

In the business community, a related development has been the diffusion of the idea of *eco-efficiency*, most prominently promoted by the World Business Council for Sustainable Development (WBCSD). The WBCSD (1996) defines eco-efficiency as "the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle to a level at least in line with the Earth's carrying capacity". A briefer definition would be "doing more with less". Some companies, however, use the term today more or less as a synonym for "environmental improvement". Although it can be interpreted in many ways, the idea of eco-efficiency has reinforced the notion among business decision-makers that environmental conservation can save resources and be profitable.

There is still considerable disagreement about how significant a role the reduction of total materials use should gain in environmental policy. Conventionally, the focus in environmental policy has been on identifying and reducing substance flows and interventions that are *known* to harm the natural environment. A focus on overall natural resource use takes a different stand: as the harmfulness of many interventions and substances cannot be definitively established, it is a wise precaution and a useful heuristic to simply try to minimize all substance flows and interventions (which does not preclude additional measures on the harms that *are* known). Some operationalizations of "eco-efficiency" have attempted to integrate both substance inflows and outflows into a single indicator of environmental harm (e.g., Helminen 2000). But this still leaves unaddressed the issue of where these substance flows occur, and in what concentrations. The other alternative is simply to sum up all substance flows into a single indicator of material input, assuming that "what goes in, must come out". It is important to note that the choice of indicator also has implications for what policy measures are considered: a focus on the harmfulness of outflows into the environment emphasizes abatement technologies and materials substitution, while a focus on total natural resource input places the focus on the *amount* of production and consumption, and on the structure of the economy.

Ideas about a post-industrial service economy have been around for a few decades (e.g., Bell 1976; Gershuny and Miles 1983). However, " *eco-efficient services* " are a much more recent and business-oriented idea. They relate to service designs that reduce the need for material products through shared or more intensive product use, or by delivering the desired outcome through a professional service. Frequently mentioned examples include car-sharing, product rental and refurbishing, centralized voice mail, and chemicals management services (e.g., Hockerts 1999; Mont 2000; White et al. 1999). Schmidt-Bleek and Lehner (2000) believe that such services will be central to the emergence of a "customized economy", a knowledge-intensive, customer-oriented and dematerialized society. This new field of development owes much to early work by Stahel (1983-2001), but has since acquired a life of its own.

Many of the new services that are of topical interest relate to ICT. For example, e-commerce, tele-work and videoconferencing have been brought up as innovations that can significantly reduce materials and energy intensity (e.g., von Weizsäcker et al. 1997; Romm 1999). More generally, ideas about ICT-enabled services resonate with ideas about the information society as a "weightless economy", in which "bytes replace kilograms". There are many commonalities between the ideas on "eco-efficient" services and some developments popularized by recent business writers. Rifkin's (2000) *The Age of Access* expounds on a number of recent developments in the US: the explosion of digital commodities, the increase of lease-based contracts and the rise of the "experience economy" (see also Pine and Gilmore 1999). Companies are reducing inventories, selling off real estate and becoming 'weightless' (virtual): "material goods are nothing; business concepts are everything". Similarly, *Blur* by Davis and Meyer (1998) focuses on how products and services are merging in the digital economy; products become merely platforms for delivering services to consumers. These affinities are also highlighted by leading figures in the dematerialization community (e.g. Schmidt-Bleek and Lehner 2000; Stahel 2001).

The discussion on dematerialization and services presents the inspiring view that economy and ecology can be combined in a new way. It is an unprecedented phenomenon in environmental discourse, because it also suggests radical reductions in natural resource use through innovations. In a few years, it has engaged a range of actors from different interest groups (business managers, environmental organizations, policy-makers). Although this pluralism is uplifting, it has had two consequences that complicate analytical research in the field.

The first is the conceptual ambiguity that this emerging discussion has initiated. Of course, popularizing ideas among different constituencies requires different language. Yet for analytical purposes, it would be useful to understand the relationship between, e.g., eco-efficiency and factor targets (see chapter 4). It would also be helpful to be clear about whether we should increase resource *productivity* by a factor X, or actually *reduce resource* use to one-tenth of the current rate. Finally, services are referred to in a variety of different meanings (see glossary), most of which depart from conventional statistical or marketing definitions.

The second is the glossing over of philosophical and political tensions in the "new marriage of ecology and economy". Ideas about eco-efficiency, if taken seriously, are far removed from the incremental approach of "continual improvement" prevalent in the business environmental management discourse. On the other hand, they also depart from the emphasis on self-sufficiency, frugality and connectedness with nature that can be found in traditional "deep green" discourses of environmentalism (cf. e.g., Welford 1997; Dryzeck 1997). Ideas about eco-efficient services promote *radical* (rather than incremental) changes in technology, economic organization and everyday life. On the other hand, they are relatively silent about value changes, institutional changes and changes in social structure. Leading figures in this discussion do criticize the suitability of GDP as an indicator of well-being, and do speak of the need for "sufficiency" - usually in the final chapters of their books (e.g., von Weizsäcker et al. 1997; Hawken et al.1999). Yet the main force of their arguments is phrased in the language of efficiency, competitiveness and win-win solutions.

Successful ideas are often quite ambiguous. Business managers find points of interest in ideas that refer to productivity, competitiveness and high-tech solutions, while environmentalists focus on such aspects as the shared use of goods and increased product durability. This is what creating a sufficiently broad social movement requires. However, when trying to imagine the future of dematerialization, it would be good to know what kind of a society one is expected to envisage. Is it one in which large corporations increasingly take charge of our lives by efficiently and effortlessly fulfilling our needs and desires though innovative electronic services? Or is it one in which people self-organize co-operatives to share goods and in which craftsmen repair products to make them last for generations?

Dematerialization through services and ICT in Finland?

There is a relatively long tradition of materials and energy analysis in Finland; especially the energy analyses of Mäenpää et al. (1981; 1986) and Nurmela (e.g., 1986; 1993) are worth mentioning. As a distinct policy approach, dematerialization and eco-efficiency entered the agenda in the late 1990s, largely as a response to the international debate. As elsewhere, the discussion has engaged a surprisingly broad range of interests and perspectives:

- *Environmental organizations* opened the debate with the book *Sustainable Finland* (Ulvila and Åkerman 1996), along the lines of similar volumes elsewhere in Europe, with a strong focus on "environmental shares"[1]. The Association for Nature Conservation has continued to contribute research and educational ef forts in the field. An annual fair, *Eco-efficient Finland*, has been organized since 1998. The same association is one of the organizers (together with the extension training centre of the Helsinki University of Technology) of an ongoing environmental training programme with the title Factor X, as well as a central popularizer of Schmidt-Bleek's ideas (e.g., Schmidt-Bleek 2000).
- The Ministry of Trade and Industry set up an ad hoc committee that published the report *Eco-efficiency and Factors* (KTM 1998), which highlights the preventive approach of eco-efficiency, the need for radical changes in consumption patterns, and the observation that a growth in welfare and environmental sustainability are mutually compatible. It suggests that the focus should be shifted from improving labour productivity to improving natural resource productivity, and suggests a shift of the tax burden from labour to natural resources. No major follow-up activities are visible, but since 1998, the Ministry of Environment has conducted a research and development programme with a strong focus on eco-efficiency (*The Environmental Cluster Research Programme*).
- The Federation of Industries and Employers has published a number of reports referring to eco-efficiency (e.g., TT 2000), especially in the context of eco-competitiveness. Individual companies are also increasingly employing the term.
- Connections between the *information society and sustainability* were raised in the Government Programme for Sustainable Development (1998). In 1999, the Ministry of Environment commissioned a study on the Sustainable Information Society (Kahilainen 2000), and has since launched an extensive research programme on the issue.
- Finnish futurologists have contributed to this field extensively (e.g., Heinonen et al. 2001, see also chapter 2). Conceptual development of dematerialization and related topics has been contributed to especially by Malaska and colleagues (Malaska 1998; Malaska et al. 1999). One innovation in this field is the term "immaterialization" to denote the role of demand-side factors in dematerialization (see Glossary).
- Materials flow analysis has gained a new impetus, as recent reports (e.g. Mäenpää et al. 2000; Hoffrén et al. 2001), indicate (these are discussed in more detail in chapter 1). Eco-efficiency at the company level has been studied by Helminen (2000) in the case of Finnish pulp and paper companies and Pesonen (2001) in an analysis of the eco-efficiency of Nokia base-stations.

A factor that has not been studied or developed much in Finland is the role of services in dematerialization, although such ideas are increasingly referred to in casual discussion. Some underlying conditions in Finland in this respect are briefly pointed out in the following.

Finland is not very much of a service society. Finnish private services only account for 40% of GDP, which is about 10% less than the EU average. Furthermore, the share of private services actually declined during the 1990s. This is attributed to the aftermaths of the severe economic recession in the early 1990s. The competitiveness of labour-intensive services is also severely hampered by the amount of direct and indirect taxes on labour-intensive services (e.g. Böckerman 1999), since 1994 also including a value-added tax of 22%. Services have also been almost totally overlooked in industrial policy. This problematic state of affairs has been recognized, e.g., by the Ministry of Trade and Industry (1996), which has suggested a number of reforms to improve the competitiveness of services.

On the other hand, Finland has been swiftly transforming into an information society. By 1999, the gross value of the Finnish ICT cluster had grown to about 7% of GDP, of which ICT manufacturing made up slightly less than half, and ICT services (telecom, software, IT services), slightly more than half. While manufacturing has up until the present been the more dynamic and fast-growing part of this cluster, the focus in the telecommunications business is shifting toward content provision (Paija 2001).

Some conditions appear to be favourable for adopting new service innovations, and others unfavourable. For many decades, Finland was a markedly industrial and export-oriented economy, in which the general mentality and industrial policy has favoured large companies and heavy industries. As a culture, Finland is a typical modernist Nordic country: people are relatively egalitarian, and unbound by tradition or extended family. Two-income families are predominant, which has been supported by the relatively large share of public services. In adopting technological and other novelties, Finns are considered relatively innovative. Innovations diffuse swiftly in such small countries, which is perhaps reflected in the speedy diffusion of ideas about eco-efficiency described previously.

Approach of this study

The aim of the present study has been to evaluate the potential of services and ICT to contribute to a substantial reduction in natural resource use. We take no specific stand on exactly how substantial the reductions should be, but for the sake of argument, compare them at some points with the factor 10 target. Also for the sake of the argument, we assume that this should occur without significant changes in economic targets (e.g., GDP growth) or social or political structure - although we agree with critiques of GDP as an indicator of welfare and overall human well-being. We have not set out to explore the social conditions or impacts of dematerialization in general - but we do point to some of the most obvious ones arising from the case studies.

The question concerning the potential for dematerialization is prospective. It could be specified in at least the following ways:

- On the basis of historical data, does it appear likely that natural resource use will decline in the future?
- Is it technically and economically possible to combine considerable reductions in natural resource use with sustained wealth and welfare?
- Can believable and desirable scenarios be built that combine these targets?
- Are there signs of developments that could be utilized to achieve these targets?

These questions reflect different approaches to forecasting in futures studies (e.g., Bell 1997). Conventional approaches, still relatively prevalent in energy forecasts, take off from historically observed trends, and project them into the future. A counter movement to such forecasts has been to project alternative resource use futures from technological possibilities, as in alternative energy forecasts by environmentalists.

In a sense, these both types of forecasts refer to "objective" starting-points for forecasting, although the reference points are different. An alternative to such approaches, which makes decision-makers' preferences explicit, is constituted by "participatory" futures studies. Participatory approaches stress the idea that our decisions shape the future, that different constituencies have different preferences, and that the relevant constituencies should get together and search for futures that are preferable, reachable and mutually compatible. In contrast, other scholars highlight the uncontrollable nature of development, and the role of discontinuities and emergent processes, which confound both mathematical projections and well intended planning. From this perspective, e.g., "weak signals" of change can be sought for in the decision environment (e.g. Ansoff 1976), and potential interactions between events or processes that may lead to significant discontinuities can be monitored.

Thus, explorers of the future need to take a stand on the roles that they assign to (1) history, (2) technological possibilities, (3) planning and societal decision-making and (4) non-linear, discontinuous processes. Previous analysts have employed roughly corresponding approaches to forecasting natural resource use. We present a brief sample of each:

- Forecasts based on historical trends are discussed in a recent article by Smil (2000), which presents an analysis of energy forecasts for the US made by the author and others during the past four decades. Such forecasts are based on population growth, assumptions about economic growth, and the assumed or observed historical relationship between these and energy demand. Smil notes that all mainstream forecasts have been clearly above the actual consumption in the year 2000, some by even more than 100%. A similar phenomenon, although less marked, can be seen in Finnish energy forecasts (see chapter 5). Such forecasts may be self-serving (e.g., motivate new energy generation capacity), but they may also help to point out threats: what happens if nothing is done? For example, the energy forecast by Nurmela (1996) used an innovative demographic design to show that household energy consumption (including energy accrued in goods) may increase by one-fourth during 1990-2015, largely because of the increasing number of small households.

- Alternative energy futures usually take off from what is technically possible. For example, the "soft energy path" of Amory Lovins (1976) is a well-known normative projection that shows what could be achieved in the US using efficient end-use technologies and renewable energy sources. A normative scenario by Finnish environmentalists (Ulvila and Åkerman 1996) suggested a sharp decline in 1995 resulting in a halving of energy consumption by 2020. Suggestions for a factor 10 reduction in OECD materials intake is in a way a similar normative scenario, although no detailed calculations have been presented on how this should be reached.

- A participatory planning approach to the future of dematerialization is exemplified in the Dutch project on *Sustainable Technology Development* (Weaver et al. 1998). The study took as its starting point the need for at least a factor 10 improvement in natural resource productivity by the mid-21st century. The authors emphasized the need to *build constituencies that support* such technologies and the necessary re-structuring of incentives and behaviours. They also highlighted the need to develop technological replacements capable of fulfilling multiple roles: services to consumers, economic growth, employment and cultural development. A conscious and concerted effort by government, business and societal groups was identified as central to sustainable technology development. The aim of the study was thus not to forecast, but to demonstrate that sustainable technology development is achievable, and to promote such development in the Netherlands. This was done by engaging central constituencies (government, business, consumers and societal groups) in an evaluation and elaboration of how to reach *sustainable technology* scenarios. As an outcome of this exercise, scenarios for, e.g., the introduction of novel protein foods (e.g., mycoprotein) and for designing new consumer services were developed.

- A "weak signals" approach is implicit in some of the recent work by Stahel (1998; 2001), among others. It combines the need to reduce natural resource use and retain materials within the economy ("cyclical economy") with some developments in different industries and in the business environment. Stahel points out that several multinational companies have turned to managing the stock of existing assets, and have thus de-coupled turnover from manufacturing volume. Lift manufacturers, copying machine manufacturers and chemicals management services are mentioned in this connection, as well as the increasing popularity of leasing and outsourcing. This shift, according to Stahel, is driven by business, science and technology, and shareholder value, as well as the general focus on intangible rather than tangible assets. The links between the need to reduce natural resource use and the emerging new business logics are not made explicit, but the argumentation seems to be semi-normative, semi-predictive: the developments are expected to converge, and companies can gain advantage by being first movers in the field.

The present study is not committed to any one of these approaches. We have combined historical data on materials (chapters 1) and energy (chapter 5) with prospective ideas on services (chapter 3) and ICT (chapter 2). We have also tried to evaluate how developments on the micro-level (in companies or consumer behaviour) could influence natural resource use on the level of the national economy (see chapter 4 on the relationship between eco-efficiency and dematerialization, and chapter 9 on rebound-effects).

Lacking distinct views on the issue ourselves, we did not opt to construct scenarios with stakeholders, yet. However, the study on the dematerialization potential of electronic grocery shopping (chapter 6) utilizes a Delphi-method to articulate probable and desirable developments in the field. This and the study on the potential of ICT to reduce business travel also investigate the social and cultural feasibility of the adoption of new innovations. The study on new office services (chapter 8) is closest to a "weak signals" approach, aiming to identify promising aspects of recent developments in the field.

The future of dematerialization? - key findings of the studies

This section presents some highlights from the studies in this volume, along with a running commentary. It starts with historical data, and continues with the prospects of new innovations. These are followed by a discussion of the relationship between eco-efficient innovations and dematerialization of the economy.

Is de-linking occurring?

What is the relationship between economic growth and natural resource use? Natural resources are an obvious factor of production, but not the only one. Some authors claim that role of natural resources in producing economic value has been changing in recent history, due to the maturation of industrial society (e.g., Jänicke et al. 1989). They claim that the economy is progressively *de-linking* from the natural resource base. The rise of the role of information as an independent factor of production has provided more grist to this mill (e.g., Romm et al. 1999). In chapters 1 and 5 in this volume, Mikko Jalas and Raimo Lovio explore recent developments in the relationship between natural resource use and economic growth.

Chapter 1 explores the de-linking debate, including the discussion on the environmental Kuznets curve (eKc). It identifies total materials use as one useful indicator of the environmental load of a nation, but also highlights some biases. Apart from the differences in the environmental relevance of different material flows, there are also the problems of import and export. Furthermore, yearly fluctuations in materials intensity seem to depend on economic and investment cycles, so relatively long time periods should be studied.

The environmental Kuznets curve hypothesis predicts that with continued economic growth, environmental loads will first decline relative to economic output, and finally, in absolute terms (i.e., the development of environmental loads will follow an inverted U-curve). This phenomenon has been observed for some pollutants, but it does not appear to apply to total materials requirements (or other environmental indicators that cannot be reduced using abatement technologies).

Existing studies indicate that materials use has started to stabilize in Finland, as in many other industrialized countries, and according to Mäenpää et al. (2000), the materials intensity of the economy has decreased at an annual rate of 4,6% in the last decade. The rate of reduction has fluctuated considerably, however, and no signs can be found of the inverted U-curve predicted by the eKc hypothesis. Historical observations do not provide grounds to forecast the future shape of developments - except perhaps in terms of what a maximum speed of dematerialization could be. Existing infrastructure (e.g., buildings, factories) will most probably continue to consume energy and materials far into the future.

The role of the service sector is also investigated. Some authors have pointed out that (1) the service sector is not in fact much less energy-intensive than the economy on an average and that (2) the less-energy-intensive services cannot grow enough to accommodate for economic growth with reduced energy consumption (e.g., curtailment of public services). Data from Finland show that the growth of the service sectors does contribute modestly to a decrease in the materials and energy intensity of the economy. However, the Finnish data also support the idea that it is unlikely that statistically-defined services could grow significantly and rapidly B in fact, the share of services in private final consumption actually declined during the 1990s.

The share of services in private final consumption is not the only relevant indicator, however. It may be much more important that the share of intermediate services (used in the production of goods and services) grows, thus providing consumers with goods with an ever-higher service content. Furthermore, some services (e.g., those provided by manufacturing companies) do not show up in statistics at all.

Chapter 5 continues on this issue in the context of energy use and responses to the climate change convention in Finland. It finds that the importance of dematerialization (e.g., energy efficiency, structural change) in climate protection has grown. Among the government's scenarios for meeting the climate convention, the mildly interventionist "KIO1" scenario is found to be a relatively realistic projection, in which the energy intensity of the economy declines at annual rate of approximately 2%. This is in line with recent structural changes in Finnish industry, as well as with data indicating that energy use for transportation and space heating is stabilizing.

It is possible that energy consumption will cease to grow in Finland during the following 20 years. However, existing trends do not give reason to forecast a significant decline in total annual energy consumption in the near future. More efforts (e.g., price incentives, technological and institutional innovations) are needed to actually turn the trend toward reduced energy use in absolute terms. Reducing energy consumption on a factor-scale may also be more difficult than reducing materials consumption due to the dissipative nature of energy use (e.g., materials can be reused or recycled, energy cannot).

One can conclude from these chapters that recent history does show some extent of de-linking between economic growth and natural resource use (i.e., *relative* dematerialization). This de-linking is due to increased efficiency in both materials and energy use, and to changes in the structure of the economy. It appears to be more profound in the case of *materials* intake than of *energy* consumption.

Even Finland, traditionally dominated by heavy industries, and a late but swift industrializer, seems to be experiencing some level of maturation in terms of economic structure. Changes in economic structure have been more within industrial production than between industrial production and the service sector. The energy use for buildings and traffic seems, however, to be levelling off. In spite of this, the de-linking does not appear to be strong enough to predict significant reductions in *absolute* natural resource use, certainly not in the time-frame and to the extent required by factor 10 targets under business-as-usual (or even cautiously interventionist) scenarios.

The potential of innovations to change the course of business-as-usual trends

The future is not predetermined. People can use their innovativeness to solve problems looming on the horizon. Two types of innovations have been identified as especially promising from the point of view of dematerialization. One are the technological opportunities provided by advances in information and communication technologies (ICT). The other consists of new ideas about eco-efficient services that enable material goods to be used more efficiently. In chapters 2 and 3, Anna Kärnä and Eva Heiskanen review the current literature on the roles of ICT and services in dematerialization.

Chapter 2 reviews the discussion on ICT and sustainable development - a recent, but vigorous field of debate. It is noted that information society policies in Finland and the EU have paid little attention to the environmental aspects of ICT, and the ICT industry has also been relatively silent on the issue. Some recent commentators are, however, enthusiastic about the possibilities of ICT to reduce natural resource use (e.g., Romm et al. 1999). ICT has enabled a structural change in the economy, which in Finland is evidenced, e.g., in the doubling of the share of consumer expenditure on telecommunications during the 1990s. On the other hand, ICT has increased the efficiency of existing sectors in the economy: for example, electronic customer services have both decreased energy use, and increased productivity, in the banking sector. In principle, many ICT-based innovations, such as distance work, videoconferencing and electronic commerce, could reduce the need for natural resources considerably.

The review identifies three potential ways in which ICT can conserve natural resource use. Firstly, ICT can help improve the efficiency of business operations (e.g., logistics). New forms of communication between suppliers and customers can enable the customization of products, thus reducing waste throughout the product life cycle. Secondly, ICT enables the development of new product-service systems (e.g., electronic commerce), which changes the way value is produced in existing sectors. Thirdly, the production and transmission of information-intensive services has become cheap and easy, which has enabled, among other things, totally new products (e.g., computer games, mobile phone dial tones) with a low materials intensity.

The most enthusiastic commentators believe that the "new economy" will considerably speed up a de-linking between economic growth and natural resource use. Others are more cautious: in addition to *substituting* for other resources, information and communication technology also *generates* new economic activities. For example, it may increase consumption by liberating consumers from the constraints of time and space. It is thus possible that ICT development may also lead to increasing environmental problems, if not critically monitored. Thus, the chapter closes with suggestions for how developments should be steered and influenced, among other things by introducing environmental concerns into early stages of technology development.

Chapter 3 is a review of new ideas about how innovative services can contribute to dematerialization by placing the use and *utility* of products at the centre of economic activities. Instead of traditional services, this discussion focuses on *product-based services* (e.g., enabling the shared use or more intensive use of products), and *results-oriented services* (replacing products with services performing the same function)[2]. These ideas are active attempts to promote new forms of economic organization that enable more sustainable production and consumption patterns.

In principle, product-based services are a more efficient way to organize product use, as individual products can be shared by multiple users, either through time-sharing (e.g. car-sharing) or consecutively (product rental and refurbishment). Obtaining products as services can also allow users more flexibility to select appropriate products for their needs (e.g., less "overkill"). If manufacturers offer such services, they also encounter new economic incentives: their revenues are no longer derived from pushing new products onto the market, but from making the most efficient use of existing products. This should, in principle, increase efforts to design more durable products.

Results-oriented services (e.g., laundry services) should in principle bring additional gains: more capable execution of tasks by professional service providers and scale-related efficiency gains. Professional service providers also assume the total cost of providing the service, thus creating incentives for them to reduce energy and materials at the use stage (e.g., economize in energy and detergent use at commercial laundries).

There are some, but not many, examples of innovative, eco-efficient services commercially available today. They indicate that the previously-mentioned efficiency gains do exist in some services, but also show that the extent to which such gains can be captured varies from case to case. Few detailed analyses exist of the *scale* of materials savings to be gained by service innovations. In a few cases, estimates are close to a factor 10, but usually, they are much more modest. In some cases, the gains may be offset by other issues (such as the energy required by machine-drying in commercial laundries). There is also limited empirical evidence of how the economic incentives that are expected to emerge in service solutions actually work.

It is concluded that eco-efficient service solutions are probably not the ultimate solution to factor 10 reductions in natural resource use. The examples described in the literature, so far, are meant to stimulate, rather than provide comprehensive analyses. Many have also actually been developed by companies independently from eco-efficiency concerns. Their most important contribution may be to stimulate new thinking in the business community, and to extend the scope of environmental management beyond incremental improvement to entirely new business concepts.

Information and communication technologies are primarily technical innovations, and new eco-efficient services are primarily organizational or institutional innovations. However, the borderline is not clear: for example the Internet is one of the most radical and far-reaching institutional innovations in the modern world. It is both an ICT application and a service for sharing computer networks, as well as a platform for a multitude of services.

In principle, ICT can improve the efficiency and productivity of new services (e.g., car-sharing), enable the development of customized but automated services, as well as replace physical products or activities (e.g. voice mail, videoconferencing). Technology developers are becoming increasingly aware of the fact that mere technical solutions are not enough: they need to be filled and surrounded by services for customers to adopt them.

Services and ICT are not the only kinds of innovations that can contribute to dematerialization (others include, e.g., biotechnology and nanotechnology). However, ICT and services are especially interesting, as they have the potential to change not only production processes, but also the way economic value is created in general. Many authors believe that such a transformation is necessary to de-link economic activity (business) from materials flows (producing more and more physical products).

How innovations are adopted - or fail to be adopted

Even good inventions are not usually adopted effortlessly and immediately. They are also often not adopted in the form originally envisaged by their developers. Furthermore, their adoption may have unexpected consequences. These issues are explored in two case studies. In chapter 6, Anna Kärnä investigates the dematerialization potential of electronic grocery shopping, tracing the emerging business models, and applying a Delphi study to investigate probable and desirable future developments. In chapter 7, Minna Halme investigates the reasons for the painfully slow adoption of videoconferencing in business-to-business communications.

Chapter 6 studies the emergence and potential impacts of electronic grocery shopping in Finland. E-commerce is one of the ICT-applications in which some researchers see considerable potential to reduce natural resource use. E.g. Cohen (1999) believes it could "reduce or eliminate the need for products, for warehouses, for retail storesYcurb automobile use, reduce traffic, and enable business and consumers to be savvy green shoppers".

Grocery shopping is especially relevant in this context, as groceries are bought repeatedly and in great quantities. Using a private car to visit the supermarket is an extraordinarily inefficient way to transport groceries. Cars are needed for this purpose more and more today in Finland, as grocery retailing continues to migrate to fewer, larger and more distant hypermarkets.

Today, electronic grocery shopping is a very small-scale activity in Finland: less than one per cent of all groceries are ordered by Internet. A variety of business models co-exist: they can be built upon existing physical retail outlets or based on dedicated purchasing and warehousing systems. Deliveries can be organized in different ways. The goods can be selected from the suppliers' website, but also automatic shopping lists can be used, and mobile devices can be used to make orders. The business appears to be in a stage of "uncertain design competition", which both slows down its growth, but also provides the opportunity to influence developments.

The study identifies expected and environmentally desirable future scenarios in electronic grocery shopping using a Delphi-survey. The survey was directed at three groups: environmental and social experts, e-business experts, and retail trade representatives. Expected scenarios on how electronic grocery shopping will develop by 2010 included quite moderate growth (5-10% or less of grocery sales). Different EGS service models are expected to co-exist: regional or local warehouses and distribution centres, with some automated order processing and collection of products, will become a dominant model in densely populated areas, but orders will still also be delivered from existing retail stores. Views differed on what will be the dominant mode of delivery reception (home, pick-up point, unmanned reception box). The total impact of EGS on material and energy consumption compared with traditional grocery shopping is not clear: the dominant views were that it would reduce materials and energy requirements, or have no significant net effect on them. But some experts also believed that EGS would actually increase energy and materials consumption. From the point of view of dematerialization, the most frequently preferred scenario would be based on pure online retailing and virtual supermarkets that can offer the same or a larger variety than a physical supermarkets, an efficient collection of shopping baskets from regional or local distribution centres, and deliveries to unmanned reception boxes or to pick-up points.

Today, and in the near future, electronic grocery shopping appears to complement existing forms of grocery retailing, rather than replace them, or stop the increasing concentration of retail outlets. As long as it remains this way, it will not significantly reduce energy consumed in grocery deliveries. In order to be efficient, electronic grocery shopping requires a relatively dense urban structure and a comprehensive customer base.

Chapter 7 explores the potential of ICT-based solutions such as videoconferencing to replace business travel. Business travel is an increasing environmental concern: it has increased at an average annual rate of 5%, and is a significant contributor to, e.g., CO_2 emissions in Europe. It is also a significant cost item for companies. Travel consumes staff time, causes fatigue and disrupts family life. However, it appears that travel management remains an operative level task in companies, and few steps are taken to actually reduce travel.

Technologies exist to replace business trips with other forms of communication (e.g., group and desktop videoconferencing systems), and new technologies are being developed continually. They could be very relevant for dematerialization: e.g., von Weizsäcker et al. (1997) claim that replacing a transatlantic trip with a videoconference could save 99% of the energy needed. For the past few decades, proponents of these technologies have launched expectations that they would replace physical travel, but these expectations have not been met.

The large Finnish companies interviewed for this study had videoconferencing equipment available, but in most companies, it was not used intensively. Some companies used videoconferencing for company-internal or domestic meetings, but one company had even disassembled their videoconference room due to under-use. A number of cultural factors influence the viability of replacing face-to-face meetings with ICT-based exchange. ICT-solutions are most viable when (1) participants share the same social and cultural context (2) trust has been established between participants (3) the information to be exchanged is explicit and codified (rather than tacit and intricate) and (4) meetings can be kept short. Why has ICT failed as yet to reduce corporate travel? While ICT-based modes of communication can replace face-to-face exchange, they have also contributed to the globalization of business, increased internationalization of companies, and the increased mobility of staff, all of which generate new needs for exchange. Furthermore, travel does *not merely serve the function of information exchange*: decisions to travel are influenced by a multitude of motives, symbolic functions and actions. For changes to occur, individual and corporate values need to shift, not only with respect to corporate travel, but concerning the entire quality of working life. Top-level management needs to recognize the cost, time, human resource, and environmental implications of increasing travel. Human resource management and environmental functions need to be involved in developing travel policies and strategies.

In many companies, ICT specialist support and the usability of the equipment also appeared to be lacking. Suppliers of videoconferencing technologies and services had been surprisingly reticent: merely providing the use of equipment may not be enough to change customers' practices. More encompassing services would most probably make the new technologies more attractive to use. On the broader societal level, an important aspect is to remove tax benefits on air fuel. Educational institutions and public organizations could point the way by helping people to get familiar with this new form of communication.

Early phases of technological change are characterized by considerable uncertainty: developers are uncertain about which kinds of solutions they should invest in. Studies of the history of technology show that new inventions need a technological constituency that speaks for them, and that consolidates the future shape of technology by institutionalizing specific technological solutions and forms (e.g., Rosenkopf and Tushman 1994). Technologies and organizational forms are embedded in intricate social and economic systems. Many parts of these systems need to change to adjust to the new mode of operating. For example, when adopting electronic grocery shopping, consumers need to change their daily routines, but the new mode of operating also implies changes in retailing and possibly the whole food chain. Replacing business travel with videoconferencing implies changes in the work profile of individual workers, but also in how business travel is organized. The changes do not stop here: changes in business travel have implications for the organization of work and interorganizational communication, for organizational hierarchies and reward systems, and for interpersonal relations.

Innovations also include *network effects*, which are especially profound in communication technologies (e.g., Shapiro and Varian 1999). A single videoconference facility is obviously useless, if no one else has one. The more and more organizations use videoconferencing, the more useful it becomes. Electronic grocery shopping involves a specific kind of network effect: home deliveries are very inefficient for an individual customer, but become more efficient the more customers join the service.

E-commerce and videoconferencing have not been developed for the purpose of saving natural resources. Environmental efficiency is thus not a central concern for those developing these technologies and services. Thus, it appears that additional efforts are needed to apply these solutions in a socially optimal manner. An important issue in developing new ICT-based services is identifying *lead customers and pioneering* *areas*. For example, in the case of videoconferencing, it makes more sense to try to find organizations and functions that can benefit immediately from adopting the innovation, rather than propagate the solution in general. Kemp (1994) calls this a *niche management strategy*. In protected niches, technologies can mature, the social practices and meanings surrounding them can develop, and constituencies can evolve. Technology developers themselves do not seem to be very active in this field: perhaps public institutions should encourage the development of more services in this area through their own demand?

On the other hand, the development of services such as electronic grocery shopping needs to be *steered* in order to include societal concerns, such as dematerialization, into the development process. Technology developers are not necessarily aware of the demands of society (the technology selection environment), while those having a stake in the future impacts of the technology do not know how it might influence their interests. Thus, active efforts are needed to bring societal concerns into early phases of the technology (and business) development (e.g. Schot 1992; Kivisaari and Lovio 2000). The Delphi study reported in chapter 6 indicates how the possibilities and implications of a new solution can be articulated in order to enable more stakeholder input into future developments.

"Weak signals": the emergence of new office services

There are many forces obstructing the diffusion of new innovations that could conserve natural resources. If the innovations are finally adopted, new forces arise that alter their impact, so that outcomes can never be predicted reliably. There is, however, another side to this coin. Innovations that conserve natural resources, or potentially could do so, may find *unexpected allies*. The idea of "weak signals", originally put forth by Ansoff (1976), suggests that organizations should monitor their environment for phenomena that may in the future become important. Combined with other phenomena, their impact can be reinforced.

The emergence of a new service-orientation among companies can be viewed as one such weak signal. In itself, it does not perhaps mean much in terms of dematerialization. But it indicates promising patterns that can be supported, channelled and worked on. Following this line of reasoning, Minna Halme and Eva Heiskanen explore new services provided for offices in chapter 8.

> Chapter 8 explores the emergence of new services provided for office customers. Offices are a suitable case to study, as their output is mainly immaterial, but they require a considerable physical infrastructure for support functions (e.g. buildings, equipment, paper, furniture and energy). In recent years, many new kinds of services have appeared in the office supply industries. These include the leasing and rental of equipment (e.g., IT, furniture) and the outsourcing of various activities (e.g., IT-systems, facility management, document management). A few innovative new services have also been launched with a stronger focus on natural resource conservation (e.g., car-sharing, "negaservices" for energy conservation and space planning).
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> Most of these services have been developed and adopted for other reasons than natural resource conservation. Customer companies aim to concentrate on core business competencies, and conserve capital for productive use. Suppliers have developed new services in the face of saturating product markets, and in an attempt to "go downstream" in the value chain, ensure customer loyalty and find new business opportunities. Different kinds of companies are involved — ranging from product manufacturers engaging more and more in the use of their products to entrepreneurial service companies focusing on previously overlooked, specialized market niches (e.g., energy service companies).
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> The potential of these new services to conserve natural resources varies considerably. For example, leasing and rental services do seem to improve end-of-life product management and product reuse somewhat, but refurbishing of products is limited, and the new business model has not, at least yet, motivated the design of more durable products. The outsourcing of activities (i.e., results-oriented services) does appear to lead to more professional

operation and some scale-related gains. However, energy and material costs are not necessarily part of the contract, and thus incentives for suppliers to economize in such costs is lacking.

Promising signs include an increased interest in facility management contracts based on energy performance. An interesting development is also that construction and installation companies are increasingly adopting a "design-build-operate" strategy, thus taking more responsibility for their products throughout their life cycle. IT outsourcing in the form of server-based computing (programmes are run on the service provider's server) could in principle reduce the pressures on customers' PC capacity, and hence stop the endless equipment replacement cycle. Innovative new services, such as "negaservices" and car-sharing are very small-scale today, but they can act as spearheads for new ways of doing business. These developments, however, need to be monitored and supported to make them to work for dematerialization on a significant scale.

There are signs (in the office service case and elsewhere) that at least some companies are increasingly focusing on developing new services and solutions for their customers. It also seems clear that it is possible to conserve a significant amount of natural resources by organizing the *use* of products in new ways - and that this potential is probably much larger (e.g., energy conservation, product life extension, shared resources) than what can be achieved in the production of products. New services can capture this potential if provided the right incentives. It is striking that few services have been subjected to any kinds of environmental policy interventions, and they are not addressed in environmental management systems or educational efforts.

Where services and needs-orientation have been taken up in environmental training, the idea is usually addressed at product designers. It is, however, worth noting that the services identified in chapter 8 have not emerged out of product development departments. They were developed by marketing or maintenance departments, as a result of high-level strategic planning, or by independent entrepreneurs. It is important that organizational linkages are established so that the new business model feeds into better product designs. However, environmental educators and advocates should consider addressing their suggestions to other functions as well.

It would appear that some form of a new business logic is emerging, which is perhaps more important than the *direct* potential of these services to conserve natural resources at present. It is not yet quite clear what this business logic implies. If manufacturing companies turn into service providers, does it mean that they take over the business of existing service companies or of the employees of their customer companies, or can they actually increase the volume of the service business as a whole? Do they consequently produce fewer products? These are some of the issues that need to be monitored as we attempt to understand the impact of micro-level developments on consequences at the level of the entire economy.

Eco-efficiency, dematerialization and rebound effects

Dematerialization of the economy can only occur through (conscious or unconscious) changes in the behaviour of economic actors. One of the ways in which dematerialization has been promoted is by inducing companies to adopt the target of *eco-efficiency*, which is today frequently defined as increasing value-added in relation to natural resource use (e.g., Helminen 2000). This can be achieved by raising more revenues, by decreasing natural resource use, or both. Companies attempting to "go downstream" in the value chain (e.g., by providing additional services to their customers) gain increased revenues, while natural resource use can be reduced, for example, by making smaller and lighter products.

Eco-efficiency can also be understood in *absolute terms*, as the ratio of natural resource use to a fixed indicator of output. For example the MIPS indicator (material inputs per service), as employed, e.g., by Schmidt-Bleek (1994; 1998), can be understood either as an absolute or as a relative measure. Service in this context refers to the utility derived from a product (e.g., kilograms of clothing washed, kilometres driven). If we believe that there is a fixed demand for this utility (e.g., a given amount of laundry anyone would want to wash), MIPS is an absolute indicator.

It is, however, not obvious how these strategies influence dematerialization at the level of the entire economy. Absolute eco-efficiency, relative eco-efficiency, absolute dematerialization of the economy and relative dematerialization of the economy are four different things (see Glossary). In chapter 4, Mikko Jalas considers the relationship between these different measures. This is not merely an academic issue: it is also important for identifying what kind of developments are most promising for achieving both absolute and relative dematerialization at the same time, i.e., promoting both environmental and economic policy.

It is also not obvious that there is a fixed level of demand for goods in society. Of course, no matter how cheap and easy it becomes to wash clothes, people will not probably increase their laundering very much. Yet, if they save money on laundering, they will most probably use it for something else. And if they save time on laundering, they will do something else on the time saved. This is what is today frequently referred to as the *rebound-effect*. In chapter 9, Mikko Jalas uses a novel approach in materials and energy economics, time-use surveys, to explore the implications of eco-efficient services on total energy consumption.

Chapter 4 considers the relationship between eco-efficiency at the micro-level and dematerialization at the level of the entire economy. There are differences between promoting eco-efficiency at the product level, and de-linking economic activity from the natural resource base at the macro-level.

Company-level *eco-efficiency* (as defined by the ratio of value-added per natural resource use) is not necessarily the best possible indicator from the point of view of de-linking economic growth from materials or energy use. For a very labour-intensive firm (e.g., an IT-consultancy), the easiest way to increase eco-efficiency is to lower its natural resource use (e.g., get people to turn of their computers when leaving work). For a very materials-intensive firm (e.g., a paper mill), the easiest way to increase eco-efficiency is to increase value-added (e.g., make more expensive qualities of paper). Both are commendable actions, but not perhaps the most effective ways to de-link the economy from the natural resource base.

The relationship between the different measures is demonstrated using the example of car-sharing. As car-sharing reduces the number of kilometres driven, increases fuel efficiency and saves space, it is an *eco-efficient innovation* in absolute terms (e.g., decreases the environmental load of people adopting it). But as car-sharing is also cheaper than owning a car, the value generated in the provision of this service is lower than that generated by selling cars (including insurance, interests, etc.). So in terms of the ratio of value-added to natural resource use (relative eco-efficiency), car-sharing is not an eco-efficient service. Because it conserves both natural and other resources in equal proportion, it does not contribute to a de-linking of the economy.

On the other hand, *adding extra service components* to products need not in all cases increase their eco-efficiency in absolute terms. Of course, if they relate to, e.g., maintenance and refurbishing, they will do so by extending product life. But absolute eco-efficiency is not necessary for relative dematerialization (de-linking). Even if services merely add value by entertaining the consumer (e.g., a violinist in a restaurant, or a funny figure on your office PC), they contribute to de-linking.

Innovations that reduce natural resource use in *absolute terms* per a given function, and also save money, are attractive for consumers. But if they improve both the productivity of natural resources and the productivity of labour and capital equally, such innovations alone cannot contribute to a de-linking of the economy from the environmental base - if the savings gained are not invested in something less materials-intensive than the original activity.

Ultimately, the natural resource use of the economy boils down to the lifestyles and consumption patterns of individual people - even though it is clear that these are not only individual choices. Chapter 9 demonstrates a *time-use approach* to the materials-intensity of consumption. It is also a critique of, and alternative to, a functional view of consumption (i.e., considering consumption merely as a way to fulfil clearly-defined needs).

Because of *rebound-effects,* environmental savings in individual consumption items do not necessarily lead to savings on the scale of the entire economy. This occurs, for example, when electronic products become smaller, but also cheaper and more widespread. The efficiency gains are invested into additional production and consumption. Thus, even products that are eco-efficient in *absolute terms* may not always lead to absolute dematerialization of the whole economy, at least not to the same extent as the savings gained in individual activities.

Consumer expenditure is one way to measure rebound-effects. If money is saved by energy-saving equipment, where is this money invested? Or if people spend more on mobile phone bills, what do they save on? An alternative to this is a time-use approach to studying rebound-effects: if a consumption activity is downscaled, or replaced with one requiring less time, what is done with the new extra time?

This study indicates that services that save consumers' time (even if eco-efficient in conventional terms), also create the potential for a time-related rebound-effect. For example, restaurant services are an example of a service that is eco-efficient in relation to economic value. Compared with cooking for oneself, having a meal at a restaurant is more expensive. The analysis of time-use rebound presented in chapter 9 shows, however, that such services as restaurants make it possible to effortlessly consume an energy-intensive 'package' in a short time, thus leaving extra time for other consumption activities.

It is important to analyse what kind of lifestyle changes services generate. If people spend their new spare time connecting with friends and family, society and dematerialization will benefit. But if services enable people to work more, earn more and spend more, their efficiency gains may be undermined.

To achieve both absolute dematerialization and a de-linking of the economy from its natural resource base, *both eco-efficient service innovations and a structural change in the economy* will most likely be needed. Eco-efficient services innovations can help to organize the use of material goods in the economy in a more effective manner (e.g., by enabling the sharing of cars, or computer resources, or by making buildings more energy-efficient, or by decreasing business travel). But these services are not necessarily more labour-intensive than the activities that they replace. In fact, it appears that their competitiveness depends on the possibilities to conserve human resources in service production, in many cases using ICT-technologies (e.g., automatic booking and locking for car-sharing, remote monitoring and adjustment of building energy use).

Another lesson that can be drawn from the previous chapters is that LCA-type materials or energy analyses of individual activities are not the only - or perhaps best - indicator of how these activities contribute to dematerialization. If a new activity *is* eco-efficient on the product level, it does not necessarily decrease materials use in the entire economy in proportion. Activities that are *not* eco-efficient in an LCA manner may yet contribute to dematerialization by altering the logics of business activities (see chapters 3 and 8). This is the old wisdom that changes in individual system components do not translate directly into the condition of the system as a whole - especially if the system is as dynamic as the economy.

Conclusions

The aim of the present study has been to provide some prospective views on how services and ICT can contribute to dematerialization. The topical interest in services and ICT seems to relate to hopes that they could combine absolute reductions in natural resource use with continued economic growth. If we take, for example, the "factor 10" target for 2040, then natural resource productivity should increase at an annual rate of 6 per cent (KTM 1998). If we want an absolute reduction in natural resource use to one-tenth, economic growth should also be taken into account. With, e.g., an annual GDP growth-rate of 2%, this would require an annual 8 per cent improvement in natural resource productivity. With respect to this type of target-level, our study points at four central conclusions, which are discussed in more detail below:

- Services and ICT do not automatically lead to significant absolute dematerialization
- ICT and services have three roles in dematerialization: (1) process efficiency, (2) the efficiency of value chains and (3) providing an outlet for new consumption activities
- Services and ICT are a necessary, but not sufficient, condition to combine a significant reduction in natural resource use with economic growth
- The future of dematerialization cannot be predicted, but can be influenced

Services and ICT do not automatically lead to absolute dematerialization

Statistics indicate that relative dematerialization is progressing. During the 1990s, the materials-intensity of the Finnish economy has decreased by 4,6 per cent annually (Mäenpää et al. 2000), and energy-intensity by about 1 per cent. In the past four years, energy intensity has also declined more rapidly than before (almost 3% per year). While there are signs of a continual de-linking of economic activity from the natural resource base, the rate of decline is so variable that no consistent pattern (e.g., as predicted by the environmental Kuznets curve hypothesis) can be identified.

There are also signs that the nature of the economy is changing, at least in the well-to-do North. Such changes are characterized by the rising role of information as a factor of production and by an increasing focus of companies on providing services, access or solutions, especially in relatively saturated markets. In Finland, some of these developments have been swifter, others slower, and yet others have not appeared at all, yet. The share of ICT cluster has grown to 7%, and it appears that the future focus will be increasingly on ICT services. However, the overall share of services (private and public) in GDP actually declined (relative to the 1980s) sharply at the onset of the recession in the early 1990s.

However, the share of services in economic output (as defined by statistics) is not the only point of interest: another important aspect is their integration with other economic activities. It seems that the statistics become continually less useful in depicting structural change as products and services increasingly merge into product-service systems.

Many of the innovations suggested in the eco-efficient service literature would not result in structural change as captured by statistics. They are more an issue of structural changes within industries, i.e., in the way value is produced in existing industries. Some signs of such changes can be seen in business-to-business services in Finland, in which product suppliers are increasingly turning to supplying services (e.g., IT-services, facility management). Finnish companies appear to be middling in the adoption of such services: clearly slower than the US, but swifter than some other European countries.

It has also been established, on the basis of the literature, that at least some new innovative services and ICT-solutions can in principle provide the desired functions with considerably less materials use. However, there are not many detailed calculations of the scale of these gains. In innovative service examples such as concepts of shared use (e.g., car-sharing, sharing of appliances), or results-oriented services (such as laundry services), the gains vary. They are, however, not usually in the scale of a factor 10, although one should note that even these 'success stories' are rarely optimized from a materials perspective. A greater concern, however, is the extent to which they will be adopted, and the extent to which similar ideas can be applied in new areas.

In spite of this, services and ICT may have a central role in dematerialization. This is explained in more detail in the following sections.

Services and ICT have three roles in dematerialization

Environmental impact has often been decomposed using the IPAT identity formulated by Paul Ehrlich. Environmental impact is the product of population, affluence and technology. By improving the efficiency of technology, the impacts of affluence and population growth can be counteracted.

Our study indicates that the technology factor needs to be decomposed further. Firstly, technology can *improve efficiency within individual operations* so that natural resource productivity is increased (e.g., improved logistics, higher manufacturing yields). This is the kind of efficiency we usually think about. However, technology can also contribute to a *shift within sectors*, so that the way the sector produces value changes (e.g., companies use more services and less natural resources, or delivery chains are restructured by electronic commerce). Finally, technological development can lead to *a shift in consumption from one sector to another* (e.g., from material goods to ICT or personal services).

The first kind of efficiency does not seem capable of delivering factor 10 reductions in natural resource use, at least in manufacturing industries, if their outputs remain the same (see, e.g. Nord 1999). There are physical limits to how much the efficiency of, e.g., paper manufacturing or agriculture can be improved. The discussion on services shifts the focus to the latter two types of efficiencies: how established industries produce value (what inputs they use and what outputs they produce), and which industries consumers' demand is directed at. These two latter types are not merely technological issues, but also issues of how the production of wealth and welfare are organized in the economy.

To achieve considerable dematerialization, all three types of efficiencies are needed. Operations need to be conducted efficiently (e.g., paper needs to be manufactured efficiently). The way the publishing and other paper using industries produce value needs to become more efficient (e.g., reducing paper use through digital data transfer). Consumers need to change their behaviour so that they loan books and magazines from the library, obtain casual information through electronic channels, etc.

The discussion on new services focuses on the borderline between the last two types of efficiencies. New institutional arrangements (or old ones such as libraries) can help to organize product use more effectively. They are a necessary complement to technological improvements because they:

- focus efficiency efforts on the final stages of the production chain (e.g., on the utility derived from books, rather than on the production of the physical material for books)
- facilitate the diffusion of efficient technologies (companies that are primarily service providers have more incentives to devise new ways to deliver the service than companies that are primarily factory owners)
- enable the growth of labour intensity or help to maintain employment (i.e., e.g., the economy does not ground to a stand-still even though less paper is used, because new economic activities arise around the provision of electronic information)

Defined in this way, the different kinds of efficiencies are not merely technological issues, but issues of economic organization and new institutional arrangements.

Services and ICT are necessary, but not sufficient - viewpoints on service design and the need for different types of services

New institutional arrangements are not, however, enough. If they have no feedback into technological design, their full efficiency potential is not realized (cf. also Brezet and Ehrenfeld 2001). Leasing of products does not necessarily conserve natural resources if it does not close the loop in terms of actually leading to product refurbishment and the construction of more durable products. Household delivery of groceries can be more efficient than having each consumer drive to the shop, but not if it is not designed very efficiently. New institutional arrangements *can, but do not necessarily, lead to a better design of the entire service-delivery system.*

It is also not self-evident that the efficiency potentials of services and ICT are directed specifically at *saving natural resources*. Efficiency improvements can also be directed at conserving human resources. For example, the IT outsourcing services discussed in chapter 8 are today geared mainly at reducing labour costs, whereas energy and materials costs are mostly overlooked, and will probably remain so as long as labour costs are much more significant. *Thus, the shift toward services does not necessarily remove the need* to alter the price structure of production factors by internalizing environmental costs into the cost of materials and energy.

Taking into account these provisions, *service innovations can be more effective in organizing the use of material goods* than product or process innovations (as was indicated in the previous section). This is because they involve a broader system that also includes the product use and demand for new products (e.g., Mont 2000). Thus, products can be shared, or used by subsequent users, or used more effectively by professional personnel.

On the other hand, *services that do not directly replace products*, but have a low material intensity (e.g., 'non-material services' such as personal services, ICT-services) can *shift the structure of consumption towards a lower natural resource intensity*. These two types of services are complementary. We cannot fulfil all needs or desires with 'pure information' (e.g., bytes or human interaction). Materials-related (product-based or result-oriented) services can help to make material consumption more efficient.

If service innovations are used to make the consumption of material products more efficient, these activities either cost less or are produced with more labour and less materials. Probably both. Many new service innovations seem to be competitive because they are not labour-intensive. Some, on the other hand, can save the consumer's time. In many cases, resources are released that can be used for further consumption or investments.

The rebound-effect means that gains achieved in individual activities are not necessarily fully translated into gains in the whole economy. This depends on the extent to which the structure of the entire economy changes (economic activity is progressively de-linked from natural resource use). Materials-replacing and non-material services are complementary in this respect, as well. *Thus, services do not self-evidently solve the problem of rebound-effects. Both materials-replacing service innovations and non-material-related services are needed to combine efficiency gains with structural change* (and absolute dematerialization with economic growth).

Services and ICT are necessary, but not sufficient - viewpoints on overall resource consumption

While necessary, services and ICT are not sufficient - even when taking into account the previous provisions - to reach a significant reduction in materials use, at least in the sense in which they are currently understood. Most of the existing examples of service and ICT innovations (studied here or in the literature) relate to improving the use of durable or information-intensive goods and services, or to avoiding waste (of materials or energy) by more efficient operation. Examples include:

- car-sharing, or shared use, rental and refurbishing of durable goods
- energy services, facility management, space planning
- (partial) replacement of travel, computers, paper or other information media with digital data transfer
- improved materials management (e.g., chemicals), process management (e.g. monitoring, automation), logistics and deliveries, reduced inventories (e.g., e-commerce)

There are sectors in the economy that are much more difficult to transform by services (see also Stahel 2001). For example, the energy needed to produce and deliver the food we eat makes up about 14% of household energy consumption in Finland. Although services may, in principle, help to reduce energy consumption and waste in food processing, delivery, storage and preparation, it is not obvious how they could significantly reduce energy consumption in agriculture. A central issue here is the share of animal protein consumed. Technology development (e.g., novel proteins), product development in the food industry, and consumption patterns seem to be central in this context (e.g., Weaver et al. 1998). Thus, the focus shifts from services relating to how finished goods are used to R&D inputs within the production process (which are classified as services if purchased from research laboratories or universities, but not if they are produced in-house).

Services and ICT can also - in principle - help to reduce energy and materials consumption in buildings and transportation (both, e.g., 30% of total household energy consumption). Examples include reduced inventories in households and business, distance work, space planning, facility management, monitoring and control technologies, and energy service contracts. It appears unlikely, however, that merely reorganizing the *institutional arrangements* or *information flows* related to these activities could decimate natural resource use in these areas during the coming 40 years.

So, the point is that services and ICT-solutions need to be designed and considered very carefully in order to reduce materials consumption significantly. And, at best, they are only complementary to overall technological development and lifestyle changes. They do not obviate the need to search for more materials-efficient solutions in all industries, at all points of the production chain, and concerning both what products are produced, and how. If significant reductions in natural resource use are required, also lifestyle-changes will be needed, although services and product innovations can potentially help to make such lifestyle changes more attractive.

The future of dematerialization... cannot be predicted

The previous conclusions focus on what services and ICT can accomplish in principle. Earlier studies from the history of technology warn us that the adoption of new solutions is often slow and difficult, because it requires adjustments in many social, cultural and political processes. Furthermore, new technologies or forms of organization are rarely adopted in the same way as expected, and they usually entail unexpected changes (e.g. Schot 1992; Weaver et al. 1998; Geels and Smit 2000). So the future potential of services and ICT depends also on whether they are adopted, how, and with what consequences.

To what extent are new innovations and forms of wealth-creation adopted?

The fact that a new solution is technically feasible is not enough. Even the fact that it is economically profitable does not guarantee that is actually adopted. A blatant example of this is the almost non-existent adoption of videoconferencing to replace business travel. The real world is not like the ideal world of neoclassical economics - innumerable potentially profitable avenues are left unexplored because of bounded rationality: people usually solve problems in the easiest way (rather than the best way), because there is a limited amount of time, effort and information available. This applies both to businesses and to consumers.

The example of energy service companies (see chapter 8) indicates that entrepreneurial services can go some way to solving this problem. They capture savings potential that exist exactly because managerial focus is limited (i.e., companies prefer to invest their money and efforts on more central and obvious targets than energy conservation). This provides energy service companies opportunities, but at the same time constitutes a problem for them. It is difficult to get managers in customer companies to make even the small effort of considering an energy service contract.

There are also other promising signs. ICT development, and especially ICT services are under very intensive development in Finland today (e.g., Sitra 1998). There are also signs that companies in other sectors are focusing more on services, and new businesses centering on services are arising - especially in the business-to-business service market[3]. Common ground can be found between these developments and dematerialization, although these two issues are today rarely linked. However, there are very few really eco-efficient new service innovations available in Finland as yet.

The opportunities and obstacles to the adoption and diffusion of new services are very contextual - hence, it is difficult to predict what their diffusion pattern could be in general. Some patterns, such as the reduced importance of asset ownership and an increased focus on service development, seem to be spreading through the business community. It is too early to say whether similar developments will occur in consumer behaviour.

How are the new solutions adopted, and what are their direct and indirect effects?
Dematerialization or eco-efficiency have not until now been the driving force for developing new services or ICT solutions, except in a few very exceptional cases. This means that they can be improved (see below), but left alone, they may also evolve to merely complement, or augment, materials-consuming activities, rather than replace them.

Today, the existing ICT and service innovation *co-exist* with traditional forms of operating. For example, companies have videoconference facilities as an additional option alongside growing business travel. Electronic grocery shopping co-exists with a variety of modes of grocery retailing, from farmers' markets to hypermarkets. Office IT can be purchased, leased, rented, outsourced - or partially or totally delegated to server-based systems. Copying machine manufacturers sell and lease copying machines, provide outsourcing services, and even engage in entire facility management contracts.

There are many examples in the history of technology of products that have not replaced, but even augmented the use of other products. The "paperless office" that never resulted from office automation is a notorious example of this. Even though new products do not usually simply replace old ones, there are other, more complex ways in which they may undermine existing products (e.g., Evans and Wurster 2000). Evolutionary and social science approaches to the relationship between old and new technologies (see, e.g., Pantzar 1996) would be useful in investigating the impact of ICT and service innovations on society and natural resource use.

In terms of direct and indirect effects, much research remains to be done. Many of the new solutions studied here are so new that it does not make sense even to try to estimate their *direct effects*, except in terms of what could potentially be best or worst cases. More experience will be needed until *indirect effects* (such as the impact on user behaviour, rebound-effects, or indirect impacts on consumption) can be evaluated. The final sections of chapters 2, 3, 6, 8 and 9 indicate some central research needs and directions in this area. Taken together, these studies suggest some new indicators that need to be monitored in order to follow and influence developments.

What developments should be monitored in the future?
The early stage of the development means that the impact of new services and ICT solutions cannot be assessed at present. Moreover, presently existing data are not geared at measuring their effect. The present study suggests a number of new measures or indicators to monitor:

- Current statistics are unsuitable for monitoring the shift toward a 'new service economy' as it is understood in the environmentally-informed debate. For example, industries classified as 'services' are not of interest as such. Rather, it is important to follow the development of industries with low materials intensities (e.g., information-intensive services, ICT-services, personal services) and identify the determinants of these developments.

- Another important aspect to follow is *structural change within sectors*. There is evidence that services are 'hidden' within manufacturing sectors, and on the other hand, manufacturing activities are 'hidden' within service sectors. Finally, the links between services, manufacturing and ICT will need to be studied in more detail. Input-output statistics, network analyses and sectoral analyses (e.g., Michael Porters' "clusters") may be useful methods in this context.

- One of the motivators for exploring the potential for new services is to find ways to change toward sustainable consumption patterns. Many authors speak of *lifestyle changes*, but there are few suggestions on how to measure lifestyle from an environmental perspective. *Time-use surveys* are one way to grasp central aspects of lifestyles in a statistical manner, and explore how changes in the economy (including a shift toward services) influence consumer behaviour.

- The shift toward services in *companies* can be investigated on many levels. Today, it is mostly the rhetorical level that can be studied, as the consequences of new strategies have not yet unfolded. In the future, one should follow how service activities in companies are developed, how they alter the division of labour within the supply chain (e.g., are activities merely taken over from other companies), whether company efforts actually manage to increase the volume of services delivered and decrease the volume of production output and natural resource use, and how organizational links are built between service delivery and product design.

- It is also not self-evident *what kinds of companies* are best geared to providing their customers with radically new ways to deliver services. Our studies identified two types of services: specific services provided by independent service companies (e.g., energy service companies), and services provided by product manufacturers (e.g., design-build-operate). Both have their pros and cons. Manufacturers can alter product design more easily, but at least in a transition stage, there are potential conflicts of interest between manufacturing and service provision. Specialized service companies can focus all their efforts on their core business, and have fewer sunk costs in specific technologies, but they may not be able to influence product design as easily. The consequences of these two strategies will need to be followed as more experience accumulates.

Materials and energy analyses of individual services or solution (even ones involving a life-cycle approach) are not necessarily the only - or always most suitable - indicator of their dematerialization potential, because this requires monitoring a systemic shift:

- They may be too 'soft' (uncritical) on the new solutions, because they are unable to address the second-order effects (e.g. changes in user behaviour, rebound effects) that should be addressed alongside first-order effects (e.g., materials saved per function delivered). Chapters 4 and 9 of the present study point the way for some complementary approaches.

- They may be too 'harsh' (critical) of the new solutions by only addressing their direct material savings potential. Due to network effects and critical thresholds, some solutions may not be very efficient in their early stages, but perform better if applied on a larger scale (e.g., delivery services). On the other hand, new solutions may be important in introducing new ideas (e.g., what is profitable, useful or what creates value) to consumers and the business community. These ideas in their original form may not lead to significant material changes, but their cumulative effect on perceptions and expectations may be more important.

The future of dematerialization... can be influenced

The fact that new services and ICT solutions are still at an early stage also provides opportunities to influence developments. In many of the examples studied, there is considerable uncertainty about dominant design, and many alternative business models co-exist. Some suggestions for interventions in the evolving developments are presented below.

It is important to get environmental and natural resource considerations into the *early stage of the development process*. Developers of new technologies and services are often unaware of society's expectations (e.g., concerning dematerialization), while potential technology users and regulators are not aware of what the new technology or solution holds in stock (see, e.g. Schot 1992). For example, the study on electronic grocery shopping in this volume used a Delphi study to identify probable and environmentally desirable developments for this service, i.e., articulate the potential of the technology or service and the expectations of relevant stakeholders. A variety of other development approaches exist to take such processes further (see, e.g., Schot 2001).

In general, services and ICT have been overlooked in environmental policy, and they have not as a rule been perceived of as environmentally relevant by customers (or the companies themselves). They are usually overlooked, or dealt with in a trivial manner, in environmental management systems, where such are in use. This means that there are few environmental requirements on these services or solutions, and hardly any focusing on the environmental performance of the services themselves. Some developments in, e.g., telecommunications (company environmental management, voluntary initiatives) and facility management (voluntary agreements) indicate that this situation may be changing. This is a development that needs to be supported.

Public purchasing has recently gained attention as an environmental instrument (e.g., in the EU Integrated Product Policy, see CEC 2000). Although the EU procurement directives set some limits on the way in which environmental aspects can be used in selecting products and services, there are opportunities to stimulate the development of new eco-efficient services and solutions in this field. Purchasers could (1) place environmental requirements on service providers, e.g., when outsourcing services, (2) consider alternative ways of fulfilling functions such as travel, data storage or new construction, and (3) establish pilot projects to test new cost-effective ways to reduce the need for products through services (e.g., educational institutions would be a good test-field for new, resource-efficient IT-solutions such as server-based computing or increased use of videoconferences).

The discussion on eco-efficiency has been introduced as a way to avoid the political problems that legislation or economic instruments have encountered. Companies are pointed out win-win solutions, in which natural resource conservation also saves money and brings profits. One the scale of the entire economy, such win-win solutions will not ultimately reduce materials throughput if the efficiency gains are invested in increased material production. Thus, it is important that the new service economy is a more labour-intensive economy, in which savings in natural resources are actually used to employ, e.g., more designers, engineers and service staff in companies - or more educators, content providers, cleaning help or childcare in the economy. *Ultimately, this will most probably require changes in the cost structure (e.g., an ecological tax reform), although this in turn may be easier to accomplish politically as the natural resource dependency of companies (and individuals) declines.*

Managerial and economic aspects are not the only ones that need to be taken into account when attempting to influence developments. The findings of our study also support earlier work that emphasizes the social embeddedness of technological change and change in economic organization.

Views of *what is efficient or functional are subject to negotiation*; they are socially constructed. They depend on what aspects are optimized, on what systems level, and under which constraints. The new services discussed in chapter 8 show how such views can change, for example, concerning the value of ownership. New innovative services can introduce changes in the way economic agents understand efficiency and utility, but their diffusion also depends on such changes. Important aspects to work with in this field are identifying *lead users* (e.g., opinion-leading groups or organizations with specific motivations to adopt new practices). The videoconference example also shows how there are areas in which changes can be introduced more easily than in others. Change needs to be *viewed as a process, in which people and organizations learn about new ways of doing things, and develop social meanings for them.*

Social embeddedness also means that one cannot just take out one activity and replace it with another, even if it provides the same overt function, and still expect everything else to remain the same. This is not necessarily a problem - changes are always underway in any case. For example, new workplace designs or new business travel practices may collide with, but also challenge existing signifiers of organizational status. Replacing product ownership with product use may solve administrative and managerial problems in organizations and for individuals. It is not so important whether the innovations provide exactly the same functions, but rather, how well they fit in with the values and aspirations of their intended users. Efficiency may be an important consideration for some influential actors, but it may not be a sufficient argument to engage all stakeholders. *Other meanings, alongside efficiency, need to be developed for resource-conserving solutions*. This is challenge for the social marketing of dematerialization, and of the innovations that are intended to advance it.

Glossary of terms used

Dematerialization has been used in many different meanings. Early writings such as Herman (1988) and Wernick et al. (1997) used it in a wide meaning to denote reductions in materials use in general, including ones on the level of individual products, on the level of sectors of the economy, or in the economy as a whole. More specific uses narrow dematerialization to denote materials reductions per physical outputs such as products or process flows (Romm et al. 1999, Kahilainen 2000, Farla and Blok 2000). In contrast, Hinterberger and Luks (1998) and de Bruyn (2000), use dematerialization to mean reductions in materials use on the level of the entire economy.

We have adopted a broad scope for this term, including both product-level reductions and reductions in the materials use of the entire economy. Dematerialization thus means reduction in natural resource use in relation to some reference point. For dematerialization at the product or business level, we also use the term eco-efficiency (see below).

Our interest, however, is especially in how product-level or business-level reductions contribute to dematerialization of the entire economy. Improvements in individual products, companies and sectors can contribute to dematerialization at the level of the entire economy, but it is important to note that the connection is not straightforward (see, e.g., chapter 4). Improvements in individual products may be counteracted by rebound-effects or by economic growth in general. On the other hand, changes in the structure of the economy may also contribute to dematerialization of the economy. Furthermore, we distinguish between:

- **absolute dematerialization**, meaning that less materials and energy are used (e.g., per year in Finland)
- **relative dematerialization**, meaning that less materials and energy are used per unit of economic value produced (e.g., GDP). See also de-linking.

De-linking of economic growth and natural resource use. This term refers to the same phenomenon as relative dematerialization, i.e., that progressively, less materials and energy are used per unit of economic value produced. Thus, economic growth is separated from the natural resource base (see chapter 1 for more details).

Eco-efficiency is a very ambiguous term. The WBCSD (1996) defines eco-efficiency as “the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle to a level at least in line with the Earth’s carrying capacity”. The OECD (ref KTM 1998: 14) defines eco-efficiency as “A management strategy based on quantitative input-output measures which seeks to maximize the productivity of energy and materials in order to reduce resource consumption and pollution / waste per unit output and to generate cost saving and competitive advantage”. In the present study, eco-efficiency refers to improvements that use less natural resources (energy, materials) than previously. We use the term to denote activities or outcomes at the micro level of companies or individual products (‘dematerialization at the micro-level’). Here, we can distinguish between:

- **absolute eco-efficiency**, meaning that less natural resources are used per physical unit (e.g., company, product, utility derived from a product) and
- **relative eco-efficiency**, meaning that less natural resources are used per economic unit (e.g., price, value-added)

Eco-efficient service innovations refer to new services that can deliver the use of a product, or the desired outcome of using a product (the function of a product) in a way that can reduce materials use significantly (see services).

Immaterialization has been introduced by Malaska (1998) to take up the difference between GDP and alternative welfare indicators. Immaterialization in this early use referred to the materials intensity of welfare. On the other hand, Kahilainen (2000) and Hoffrén et al. (2001) provide another formulation. For them, dematerialization refers to the changes in materials intensity of a sector of the economy, and immaterialization is the combined effect of dematerialization and structural changes in the economy. The issue is further obscured by references to immaterial consumption items such as digital goods (Kahilainen 2000).

Due to this confusion, we have avoided using the term. ‘Non-material-related’ services (i.e., services that do not directly replace material goods) have some connection with this term. In our framework, they can promote dematerialization (relative to economic growth) by serving as ‘relatively harmless’ and labour-intensive outlets for future growth, and also as outlets for resources saved by making materials-related consumption more efficient.

Compared with previous formulations, our framework also includes an additional component: the natural resource efficiency of materials-related consumption, which may be improved by eco-efficient service innovations (or traditional services such as libraries).

Information and communication technology (ICT) is defined here as industries that produce electronic equipment (ICT hardware), telecommunications, information technology, software and programming, and content provision. The relevant functions that these technologies produce are automatic information processing (computation) and the transfer of information (communication). Although there are industries that are central in the development of ICT, what is more important about ICT is that it is ubiquitous (can be found in all other industries), and that it contributes to the disintegration of traditional industry boundaries (e.g., Shapiro and Varian 1999).

Natural resources refer here to any significant natural substances that are taken into the economy and used to produce goods and services. The central indicators used here for natural resource use are materials (in aggregate) and energy. Land use would be a useful additional indicator (see e.g., Hakanen 1999), but it has not been practicable to use here. The main concern with natural resources today is not their depletion, but the environmental pollutants (e.g., CO_2) and disturbance (e.g., destruction of habitats) caused by over-using nature. As there are so many types of pollutants and disturbances, inputs of materials and fuels serve as a rough indicator of the damages at the output side.

Rebound-effects refer to the phenomenon that improvements in the productivity of a resource decrease the cost of using the resource and thus increase demand for the specific resource. While this observation had already been made by Jevons in the 19th century, it was first systematically treated in energy economics in 1980s (Khazzoom 1980): energy efficiency gains are partly translated into increases in the consumption of energy. Apart from these direct effects, some of the saved funds spill over to other consumption categories and cause indirect rebound effects. It is worth noting that while some people (e.g., Hoffrén et al. 2001) use the term in a broad sense to denote any effects that undermine the impact of efficiency improvements, this report uses the term in a more narrow sense. Different types of rebound effects are discussed in chapter 9.

Services and service-orientation refer here to a broad range of phenomena, many of which are not captured by present-day statistics.

- Firstly we have the **traditional service sector** as defined by national statistics (industry classes 50-93.). Not all these sectors are less materials-intensive than all industrial sectors (see chapter 1, section 1.4.4).**Intermediate services** are used within industries as a factor of production. A shift toward services can occur in different ways, either as a growth in the service sector, or as a growth in intermediate services. If services are provided by companies in other industries (e.g., manufacturers lease products), present-day statistics may not be able to capture such changes at all (see chapter 1).

- The eco-efficient service discussion focuses mostly on **product-based** and **results-oriented** services, which replace the ownership or use of products with services that deliver the same function (see chapter 3). They do not necessary appear in national statistics as a growth in the service sector, but as a change in the factors of production used by the different sectors. For example, if an accounting company replaces business travel (a service) with videoconferencing (may be obtained as a product or a service), the use of natural resources declines in the production of accounting services (see chapter 7).

- Taken together, the previous kinds of services can be called **materials-replacing services** (although, of course, they do not fully replace the need for products and materials). These can be distinguished from non-material-related services (e.g., psychologists, hairdressers, mobile phone dial tones) in which there is no obvious product to replace (of course, the distinction can be debated in individual cases, and can only be determined with respect to existing consumption patterns at a given time).

- Traditional definitions of services also typically require that services include a singular component per each transaction, in addition to a repeatable, standard component (Kotler 1997). This would exclude information technology based services (e.g., search engines) and design activities, as they are not performed by a human being individually for each customer. **We define services as economic activities that replace the customer's own labour with activities conducted by the service provider, either personally, automatically or in advance through planning and design** (see chapter 2 for examples of ICT-based services).

- A service-orientation also refers to a functional orientation in product design, focusing on the utility (service) provided by products, rather than on improving the product itself. This may lead to finding alternative ways to provide customers with solutions to their problems (see chapters 3 and 8).

Part I
Reviews and Conceptual Analyses

Dematerialization and Structural Changes Through Services:

Propositions and Research Approaches

1

Mikko Jalas

The purpose of this chapter is to review the debate on the interactions between economic growth and the state of the physical environment. More specifically, it focuses on the documented relationship between the growth of the economy and selected environmental indicators. Materials use is an indicator that has received growing interest from the point of view of the environmental concerns in the recent years, and it is central to the debate of dematerialization. The following review will include some consideration of other environmental indicators, but it will concentrate on the issue of aggregate materials use and on the related method of Materials Flow Analysis (MFA), placing special emphasis on studies concerning the Finnish economy.

Materials use in economic activities can be assessed at different levels of the economy; these assessments are differently suited to specific needs. If the main concern is, for example, the carrying capacity of a physical area, the economic activity as a whole within that area is a suitable subject for analysis. Likewise, the application of policies to advance dematerialization call for a level of analysis within their area of influence, which may, for example, be a sector of the national economy. On the other hand, an interest focused on resource scarcity and efficiency calls for an approach that takes into consideration the effects of international trade. Such analysis also serves the question of international equity in using resources. Finally, in order to understand the drivers of dematerialization, a third level of analysis is needed, which looks at dematerialization at the level of individual materials, products or technologies.

The following analysis builds upon national statistics and on the accounting of physical resource flows. The data allow the investigation of changes in materials use and materials intensities of economic activities, but it is difficult to understand the causes for the changes on the basis of these statistics alone. As such, the economy-level analyses mainly offer a rear-view mirror of past changes, with little insight on any future developments. However, it is possible to disentangle some Finnish developments relating to the structural change of the economy and to the role of services in the past, which may help to also gain more insight on the future potential of services. The development of ICT has raised much hope for concurrent dematerialization. Past developments and future hopes and projections relating specifically to ICT are discussed in chapter 2. The more detailed case studies of new services in chapters in 6, 7 and 8 provide more detailed understanding of the drivers of dematerialization.

1.1 The debate over materials use

Historically, economic growth has paralleled an immense increase in the materials use and in the load on the assimilation capacity of nature to absorb anthropogenic waste (e.g. Wernick et al. 1996). The dependency on natural resources has triggered a debate, which has been concerned both with the availability of materials and with the environmental consequences of their use. The first of these concerns, the future availability of resources such as metals and energy carriers, is more long-standing. In their book, *Limits to Growth*, Meadows et al. (1972) raised the question of the exponentially growing use of unrenewable resources in the industrial countries. Their view was that the present growth rate could not be maintained, but would be hampered by resource scarcity. When their prediction turned out to be premature, if not wrong all together, it was argued that they did not see the potential of technology development and substitution between materials.

The claims based on the substitutability of materials contrast sharply with those requiring the maintenance of natural (capital) stocks, often referred to as strong sustainability[4]. Building support for the case of strong sustainability, the discussion since *Limits to Growth* has recognised that the environment provides the economy with other essential services than just the materials to refine and the energy of chemical bonds. Rather, materials use is viewed as a two-sided coin, since what goes in the economy will also eventually be disposed of by some means. The appearing environmental concerns such as heavy metal dispersion, acidification, eutrophication, stratospheric ozone depletion and the intensification of the green house effect all manifested that the sink capacity of the nature has limits that could be, and for some pollutants had been, exceeded. Indeed, it has been claimed that the sink capacity of the ecosystems, the processes of assimilation and regeneration - such as the carbon cycles that absorb CO_2 - may be more restrictive than the availability of resources. Thus, it is increasingly emphasized that materials use is an essential parameter in managing natural systems, as well as in managing the economy itself.

The concerns over materials use, be they rooted in the future availability of materials or in the present consequences of their use, open up two fundamental questions. Firstly, how will further development in the industrialised countries affect the environment? Secondly, will the developing countries follow the path that took place in the industrialised countries? These questions certainly lack definite answers, but there are, nevertheless, hypotheses on the relationship between economic growth and pollution or materials use. In the following, some of the prevailing thoughts will be introduced, which are then examined in the light of the Material Flow Analysis studies.

1.1.1 The hypothesis of the environmental Kuznets curve

The problems of the limited assimilation capacity of the environment originated in the countries that were growing rapidly, and the links to industrial production were obvious. However, some of the problems could also effectively be alleviated by new abatement technology. As this technology was developed and first put into use in the wealthy industrial economies, it became apparent that further growth of the economy benefited the solution of some of the problems the initial growth had raised. The phenomenon became known as the Environmental Kuznets Curve - hypothesis (eKc), which suggested that the environmental impacts of an economy show an inverted U-shape[5]. The shape implies that after a certain per capita income is reached, the level of emissions starts to decline first in relation to economic activity (declining intensity) and later also in absolute terms. The important implication of the hypothesis is that it suggests that further economic growth is compatible with environmental well-being or even necessary in order to protect the environment.

The reasoning for the U-shape of the curve and for the causality from economic growth to environmental improvements is versatile and it builds upon the theories and hypotheses of ecological transition, restructuring and modernisation. On the one hand, the transition of agrarian economies in to industrial economies is thought to be continued towards more high technology products and followed by another transition from an industrial economy to a service economy (e.g. Bell 1976; Labson and Crompton 1993; Baldwin 1995: 52; Grossman 1995: 21) or to an information society, in which knowledge becomes an ever more important factor of production (e.g. Shapiro and Varian 1999; Windrum and Tomlinson 1999). Technological development and the accumulation of knowledge that leads to greater efficiency in using environmental resources may be another reason for the U-shape (Johnson 1997). Haukioja and Kaivo-Oja (1998) also mention increasing competition as one driver for efficiency in materials use. It is also suggested that as societies accumulate wealth, they can afford and will start to value a clean environment (e.g. Baldwin 1995). Further causes of ecological transition that are mentioned are the worsened state of the local environment and the consequent change in preferences (Bradford et al. 2000, de Bryun 2000 ch. 11) and the relocation of polluting industries to less developed countries (de Bryun 2000, Baldwin 1995; Bradford et al. 2000).

The link between economic growth and environmental impacts has been studied empirically to test the hypotheses of eKc and delinking. In such analyses, one fundamental question is the selection of the indicator for environmental impacts. Should one focus on the inputs of the economy such as materials and energy carriers, or on the conventional environmental bads, the individual emissions and waste streams of human activity? The discussion on these two alternatives deals with issues such as abatement technology and the precautionary principle. While abatement technology does not help to reduce the materials inputs, it can effectively transfer emissions into different and less harmful forms. On the other hand, it is possible that abatement improves one indicator at the cost of another. Such interventions that prioritise emissions and waste streams rely on the present understanding of the physical mechanisms of environmental degradation, while a focus on materials and energy inputs embraces the precautionary principle (Ayres 1998).

Because the emissions of different pollutants are embedded in a different social and technological setting, economic growth may, independently of regulatory interventions, lower the level of one pollutant, but not another. Recognizing that the interest of the eKc-debate is in the relation of economic growth and the state of the environment in general, the use of single output indicators thus requires careful consideration of the conditions under which a reduction has taken place in order to be generalised as a phenomenon affecting the economy and the state of the environment in general.

Studies on emissions of air and water pollutants have found evidence that growth is able to alleviate these environmental problems. However, the evidence shows an eKc for some but not nearly all pollutants (Bradford et al. 2000), and the pollutants for which an eKc has been found are mainly the ones for which there was a technical solution. As de Bruyn (2000, ch. 11) puts it for reduction of airborne emissions in the North Rhein - Westphalia area: “it was a matter of the pollution control instead of changes in the structure of the economy”.

There are, thus, arguments both for the analysis of the aggregate material flows and for the analysis of the partial subflows. These approaches are complementary, rather than contradicting. It is obvious that the precautionary focus of total materials use overlooks the important possibilities of abatement technology. However, considering the sweeping hypothesis behind the eKc-discussion, a materials-use focus may provide a better understanding of validity of the eKc-hypothesis.

1.1.2 Materials use as an indicator of environmental impacts

The interest in materials use has had very different grounds in the course of time, which is also reflected in the terminology of the discussion. The economically concerned discussion stemming from the first oil crises was interested in *materials use* in contrast to the present environmentally oriented discussion, which is interested in *materials flows* or in *materials throughput*, thus indicating that the inputs into the economy determine the outputs to the natural environment. These different interests also scoped the question relating to materials use differently. The earlier discussion was interested in the availability of selected individual materials regarded as important for the economy, whereas the present discussion on materials flows is interested in the aggregate materials use. Dematerialization has, thus, been traced with various indicators and with various system boundaries of the analysis. The boundaries range from the use of individual materials to the total materials requirement, which includes the effects of international trade, and hidden flows such as mining overburden. Among these alternatives, there seems to be a general trade-off; the wider the system boundary is, the fewer data are available. Consequently, even if a wide system boundary can better capture the phenomenon of dematerialization, the lack of adequately long time series and differences in ways of accounting present obstacles to drawing conclusions (Cleveland and Ruth 1999).

Within the economically interested discussion, Malenbaum (1978, ref. de Bruyn 2000: 140) put forward the hypothesis of the *intensity of use* (IOU), which suggested that due to the changes in technology, the intensities of use of materials (kg of the material / size of the economy) decrease in time. Labys and Waddell (1989) showed that the use of commodities follows a life cycle with a decline as new substitutes appear, and labelled this transmaterialization instead of dematerialization. In their environmentally concerned paper Wernick et al. (1996) argue for such transmaterialization based on the findings that the intensities of lead, steel copper and timber have been reduced in the US during the 20th century while the intensity of plastics and aluminium has increased. However, these studies claiming determinism in the intensity of use of single materials have also been criticized. Labson and Crompton (1993) point out that changes in the intensity of use of metals have been stochastic, rather than having followed a predetermined path such as suggested by the hypotheses of the intensity-of-use or the eKc.

The substitution between different materials renders the studies on the use of single materials a questionable indicator of the total materials use. The energy statistics provide another, more solid reference to approximate total materials flows, as the fossil fuels constitute a major share of the total materials flows (Matthews et al. 2000). However, using energy as a proxy for materials may also contain difficulties. Firstly, energy, to a degree, substitutes for materials in recycling loops and therefore trends in energy and materials use may be contradictory rather than parallel. Secondly, energy and materials use indicators are sensitive to different issues; the analysis of the total materials requirement is, for example, greatly influenced by the average grade of minerals and types of mines used (Mäenpää 2000: 38), whereas an analysis that looks at energy consumption may view this as a minor change in the energy intensity of one sector of the economy.

Even though the importance of materials flows as an indicator of human-induced environmental toll is generally accepted, there are methodological controversies. Cleveland and Ruth (1999) raise a question of how the different material flows should be aggregated. They prefer a price-based aggregation instead of a weight-based aggregation primarily because of two reasons. Firstly, weight does not acknowledge the different properties of materials in industrial production, and thus makes no allowance for the different uses and different marginal productivities of the specific materials in the economy. This question remains open to debate and reflects the different focuses of natural sciences and economics. Approaches that seek to look at both material flows and the related entropy and exergy changes are attempts to combine these two perspectives (Connelly and Koshland 1996).

Secondly, Cleveland and Ruth (1999) argue that weight does not represent the environment harm of materials and call for their toxicological effects to be taken into consideration[6]. Furthermore, according to them, it is not only the specific nature of the material that affects the environmental impact, but also the nature and context of the specific emission. This observation of the extreme complexity of the interactions between technological systems and nature is, however, one of the grounding arguments for a rough weight-based aggregation (Ayres 1998).

1.1.3 Material Flow Analysis

According to the World Resource Institute “Material Flows Analyses track the physical flows of natural resources through extraction, production, fabrication, use and recycling, and final disposal, accounting for losses along the way. The goal of ... materials flow studies is to develop new thinking, new metrics, and new management tools, which will help bring about the transition to more efficient and less environmentally-harmful patterns of material use in modern societies” (WRI 2000).

Material Flow Analysis is, thus, a method to provide the decision-making processes with information on the physical basis of the economy to complement the economic accounting. It measures physical units such as kilograms instead of monetary units, and describes the size of the economy in terms of total materials requirement instead of gross domestic product. The total material requirement of an economy can be disaggregated in different ways to serve different purposes. It can also be linked to a given population or to the volume of the economy in order to study the delinking of the size of the economy from the materials use.

Total Materials Requirement (TMR) measures the total amount of materials related to the economic activity. As TMR was first calculated by the World Resource Institute (Adriaanse et al. 1997), the TMR of a single nation included all materials flows that were required both by the imports and by the exports, which lead, at the global level, to double accounting of all materials requirements relating to international trade. In order to avoid double accounting, the later country reports of Matthews et al. (2000) focus on the materials output flows within national borders. In their terminology, the national materials output flow consists of three components:

1) *Domestic Processed Output* (DPO), which refers to the materials flows that exit the national economy as waste or emissions,
2) *Hidden Flows*, which refer to such materials flows of national extraction and cultivation activities that do not enter the economy, and
3) *Net additions to Stock* (NAS), which refers to the difference between the mass of new infrastructure and durable goods and the mass of demolition and discarded products.

The output-based method of Matthews et al. (2000) thus includes all materials requirements of the economy and eliminates double accounting for international trade. From the perspective of a single country, all manufacturing operations show in the DPO of the exporting country whereas exported goods show in the DPO or NAS of the receiving country. They further define Total Domestic Output (TDO) that sums up the DPO and the Hidden Flows. TDO and NAS, then, together equal the total flow of materials.

Mäenpää et al. (2000) report TMR values for Finland, although they acknowledge the problem of double accounting. In addition, they define Total Materials Consumption (TMC), which eliminates the international double accounting, but in a different way than the concept of TDO&NAS used by Matthews et al. (2000). *Total Materials Consumption* refers to the hidden and direct material flows of the final consumption in a country. Thus, all the hidden flows and waste that are created in other countries, but relate to the imported goods are included in the balance of the receiving country, but, respectively, all material flows related to exports are excluded.

When approached from the input side, the materials flows can be separated into *Direct Material Input* (DMI), which consist of materials that enter the economic accounting and, into the hidden flows. Hoffrén (1999) has analysed the Direct Materials Input of the Finnish economy. However, in order to make comparisons against the TDO&NAS or the TMC figures, it would be necessary to eliminate the international double accounting by deducting the weight of either exports or imports from the DMI figures.

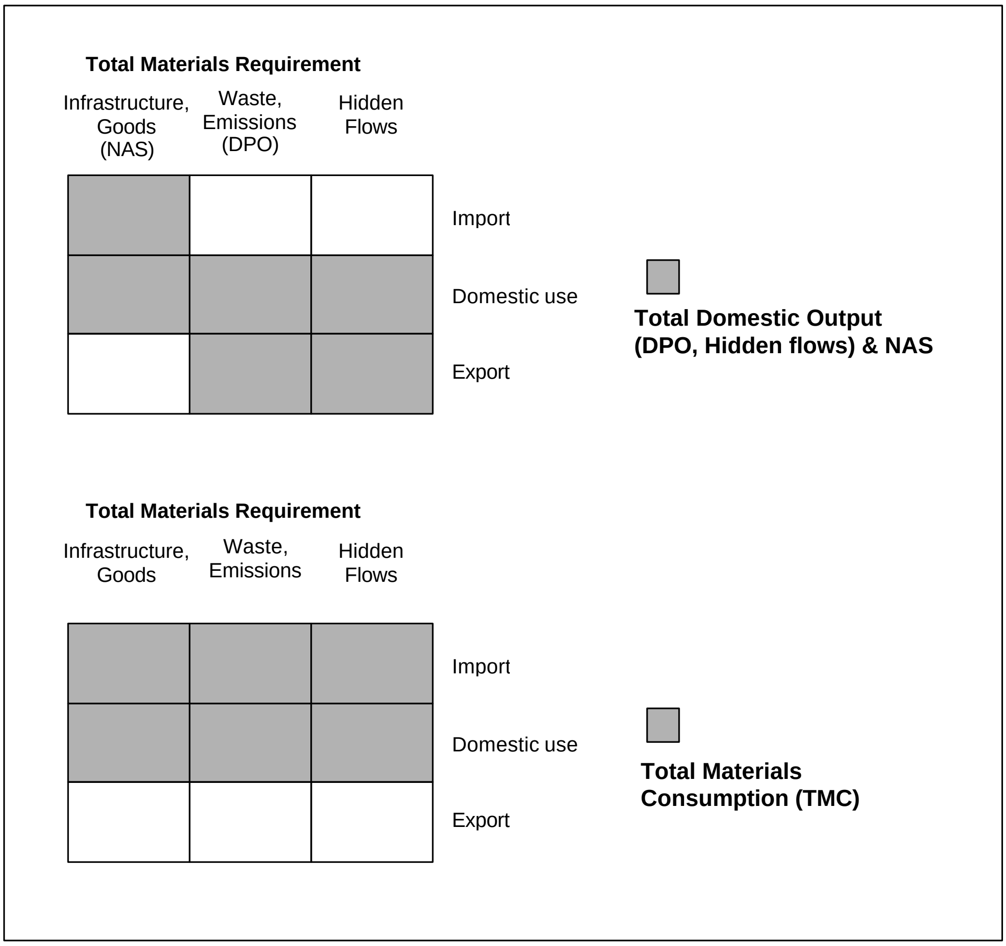


Figure 1. The components of the Total Materials Requirement (TMR) and the extraction of TDO&NAS and TMC.

Figure 1 presents the components of TMR and the two extraction principles used by Matthews et al. (TDO&NAS) and Mäenpää et al. (TMC). The concepts of TDO&NAS and TMC imply a different logic in the allocation of the materials requirements of international trade: the first allocates the resource use to the producer and the second to the consumer. This difference is significant for countries in which exports and imports have a high share of the overall economic activity and in which they consist of different types of goods, thus differing significantly in terms of materials requirements. TDO&NAS, which describes the materials flows that enter a physical area, for example Finland, relates to the limits of the local or regional carrying capacity. Thus, if the impacts of the emissions are mainly local and depend on the receiving environment, TDO&NAS provides an important view of the materials flows. TMC, on the other hand, allocates all impacts that relate to trade into the balance of the final consumer. For emissions such as CO_2 that are mainly of global relevance, TMC provides a point of view that emphasizes the overall efficiency. Furthermore, TMC also emphasizes global equity and efficiency in materials use. Both of these issues can be illustrated by looking at the materials-intensive paper exports of Finland: they show in the TMC's of the receiving countries, which are the final consumers of the paper, but in the TDO&NAS of Finland. Hence, the Finnish forest industry, if more efficient in its use of resources, contributes to the world-wide lowering of materials requirements, even though Finland simultaneously has high per capita TDO&NAS figures (Mäenpää et al. 2000). On the other hand, allocating the impacts of the pulp and paper industry into the balance of the end-use of the paper may obscure the importance of the sector as a source of locally relevant emissions in Finland.

Both allocation principles have weaknesses. If the local carrying capacity is not taken into consideration, its is clear that the global optimum can lead to severe environmental implications at the local level. On the other hand, looking at the materials flows inside a single nation may lead to the reallocation of the polluting industries to countries with less stringent environmental policies (environmental dumping) and less developed technology. There is also a difference in the data requirements; the calculation of TMC values requires an international system of materials flow accounting whereas TDO is based on national statistics. A further observation may be that TDO&NAS is more in line with the principles of free trade, which do not allow discrimination by the origin of the product. TMC, on the other hand, puts forward a life cycle approach, in which the responsibility in the product chains lies with the final consumer.

1.1.4 Delinking towards absolute reductions in materials requirements

In addition to having different systems boundaries and employing different indicators, the discussion on materials use has also distinguished between absolute and relative changes. Relative changes refer to a lowering materials intensity of the economic activity achieved by, for example, such economic growth, in which the materials inputs to the economy do not grow proportionally to the growth of the economy (see also the chapter 4)[7]. They result, thus, in a *delinking* of the economic growth and materials requirement. However, delinking is not the ultimate concern of the environmentally driven interest in materials use, because an ongoing delinking and constantly growing absolute materials requirements are not mutually exclusive. The environmental concerns for the impacts of human activities call for absolute reductions in materials use especially in the wealthy industrialised countries (Schmidt-Bleek 1994).

As the materials use is not declining in absolute terms in the wealthy industrialised countries, thus implying no progress along the inverted U-shape of the eKc, a question of the prospects of absolute reductions in the future is very relevant. Will delinking accelerate and turn into reductions in absolute materials use? The eKc-hypothesis combines the two concepts of relative and absolute dematerialization by presuming reasons for permanent and accelerating delinking and consequent absolute reductions above a certain per capita income. It thus claims that the second-order derivative of environmental impacts as a function of per capita income turns negative after certain per a capita income level is achieved and will stay so in future until also absolute reductions in the emissions or materials requirements take place[8]. Thus, even though economic growth may require additional natural resources, it should eventually also bring about a stage of absolute reductions in materials requirement.

The delinking of economic activity and materials use can be examined by decomposing total materials use, according to the IPAT-equation, into population (P), the per capita output of the economy (A) and thirdly into the level of technology (T), which determines the materials intensity of the economy[9]. The changes in the materials intensity can be further decomposed into structural change (towards the dominance of less intensive sectors) in the economy and into the improvement of the technology within the various sectors. While recognising that population growth may be the single most important issue of the debate, it is left out of the consideration in the further parts of this review. The relevant question hence is, whether the technology factor (T) can be improved so that the overall impact (I) is reduced or kept constant despite further per capita economic growth (A). The eKc-hypothesis claims that this is possible, and even to be expected, after a certain level of GDP per capita. However, the hypothesis does not differentiate between structural changes and technology development, but combines these two factors.

The following text will review some of the evidence presented about the relation between economic growth and materials use. As stated above, mere delinking is not a sufficient condition for absolute reductions in materials use. The rate of delinking should also be accelerating.

1.2 Empirical studies on materials use

This discussion will concentrate on such studies that track changes in the total materials requirement as a measure of the overall environmental impacts (I) and materials intensity as a measure of technology (T). Mäenpää et al. (2000) and Hoffrén et al. (2001) both present recent analyses of the materials flows in Finland, which are of particular interest for the work at hand. These analyses will be complemented by looking at the work of Jänicke et al. (1989) and Matthews et al. (2000).

1.2.1 Structural change and environmental impact (Jänicke et al. 1989)

Jänicke et al. (1989) have developed a comparative index for materials use by using the per capita figures of energy and steel consumption, cement production and freight transport weight. The deviations of each of the four figures from the average of all countries were summed up in a single index for each country. In a sample of 31 countries, they found that in the countries with a high level of per capita income in 1970, the further growth that took place up to 1985 was less resource-intensive than in the countries with a relatively low initial per capita income. Within the limits of this indicator, it thus seems that the second derivative of the index with respect to economic growth was negative for the time period of 1970-1985. Jänicke et al. also point out that in countries such as Japan with high industrial growth, the delinking within the sectors was partly eliminated by a structural change towards industrial production.

de Bruyn (2000) has used the same index as Jänicke et al. (1989) and found that the process of delinking that was found by Jänicke et al. was interrupted in the late 1980's. In the analysis of 19 countries[10] from 1966 to 1990, the wealthier countries show first an inverted U-shape in the index value as Jänicke et al. claim, but after 1984, a significant relinking, which refers materials intensive economic growth.

1.2.2 The weight of nations (Matthews et al. 2000)

The report by Matthews et al. (2000) utilises the concepts of Material Flow Analysis that were introduced above, and presents data on the physical flows of the economies of Austria, Germany, Japan, the Netherlands and the USA during the years 1975-1996. The international allocation follows the concept of TDO&NAS and thus the report assesses the materials outputs within the national borders, excluding the indirect flows of imports and the final weight of exports. Concerning the sectoral analysis, it is important to note that this work is an output analysis that looks merely at the emission sources rather than allocating the materials use to final consumption. In contrast, Mäenpää et al. (2000) also report the embodied materials use of final consumption with a reallocation of the intermediate use of materials.

In all of the five countries, the Direct Processed Output (DPO) is dominated by the CO_2 emissions, which contribute between 80 and 90% of the DPO. Thus, Matthews et al. conclude that the atmosphere is the largest waste dump of the still carbon-based Western economies. Looking at TDO, which includes the domestic hidden flows, mining waste appears as dominant in Germany and in the US. Consequently, the report views the use of DPO as being better fitted for international comparisons, as the specific structures of the economy do not have as great an impact on the results. In all of the countries, there is a tendency that the share of DPO of TDO is increasing. One explanation given to this trend is the improved erosion control that has been implemented for example in the US. In Germany and Austria, the decline of lignite mining has lowered the hidden flows and thus raised the share of DPO. The DPO values do not include the Net Additions to Stock, which constitute a significant share of the TDO in all five countries and are largely determined by the (cycles of) infrastructure building. Since DPO is less dependent on single activities and sectors, it may better describe the structure and performance of the economy in general and thus reflect the kind of changes in the economy that are assumed by the eKc-hypothesis.

The DPOs of all the countries have been diminishing in relation to the size of the economies, and thus the economic growth has been delinked from the materials use of these economies with a rate varying between 26 and 42% during the study period 1975-1996 (Matthews et al. 2000: 20). The report does not analyse the causes of delinking in detail, but does suggest that the observed delinking is partly a result of successful attempts to lower the waste volume and to increase recycling. The mass of landfilling has been reduced by 34 % in the NL and by 31% in Austria. However, according to Matthews et al., "delinking appears to owe more to the efficiency improvements and ongoing structural change away from the traditional materials and energy intensive industries towards knowledge-intensive industries, and the financial and other service sectors" (Matthews et al. 2000: 17). They also anticipate that new patterns of economic development such as e-commerce may further drive delinking. Despite all this, the report notes that the rate of delinking has been lowering towards the end of the period. This observation is in contradiction with the hypothesis of eKc, which assumes the process of delinking to be accelerating.

There are no signs of absolute reductions in materials use, either. Despite the clear delinking, the per capita materials use has not been reduced during the period, but has fluctuated with the economic cycles and been strongly influenced by the volume of construction, ending up in 1996 roughly at same amount as in 1975. In absolute terms, the national DPOs of all the countries have raised since 1975. In the US, for example, coal and metal mining waste has increased during the study period. Thus, even though there are new patterns of economic growth, this growth is not taking the economy "away" from the tradition materials-intensive sectors but rather building on them. As Matthews et al. (2000: 35) put it, "the efficiency gains brought by technology and new management practices have been offset by the scale of the economic development and consumer choices that favour energy and materials intensive lifestyles."

Economic growth has been given two distinct and contradictory roles in the above reasoning. Firstly, the rates of delinking and economic growth are seen to be correlated and to occur at the same time, due to new, less resource intensive areas of economic growth. Secondly, it is argued that economic growth is one reason why the absolute materials use has not declined despite efficiency gains. It is obvious from these points of view that, while new less resource-intensive areas of economic growth may drive delinking, they do not contribute to a lowering of absolute materials use. It is only such delinking that takes place inside the current production structures that holds potential to reduce the absolute materials flows. On the other hand, the new less resource-intensive sectors provide employment and an outlet for new consumption, and may thus be very important in stabilizing materials use.

The concepts of consumer choice and lifestyle also call for some clarification. Along with the delinking of the economic growth and materials use, also the purchasing decisions of consumers have become less materials-intensive. The life-style change noted by Matthews et al. (2000) does not thus refer to what is being consumed, i.e., the structure of consumption expenditure, but to the volume of consumption[11]. From a consumer point of view this means that consumers have managed or come to fit ever more consumption into their daily routines. In other words, the way products and services are used has become more intensive in respect to consumption time (e.g. Röpke 1999a), which has resulted in additional materials requirements and offset the efficiency gains and the structural change of the economy. (See chapter 9 for a discussion of life-style and time use).

The Net Addition to Stock (NAS) describes the annual net change in the materials embodied in the infrastructure and in durable goods. Of these two, the infrastructure - roads, buildings etc., clearly dominate over other durable goods. For example in the US in 1996 other durable goods only counted for 7% of NAS, even though their absolute weight had increased by more than 40% since 1975 (Matthews et al. 2000: 111). In Germany, Austria and Japan, NAS was approximately of the size of DPO, in the NL about half and in the US about one third of the size of DPO. The economies of the two latter countries thus turn more of the Direct Materials Input directly into waste instead of creating Net Additions to Stock. The US also scores the lowest in the absolute Net Additions to Stocks, with a 1996 per capita figure of 7,7 metric tons per capita in comparison to 11,5 metric tons per capita of Austria and Germany. Even though the accumulation of stocks temporarily lowers the waste volumes, the growth of the stock also brings about further problems. The Austrian report points out that the sheer maintenance flow required by the material stock grows with the increasing size of the stock and can reach significant levels. In Austria, for example, the costs of freeway maintenance are higher than the costs of building new freeways (Matthews et al. 2000: 52-53), although the implications of these cost structures on the material flows are not given. The country reports of both Austria and the Netherlands conclude that the size of stock is very relevant for any future policies directed at managing the material flows.

DPO, which in essence assembles all emissions and waste flows from the economy, is dominated by the CO_2 emissions. Thus, DPO may also give a narrow view of the transformation of economic activity, although with a different bias than TDO, which is largely determined by the mining and construction activities. In the DPO figures, the role of energy consumption and the changes in energy sources, for example from coal to natural gas, are raised to central positions. While energy consumption and the portfolio of energy sources have great environmental implications and certainly reflect the structure of the whole economy, some transitional aspects may be obscured when focusing on DPO. In order to avoid this, figure 2 presents the DPO figures without the contribution of CO_2[12]. It shows that Germany, Japan and the NL have been able to clearly reduce the per capita values of DPO excluding CO_2, despite the fact that both TDO and DPO in the same countries have increased rather than decreased.

It is often claimed that there is empirical evidence for an inverted u-shape of the eKc only for such pollutants that can be affected by end-of-pipe solutions (e.g. Matthews et al. 2000: 52). Such development does not contribute to the reduction of aggregate materials flows, and technologies such as sulphur reduction are criticized for merely shifting the emissions from one environmental media to another. However, as the data in figure 1 suggest, Germany (-17%), Japan (-24%) and the Netherlands (-23%) have reduced DPO-excluding CO_2 in a way that can not be explained with a shift in the receiving media due to abatement measures. Rather, the absolute reductions have either been catalyzed by additional energy use or taken place irrespectively of it[13].

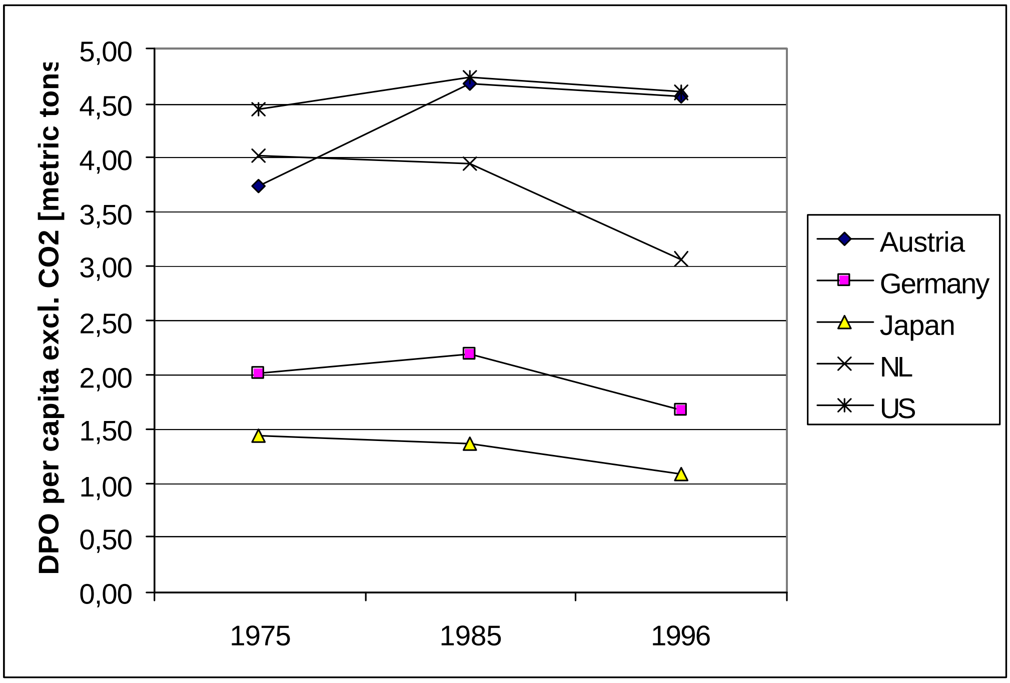


Figure 2. Changes in the per capita Direct Processed Output of the studied countries from 1975-1996 excluding CO_2-emissions.

1.2.3 Material flows of the Finnish economy

Mäenpää et al. (2000) set out to describe how the use of natural resources has developed in the Finnish economy and to analyse how this use depends on the structure of the economy. In order to study the dependencies, they use an input-out table of the Finnish economy. This method enables the analysis to allocate the intermediate materials use to the different components of the final use of GDP.

Mäenpää et al. compare the TMR values of Finland with those presented by Adriaanse et al. (1997) for Germany, Japan, the NL and the US. According to this comparison, the per capita TMR has only been reduced in the US, and the value for Finland has grown the most. However, as TMR implies a double accounting of imports and exports, the significant opening of the Finnish economy during the study period causes a considerable error in the figure.[14] Matthews et al. (2000) have eliminated the double accounting in the analyses of the same four countries studied by Adriaanse et al. by focusing on the TDO&NAS as discussed previously. Their data reveal a delinking of about 40% from 1975 to 1996 for all countries except for Germany, for which the figures are not comparable because of the re-unification in 1990. According to Mäenpää et al. the Finnish total materials consumption (TMC), which treats imports and exports differently than TDO&NAS (see above), but does not include double accounting and is as such a better reference for comparison than TMR, has been delinked by approximately 35% from 1975 to 1996. Since there has been a significant reduction in the intensity of exports, which is ignored by TMC but would effect TDO&NAS, the delinking rate of TDO&NAS would probably be higher than that of TMC, and thus Finland would be placed close to the other countries of the above international comparison.

Mäenpää et al. (2000: 69) decompose the changes in the materials use of Finland into the following effects:

- economic growth.
- a change in the macrostructure, which refers to the relative shares of private and public consumption, investments and exports.

- a change within the structures of each element of the macrostructure; private consumption (16 subcategories), public consumption (3 subcategories), investments (6 subcategories) and exports (21 subcategories).
- a residual factor, which they interpret as a technological change.

According to the eKc hypothesis, the second-order derivative of materials use as a function of GDP should be negative. Arguments for this include a structural change towards less resource-intensive sectors. If the less resource-intensive sectors grow faster than the economy in general, the impact of structural change grows exponentially. However, the decomposition analysis of Mäenpää et al. shows that the structural change has not been consistent over time and across the different final-uses of GNP. Table 1 summarises the effects of structural change within each component of final use for two periods of time, 1975-90 and 1991-1997. A growing delinking-effect of structural change shows as a change from positive to negative contribution or as increased a negative contribution. This is the case only for investments, exports and technological change, but not for private or public consumption. However, the period of 1991-97 included a drop of the GDP in the early 1990s and for the whole period the GDP growth was lower than for the previous period, which may explain some of the non-conforming observations.

Table 1. The contribution of structural change inside the end-use segments of the Finnish economy and of a general technology effect calculated as a residual factor. + refers to increased intensity kg/FIM and to a change towards a more materials-intensive structure, B to decreased intensity and to a change towards a less intensive structure (Mäenpää et al. 2000: 69).

End-use	1975-1990	1990-1997
Private consumption	-	+
Public consumption	-	+
Investments	-	--
Export	+	-
Residual factor (technology)	-	--

The number of categories that are used in the decomposition affects the allocation of structural impacts. The fewer categories are employed, the more of the impact will be regarded as technological (residual) impact. Because of this and the fact that also technological change is presumed to participate in the eKc development, it is meaningful to look at the summary data on the materials intensity of the economic activity and changes in it, irrespectively of whether they represent structural changes or non-specified technology effect.

Table 2. The rate of annual delinking of Total Materials Consumption of the Finnish economy (Mäenpää et al. 2000: 75).

	TMC/GDP
1970-1997	2,6%
1970-1980	2,9%
1980-1990	0,7%
1990-1997	4,6%

The rates of delinking of TMC presented in table 2 have also fluctuated. Even though the rate has not increased consistently as the positive second-order derivative would imply, the rate of the last period 1990-1997 is higher than the average for the whole period. de Bruyn found a relinking in the TI-index of Jänicke et al. (1989) during the years of 1984-1990 and Matthews et al. (2000) note that the rate of delinking has lowered during the period of 1975-1996. The TMC data of Mäenpää fits these observations. The delinking of TMC during 1970-1997 has been slowest in the period of from 1980 to 1990 (the materials intensity even increased 87-88). However, it accelerated thereafter in the period of 1990 to 1997 to 4,6%. Thus, in Finland the phase of relinking has been reversed, notably by the structural change towards lower share of the investments in the TMC and by a structural change within the category of investments (Mäenpää et al. 2000: 69). The rapid growth of the exports of the electronics industry has not affected the TMC figure, because it is allocated to the receiving country.

According to Mäenpää et al., the change in the structure of the investments can partly be explained by the low level of road construction. Such a strong single reason leads one again to question the use of TMR or TMC as an indicator for such a wide and thorough transition as suggested by the eKc hypothesis. Because of this single reason, the changes in private and public consumption towards a more materials intensive structure are compensated and the overall figure of TMC shows a high rate of delinking in the 1990's.

In another Finnish study, Hoffrén (1999) analyses the materials consumption of the Finnish economy. According to the definitions put forward earlier, the subject of the analysis of Hoffrén is the Direct Material Input, which excludes hidden flows. The reduction of Direct Materials Input in Finland during from 1989 (203,1 million tons) to 1993 (166,2 million tons) has been over 18%. This same sharp decline is visible also in the data of Mäenpää et al. 2000, but it is even more prominent in the DMI figure, because DMI also includes the rapid decline in the volume of the materials-intensive Finnish export industry, which is not visible in the TMC figures[15] . Hoffrén states that the delinking of DMI in the 1990's means that " from smaller amounts of materials it has been possible to produce greater amounts of wealth as measured by Gross Domestic Product" (Hoffrén 1999: 37). However, the specific economic conditions of the recession of the early 1990's cast a shadow on this optimistic record. Later during the 1990's, the DMI started to increase again, although it was accompanied by strong economic growth and consequent delinking (Hoffrén et al. 2001).

Hoffrén and colleagues (2001) provide another decomposition analysis of the Finnish total materials use in 1960-1996. Their method of decomposition is different from Mäenpää et al. and contains no residual factor. Therefore, they are able to allocate the effect of technological improvements to specific sectors. However, the decomposition is also performed on a more limited number of sectors, which increases the technology-effect. They conclude that in an analysis of 9 sectors, technological improvements within those sectors have been more significant than the structural change between those sectors. However, they also show that the technological improvement has varied considerably between the sectors. The pulp and paper industry, wood and wood products industry and electricity, gas and water supply are the sectors that have been able to achieve the largest efficiency gains, which are observable as the decreasing materials intensity of the sectors.

There is no evidence for the increased pace of delinking in the data of Hoffrén et al., either. During the period of 1960 to 1996, the materials intensity of the economy has been reduced at a fairly constant rate, the oil crises and the 1990's recession accounting for the most significant alternations. As a whole, the materials intensity has decreased with a factor of 1.75 during the same period, which raises doubts about the feasibility of factor 4 or factor 10 efficiency improvements within the next few decades (Hoffren et al. 2001).

1.2.4 Summary of the reviewed empirical evidence

The evidence that has been reviewed includes the material flow analysis of Matthews et al. (2000), Mäenpää et al. (2000) and Hoffrén (1999) and the decomposition analysis of Hoffrén et al. (2001). The Finnish studies have used Adriaanse et al. (1997) to make international comparisons of the Finnish materials use. In addition, the review utilized an earlier study of Jänicke et al. (1989), which used an indicator of concrete production, steel and energy consumption and freight weight as a measure of the resource intensity of the structure of the country. de Bruyn (2000) has used the same indicator as Jänicke for a longer time period expanding the analysis from 1966 to 1990. The time span of Mäenpää et al. is from 1970 to 1997, Hoffrén et al. from 1960 to 1996, and Matthews et al. from 1975 to 1996.

All studies show a delinking of economic growth and materials use. However, its is possible to have ongoing delinking without absolute reductions in materials flows. In the reviewed empirical evidence, the growth in materials use has levelled off, but there are, indeed, no signs of absolute reductions. The hypothesis of the Environmental Kuznets Curve proposes that the environmental impacts show an inverted U-shape as the countries acquire wealth, and thus predicts that even in the absence of absolute reductions the rate of delinking should accelerate continuously. Both Matthews et al. and de Bruyn note the opposite - the rate of delinking has rather declined than increased towards the end of the studied periods. Mäenpää et al. find, however, that the rate lowered in the 1980s in Finland, but increased again during the 1990s in Finland.

The hypothesis of ecological transition and the eKc assume a variety of changes that would maintain and drive further delinking of economic growth and materials use. The evidence that has been reviewed does not allow the consideration of the driving forces of delinking. In the decomposition analysis, the division between structural and technological effects is, to a degree, arbitrary. Furthermore, also the aggregate materials flows may be influenced by individual factors. For example, the main factor for the important observation of Mäenpää et al. that the rate of delinking of Finnish TMC increased in the 1990's, was the lower volume of investments, road construction among others. In the same vein, the reduction of lignite mining has strongly influenced the Total Domestic Output of both Germany and Austria.

The impact of mining side rock and infrastructure building can be eliminated by looking at the Domestic Processed Output, which describes the materials that have entered the economy and leave it as any kind of waste or emission. The different system boundary does not change the picture: DPO does not show a trend of absolute reductions, either, but in fact the contrary. However, the figure of DPO is strongly influenced by carbon dioxide and reflects mainly the changes in the energy use and the energy sources. To get a figure that would better reflect the broad range of different assumptions behind the eKc, the present analysis extracted a DPO of non-CO_2 emissions from the data of Matthews et al. (2000). For this figure, there are clear absolute reductions in the figures of Germany, the Netherlands and Japan, which are not obvious when looking at the DPO with CO_2. Furthermore, the rate of delinking of these figures was higher in 1985-1996 than in the earlier time period 1975-1985, which fits the hypothesis of eKc and accelerated delinking. However, the implications of this partial finding are naturally very limited. CO_2 is the major environmental concern that is deeply rooted in the structure of the economy.

One plausible explanation for the eKc is that richer countries transfer polluting activities to the poorer countries. This would mean that the developing countries could not mimic the development path of the wealthier countries as no possibilities for 'environmental dumping' would remain for them. Stern et al. (1996, ref. de Bryun 2000: 198) have labelled this explanation the displacement hypothesis. However, the evidence does not support this explanation (Grossman 1995:43, de Bryun 2000: ch. 10.5). Support for the displacement hypothesis should show as a structural change in both the wealthier economies and developing countries (de Bryun, 2000: 181). However, structural change is not the major explanation of the delinking of the wealthier economies. To test the hypothesis thoroughly, one would need to take into account the materials-intensity of international trade. As shown in table 1, Finland seems to have been in a phase of increasing materials intensity of exports up to 1990, which is characteristic of countries in the beginning of industrialisation according to the eKc-hypotheses. Only after this period, the export has entered a phase of significant reduction in materials intensity with the growth of the electronics industry. Despite this, the intensity of Finnish consumption, TMC / GNP has declined more rapidly than the materials intensity of Finnish exports (Mäenpää et al., 2000:74-76). It thus seems that Finland has rather been a subject of environmental dumping. On reason for this is that the high relative price of labour benefits the capital (and resource) intensive sectors of production. For example the Finnish pulp and paper industry counted for 26,8% of the value of exports and 36,6% for the materials use of export in 1995, but only employed 1,8% of the labour force in Finland (Mäenpää et al. 2000, Statistics Finland 2000a). There are other international examples that demerit the displacement hypothesis. For example, Jespersen (1999) notes that the imports of Denmark in 1990 had only a very slightly higher energy intensity than the exports, which indicates that Denmark was not exploiting its trading partners environmentally, either. However, at the same time it should be noted that data on the materials intensity of the imports and exports of developing countries are not available. [16]

1.3 The role of services

1.3.1 What are the main questions?

Services have long been in the focus of the discussion on structural change in the industrial economies. More specifically, there are both predictions of and prescriptions for a change towards a more service-oriented economy in the literature that is concerned with employment and the environmental impacts economic activities. Such a change can be traced after in the economic statistics by posing questions like what is the share of services in the GDP or in consumer expenditure. However, the implications of a possible shift towards services are an equally important question: are services less resource intensive than manufacturing?

Both of these questions depend on what we mean by services. The national accounts distinguish primary production, secondary production, and services as a residual sector. Such services can be further divided into intermediate services and final services depending on whether they are used in productive activities or consumed by end-consumers. In addition to private final services that are provided by the market actors, also the public sector provides such final services as health care, education and social services.[17] However, there are no clear bases to define services. It has been suggested that this could be better done according to the value-added or the information 'content' of the activity (Rada 1993).

The second question of whether services are environmentally benign is very sensitive to the definition of services. Services include labour-intensive areas of production, in which the share of materials or capital costs is consequently low. However, there are other areas, most notably transport services that are energy and materials intensive. Whether all these activities should be considered as an entity with average resource intensity or as separate individual fields depends on the point of view. Are there external drivers or policies that would affect the whole range services or are the impacts more segmented?

In order to address these questions and in general the role of services in the delinking of economic growth from its materials basis, the following discussion will first review some of the critical comments that have been presented concerning the potential role of services. These critical comments are then discussed in the light of statistical data on the Finnish economy.

1.3.2 The possibility of a shift towards services

Despite the wide and optimistic discussion about services, there are also writers who take a critical stand on the potential of services as such to bring about structural changes or dematerialization. The possibilities of and obstacles to a shift toward services have a different outlook whether one considers intermediate services or final private and public services. Jonathan Gershuny, for example, questioned the possibility of a general shift towards services in his book *After the Industrial Society. The emerging self-service society* in 1978. He claimed that the productivity improvements in manufacturing lower the competitiveness of services and consequently the share of services is declining instead of increasing[18]. Bhagwati (1993) describes this 'cost-disease' in that services, which are not able to increase their productivity retreat to household do-it-yourself activities.

Gershuny (1978) also pointed out that there is a statistical difference in defining the service sector and service occupations. Manufacturing activities involve service tasks and if these tasks are outsourced, there may be an apparent shift towards a service-bias in the economy without any change in the number of service occupations. According to Gershuny, such a phenomenon partly explains the statistical growth of the service sector. However, the same difference between apparent and real changes can also take the reverse form. If manufacturing companies add internally produced service components to their products, all this will be counted as manufacturing (Stahel 2000).

ICT has had a significant role in raising the relative performance of manufacturing against services. However, ICT can also work in the opposite direction. One early note of such impacts can be found from Gershuny and Miles (1983). They embrace the possibility that ICT can help to maintain the relative productivity of service sectors such as healthcare and education, by making the delivery of these services more efficient via telemedicine and distant learning. Bhagwati (1993) and Rada (1993) both emphasise that ICT makes services increasingly transportable and tradable, which in turn facilitates economies of scale and the 'manufacturing' of services. This does not only affect final services. Grubel notes that intermediary business services benefit from ICT and economics of scale, which enable the sectors to improve their productivity. Thus, the demand for intermediary services increases and these services are increasingly embodied in goods (Grubel 1993). The earlier trend of the relative productivity of manufacturing gaining over services, noted by Gershuny (1978), could thus be slowed down by the introduction of ICT in the service sectors. ICT also plays a role in the topical examples of eco-efficient services. For example, car-sharing companies utilize the benefits of mobile communications networks to streamline the operation of the network. Indeed, whereas the information processing capacity of ICT mostly benefited manufacturing, it may be that the communication technologies, such as the Internet and mobile phones benefit services more.

Jespersen (1999) claims that the proposition of a shift from manufacturing to services does not acknowledge the structure of the service sector. Despite the fact that private services accounted for nearly 50% of the Danish GDP in 1990, they only accounted for 8% of the final consumption. The remaining services are used as inputs in the other sectors of the economy. According to him, the fact that goods and services are tightly intertwined and produced in complementary processes limits the possibility of a shift from manufacturing to services. However, this claim contradicts recent developments. Whether apparent or real, intermediate services have grown rapidly in the western countries (Bhagwati 1993, Grubel 1993, Rada 1993, Windrum and Tomlinson 1999) and an increasing share of these services relate to information processing and dissemination (Rada 1993). Windrum and Tomlinson (1999) further distinguish knowledge-intensive intermediate services and present a hypothesis that these services are conductive to the international competitiveness of a nation instead of the deteriorating nature that has been often attached to services. Thus they claim that a shift towards intermediate services is not only possible, but also preferable for the economic wealth of nations.

From the point of view of materials use, the shift towards less resource-intensive public services has been of particular interest. For example, Norgård (1994) and

Jespersen (1999) point out that these services are significantly less resource intensive than manufacturing or private services. However, they, among others, also raise the concern that this shift is limited by public funding (Norgård 1994, Röpke 1999a) as well as by the interconnections of private and public sectors (Jespersen 1999). Jespersen (1999) claims that only half of all public spending serves the actual final consumption although all of it is counted as final consumption, while the other half partly relies on the private manufacturing sector and should not analytically be treated independently of the volume of the private sector. While both claims are valid, especially in the so-called welfare states, in which the state has assumed responsibility for many services such as education and health-care, there may still be some scope for the growth of these services. As these services may as well be produced by the private sector, it is partly a political decision whether the services appear in the public spending or in the private consumption expenditure, and thus the growth of these services may well take place in the private sector in the future[19].

1.3.3 The case of Finland

In Finland the service sector has grown rapidly in the recent decades, but it seems that this long-term trend has been interrupted during the 1990s. Statistical data are available from both the national accounts and from the household expenditure survey. According to the household expenditure survey, the share of services in private consumption increased from the 1960's to the beginning of the 1990's, but thereafter there has been a slight decrease from 24% to 23% by 1998. Rents and housing expenditure, often counted as services, accounted for another 24% of the private consumption in 1998. When considered together, the share of these service expenditures has continued to rise slightly also in the 1990's. If individual governmental expenditure on such services as education and healthcare is included, the share of services was 59% of the household expenditure of Finnish households in 1998. (Statistics Finland 2000b).

Intermediate services have been the engine of growth in the service sector (e.g. Windrum and Tomlinson 1999). However, the national statistics do not directly provide the data on intermediate services, as both businesses and consumers use services such as banking, insurance and even restaurant services. In order to derive an estimate of intermediate services, Grubel has multiplied final consumption expenditure on services by a factor of 0,6, which represents an estimate that the value-added of the service sector is 60% of the turnover of the sector. The same method is used in figure 3.

Figure 3 shows that the share of services of the GDP (1) has grown until 1991 but has since then reduced significantly, while the share of services in total individual consumption expenditure (2) rose in the beginning of the 1990s, and has since then remained relatively stable. Because services increased their share in final consumption expenditure, the decline of the service sector in the early 1990s has mainly been due to the decline of intermediate services. This effect is especially vivid if the value of intermediate services is compared to the value of primary and secondary production (3).

The strong economic recession of the early 1990's is one explanation for the development in service sector. The household expenditure on services rose relatively as the sales of durable goods such as cars fell rapidly in the beginning of 1990's (Statistics Finland 2000b). The economic recession, the decline of the GDP, and the decline of intermediary services coincide, as suggested by Grubel (1993) and Windrum and Tomlinson (1999). Looking at the economy as a whole, it is significant that the recovery period from 1993 onwards was marked with a high growth of the exports of pulp and paper industry and the electronics industry. Despite the growth of exports of goods, the share of intermediary services rose simultaneously. In the later 1990's, the relation of production and intermediate services has been fairly constant.

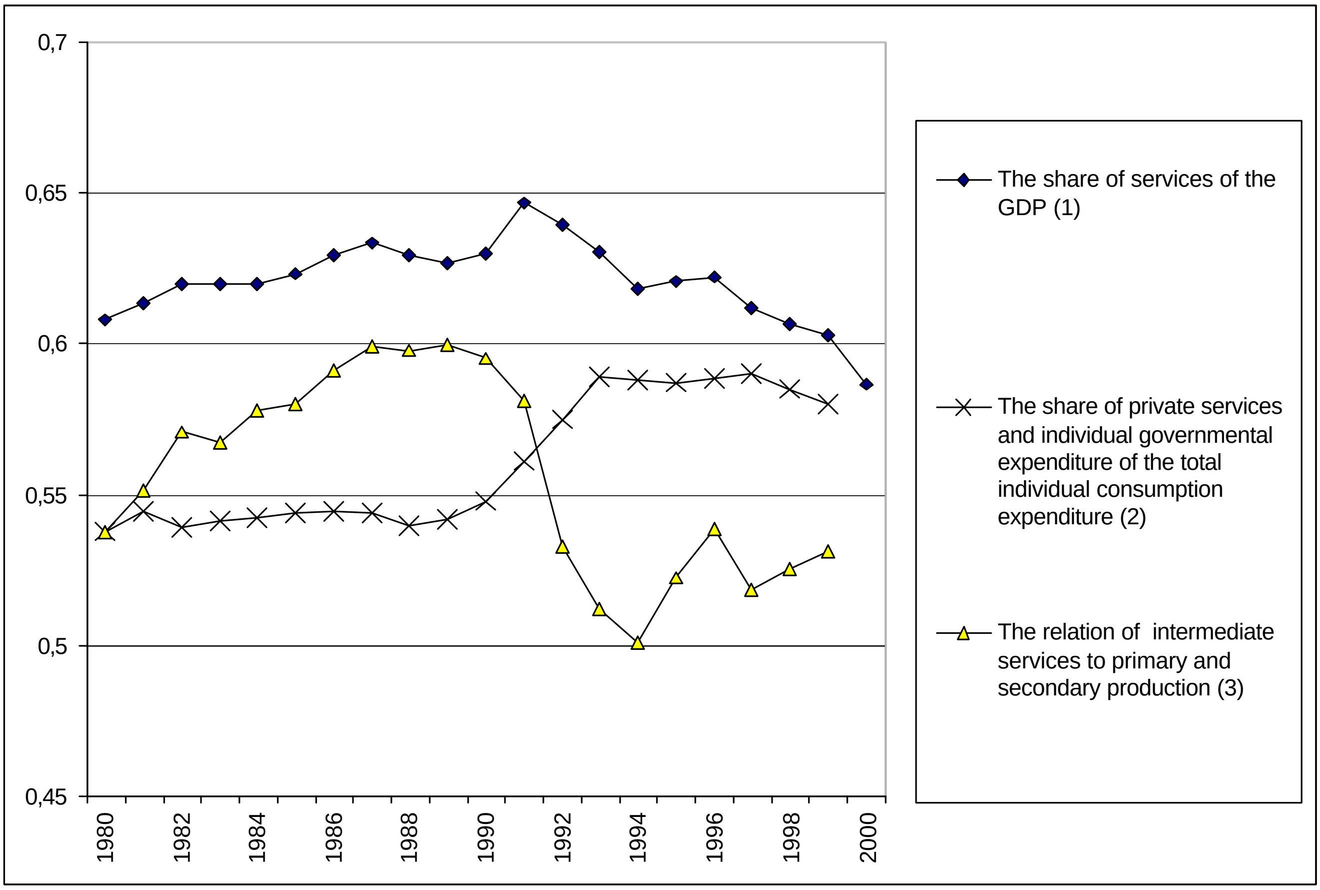


Figure 3. Services in the Finnish National accounts in 1991-1999. All in 1995 prices. (Statistics Finland 2000a and 2001a)

(1) (GDP-primary production-secondary production)/GDP
*(2) (Household expenditure on services + individual public consumption expenditure)/consumer expenditure of households**
*(3) (Value-added of the service sector - public consumption expenditure - (household expenditure on services) x 0,6 / (primary production + secondary production)**
** Data not available for 2000*

During this period the downward slope of the share of services in Finnish GDP appears to be explained by the changes in final consumption. However, the rapid, export-lead growth of the GDP in the later 1990s has also contributed to the lower share of services in GDP.

One of the explanations for the decline of services is the value-added tax placed on them in 1994 as a consequence of the EU membership of Finland. This established a real handicap on the labour-intensive private services, which were exempted from VAT before the reform (Böckerman 1999). Böckerman also observes that this was done in the midst of the recession and thus the service providers were not able to add the tax immediately to the prices. Thus, the stagnation and slight decline of final services beginning from 1994 most likely bears a relation to the changes in taxation.

1.3.4 The merits of services

The environmental merits of services have been questioned as many services rely on the material production of the manufacturing sector and use significant amounts of energy. In addition, there is obviously variation in the importance of such factors as resources and labour within the service sector (Rauhanen 1999). As the interest of this presentation is mainly on the implications of broad structural changes, the methods for assessing the implications must allow comparisons across different areas of activity. Consequently, the national input-output tables and the energy and materials intensity figures of different sectors serve as a useful reference in such comparisons, whereas the more specific methods such as Life Cycle Assessment and Materials Balances are less applicable to the questions at hand.

Table 3. The energy intensities of selected Danish production sectors and final consumption expenditure in 1990 (Jespersen 1999)

Sector	Energy intensity [MJ/DK]
Manufacturing	1,12
Intermediate services	0,92
Transportation	3,44
Private final consumption	1,12
Private final services	0,83
Public spending	0,41

Jespersen (1999) has reported the energy intensities of selected sectors of the Danish economy, some of which are presented in table 3. This analysis shows that private services require almost as much energy per economic output as the manufacturing activities in 1990. Thus, a simple shift from products to services in the 1990 context of the Danish economy does not seem to offer any significant possibilities to lower the energy intensity or energy demand of the economy. However, the table also points out that transportation services have a much higher energy intensity than other intermediate services. Therefore, even though the intensities of manufacturing and intermediate services are close to each other, a service-bias in production may carry more potential than can be concluded from the average figures.

In the Finnish context, Mäenpää et al. (2000) have calculated the materials intensities of the sectors of the Finnish economy in 1995. Within production, all of the service sectors have an intensity lower than the average of production. Within the service sectors, transport ation, real-estate services, restaurants and lodging and telecom services score the highest. The same is also visible in table 4, which presents the materials intensities of consumer expenditure and public expenditure.

Table 4. The materials intensity of selected items of Finnish final use in purchaser prices in 1995 (including taxes and subsidies) (Mäenpää et al. 2000: 57 and 68)

Sector	Materials intensity [kg/FIM]
Healthcare	0,10
Transportation services	0,12
Recreation, culture, education	0,15
Rents of housing	0,20
Restaurants and lodging	0,25
Telecommunications	0,28
Public spending; individual	0,09
Public spending; road and rail construction	3,35
Average of the Finnish economy	0,28

Both the energy and materials intensity figures point out that services are somewhat less resource intensive than the economy in general. However, more important may be that there is variation between the service sectors; there are services that hold potential to lower the average materials intensity of the economy. The materials intensity figures differ from the energy intensity figures as the relative importance of these 'inputs' varies across the economy. This is most clear in the case of transportation services, which are very energy intensive, but score relatively low in materials intensity. The materials intensity of the telecommunications expenditure in table 4 also seem high in comparison to Nurmela (1996), who has reported the telecommunications services to have one of the lowest energy intensities of the Finnish economy in 1990[20] . Similarly to Nurmela, Behrensmeyr and Bringezu (1995) report that also the materials intensity of communication was among the lowest in the German economy in 1990 (ref. Röpke 1999a). Concerning the public sector, table 4 points out a significant factor; there are large differences in the material intensity within the public sector. Thus, even if the overall budget of public spending may have reached its upper limit, there are great possibilities to reduce the materials use and achieve delinking by changes within the public sector.

Labour-intensity is another indicator of the merits of services as it consequently means low capital requirements. Household services are the most labour intensive sectors of the economy together with activities such as agriculture and construction of residential buildings. On the other hand, business-to-business and facility services, and banking and insurance are among the lowest in terms of working hours per financial output (Rauhanen 1999). Part of the reason for this may be that these sectors buy labour-intensive services and thus the labour-input takes place in other sectors. For example, according to Mäenpää et al. (2000) the materials requirements of these service sectors are very low when considering both direct and indirect materials use. It seems quite obvious that the low labour intensity of a sector does not translate into high materials intensity, but that productivity and the types of capital used in the sector greatly influence the materials intensity of the sector.

1.3.5 Services and the future delinking of economic growth and materials use

The contribution of services to the materials use and the materials intensity of the Finnish economy is not obvious. They may contribute to the structural change of the economy in many different ways. On the one hand, services provide new business opportunities and therefore room for economic growth. On the other hand, this growth changes the structure of the economy both in real and in statistical terms; the new service businesses contribute to a raising share of the service sector as such, but service-orientation may also turn traditional manufacturers or their specific departments into service companies and, thus, transfer them to the service sector.

Gershuny (1978), Jespersen (1999) and Röpke (1999a) claim that the possibility and magnitude of a shift towards services are limited. The Finnish statistics partly support this. The share of services has, indeed, been declining in the 1990s. However, it is difficult to say whether the development really marks a change in the long-term development of the rising share of the service sector. Even if the use of final services is limited by the competitive advantage of manufacturing and by the budget for providing public services, it seems plausible that the role of intermediate services grows. The increasing R&D expenditure, the rising role of industrial design and the claimed rise of knowledge as a factor of production are all examples of the rise of the intermediate services, which may be driven by increasing competition between product manufacturers and changes in the structure of the manufacturing industry. In the words of Gershuny (1978), the consumers may find themselves in a self-service economy, but utilize products that have an ever-higher embodied service content in them. However, as these services may not show in the national statistics as services, the most important structural change may not take place between manufacturing and services, but inside the manufacturing sector as a shift towards a lower materials or energy intensity of the end products.

Altogether, the potential of services can not be defined beforehand, but depends on courses of future action. Services in general are less materials and energy intensive, but the possibility of a structural change towards services is limited. Final services are flawed by low productivity. On the other hand, intermediate services, which are increasing, are more resource intensive. The competitiveness of services against products and their possibilities to ally with products to save resources can be affected by policy. The introduction of value-added tax on services has been a reverse incentive (Rauhanen 1999). The Finnish technology policy has not so far favoured services, either (KTM 1996). However, writers such as Grubel (1993), Bhagwati (1993) and Windrum and Tomlinson (1999) emphasize that the traditional view that services are inferior in creating national wealth has been outdated long ago.

1.4 Discussion: does the reduction of environmental impacts require economic growth?

The hypothesis of eKc and the empirical evidence collected for it suggest that economic growth brings about changes in the structure of the economy, in the efficiency of technology and in relative prices leading to higher efforts in abatement. These factors, the rising share of services among them, are supposed to lower the impacts of further economic growth and altogether to even counterbalance the impact of the growth and to lead to a lowering of the total environmental impact. Policies that argue for the need for further growth assume that these factors gain increasing momentum with further growth[21] . Thus, they presume that even if structural and technological factors are not presently strong enough to curb the materials use and the emission levels of such pollutants as CO_2, in the future they will be.

Another important assumption is that these counterbalancing factors of ecological transition are mainly due to economic growth. If they were achievable without economic growth, their impacts would not be one of slowing down the growth of emissions levels or counterbalancing the growth, but a greater net effect in reducing the emission levels. Regression models of the relationship of economic growth show that structural change, efficiency improvements and abatement correlate with economic growth, but not that they are determined by it. Rather, the causality between economic growth and the changes in the state of the environmental is controversial. Whereas the eKc-hypothesis in principle suggest that the state of the environment depends on the wealth of the country, some authors are more hesitant on the question of causality and argue that, instead of a predetermined development, the factors of change can be influenced by policy. Grossman (1995: 43), for example, sees the induced policy response as the strongest constitute for a link between increasing income and decreasing pollution. Similarly, Labson and Crompton (1993) emphasise that the relation of metals use and economic growth has not historically been deterministic.

de Bruyn (2000) has examined a number of studies that have looked at the relationship between economic growth and environmental pressures. According to him, the "...discussion casts serious doubt on accepting the claim that economic growth benefits the environment". An eKc has only been found for a few selected indicators of environmental pressure and the evidence for these selected indicators is far from unambiguous" (de Bruyn, 2000: 97). de Bruyn (2000: 117 and 132) concludes that the environmental improvements in the wealthy countries seem to have been achieved not because of economic growth, but despite of it.

Ayres (1998) explores the possibility of ongoing economic growth while simultaneously reducing the associated environmental impacts. He questions whether there are any fundamental technological limits to improving efficiency (except the second law of thermodynamics) and looks for possible technological fixes that would enable permanent delinking. According to Ayres, the same question can be formulated also as a question of rising resource productivity and overall productivity at the same time. He claims that some additional labour might enable significant reductions in the resource inputs of the economy and maintains that there are possibilities for win-win solutions, because of the present information deficits and the new innovations that are not anticipated. However, most technological fixes also create losers, pain and strain. Thus, according to Ayres, it is important to have a strong political support to drive innovation towards resource efficiency gains.

The outcome of the above discussion is important for further work as it emphasizes that no overriding link between economic growth and reduced environmental impacts has been documented. An unleashed economic growth is no cure for the current environmental problems. Rather, the nature of growth can be impacted. Within the context of this work, the role of services and information technology are of particular interest. There is a need to better understand the relationship between services and manufactured products. What are the applications and areas of activity in which services can contribute to efficiency gains and substitute physical inputs rather than just adding an extra layer of materials use? Such understanding of the potential future role of services may not stem from the service statistics, but rather from more detailed case studies. In addition, the focus needs to be extended beyond the traditional service sector into services that act between manufacturing and consumption as the media for organizing product use.

ICT, Efficiency Gains and Dematerialization Potential in Business Operations

2

Anna Kärnä

Information and communication technology (ICT) has enabled some major technological and institutional innovations, such as the Internet and electronic commerce, that facilitate commercial activity.[22] Information and communication technology has significantly refined the practices with which products and services are designed, produced, marketed and operated. In the same vein, information technology changes our ways of living, working and spending our leisure time. ICT has not only made existing operations more efficient, but it has also enabled new products and services that create welfare and new needs for people. Diffusion of information and communication technology seems to influence contemporary society in all its articulations (Manzini 1995). ICT is also transforming the way in which we interact with our environment. Although researchers have begun to focus on the effects of ICT on society (e.g., Inglehart 1990; Castells 1999), knowledge of the impacts of ICT use on the environment is still scarce.

According to some commentators, we are gradually moving towards a 'knowledge', 'information', 'digital' or 'new' economy (e.g., Shapiro and Varian 1999; Henry et al. 1999; Wilsdon and Miller 2001). This is partly because information technology and its applications have developed rapidly and enabled economic growth, and the significance of the ICT industry within some national economies has increased recently.[23] What is interesting in these information economy visions from the perspective of natural resource consumption is the new role given to information and knowledge as a source of productivity and innovations (Castells 1996). It is claimed that the use of ICT can enable more information- and service-intensive production structures which can replace natural resource- and labor-intensive production structures (e.g., Ayers 1998). According to some commentators (Romm et al. 1999; Laitner et al. 1999), the recent growth of the ICT sector and the increased use of the Internet may also produce dematerialization due to less energy- and material-intensive manufacturing.

Some other analysts are less optimistic and consider that the resource efficiency gains brought about by the shift from heavy industries toward more knowledge- and service-based industries will increasingly be offset by the type of economic growth and consumer choices that favour energy- and material-intensive life-styles (e.g., Matthews et al. 2000). Positive environmental impacts can be offset by increased consumption, and therefore, the associated potential rebound effects should be carefully examined.

The aim of this chapter is to review evidence and discuss if, and under what kind of conditions, ICT can reduce material consumption in business operations and produce welfare in a dematerialized way. The on-going discussion has mainly concentrated on how ICT can improve the efficiency of labour and capital use in production activities. The potential efficiency gains related to materials and energy use have been less explored. The focus of this chapter is on discussing the environmental implications of ICT use in business operations. The environmental impacts related to ICT manufacturing (such as manufacturing of semiconductors) or to the end-of-life ICT equipment are, in turn, excluded from the analysis.[24]

Section 2 of this chapter reviews the discussion on the information society and sustainability, and how environmental impacts associated with ICT use could be assessed. Section 3 continues with providing examples of how current studies and commentators discuss the role of ICT in the structural change that is taking place in many economies as well as potential productivity and efficiency gains achieved by ICT use. Also recent studies on the impact of the Internet economy on material and energy consumption are shortly reviewed. Section 4 discusses in more detail how ICT use may influence material consumption in business operations, i.e., what kind of positive and negative dematerialization potentials can be identified. Section 5 draws conclusions and raises questions for further research within the context of dematerialization and the information society.

2.1 How to assess the social and environmental impacts of ICT use?

Until recently, the analyses of ICT use in Finland have mostly focused on what kind of technical *opportunities and obstacles* are related to the development and use of ICT applications. Now the discussion has shifted more to the question of *what kind of ICT-based products and services people* need and want, i.e., in what directions should ICT applications be developed, whereas the assessment of the *impacts of* ICT use in society is still in its early phases. For example, what kind of impacts can be observed and are expected, in which multitude and when, in our everyday lives, in business and in the society in general? ICT development and its implications can be analysed from numerous angles, including the following:

- how technological innovations have come into existence (e.g., electronic commerce)
- how information networks have dramatically changed our dependence on time and place (e.g., distance work)
- how information technology changes the structures of the economy and labour market
- how the ICT sector constitutes an increasing share of production and employment, or
- how our culture is saturated with information-based products and services (information overflow)

In science and policy-making, information society and ecologically sustainable development have most often appeared as rival discourses with not very many points in common (Jokinen et al. 1997). Political visions on information society in Finland and within the EU have mainly concentrated on improving the competitiveness and productivity of the national economies and maintaining the well-being of citizens (Heinonen et al 2001). They have referred to the environmental implications of this development randomly and seldom.[25] In this context, sustainability is often conceptualized as social and economic, but not as ecological. The work of defining what ecological sustainability in information society means is still in its early phases. Within Europe, some initiatives already exist in this area, including the Alliance for Sustainable Information Society (ASIS), the ACTS program (Advanced Communications Technologies and Services) and the Working Circle on Sustainability and the Information Society of the European Commission, among others.[26]

In Finland, futurologists and social scientists have contributed most actively to the discussion on information society and its sustainability aspects (e.g., Heinonen et al. 2001; Kahilainen 2000; Malaska et al. 1999; Sairinen et al. 1999). It is notable that, so far, ICT business people (such as mobile phone manufacturers and teleoperators) who create visions on our future 'mobile information society' have not participated actively in the discussion on the impacts of ICT development, not to mention its environmental impacts.[27] Until very recently, environmental policy-makers have not utilized the information society framework in their programmes, either (Heinonen et al. 2001). In 2001, the Finnish Ministry of Environment started a large research program "Sustainable Information Society" (KESTY) that supports research on the conditions and realization of a sustainable information society.[28]

ICT holds considerable potential to conserve natural resources but at the same time, the ways in which ICT affects the environment are complex. Most commentators see both *positive and negative environmental potential* in the current development of information society. The environmental implications of distance work, videoconferencing and electronic commerce, among others, are increasingly debated (e.g., Heinonen 2000; Allenby and Richards 2001; Geels and Smit 2000; Cairns 1999; Romm et al. 1999). Some further areas where ICT can have a significant impact on the environment include new forms of mobility, remote sensing and distant monitoring, health services, e-learning, new production and working methods, as well as traffic management (Kahilainen 2000).[29] In a broader context, information society is often associated with a structural change and ecological modernization that is presumed to be occurring in our society. This should manifest itself in a shift from production- and material-intensive economic activities to more information- and knowledge-intensive production and customized consumption (Sairinen et al. 1999).

The environmental implications of information society development seem to be as complex and interconnected as the underlying technical systems. The information technology itself and its applications change and develop rapidly, and some of the environmental implications are not visible yet. This is one reason why studies on the environmental impacts of key activities in the information society are still scarce. For example, a broader discussion on the environmental impacts of electronic commerce has started only recently, and at this point only tentative conclusions and some rough scenarios about the future development have been drawn (e.g., Cohen 1999; Romm et al. 1999; NYAS 2000).[30]

What kinds of tools exist for measuring and comparing the environmental impacts of ICT use? Systematic analytical structures or methodologies to increase the ecological transparency of the information society are still undeveloped (Allenby 1999; Heinonen et al. 2001). Heinonen has suggested that because the environmental impacts of information society are in every respect so difficult to understand comprehensively, a useful starting point could be to analyse in more detail such areas or activities of information society that seem to have a significant impact on the environment.

The EU ACTS programme[31] has proposed that ecological sustainability impact assessment for ICT could be built on two existing approaches: 1) on impact analysis methods related to ICT but not necessarily focused on sustainability (such as business forecasting and social impact analysis) or 2) on approaches deriving from environmental impact analysis (such as life cycle assessment and environmental impact assessment). Currently, however, there is no real connection between these two approaches yet, and therefore ACTS suggests the combination of elements from both approaches to develop an adequate method (ACTS 1998b).

The ACTS guideline further recommends that there is first a need to identify the *main sustainability hypotheses* related to the ICT service or application at hand (such as electronic commerce) and the *main rebound effects* that might occur.[32] On the basis of this analysis, an *impact assessment scenario* should be constructed which is able to compare an "As-Is" scenario against possible events and / or proposed actions, leading to a "Should-Be" scenario. After that, a *series of key variables* still need to be developed and tracked. The ACTS guideline further emphasizes that all the actors affected by an ICT service or application should be involved in the process of defining what the key environmental variables are, as their options have strong inter-relations. The guideline considers this a political exercise aiming at consensus building and asking "do we agree that these are our objectives, these are our indicators, and my action influences your objectives in this manner" (ACTS 1998b).

There is growing recognition that active efforts, such as those suggested by the ACTS guideline, are needed to bring societal and environmental concerns into early phases of the technology development. This is because technology developers are not necessarily aware of the demands of society, while those having a stake in the future impacts of the emerging technology do not know how the technology might influence their interests (e.g., Schot 1992). Technology development should and can be influenced, at least to some extent, towards the "Should-Be scenario". Therefore, at the early phase of technology development, the visions, expectations and discourses of different actors concerning the technology and its environmental impacts play an important role. Future expectations are often interventions that aim to affect the direction and speed of technological developments (Geels and Smit 2000). Gradually broad and diffuse expectations turn into more concrete requirements and technological applications, with associated impacts and social practises. It is therefore valuable to try to identify and make more transparent the areas of information society development that are seen as significant from the environmental perspective, and to understand better by whom and why. A further aim is to show points in common in the diffuse future expectations, and to find common grounds for decision-making on ecological sustainability objectives and means to achieve them.

2.2 ICT, structural change and efficiency gains

In recent years, speculations have been set forth that the so called 'old economy' will gradually be replaced or at least complemented by the 'new economy', in which the ICT sector together with its products and services would be a significant source of economic growth. One impetus for these speculations has been the exceptionally positive economic outlook in the US from the mid 1990s until recently; the productivity has grown steadily, the GNP has grown rapidly, inflation has stabilised and the unemployment rate has been low (Hämäläinen 2001).[33] This section will review the discussion on the influence of the new economy on natural resource use through structural change and increased resource productivity.

Structural change can reduce natural resource intensity when growth shifts to sectors of the economy that are not particularly energy-intensive, such as the ICT industry, and away from such sectors as chemical or pulp and paper manufacturing (Romm et al. 1999). In Finland, the ICT sector has grown exceptionally fast during the 1990s. The production of the ICT sector has grown fivefold during the 1990s, and its share in the total industry output grew up to 20%. In 1999, the share of ICT sector (ICT manufacturing and ICT services) was 6.9% of GDP. Manufacturing of ICT equipment and electronic components dominates the sector, representing 70% of the gross value of the sector production. During the 1990s, Finland became the most specialized country in telecommunications exports within the OECD, in other words, in Finland the share of telecommunications equipment in total exports is higher than in the industrialized countries on the average. While equipment manufacturing has up until the present been the more dynamic and fast-growing part of the ICT sector, the significance of content provision, software supply and other IT services is growing in the telecommunications business (Ali-Yrkkö 2001; Paija 2001; SET 2000).[34]

Besides the growth of the volume and share of ICT manufacturing, ICT has also influenced other structural changes in the economy, including those occurring in final consumption. ICT equipment and services have directly entered consumers' budgets and created structural effects in final consumption. From 1990 to 1998, the share of communication expenditure has almost doubled in Finland; in 1998 it accounted for 2.7% of all private consumption expenditure (Statistics Finland 2000b).

ICT has enabled increased efficiency in business operations within different sectors of the economy. Efficiency gains are achieved when businesses introduce operational changes that reduce energy and material use relative to their output of goods and services (Romm et al. 1999). One example of this is the gradual shift from paper to digital invoicing. The Finnish Post expects to deliver 65 million electronic letters in 2001[35]. E-letters are sent electronically from companies to the information system of Post, from where they are delivered electronically to the Post's region centre nearest to the receiver, after which they are printed and delivered to the receiver. This saves the both costs of posting business letters and the reduces delivery routes of letters considerably.[36] Similarly, the Finnish banks have been in the forefront in developing electronic customer services and connections (e.g., cash dispensers, invoice payments on Internet, chip cards, and corporate Web invoicing instead of paper invoicing). The primary incentive for developing electronic services has been to cut down costs related to traditional bank services, but there is also potential for considerable energy savings. It has been estimated that paying an invoice on the Internet saves about 0,3 kWh per invoice compared with paying it in a bank or via a payment automat (Pesonen 2001).[37]

There have been differing views on the extent to which ICT use influences productivity growth. Plepys (2001) proposes that ICT's role may have been overestimated in this context. Despite heavy investments in information and communication technologies, it seems that the overall productivity has only recently begun to increase in the US and has not yet done so in Europe (Henry et al. 1999). Since the beginning of the 1980s several empirical studies of economic productivity have been performed in the US, showing mixed results. The majority of them, however, indicate very small or insignificant effects of ICT on productivity growth (Plepys 2001). Some commentators are of the opinion that the ICT does not drastically improve economic productivity outside its own sector. According to others, there seem to be industry sectors in the economy where ICT use increases productivity more than in others. Especially in the service sector, the impact of ICT use on productivity has proved to be difficult to measure.[38]

ICT may influence the efficiency of operations and productivity in different ways depending on the sector. Jalas proposes in Chapter 1 that while the automation of activities and information processing capacity of ICT have mostly benefited the manufacturing sector, it may be that the communication technologies, such as the Internet and mobile phones, will benefit the service sector more than automation. This is partly because the efficiency of manufacturing can be improved in a more centralized manner through automation than the efficiency of services, as service activities are often highly dispersed (e.g., distance health monitoring and care). In service activities ICT may have a stronger effect on efficiency through its ability to improve communication and co-ordination between different activities and actors.

How has ICT use influenced energy and material consumption in the economy? The potential impacts of ICT use on energy consumption in the economy have recently been brought under discussion especially in the US (e.g., Romm et al. 1999; Laitner 1999; Kawamoto et al. 2000; Mills 1999).[39] One starting point for the analysts has been the observed recent annual decline in US energy intensity and the simultaneous economic growth. From 1960 to 1996, the US economy measured by the GNP grew by an average 3.4% per year. In the same period, the nation's primary energy use grew 2.1% annually, which meant a yearly decline in energy intensity by an average rate of 1.3%. However, between 1996 and 1999 the energy intensity declined more, at a rate of 3.4% annually, while the energy consumption remained at the level of 1996 and the economic growth was about 4% per year. In terms of absolute energy consumption, this drop implies a significantly greater reduction than that which occurred during the "oil crisis" years of 1973 to 1986. This three-year trend has occurred in the absence of either price signals or major policy shifts (Laitner et al. 1999).

Some analysts attribute most of this change to weather, while others point to a structural change in the economy that seems to be emerging as a result of the growth of the new Internet economy. The US EPA suggests that roughly one third of the energy intensity improvement could result from a *structural change* in the economy (Romm et al. 1999). The remaining two thirds of the improvement are believed to result from *energy efficiency gains* in all sectors.[40] Romm et al. (1999) embrace the possibility that if the decline of the energy intensity of the US economy is even partly due to the Internet economy, there is much more to come because the Internet economy is projected to grow more than ten-fold within some years.

Although the short-term data presented above are insufficient to establish any meaningful trend, rapidly growing Internet use and electronic commerce may account for at least some influence in the structural change. Preliminary analyses also suggest that while the energy use in the economy will continue to grow in the future, the growth may be somewhat slower than the mainstream economic forecasts have indicated (see Laitner 1999; Laitner et al. 1999). One reason for this is that forecasts have not taken adequately into account the information economy's potential direct and indirect impacts on energy use (see also Chapter 5 of this report).

Recently, there has been increased interest in developing more systematic accounting and comparison methods for the physical material flows (input and output flows) within the national economies. Findings on the impacts of economic growth on material consumption at the national economy level have been put forth especially by the two studies by the World Resource Institute (Adriaanse et al. 1997 and Matthews et al. 2000). These and some other material flow analyses are reviewed in detail in the Chapter 1 but they indicate that a delinking of economic growth and the material use has taken place; i.e., despite economic growth, the material outflow intensity has fallen in the studied countries during the past 10 to 20 years. This delinking is partly explained to be due to efficiency improvements (some of them due to ICT use) and the on-going shift away from traditional energy- and material-intensive industries towards more knowledge-intensive industries and the financial and other service sectors. National economies and company revenues can grow with less material input per unit of revenue than in the recent past. Despite this delinking trend and the material flow intensity decline in the studied cases, the material flow analyses show that there are no signs of absolute reductions in the aggregate materials use.

With current knowledge, we cannot say much about the direct effects of ICT use on absolute energy or material consumption in the economy due to complex *substitution, generation and rebound effects*. The implications of the extent to which ICT-based solutions can substitute certain material or energy intensive operations (e.g., the environmental impacts of distance versus office work) are still unclear. So are the generation effects, i.e., in terms of what is the impact of new ICT-based products, services and systems on aggregate material and energy use (e.g., the impacts of electronic commerce). Electronic substitution may have some positive effects, but the technology development also generates new ICT-based products and systems which complement existing ones or are totally new. It is also unknown how the anticipated ICT sector growth will affect economic activity in other sectors of the economy. It is known that efficiency improvements often entail rebound effects. From this perspective, the ability of ICT to foster structural change may be more long-standing and significant in the long run than efficiency gains in individual operations.

Considering the potential impacts of ICT on this development and the significance of the ICT sector itself, its role in the structural change from manufacturing to more service and information intensive industries and its impacts on the shifts within sectors are of most interest for further, more detailed analysis. To conclude, the potential to improve material and energy efficiency by the use of ICT seems to depend at least on the following factors:

- to what extent ICT can *increase the productivity and efficiency* of existing operations
- to what extent certain types of operations can be *substituted* with less material- and energy-intensive ICT-based operations

- to what extent *new, additional* products and services are *generated* which complement existing ICT based products and systems and which may add to the aggregate material and energy consumption in the economy
- to what extent ICT *facilitates and enables* new business opportunities and product and service structures with significant environmental reduction potential and more resource-effective ways of organizing manufacturing, services and consumption structures

Evaluating these impacts with sufficient accuracy seems to be a far too complex task at the level of the economy because of the numerous indirect impacts associated. The potential efficiency gains can be better traced at a sector or business activity level. In the next section, we will review more closely what kind of opportunities ICT use provides in business operations, especially in the case of electronic commerce, to reduce material and energy consumption.

2.3 ICT and the dematerialization potential of business operations

In recent years, the discussion on how product development, production and service structures should be reoriented to produce welfare with less material input and reduced overall environmental burden has intensified. Concepts such as eco-efficient services, product service systems, sustainable services and servicizing have been introduced in this context (e.g., Mont 2000; Goedkoop et al. 1999; White et al. 1999).[41] New focus on the essential functions or services that customers need, as opposed to focus on product sales, has been said to open up new possibilities for dematerialization and environmental improvement.

Although this service-orientation mainly applies to changes in physical products and in the way their use and often also ownership is organized, information technology usually has a considerable role in this process. Firstly, ICT facilitates many of these changes, and it is often a central factor in new or redesigned operations. For example, ICT can contribute to improved efficiency of logistic systems. In the case of car-sharing, the service-providing companies utilize mobile communications networks to streamline the operation of the network (for more information on car-sharing services, see Chapter 8). Moreover, ICT can facilitate the customization of new eco-efficient services, which can increase the chances for commercial success (Brezet et al. 2000). ICT-based solutions can also sometimes replace physical products or activities. One of the most well known examples of these substitution effects is videoconferencing, which can replace the business travel, and another one voice mail services that have substituted telephone answering machines. More important than the question to what extent ICT-based solutions can replace certain products is the question what the potential role of ICT could be in the development of new eco-efficient services. Information and communication technology, when consciously applied in new or redesigned product-service combinations, can create business opportunities with a significant environmental reduction potential (Brezet et al. 2000).

The application of ICT does not, however, automatically lead to environmental benefits. In many cases it can be shown that ICT services, instead of substituting for materialized products, bring new services and functionalities into the market which involve even larger volumes of materials and energy. ICT can lead to the creation of extra, added functions for the user, resulting in more complex products and added functions instead of substituting for functions formerly fulfilled by products.[42] In addition, it seems that only few products and appliances are being substituted by the new ICT-based solutions. New products and services seem to have a more additive character. Also the amount of different ICT equipment types within the same product category (e.g., PCs or copying machines) has increased rather than decreased.

So far, only few sources can be found that address the role of ICT in the development of eco-efficient services in more detail (Brezet et al. 2000). However, areas associated with intensive ICT use that also hold potential for environmental efficiencies - or negative developments - can be easily identified. These areas include, among others, distance work and electronic commerce. [43] ICT has enabled working at any location other than the traditional office or from geographically remote places (e.g., work done at the client's location or at home). ICT has lead to an increased independence of place and time in organizing work. The impacts of distance work on commuter and leisure time travel and its associated CO_2 emissions, on energy consumption at offices and homes, on ICT equipment use efficiency and on other needed infrastructures have long been argued (e.g., Heinonen 2000; Mokhtarian 1998). Another interesting emerging area is electronic commerce. The impacts of electronic commerce on such aspects as warehousing, transports and packaging are discussed with mixed expectations (e.g., Cohen 1999; Fishbein 2000). Electronic commerce seems to constitute a diverse mixture of positive, neutral and negative effects on material and energy consumption (Fichter 2000).

In the following, we will discuss *how the use of ICT may influence material consumption in business operations, i.e., what kind of dematerialization potentials can be identified, especially in the case of electronic commerce.* Two arguments from the on-going discussion, which are also interesting from the dematerialization perspective, are used as a backbone of the analysis:

- The use of ICT improves the *efficiency* of business operations, i.e., more added value can be produced with the same or reduced material input. In what kind of operations can efficiency gains be achieved, and what kind of potential negative effects can be identified?
- ICT has enabled new kinds of *product-service systems* to emerge, in which the use of ICT plays an important role and which also hold potential for more efficient materials use. One example of these new product-service systems is electronic commerce.

Table 5 summarizes key arguments and examples that we have identified in the on-going discussion. The table is divided into three sections. The first, the *information efficiency* section, discusses the role of information and communication technology as an enabler of increased efficiency in communication and data transfer, which has led to better information availability. The second section, *production and distribution efficiency*, analyses potentials to reduce material and energy consumption in business operations by the use of ICT. The third section deals with more profound changes that may occur in *society* and in *consumption patterns* due to information technology development. The table indicates how complex the impacts of information and communication technology are. It also demonstrates different levels of analysis (which include phenomena that also influence each other) that should be considered when evaluating the impacts (e.g., impacts on business, on consumer behaviour or on changes in society). The arguments and examples summarized in the table are discussed in more detail in the following sections.

Table 5. Material and energy efficiency potentials related to the use of ICT in business operations.

The use of INFORMATION TECHNOLOGY has enabled	EFFICIENCY ARGUMENTS	In the case of electronic commerce
(1) INFORMATION EFFICIENCY Change in data transfer technology, "from paper to bits". Information can be processed, transferred and stored in larger volumes, faster and at lower cost.	Information has become a factor of production. It is increasingly a commodity that is being transferred by using ICT. More information is available, and it is 'real time' information > the significance and value of information has grown. To create information products is expensive, but to reproduce and duplicate them is inexpensive.	More product-related information can be provided via the Internet; customers can search and compare information/products and make better informed, "right choices". Information overflow: selectivity becomes more important: search robots, personalized search and buying criteria. Virtual versus physical product sales: - information needs not to be attached to the physical product - marketing function of Internet sites increases and that of product packaging decreases. Can reduce the size and weight of product packaging.
2) PRODUCTION AND DISTRIBUTION EFFICIENCY Improvements in the efficiency and productivity of economic activities.	ICT has modified and become an integrated, even critical factor in production and distribution systems (e.g., printing process, software, automated storage) ICT has made <u>existing</u> operations more efficient (e.g., avoidance of some previously work-intensive stages in manufacturing, better supply chain co-ordination, shorter distribution chains) ICT has <u>created new ways of operating</u> (e.g., b-to-c electronic commerce) which may substitute or complement traditional ways of operating. More efficiency in MATERIALS USE (less use of raw materials, reduced waste). Higher ENERGY EFFICIENCY of different activities.	MANUFACTURING AND INVENTORY MANAGEMENT: - on-demand manufacturing and delivery reduce inventory levels - better forecasting of demand: less overcapacity and product waste - customized products: user defines the product qualities or modifies the product content: more long-life products? - ICT helps in investigating customer needs: producers able to provide better service, just-enough and for-right-purpose products TRANSPORTS AND LOGISTICS: - a shift from personal commuting to stores to a centralized delivery of purchases - efficient delivery (number of deliveries, routing, population density and size of the delivery area, time-windows for deliveries, etc.) - delivery equipment (what kind of vehicles and fuel: consumption, air pollution) - delivery packaging - deliveries directly from producer to consumer? BUILDING INFRASTRUCTURE: - virtual shop or physical shop? - physical retail stores may be turned into warehouses - more products per m^2 - energy savings in heating, cooling, lighting DIGITALIZATION OF INFORMATION PRODUCTS AND TRANSACTIONS - to what extent will digital information products substitute for physical products (e.g., telephone directories, newspapers)? - impacts on paper use - efficiencies in updating and shipments of digital products
3) EMERGING CHANGES IN SOCIETY AND IN CONSUMPTION PATTERNS ICT has transformed our everyday life and activities at work and during free time Information technology development modifies the society and its institutions and values: some of these changes are slow, others faster	New ICT-based products/services that change the way in which we operate (e.g., Internet, mobile phone). They support or replace existing product and service structures. New types of needs and consumption are created through new products (e.g., computer games). The structure of consumption may change, towards environmentally sounder products and consumption?	The Internet is a 24-hour market place. Reduced need to commute to stores: how is the saved time used, is mobility increased? What kind of purchases can be expected to be made on-line? Routine products/tasks versus experience shopping. Does electronic commerce increase consumption?

2.3.1 Information efficiency

Information and communication technology and its applications have enabled a significant change in data transfer and processing technology. A shift from physical to digital information transfer has taken place, i.e., a shift "from paper to bits", and the data processing capacity has multiplied. Digital technologies have made accessing, processing and storage of information increasingly faster, easier and cheaper. The increased volume and better availability of information is changing the way markets operate and leading to restructuring of businesses through more extensive exploitation of information (eEurope 2000).

On the other hand, ICT has made information even more clearly a commodity with value. The significance of 'real time' information has gained a new meaning and its value has grown (Shapiro and Varian 1999). Information or information services are expensive to produce but inexpensive to reproduce. One of the efficiency arguments is that while the producers of digital and information goods must expend the same capital, labour and knowledge as those producing tangible goods, their products can be copied and reproduced much easier and faster. Also the costs of digital distribution are marginal compared to the distribution of printed information.[44]

Electronic information systems are transforming the way in which products are bought and sold, and better information availability plays a key role in this. For consumers, the Internet is not used just to buy products but to search for information on companies, product options and prices - even when purchases are made off-line. The Internet can provide a new dimension to (ecological) comparison shopping, both by automating it and by making it more transparent to the consumer. For producers or retailers, the Internet gives an opportunity to make information about the environmental characteristics of products more generally available, which may encourage socially conscious purchasing and consumer awareness.

The Internet also provides increased opportunities for direct communication and interaction between consumers, and between producers and consumers.[45] This can gradually lead to greater product customization (with unclear environmental impacts, see next section) and to marketing targeted to individuals and groups according to their special interests and needs. The Internet also makes it easier for companies to continue providing customers with information after they have made a purchase. This capacity can be used to provide information on, e.g., safe product use or proper maintenance for optimal performance and energy efficiency. For example, some pesticide manufacturers provide instructions via e-mail on when to apply pesticides at specific locations on specific days, according to the life cycle of specific species and the local weather (Fishbein 2000).[46]

Although the Internet has allowed opportunities for increased access to information, it has also provided an overflow of information. Therefore, filtering the interesting and essential information from this flow has become a growing necessity. Computer search engines and robots ("bots"), personalized search and buying criteria as well as web site evaluators are today a growing business. From a green consumer's perspective, these bots can potentially scour Internet sites by key words, concepts, amounts or virtually any criterion that can be defined by words or numbers, such as published energy and water efficiency ratings of appliances or data on toxic chemicals used as product ingredients.[47]

In electronic commerce the information no longer needs to be so tightly attached to the physical product. As a consequence, the marketing function of the Internet site increases and that of the product packaging decreases (Cohen 1999). The traditional marketing functions of packaging (catching the eye of shoppers, conveying product information quickly, making an impression through size) may become less significant, because the Internet site is the media that communicates a product's qualities and attracts the consumer's attention. This may create incentives for producers to reduce the size and weight of product packaging, since the backbone of on-line shopping is shipping efficiency.

Some negative developments may also follow from the better availability of information. It has been speculated that the reduced costs of producing information have led to an increase in the supply of information products. In terms of paper consumption, will this development lead to a substantial increase in the volume of printed materials and to an increase in paper consumption? Furthermore, on the Internet people have access to a larger product assortment than they normally do. How does this effect consumption? Does it lead to increased purchases or purchases from geographically more distant places? On the other hand, can a larger product assortment and increased information render decision-making even more difficult? We might also ask who has the time, possibilities and understanding to scan and process all this information.

2.3.2 Production and distribution efficiency

Information and communication technologies have modified production and distribution systems and become an integrated and even critical part of them. Not only have they affected activities related to raw material acquisition, production, transports, product use and disposal, but also activities supporting business, such as accounting, marketing and maintenance. The digitalization of the printing process, the fully automated storage systems or the increased significance of software production are all signs of this development. ICT has made *existing* operations more efficient (e.g., some previously labour-intensive stages in manufacturing have been avoided or the management of distribution chains has become more effective), but it has also *created new ways of operating* (e.g., electronic mail, electronic commerce, distance work and videoconferencing) which substitute or complement traditional operations.[48]

Dematerialization takes place when reductions are achieved in the materials intensity of economic activities. In the case of electronic commerce, the following significant areas with dematerialization potential can be identified:

- manufacturing and inventory management
- transport and logistics
- building infrastructure
- digitalization of products and transactions

Manufacturing and inventory management. ICT is increasingly used for the better management of customer demand, more efficient processing of orders and co-ordination of supply chains. These activities allow manufacturing companies to match production with demand more expediently, to introduce more efficient order processing systems and shorter lead-through times and to shift more and more to just-on-time part and component procurement, manufacturing and delivery. This may also lead to considerable reductions in production waste volumes and in inventory levels.[49] Even a 5 % reduction in inventories would have a significant financial impact (Wyckoff and Collechia 1999). Through more just-in-time inventory and manufacturing management, the space needed for storing products before they are sold can probably be decreased. This, in turn, could reduce the amount of land consumed by warehouses, the amount of materials used to build them, and the energy needed for heating, cooling and lighting.

Some companies are beginning to manufacture products more specifically designed for individual customers or groups of customers - this is called customization. The Internet enables this development by facilitating information exchange with individual customers, enabling producers (at least in principle) to find out more exactly what kind of a product the customer wants before it is produced, how it works and what variations or accessories may be needed after it is purchased. Customization can be considered a way for companies to extend their product range and service supply. Products can be customized, e.g., by technological options (cars, PCs), colour or fit (clothes, glasses), formula (pesticides, detergents, coffee, and cosmetics) or quantity (paint and fertilizers).[50] Customized products can reduce materials use by providing exactly what the customer needs and matching the amount purchased to a given need, thus reducing the amount of excess or unwanted materials and waste. Customization can also support avoiding unnecessary additives and potentially reduce the use and environmental impacts of toxic ingredients. It could also be argued that products that fit personal needs and taste better are likely to be in use longer than 'standard' products.

The environmental implications of customization are, however, somewhat unclear. Will this trend lead to increased specialization among manufacturing plants or will it be a more profound change restructuring industry-wide manufacturing activities? Some fear that customization can lead to severe inefficiencies related to the packaging and transportation of products, which is determined by the volume of orders and what kind of delivery times the customers require and manufacturers are able to provide (e.g., Fishbein 2000). In addition, although customization can be seen as a shift towards more demand-driven manufacturing activities, some basic level of inventories still needs to be maintained.

As regards manufacturing and inventory management in general, some other negative implications can be identified. ICT use has been one factor that has enabled the expansion of world-wide business activities, including more dispersed and complex distribution, logistics and warehousing systems, thus warehousing needs may not decrease overall. Manufacturers may need less warehouse space but their products might still have to be stored at distribution facilities operated by delivery services or on-line retailers. Actually, many on-line retailers have established new warehouses recently, either to allow more automated and efficient order and delivery processing or to expand operations to cover a larger geographical area.[51]

Transports and logistics. There are very diverse views on the impact of electronic commerce on transports and logistics: does electronic commerce lead to an increase in transport volumes, or does it allow transports to be organized more efficiently than before? Two specific areas of interest in this development are how ICT use influences and modifies existing logistics systems and supply chains, and what kind of new on-line delivery systems will evolve.

Information technology and real-time information can be increasingly used to improve the capacity utilization and planning of transportation systems. For example, intelligent transport systems based on global positioning satellites and dynamic modelling of transportation routes can make long-distance transportation of raw materials and finished products more efficient. The capacity of trucks can be fully used, less empty "back-haul" journeys take place, and deliveries can be tracked faster and easier. (IHDP 1999).

In the case of on-line deliveries to consumers, it has been suggested that environmental gains may be achieved if a centralized, efficiently organized delivery of purchases replaces inexpedient personal commuting to stores (see Chapter 6). There is also potential that the vans transporting on-line purchases can be used more efficiently to make both deliveries and pickups on a same route in a particular area, delivering goods and returning packaging or discarded products back to the retailer or original manufacturer.

Electronic commerce is transforming product sales and transport packaging with some positive environmental implications. The most far-reaching changes may result from the increase in on-line marketing and home delivery. The primary purpose of packaging is to contain and protect the product, but it also has an important marketing function. Although the best way to attract on-line customers is not yet known, it clearly has less to do with the package than with the strategic placement of Internet ads and the use of search engines and shopping bots (Fishbein 2000). This creates an opportunity for packaging design to focus more on storage and shipping efficiency than on visual appeal and prominence. Frequent home deliveries may give an incentive to manufacturers or on-line retailers to take back used transport packaging. Direct sales from producers to the consumer may also eliminate the layers of packaging required to distribute products from wholesalers to retailers (Fishbein 2000).

Delivery efficiency depends, however, on many aspects, including what kind of vehicles are used for deliveries, how the routing of deliveries is organized, and what the size of the delivery area is (see also Chapter 6). One major contributor to environmental impacts is the extent to which electronic commerce is adopted by consumers (how fast or slowly e-commerce proceeds and what kind of products are purchased on-line), and how the volume of deliveries grows accordingly. It has also been suggested that electronic commerce may increase direct sales from producers to consumers, thus modifying supply chains and making them more efficient (Cohen 1999). In the US this change may be faster than in Europe because the US distribution structures are more often organized by the manufacturing industry than in Finland or in many other European countries, where the wholesale trade is a strong actor as a distributor of products for the retail trade.

According to less optimistic views concerning transport development, more products and especially small packages will be shipped long distances as on-line shopping increases.[52] If customers require ever-faster or more exact deliveries, on-line retailers will have to promise them overnight deliveries, which can mean an increase in courier and express delivery services and in many cases a shift to air transport. Although air transport speeds up delivery times and shortens supply chain delays, the environmental impact of air transport can be significant.[53] Also the time window for deliveries (e.g., delivery overnight, in 3 days or in 14 days) becomes a critical factor when the environmental impacts (energy consumption and CO_2 emissions) of transports are considered. If overnight or faster deliveries become the precondition for on-line business success, the environmental burden caused by deliveries will increase considerably.

There are also potential negative environmental implications concerning transport packaging. If increasing product customization (see previous section on manufacturing and inventory management) leads to the proliferation of non-standard packages of different shapes and sizes, the result can be wasted space on pallets, in shipping containers and in transport vehicles (Fishbein 2000). It remains to be seen whether manufacturers will be willing to provide different packages for on-line and off-line versions of the same product.

Building infrastructure. Electronic commerce will affect the number, type and location of commercial buildings and the related energy use.[53] Romm et al. (1999) have estimated that the Internet economy could render unnecessary 3 billion square feet of buildings, which accounts for approximately 5% of US commercial floor space. Most space savings would be achieved in two areas: in business-to-consumer electronic commerce, retail stores can to some extent be replaced with Web sites and warehouses, and, on the other hand, business-to-business electronic commerce is expected to significantly reduce the need for inventories. These reductions in space need are likely to save a considerable amount of energy related to the construction, heating, cooling and lighting of these buildings.

Warehouses can contain more products, such as books, per square meter than retail stores, and they usually also use far less energy per square meter than retail stores in the form of heating, cooling and lighting. Books and other products sold over the Internet are likely to consume less energy per product than in traditional retail-based sales (Romm et al. 1999).[55] It remains to be seen whether the new warehouse facilities will replace their older and less efficient counterparts and how drastically electronic commerce will reduce the need for retail space, or will they add another layer of materials use to the existing product distribution infrastructure.

The growth of electronic commerce together with the expansion of distance work may affect land use and community infrastructures in both positive and negative ways. ICT equipment enables distance working and spending less time at the office. This can increase energy consumption at homes but is also likely to save much more energy in avoided office building construction and maintenance costs as well as in reduced commuting energy (Gray et al. 1993; Romm et al. 1999). However, increasing independence from time and place due to ICT use may gradually lead to more disintegrated community structures and increased consumption of land. Companies may increasingly start to store the goods they sell on-line in warehouses built on undeveloped land, and residential units are more often built far from traditional commercial services. The potential increased dispersion of on-line customers does not improve the efficiency of on-line deliveries, either.

The digitalization of information products and transactions. Digitalization can contribute to dematerialization due to reduced materials use in the production and shipping of information products. Electronic versions of printed materials are beginning to displace a wide range of printed materials and physical products, such as encyclopedias, telephone directories, newspapers, travel guides, product catalogues, instruction manuals, college textbooks and photos. The main functions of a telephone book - data storage and retrieval - are performed far more efficiently on-line than on paper. This is partly because electronic versions of telephone books can be continuously updated and they can contain a large amount of data with relatively small expenses. Also the shipments of digital products, such as software, can be made via data networks, thus replacing the need for separate product packaging.

The impacts of ICT on paper consumption have been debated since the early visions on paperless office. In the short run, paper consumption does not seem to decrease, but in the long run the need for printing electronic documents on paper may diminish as paper is compensated with other tools for reading information, such as flat panels resembling paper, electronic paper and UMTS multimedia mobile phones (Hetemäki 2000).[56] Sharply increasing marketing on the Internet can to some extent substitute paper use in marketing. In addition, when information is increasingly available in electronic form, the reader can select carefully which part of the information contents she or he wants on paper (e.g., newspapers with selected news and no advertisements). Books can be customized according to the readers' demands and printed by a print-on-demand publisher (Fishbein 2000). This could reduce the waste created by unwanted purchases, and also reduce overstock waste and the need for warehouse space in bookstores.[57]

Many transactions can be performed electronically today, which has not only reduced the stages but often also materials and costs associated with these operations. Digital invoicing and electronic banking services are examples of digitalization that are discussed in more detail earlier in this chapter (section 2.2). A further example is the communicators used especially by salesmen including phone, fax, email and Internet features which enable them to contact their company's information systems from customer's or other premises outside the office, thus speeding their work, paper transactions and order processing.

Potentials both for substituting and generating effects exist in the case of digitalization. If electronic telephone directories, for example, replace printed telephone directories altogether, they can reduce aggregate materials use, but if these two directory types complement each other, it will only lead to more products to be used. Also the added materials use and energy impacts associated with the devices required to access and use digitalized products need to be factored in aggregate materials use (Fishbein 2000). The impact on the aggregate materials use will also depend on how the downloaded products are copied and stored by users. If downloading turns out to be easy and cheap, users may print out their downloaded books on paper in addition to reading them on-screen. These additional products can offset any dematerializing effects of the new technologies.

2.3.3 Emerging changes in society and in the nature of consumption

ICT has transformed our everyday life, including work and recreation. Among recent ICT developments are the rapid growth of Internet use, the widespread use of mobile phones and the arrival of electric paper, interactive digital television and 'intelligent' appliances.[58] The decreasing real prices of ICT products and services have also contributed to these developments (Hetemäki 2000). We have been provided with many new ICT-based products and services that have modified the way in which we spend our time (e.g., playing computer games or chatting on the Internet).

For companies, ICT development has provided new opportunities to reorganize the ways in which the products are designed and operated (e.g., product ownership is beginning to be replaced by the idea that products deliver services that consumers want). This may lead to changes in the role of producers; some companies may be able to shift from their current role as providers of technologies to become information and communication "system organizers" or "service providers". They may seek to offer ICT solutions by organizing systems that combine technologies and social infrastructure in new ways (IHDP 1999). In addition to the potential changes in the role of existing producers, the emerging e-business brings also new entrepreneurs to the field. These include, among others, on-line auctioneers, on-line delivery service providers and content providers, such as those inventing and producing information services, games and other entertainment.

It has been estimated that electronic services and some consumer goods will become more dependent on each other in the future (e.g., mobile phones and information services). As a consequence, the traditional distinction between producers and consumers may become vaguer because consumers will increasingly participate in defining what kind of services they want and need, and also in maintaining and developing these services further. It will be interesting to see how consumption patterns may change when new products and services are invented to meet more individually defined needs.

The *societal embedding process* of new ICT-based products and services is highly interesting.[59] How do some new products and practices become widespread and why do they replace existing ones, while others do not?[60] At which stage do these technological breakthroughs become established parts of a society? Old and new technologies often co-exist and the newer technology and its applications are adjusted and changed when they mature (Geels and Smit 2000). Some of the new ICT applications support existing product and service structures, while others gradually replace them. In the short run, however, the speed and impacts of technological developments are often overestimated.

The impacts of electronic commerce on consumption are not clearly visible yet. The Internet has been expected to facilitate a change towards environmentally sounder consumption, mostly due to the better availability of information that can guide buying decisions. Some new purchasing patterns may also evolve, such as subscriptions to a product or group of products, as producers deliver more products directly to the consumer (Fishbein 2000). At this early phase of development, it is still too early to draw conclusions on potential changes in consumption patters or structures. Currently, electronic commerce seems to mainly offer an alternative channel for purchasing to consumers, it is not the main shopping arena.

Some highly interesting questions relate to the adoption of electronic commerce. The Internet provides us with a 24-hour market place. Not all Finns or Europeans have access to the Internet and on-line shopping yet, not to mention people in less-developed countries. What happens when they increasingly start to buy products from on-line shops? In addition, what kind of purchases can be expected to be made on-line? How do households use the potential time-saving achieved by on-line shopping? Will leisure travelling increase, thus cannibalising the environmental savings achieved?

2.4 Conclusions: future challenges and research needs

Many actors have an interest to influence the development of information society. Despite this, the environmental aspects of this development have been the interest of only a small circle of researchers, politicians and business people, at least in Finland. Although connections between information society development and natural resource consumption have been identified, they have not been considered as strongly interrelated. This is partly due to the fact that many of the environmental impacts of ICT use are indirect, invisible and emerging.

Recently, economic growth statistics and energy use forecasts, material flow analysis and an increased focus on developing eco-efficient products and services have raised new interest in the role of ICT in achieving environmental savings. The discussion on ICT sector's role in economic growth and energy consumption has started in the US. There, the ICT sector and information economy has been a significant source of economic growth during the 1990s. Eco-efficient service development and material flow analyses, in turn, have been elaborated more within the European context.

This chapter has aimed to identify challenges and further research needs in the area of ecologically sustainable information society, and to discuss how ICT can potentially contribute to dematerialization in business operations. The focal questions can be summarized as follows:

- How the ICT sector and ICT products influence the nature of economic development?
- What are the most important environmental impacts of ICT development in the future? What kinds of opportunities for environmental improvements and threats can be identified in the "business development as usual" vision?
- What kinds of opportunities exist to influence the development of information and communication technology? How should this development be redirected to achieve a more ecologically sustainable information society, and how could positive developments be strengthened and negative developments minimized?

How does the ICT sector and ICT products influence the nature of economic development?

ICT has three significant roles in economic development: it contributes to the efficiency and productivity of business operations, it enables radically new product and service innovations, and it contributes to structural changes within the economy.

Efficiency and productivity. ICT has especially influenced the efficiency of manufacturing operations through automation, better process control and increased information processing capacity. It has also improved resource planning, co-ordination of design and production operations, and the reorganization of management processes and office work. ICT use plays a significant role in globalization of business and enables the management of dispersed operations and continuously growing information flows.

Efficiency gains achieved by ICT use differ between sectors in the economy (e.g., manufacturing versus services). While the automation of activities has mostly benefited the manufacturing sector, it may be that in service activities, communication technology may have a stronger impact on efficiency through its ability to improve communications and co-ordination between different activities and actors. ICT can improve the efficiency of new services (e.g., car-sharing), enable the development of customized and automated services, as well as replace physical products or activities (e.g., voice mail, videoconferencing).

The efficiency gains in individual operations are evident, but the extent to which ICT use influences overall productivity growth in the economy is more difficult to prove. The impact of ICT investments on productivity seems to be difficult to measure in some industry sectors, such as in in the service sector. There are also industry sectors in which ICT use seems to increase productivity more than in others. According to some evidence, ICT has not drastically improved economic productivity outside its own sector.

Enabling new product, service and system innovations. ICT is an important facilitator for many new businesses, innovations and product-service concepts. Some of these new ICT-based innovations also hold considerable potential for environmental savings (e.g., car-sharing, videoconferencing, electronic commerce). ICT can create business opportunities and products with reduced environmental impacts. In the long run, the role of ICT in the development of new eco-efficient services and infrastructures may turn out to be more significant than the extent to which ICT-based solutions replace certain existing products.

Structural change. Finland has witnessed an exceptionally fast growth of the ICT sector in the economy during the 1990s. The production of the ICT sector has grown fivefold, and its share in total industry output has grown to 20%, with increased significance for exports and GDP. It remains to be seen will the growth of the ICT sector continue and will there be a shift from a strong focus on ICT equipment manufacturing to IT services and content provision. In addition, it is interesting to follow what kind of other structural changes take place in the economy: how strong will the shift from manufacturing to services and knowledge and information intensive sectors be and how ICT contributes to them.

Effects on material and energy consumption. Although substantial efficiency improvements in specific operations can be traced, we cannot say anything definite about the net impacts of ICT use on materials and energy consumption. According to economic forecasts, energy consumption will continue to increase in Finland and other economies, but the potential growth of the ICT sector may slow down energy consumption growth, because the ICT sector is not so energy intensive (see Chapter 5). Some enthusiastic commentators believe that the “new economy” will considerably speed up a de-linking between economic growth and natural resource use. Others are more cautious: in addition to substituting for other resources, information and communication technology also generates new economic activities, products and services. Although it seems clear that ICT use increases the efficiency of operations (i.e, increases resource productivity), it does not necessarily lead to any significant absolute reductions in material use.

Because the impacts of ICT use on material and energy consumption are too complex to be tracked on the national economy level, a more useful approach could be to start analysing specific operations within information society (e.g., distance work, electronic commerce) that are believed to contribute significantly to environmental impacts. Environmentally significant improvement options need to be better identified and implemented in the development processes of new ICT-based solutions.

What are the most important environmental impacts of ICT development in the future?

There are several potential ways in which ICT can help to curb natural resource use in business operations. Firstly, ICT can improve efficiency within individual operations so that natural resource productivity is increased (e.g., improved logistics, higher manufacturing yields). New forms of ICT-based communication between suppliers and customers can enable the customization of products, thus reducing material use and waste throughout the product life cycle. Digitalization of information products and transactions, electronic commerce and electronic banking services are further examples of areas that provide new opportunities to reduce resource use (e.g., less labour or materials intensive stages in operations, better co-ordination and control of operations, shorter distribution chains).

Secondly, ICT enables the development of new product-service systems and business logics (e.g., electronic commerce), which changes the way value is produced in existing sectors, i.e., what inputs they use and what outputs they produce. ICT can also contribute to a shift within sectors (e.g., delivery chains are restructured by electronic commerce). Furthermore, technological development can lead to a shift in consumption from one sector to another (e.g., private consumption shifts more from material goods to ICT services).

Thirdly, at least some of the new innovative ICT-solutions can in principle provide the desired functions with considerably less material use (e.g., distance work, videoconferencing, electronic commerce). Many of these new solutions are still in such an early stage of development that there are not many detailed calculations of the scale of the environmental gains. More significant than trying to calculate their direct potential to reduce natural resource use may be to assess the extent to which they will be adopted, and the extent to which similar ideas can be applied in new areas.

In the case of electronic commerce, several areas with positive potentials from a dematerialization perspective can be identified. Electronic commerce will considerably modify manufacturing and inventory management practices, transport and logistics as well as building infrastructure (for more details, see Chapter 6). In addition, electronic commerce and the Internet provide a powerful tool for improved information exchange and communication in supply chains (e.g., to forecast demand more accurately, co-ordinate supply chains, customize products, do comparison shopping, market products and provide customer service).

The application of ICT does not, however, automatically lead to environmental benefits. New ICT-based solutions may replace certain types of operations but also generate new activities, products and services which add to aggregate material use. The substitution and generation effects evoked by technological progress can be unexpected and in many cases, they are not clearly visible yet. It can be shown that many ICT-based services, instead of substituting for materialized products, bring new services, functionalities and products into the market that involve even larger volumes of materials and energy. It also seems that only few products and appliances are being substituted by the new ICT-based solutions. Many of the new products and services have a more additive character, and old and new technologies co-exist, complementing each other.

What kinds of opportunities exist to influence the development of information and communication technology?

The fact that many new ICT solutions are still at an early stage of adoption provides opportunities to influence developments. Environmental efficiency is not in most cases a central concern for those developing new technologies and services. Development of technologies needs to be steered in order to include environmental concerns, such as dematerialization, early on in the technology and business development process. In the early phase, developers are not often aware of the demands of society or the potential impacts of the technology on society and the environment. Similarly, those having a stake in the future impacts of the technology do not know how it might influence them and what kind of opportunities and threats the new technology provides (e.g., Schot 1992).

Therefore, there is growing interest to increase the dialogue between technology developers and the actors influenced by new technologies, and to bring them together (e.g., business people, users, authorities) to assess the impacts of developing technologies and to discuss in what directions future technology development should be steered. Biotechnology is one debated area in which attempts have also been made to collectively assess the future impacts (see, e.g., Rask et al. 1999). Also the environmental implications of information society development and its specific areas need to be similarly assessed. This work is still in its very early phase. At first these assessments may remain to a large extent at the level of speculations, visions and hypotheses on the direction of future development. These visions, however, even if they lack empirical verification, are important as such, because they help to increase consciousness on potentially significant areas for environmental improvement which have to be taken more explicitly into account when ICT systems are established and further developed.

What could companies do to influence future development towards ecologically sustainable information society? Business interests are and will be in any case the major driving force of information technology development. What is striking, at least in Finland, is that ICT business people have taken a rather passive role until now in the discussion on the environmental impacts of information society development, although they actively create for us visions of a 'mobile information society'. There is a challenge for ICT business, both for large and small companies, more strongly to promote environmental gains in future technology development. A challenge is to make creative use of the potential of information and communication technology to serve current and new needs, rather than letting only the technology and established ICT products drive the development. This means conceiving new products and services whose high technological contents confer environmental value and to which the environmental value gives legitimacy and social sense.

What is the role of consumers? The majority of consumers do not yet seem to consider, e.g., electronic commerce as a viable way to reduce the environmental impacts associated with their activities (Romm et al. 1999). This is partly due to the fact that many ICT-based services are still so new that their adoption in society is in an early phase. It takes some time for consumers to get used to new products and services and to find new meanings and ways to use them, or to give up old routines. ICT-based products and services may have a considerable future impact on consumption patterns, time-use and expenditure. Some signs of this development are already visible (see Chapter 9).

Authorities, policy makers and the research community are faced with many challenges in information society development. Local policy planning and public technology funding could be strong actors in steering sustainable information technology development. For policy makers and the research community, one of the practical challenges is to determine more precise ecological sustainability objectives for ICT development in various sectors, to match them with business and technology development, and to assess the impacts of technology adoption. For example, an electronic commerce code of management practices to address the potential environmental impacts of activities needs still to be developed. The research community should analyse prevailing social practices and future development alternatives, as well as create justified outlooks on the desirable future (Jokinen et al. 1997). For example, what are the potential social and environmental implications of the evolution of industrial and commercial practices, cultures, and institutions that, e.g., electronic commerce may encourage? The challenge is to understand better how multiple effects combine to produce an observed net outcome.

3 Review of the Discussion on Ecco-Efficient Services

Eva Heiskanen

Eco-efficient services, or sustainable product-service systems, have emerged as a popular topic in a variety of discussions on sustainability and eco-efficiency. They are part of macro-economic concepts such as “ecological restructuring” (Spaargaren and Mol 1992) and the “customized economy”(Schmidt-Bleek and Lehner 1999). Ideas about producers as “fleet managers” (Stahel 1994a) and products as “service-producing-machines” (Schmidt-Bleek 1998) have been put forth. “Product-service systems” are proposed as the next frontier for eco-design (Goedkoep 1999; Mont 2000), and analysts speak of “servicizing” existing products (White et al. 1999).

In these discussions, “service” actually refers to many different things. It may refer to the role of the service sector in the economy, or to a company’s offerings to its customers, or to the service (function) provided by a product. Some more precise concepts, such as product-service systems, have emerged in recent years. Yet, on the other hand, the debate has been expanded by references to companies’ efforts to reposition themselves as providers of “services” or “solutions” due to competitive pressures in product or capital markets.

Propagators of new ideas need to construct narratives that mobilize the interests of a range of constituencies, and link the ideas to broadly acknowledged goals and virtues. The fact that rhetorics are employed to popularize such ideas does not mean that the ideas themselves are not sound. However, when many different ideas are bundled together, it is difficult to evaluate the soundness of the claims, or even pinpoint exactly what is being claimed.

Within this discussion, it is perhaps also worth distinguishing between “modest” and “ambitious” claims for services. As a “modest” claim, one might term the argument that “product-service systems” or “servicizing” are ways to include the use and disposal of the product within the environmental management of the company, and are thus complementary to cleaner production and ecodesign efforts (Mont 2000; White et al. 1999). On the other hand, assertions that a focus on services is conductive to factor 10 reductions in materials use (Stahel 1996; Schmidt-Bleek 1998; Hawken et al. 1999) could be considered relatively “ambitious” claims. A further distinction is whether services may provide environmental advantages in some cases, or whether the service model can deliver environmental advantages in all sectors of economic activity.

Thus, there are many aspects to evaluate in the discussion on eco-efficient services. Are the examples suggested actually eco-efficient? What is the extent of environmental benefits gained from these service examples? To what extent can the ideas suggested in the examples be applied in other fields? That is, do eco-efficient services hold the potential for radical dematerialization at the level of the whole economy? Finally, whether or not the examples of eco-efficient services actually deliver direct environmental benefits at present, it is worth considering how new ideas about services could contribute to dematerialization in the long term by changing the logics of economic activities.

The aim of this chapter is to analyse the propositions that have been put forward in the discussion on eco-efficient services. This is done by identifying the different kinds of services that are linked to eco-efficiency claims, and the different benefits that they are expected to deliver. Using this framework, the evidence accumulated to date is investigated. Evidence concerning the feasibility of a shift toward services is also considered. The final part of this chapter summarizes the current status of knowledge in the field, and identifies central research needs and perspectives. The material in this chapter is based largely on the review reported in Heiskanen and Jalas (2000), with some updates, more analysis of empirical studies, and more extensive conclusions.

3.1 Defining eco-efficient services: an integrative classification

Most authors in the field agree that it is difficult to make a sharp division between products and services, and that it is an issue of degree (e.g. Scholl et al. 1998; Interim Report 1999). All products include some service components (e.g. delivery), and all services require the use of some products (e.g. premises).

Apart from this, different authors rely on varying definitions of “service”. For example, a service can be defined as including, in addition to a repeatable, standard component, a singular component per each transaction (Kotler 1997). This definition would restrict the scope of services to tasks performed by human labour individually for each customer. This would mean that information technology based services (e.g. search engines) would not be included as services, because they are executed by pre-designed programmes. Design activities in general would not count as services, either. A broader definition would be to define services as economic activities that replace the customer’s own labour with activities conducted by the service provider, either personally, automatically or in advance through planning and design.

A number of classifications of eco-efficient services have been developed by different authors (e.g., White 1999; Hockerts 1999; Mont 2000; Roy 2000). The following list summarizes four meanings or different interpretations of the service approach that could be found in the ongoing discussion (Heiskanen and Jalas 2000): non-material services, results-oriented services, product-based services and eco-design with a service approach[61] .

1. Non-material services

Services seem to be conceptualized mostly in terms of traditional or new service sectors in the discussions on ecological modernization and ecological restructuring. Traditional and new non-material services include services that are not, as such, alternatives to products. This includes traditional services such as medical and personal care, training, legal services, insurance, banking, etc. It also includes new services, such as different kinds of IT-services, which do not directly replace products (e.g., virus control). These are sectors in which material artefacts are not the primary object of market transactions, although the delivery of such services usually requires at least a supporting infrastructure.

The envisaged link to dematerialization is mainly through the decline of traditional smokestack and extractive industries, more knowledge-intensive production and potentially, changes in consumers’ lifestyles and preferences (see, e.g. Spaargaren and Mol 1992). This is often presented as a natural path for developed, post-industrial economies, and one which can be catalysed and speeded up through an ecological tax reform. From this macroeconomic approach, the essential issue is which sectors of the economy grow in the future. Thus, the shift to services can be seen as the growth of the service sector, the white collar sector in general, and information and telecommunications (Gershuny and Miles 1983). Another aspect, which comes closer to the other definitions here is the growth in the service intensity of goods (services and information as production factors).

2. Result-oriented services

Many authors identify a category of services that obviate or decrease the need for products, materials or energy by providing the desired result in another way:

“functional orientation” (Zundel 1995), “needs-oriented services” (Hockerts 1999), dematerialized services (White et al. 1999) and “result services” (Roy 2000). This type of services can be seen as including various forms of contracting, such as energy services, in which the customer’s need (e.g., for a suitable temperature or level of lighting) is central. These results can be provided with a combination of different products, knowledge and labour. Typically, contracts are defined in terms of the result, and not of the amount of a product or service delivered[62] .

Result-oriented services are services in which the focus is on fulfilling customers’ needs that were earlier met mainly by use of materials and energy through superior planning, training and redesign of the customer’s activities. Such services include energy saving contracts, facility management, waste minimization services, etc. Typically, customers pay for results or for a fixed service level, and not according to materials used. Result-oriented services can be provided by a producer (e.g. an energy utility), but are frequently offered by another company, or a different business unit, than the one producing the product (e.g. centralized voice mail, facility management). Thus, they may imply a different institutional organization than manufacturing or production-based business.

3. Product-based services

Product-based services are related to the use of a product. However, in contrast to traditional manufacturing, it is not necessarily the ownership of the product that is sold to the customer, but its use, which may also include services to assist in using the product (such as chemicals management). Some product-based services may even be based on customer ownership, but with an extended responsibility of the manufacturer for the product even after point-of-sale (extended maintenance warranties, product-take-back commitments). At least the following three types of product-based services can be identified:

- From manufacturing to repair, maintenance, upgrading, etc.
- From manufacturing to leasing, rental, etc. services
- Extending the scope of business to service provision: instead of selling products, companies use self-manufactured products and their own labour and expertise to provide customers with services (e.g., chemicals management).

Whereas the first type of product-based service is relatively close to conventional manufacturing business, it includes some additional service components. Rental and leasing services are not new, but a new development is that traditional manufacturing companies (e.g. Daimler-Benz) are starting to offer these kinds of services, as well. Finally, the product use management services are relatively close to the previous category of result-oriented services. While the transaction still involves a specified product (and not a result), a larger amount of the value-added comes from the use of labour and expertise in employing the product to the benefit of the customer.

4. Ecodesign with a service approach (functional design)

The way services are discussed in the environmental design literature does not relate to a service business model, as such. Rather, the service is the utility provided to customers by products. By focusing on this utility, products can be redesigned to use less materials. Examples include Schmidt-Bleek’s (1994; 1998) new motorcycle locks and the FRIA cold-storage chamber (redesign to gain same function with radically less materials). These new solutions may emerge from eco-design efforts in traditional manufacturing companies, but frequently, they depart so radically from existing product concepts that they are launched in the market- if at all - by new competitors.

Extensions of the service approach

In addition to the previous four categories, the service literature also includes other broadly related references. Thus, for example Stahel (1996) places the service discussion in a broader framework, which also includes systems design and sustainable technology. Individual products or services may be replaced with built-in-systems or “shared” infrastructures (existing examples include libraries and the system of lighthouses shared by ships). Furthermore, the discussion may be extended to consider a better design of the task to obviate the need for products or services (one example presented by Stahel, 2001, is the traditional practice of ploughing by night, which avoids the need for herbicides by depriving weed seeds from the flash of light needed to germinate).

Furthermore, the discussion on services often includes references that extend the discussion beyond existing business models and economic goals, as well as beyond environmental aspects as such (e.g., Ekins and Max-Neef 1992). Thus, in addition to dematerialization, issues raised include global equity, essential needs, local employment, community, alternative measures of national wealth and well-being, value-change, and sufficiency (e.g., BMBF 1998). While these are not necessarily the ‘core’ of the service discussion (i.e., are not referred to by all), they illustrate the breadth of issues that a focus on services may lead to.

3.2 Services and dematerialization: arguments and evidence

The claims for eco-efficiency of the different kinds of services are based on different lines of reasoning. A common thread is the focus on the efficiency of services gained from products (termed service yield), rather than on the efficiency of producing those products (e.g., Scholl et al. 1998; Malaska et al. 1999). The different kinds of services, however, are supported to a varying degree by technical, organizational and economic arguments (see table 6).

Table 6. Dematerialization potential of different categories of services

Eco-design with service (functional) approach (e.g., FRIA-refrigerator)	• Large technical potential for absolute dematerialization on product level • No specific organizational advantages • Economic incentives for dematerialization limited, depend on customer awareness of benefits (revenues are still gained from selling products)
Product-based services (e.g., car-sharing)	• Technical potential for dematerialization in some cases • Organizational potential for dematerialization by enabling shared product use, more intensive use, better recovery and reuse • Economic incentives for dematerialization exist (product becomes cost factor for service provider), but may not be utilized
Result-oriented services (e.g., energy service contracting)	• Technical potential for absolute dematerialization • Organizational potential through more professional planning and execution of tasks, as well as shared product use, more intensive use, recovery and recycling • Economic incentives for dematerialization may be great (service provider benefits from savings in both production and operation costs)
Non-material services (e.g., hairdresser, psychologist, virus control, new telecom services)	• Potential primarily for relative dematerialization (less-materials intensive growth); in principle, could lead to absolute dematerialization through extensive changes in the structure of consumption

Potential for dematerialization while maintaining product function (arrow spanning the first three rows)

Revenues decoupled from materials use (arrow spanning the last three rows)

The arguments supporting eco-design with a service approach are largely technical, whereas the arguments surrounding non-material services are mostly related to the structure of the economy. Eco-design with a service approach maintains a functional equivalence with existing user needs, but the organizational and economic incentives for manufacturing companies to invest in radical product changes are frequently lacking. In contrast, non-material services hold the potential for de-linking economic output from materials throughput. However, they have no obvious functional equivalence with existing user needs, and thus involve uncertainties in terms of conscious policy and management efforts. At least until now, environmental policy or company environmental management have not attempted to influence the structure of consumption (e.g., encourage people to buy fewer cars, but visit a psychiatrist more frequently).

However, the categories of *product-based* and *result-oriented* services include both a functional equivalence to existing products, and potential organizational and economic advantages in terms of eco-efficiency vis-à-vis conventional product sales. These services imply changes in the division of labour between supplier and customer in which suppliers or professional service providers take charge of tasks previously executed by the customer. In this way, at least in principle, the costs of natural resource use are borne by the party capable of minimizing them (see Lovins et al. 1999; Heiskanen and Jalas 2000).

Non-material services imply a shift between sectors. Ecodesign with a service approach is a matter of efficiency gains within a sector. Product-based services and result-oriented services are somewhere in between: their potential contribution to dematerialization lies in structural change within sectors. Especially, authors are interested in examples in which existing manufacturing companies (e.g., car manufacturers, copying machine manufacturers) start to offer such services, as this can be seen as a vehicle for evolutionary change toward a structurally less materials intensive economy.

In the following, the evidence concerning eco-design with a service approach and non-material services is first briefly reviewed. More attention, however, is devoted to product-based and results-oriented services, which are perhaps the most innovative ideas within the service debate.

3.2.1 Eco-design with a service approach (functional design)

The claims about the eco-efficiency of *eco-design with a service approach are* simple and technical. A frequently cited example is the FRIA cold chamber developed in connection with a project at the Wuppertal Institute (Schmidt-Bleek 1994; Schmidt-Bleek and Tischner 1996). The FRIA cold chamber replaces conventional refrigerators with cold storage space built into the outer wall of a house, thus enabling the use of "natural" cold when available. Other features include replaceable machinery and storage modules that can be turned on and off at need. It has been estimated that this kind of a construction would reduce the materials needed for home refrigeration by almost a factor of 7, and would reduce the energy consumption to half of the current rates.

Technically, many services can be provided with much less materials use than is currently the case. An example is the replacement of long-distance business meetings with videoconferences, which according to von Weizsäcker et al (1997) requires 99% less natural resources than a physical meeting. The idea here is that by focusing on finding efficient ways to deliver the functions that the product provides (rather than on optimizing existing products), large savings in resource use can be achieved.

There are, however, many disincentives for manufacturers to opt for such radical changes in their products, e.g., sunk costs in manufacturing facilities and capabilities[63]. Few established companies have replaced their products with radically different ones; rather, the examples in the literature (e.g., Schmidt-Bleek 1998) usually come from new competitors. As manufacturers do not bear the cost of owning or operating products (and customers are not well aware of either types of costs), there is a lack of incentives for, e.g., manufacturing radically more durable or energy-efficient products (e.g., Hawken et al. 1999).

3.2.2 Non-material services

At the other end of the continuum, *non-material services* do not replace any existing functions. A shift from products to non-material services (e.g., from spending on new clothes to spending on mobile phone services) requires a change in consumers' preferences or lifestyles. On the level of the national economy, this means that private final consumption should shift from industrial products to the service sector.

The potential for such a shift, and its prospective consequences for dematerialization were discussed in chapter 1. It was noted that, at least on its own momentum, such a shift has been slow, and was even reversed in Finland in the 1990s. Furthermore, the service sector as such (according to statistical classifications), is not necessarily much less energy or materials intensive than manufacturing industries in aggregate[64]. Yet there are services that are clearly less energy intensive than the economy on an average[65]. It was noted, however, that it is difficult to envisage that consumption could shift toward them to such an extent that it would undermine or reverse the environmental effects of continued economic growth. ICT-services are perhaps an exception here, although it is difficult to see how even they could replace existing expenditure categories (e.g., housing, food) to any significant extent.

The evidence shows that shifts in the structure of production and consumption can and do occur, but not very swiftly, and they are difficult to influence under current policy regimes. They are also most probably not shifts that existing manufacturing companies can make in the short term (e.g., transfer from producing clothes to marketing telecommunications services). Furthermore, generalized claims for the dematerialized nature of the service sector have been contested. Thus, at least in the short term, the most natural context for non-material services in the eco-efficiency discussion is as an outlet for future growth, and thus as a means for structural change and *relative dematerialization* of the economy (rather than as a stand-alone means to reach factor reductions in absolute terms).

As was concluded in chapter 1, shifts within sectors (i.e., in the service-intensity of existing industries) are probably more interesting from the point of view of dematerialization. In the terms of the present chapter, this means looking at product-based, results-oriented and eco-design services.

3.2.3 Product-based services

Product-based services are ones in which the use of the product is the subject of economic transaction, rather than the *ownership* of that product. In principle, this entails a number of organizational and economic advantages in terms of materials use.

<u>Organizational advantages</u> relate to the shared use or more intensive use of products: individual products can be used by a large number of users, either consecutively (first by one user, then another), or by time-sharing (users taking turns). Potential savings in natural resource use can be achieved due to the need to *manufacture fewer products,* or through a *more intensive use of a given stock of products* (e.g., Scholl et al. 1998). More intensive use can solve the environmental trade-offs between product life extension and technological obsolescence. Extending product life increases the number of "services" or "uses" to be gained from an individual product (i.e., service yield), but this may not be environmentally efficient for energy consuming products due to technological advances in energy efficiency (e.g., Jackson

1997). With more intensive use, the product can both provide the same number of "services" or "uses" as when owned by a single user, yet be "used up" in a shorter period of time and replaced by the newest technology (see, e.g., White et al. 1999).

Shared use also, in principle, enables *more flexible* use: from a large pool of products, the one most suitable for the task at hand can be selected (e.g., eliminates the need to prepare for future needs or contingencies when purchasing an expensive product such as a car). As the users do not bear the fixed costs of ownership, but pay for each use, they may also be more selective in their use of the product (e.g., a car), and use alternative modes of needs-fulfilment (e.g. public transport) when appropriate.

Other organizational advantages envisaged include *more capable maintenance of products*, if this is done by a professional service provider (White et al. 1999). Finally, end-of-life recovery and reuse is facilitated if the pool of goods remains in the ownership and control of a professional service provider (e.g. White et al. 1999). Some of the most difficult problems in present-day end-of-life product recycling relate to collecting end-of-life products from a large number of consumers, and to the variety in make and age of products disposed of in a given period of time. Providers of product-based services automatically get their products back after each use, and can scrap similar products at the same time, or organize the systematic reuse of reclaimed products or components.

Evidence for these organizational advantages can be found in the field of car-sharing, which is a relatively new service on a large, commercial scale. [66] The few detailed studies that exist on car-sharing support some of the claims about product-based services. Especially a recent study by Meijkamp (2000) is relevant, because it evaluates the environmental impact of car-sharing adopters in a realistic setting in the Netherlands, and includes a study of behaviour changes due to car-sharing adoption. Not all car-sharing adopters have previously owner a car (after all, car-sharing makes it cheaper to obtain a car), and some families joined a car-sharing scheme to gain access to a second car. Impacts, as calculated for the whole group of different kinds of car-sharing respondents (N=337), showed the following effects:

- Smaller stock of products: car-sharing adoption reduced the number of cars in use by 44%. According to the assumptions in the study, this does not reduce the manufacturing of new cars (or related environmental impacts), because the lifetime of a car is assumed to depend directly on the mileage run[67]. A smaller stock of cars does, however, reduce the need for *parking space* (land-use) in direct proportion (44%).
- More efficient technology: car-sharing cars are approximately 22% lighter and 24% more fuel efficient than average Dutch cars.
- Service users use products more selectively: car-sharing adopters' average car mileage was 33% less than that of an average Dutch household.

All in all, Goedkoep et al. (1999), basing their analysis partly on Meijkamp's data, find that the average car-sharing users' environmental impact is about 30% lower than that of car owners. However, as noted above, this is based on the assumption that car-sharing does not reduce the manufacture of new cars. Cars are the kind of product in which this kind of assumption is to some extent justified; however, few other products become obsolete in direct proportion to how much they are used.

In contrast to cars, the useful life of many other types of products does not depend directly on how much they are used. Frequently-mentioned examples of products that are or can be shared (e.g., through rental services) include sports equipment and rarely-used household products. Public libraries are a traditional example of a product-based service. A few attempts have been made to quantify the environmental implications of such product-based services:

- Hirschl et al. (2001) report a study on the rental of skiing equipment. Their study found that through the shared use of skiing equipment, the natural resource productivity of the equipment could be increased by a factor of 1.7 - i.e., the use of rental equipment consumes about half the resources of user-owned equipment.

- A Wuppertal-Institute study on the shared use of electric drills, in contrast, found considerable environmental advantages (BMBF 1999). In their calculation, consumer-owner electric drills were replaced with a pool of 150 households sharing two electric drills for professional use. Due to more intensive use (shared use) and better product durability (higher product quality), the material intensity per hole drilled was reduced by more than a factor of 10[68].

- Mäki (1999) has attempted to quantify the environmental savings accrued through the public library system in Finland. On an average, each individual book is loaned (used) 60 times. If all the books loaned each year from public libraries were replaced with user-owned ones, 32 000 tonnes of paper would be required, leading to, among other things, 13 800 tonnes of fossil carbon dioxide[69].

In some cases, product-based services are clearly or self-evidently a much more resource-efficient way to organize product use than the private ownership of products. Qualifications are due when product life depends directly on use (i.e., products are disposed of due to wear or breakage), when additional transport is needed (e.g., to fetch or bring products that when owned would be readily available where needed), and if not owning products makes users treat them less carefully (see, e.g., White et al. 1999; Scholl et al. 1998).

On the other hand, some of the examples indicate an additional benefit not envisaged among the mechanisms identified by, e.g., White et al. (1999) or Heiskanen and Jalas (2000): the potential role of services in conserving space (e.g., parking space, storage space at home), which, at least in the case of built and heated space, may be an important dematerializing effect (cf. Schmidt-Bleek and Lehner 2000: 252).[70] .

There is also a set of economic arguments for why product-based services should be more efficient in natural resource use than product sales. The revenues of a company selling products are based on a throughput of material goods, and the costs of product ownership and replacement are borne by the user. Companies selling their products are dependent on repeat purchases for continued revenue, which may encourage manufacturers to produce less durable products and plan obsolescence into product designs. Rental companies, in contrast, can be likened to “fleet managers”, which have an incentive to minimize the manufacturing of new products, as this constitutes a source of costs, rather than revenues, for them (e.g. Stahel 1998; White 1999).

Economic modelling, mainly in the field of industrial organization, has provided some support for the argument that companies that rent their products have more incentives to increase product durability than ones that sell their products (Bulow 1986; Goering and Boyce 1993). Goering and Boyce (1993) have some empirical evidence in support of the argument that rental companies have more interest in product durability than ones that sell their products. Their evidence is based on measures of R&D expenditure (a proxy for measure for obsolescence) and the share of sales and rental in the revenues of IBM and Xerox in 1967-1990. In this example, the shares of rental and sales were significant predictors of R&D expenditure. That is, the more the companies rented their products, the less they invested in new product development.

In spite of this evidence, it is not obvious that product rental always contributes to extended product life. Rental products are usually currently not provided by their manufacturers, and are not specifically designed for that purpose. The economic incentive to design products for durability, repair and upgrading would only apply if rental operations and R&D are linked in the same organization. While some manufacturers are currently increasing the provision of their products through operational leases (similar to renting), at least at present this has not in most cases resulted in product-life extension activities (Fishbein 2000, see also chapter 8 in this volume). Furthermore, manufacturers are not the only ones determining product life. Users may influence product life through their usage patterns, and may be subject to "moral hazard" if they need not bear the consequences of careless use themselves.

3.2.4 Results-oriented services

Results-oriented services replace the acquisition of a product with a professional service delivering the desired result. Some results-oriented services are new and have an obvious environmental aspect to them, e.g., energy service companies (ESCOs), while others are fairly conventional (e.g. laundry services). In general, results-oriented services are envisaged to include a number of benefits that can be considered additional to those accruing from product-based services.

In addition to enabling shared product use, more intensive use, and better end-of-life management, results-oriented services mean that tasks previously conducted by the product owner or user are transferred to professional service providers. This entails the *organizational benefit* of scale-related efficiency gains. Professional service providers can also be assumed to know more about the related technologies, and have access to better equipment. Tasks may be performed by a better trained and more competent person than the customer is, which may lead to more proficient operation. This should translate into less use of natural resources due to incompetence, inattention or incapability by small-scale users[71].

There are also *economic arguments* for results-oriented services in addition to those accrued through product-based services. In addition to the costs of ownership, also the costs of product use are transferred to professional service providers. While, for example, energy costs do not necessarily change from being transferred from one economic unit to another, their relevance in the cost structure changes. Private consumers or other small-scale users have many different kinds of costs, many of them small items, and it is not worth the effort to optimize each and every one of them. Specialized service providers, in contrast, have fewer different costs, but these individual items are larger, and thus more likely to be subjected to management efforts.

Some of the these logics apply in the case of commercial laundry services. Less water and energy is needed per load in large-scale washing processes than in domestic washing machines. Laundry operators can invest in state-of-the art machinery, and they can be assumed to be more proficient launderers than private consumers. Furthermore, energy, detergent and water costs can be controlled more carefully in professional operations. These ideas gain support from studies evaluating the eco-efficiency of different types of laundry services as compared with home laundering. However, due both to different assumptions and different service designs, conclusions concerning the actual eco-efficiency benefits vary considerably:

- Goedkoep et al. (1999) compared local laundry services with two home-wash scenarios: one in which home appliances are operated efficiently (e.g. full loads), and in which no tumble dryer is used at home, and a "convenience" scenario in which a tumble dryer is used by 50% of the consumers and wash loads are two-thirds full[72]. Compared with the convenience scenario, the laundry service was more efficient (the environmental load was 2 / 3 of that of home wash). Compared with the efficient home use scenario, however, the laundry service used three times more resources, due to the use of energy for drying the laundry[73].

- A study reported by Wheeler et al (1999) estimated that small-scale commercial laundries could reduce the environmental load of laundering by a factor of 3, but that similar reductions could also be gained by improving home wash techniques. However, Wheeler et al. (1999) envisage that large-scale industrial laundries could achieve larger environmental gains in the future, due to possibilities in reusing water and waste heat.

- Schmidt-Bleek (1998) states that professional laundry services use 80% less water, 66% less detergent and 77% less energy per kilo of laundry than private households.

- A life cycle assessment commissioned by the European Textile Services Association (ETSA 2001) found that industrial washing of workwear requires 52% less primary energy, 73% less water, 85% less detergent and produces 33% less CO_2 than home washing.

- Hirschl et al. (2001), comparing the total material requirements of laundrettes and home laundering, conclude that the resource productivity of a laundrette is 1.9 times better than of home laundering (i.e., natural resource use per kilo washed is about 50% less). Their study included transports, heating and lighting of the laundrette, as well as observations of actual tumble-dryer use by customers.

- A further point not considered in the previous studies is that obviating home laundering can reduce the build-up of moisture in buildings, and hence potential damage to building structures (BMBF 1999).

The laundry example shows that actual comparisons include a complex network of technical detail. Although the potentially resource-saving mechanisms (professionalism, cost control, economies of scale) are in place, this does not automatically translate into less natural resource use. The technical detail that wet laundry needs to be dried means that, at least in current service designs, the benefits of professional operations are to some extent undermined. Households can utilize space in their homes for free air drying, although as noted in the BMBF study, this may lead to harmful build-up of moisture in cold and damp climates.

Apart from laundry services, there are few attempts to quantify the dematerialization potential of results-oriented services. Few of the examples of results-based services are targeted at private households. *Centralized voice mail* (as a replacement for an answering machine) is mentioned in passing by many authors (e.g., White 1999). Mäki (1999) has estimated that the adoption of centralized voice mail services has reduced direct materials use in Finland by about 18 tonnes per year. *Energy services* are also frequently mentioned in this context, and it seems fair to assume that this type of service (e.g., counselling, promotion of energy-saving equipment) can lead to energy conservation[74] (e.g., BMBF 1999). The BMBF study also discusses *water services* (e.g., leasing of water conserving devices or equipment for rainwater utilization) and *personal services provided by housing companies* (e.g., repair, cleaning, care, home deliveries[74] of meals, etc.), but finds it difficult to quantify the related material flows. *Traditional services*, such as restaurant meals, are also sometimes suggested in this context (e.g., VROM 1993)[76]. All these result-oriented consumer services do seem to involve scale-related efficiency gains, but otherwise consist of such a variety of different activities, and are mostly so poorly documented, that it is difficult to make an overall evaluation of their dematerialization effects.

There are more examples of results-oriented services targeted at organizational or business customers. These include pest control services (Schmidt-Bleek 1998; Hockerts 1999), chemical services (White et al. 1999; Stahel 2001), facility management

(Hockerts 1999; White et al. 1999), hosted network servers (Mont 2001), and energy service companies (ESCOs)[77]. The modular carpet service concept developed by Interface is mentioned by almost all participants in the discussion[78] (e.g., Hawken 1999, Hockerts 1999).

However, few of these authors provide detailed evidence. Schmidt-Bleek (1998) reports that the integrated pest control service provided by Ciba-Geigy contributed to a factor 4 reduction in the use of agricultural chemicals. Mont (2001) reports that server hosting by the Icelandic company Alit, combined with thin client architecture at the customer side (i.e., modern-day terminals), prolongs the lifetime of customers' IT-equipment by approximately 3 years. Hawken et al. (1999) estimate that replacing only worn carpet modules in the Interface service reduces natural resource use by a factor of 5. There is also some evidence of the benefits of professional service providers' superior proficiency, cost-awareness, managerial capabilities and economies of scale (e.g. White et al. 1999; Stahel 2001). Furthermore, authors find indications that results-oriented services help to align producers' and their customers' interests. However, systematic quantification of the scale of efficiency gains in realistic settings is mostly lacking.

Results-oriented services may be one way to profitably practice the kind of systems-based view advocated by eco-design with a service approach. One could speculate that companies delivering results are not committed to a specific technology and to specific production equipment to the same extent as manufacturing companies. If revenues are gained from selling results, rather than the ownership or use of specific products, service providers may be more flexible and innovative in their selection of products and services to meet customers' needs[79]. This may be the case, especially in energy or water services (see BMBF 1999), but there is little documentation of how such companies or service units actually operate.

On the other hand, results-oriented services require that the service provider is able to control the outcome of the service. If energy usage, for example, is dependent on users' behaviour, it is not necessarily efficient to transfer the energy costs to a service provider[80]. One could assume that r esults-oriented services are most effective in situations in which the technological and managerial capabilities of professional service providers are crucial (e.g., complex technical systems such as IT). Of course, who can control the system depends to some extent also on how it is designed (e.g., fully automated and standardized vs. user-operated and ideosyncratic systems).

3.2.5 Is a shift toward services feasible?

Due to the anecdotal nature of the evidence, it is also difficult to say whether the examples of eco-efficient services are isolated phenomena, or whether they are the front-runners of a broader trend, as is sometimes claimed (e.g., Schmidt-Bleek 1998; Schmidt-Bleek and Lehner 2000; Stahel 2001). Current developments in the economy that are linked to the emergence of new (potentially eco-efficient) services include:

- saturated markets (Stahel 2000)
- strengthening of the role of capital markets, shareholder value, market value (Stahel 2000)
- the information economy (Schmidt-Bleek and Lehner 2000)
- disintegration of industry boundaries, "blur" between products and services (implicitly e.g., Schmidt-Bleek and Lehner 2000; Goedkoep 1999)
- post-material lifestyles (Schmidt-Bleek 2000; Mont 2001)
- customer orientation, relationship marketing, customer retention (e.g., Stahel 2001)
- mass customization (Schmidt-Bleek and Lehner 2000)
- lean production, focus on efficient use of capital (Hawken et al. 1999)
- focus on core competencies, outsourcing (White et al. 1999; Stahel 2001)

Some of the connections suggested (such as lean production) may be somewhat passé as management discourses, and some may be flavoured by a heavy dose of hype (e.g., the information economy). Some of the developments are mutually conflicting and internally ambiguous. These tendencies, however, are constitutive of how market actors perceive the economy, and are obviously factors motivating a shift toward services in a number of industries.

The literature seems to have established that there is a propensity among many companies - independently from environmental concerns - to position themselves as providers or services and solutions (see, e.g., chapter 8 for Finnish examples). There are also clear tendencies among business customers to prefer services to product ownership (see, e.g., Alexander 1997).

In contrast, there is not much evidence of the propensity of consumers to adopt "consumption without ownership" or to "outsource" their activities. A number of surveys have been conducted, indicating that especially young, urban consumers may be less interested in owning than using products (see, e.g. Durgee and O'Connor 1995; Littig 1998; Schrader 1999; Hirschl et al. 2001). Post-materialist values are increasingly widespread in well-to-do societies (e.g., Inglehart 1997), which is often taken as a promising sign for services (e.g., Schmidt-Bleek and Lehner 2000; Mont 2001). Increasing working hours and two-income families have made household services a growth industry in some European countries[81]. However, what all this means, or could mean in terms of actual changes in overall consumption (let alone materials consumption) has not been systematically explored.

A further note in this discussion is that even many of the examples discussed as eco-efficient services have actually been developed by companies independently from any environmental concerns. Many, if not most, of the examples in the discussion fall into this category: for example, six of the seven cases investigated by White et al. (1999) and most of the successful cases presented by Mont (2000). Many of the examples (e.g. IBM in White et al., 1999, facility management) reflect broader trends in the industries (e.g., Connor 1997; Lewis 2000). Even some of the examples designed for eco-efficiency, such as the Electrolux Professional Appliances services (see, e.g., White et al. 1999), do not seem to depart very much from ordinary business operations[82]. Critics note that many of the services may be clever business ideas, but do not transform the way value is delivered to the customer (Ryan 2000).

Is this good news or bad news from the point of view of dematerialization? Some commentators have emphasized the fact that few companies are actually developing really eco-efficient services, or even taking environmental aspects into account in their new service development (see, e.g. Charter 1999). Others argue that true service innovations are driven by money, technology and competitiveness (coupled with a new understanding of where the economy is heading), rather than by the motivation to "save the environment" (Stahel 2001). Whatever the case, it can be interpreted as a positive sign that there are some obvious business advantages in a shift toward new services, and that such a shift is occurring on its own momentum.

There are obviously developments in the economy that give rise to an increased focus on services among companies. It is too early to say what the extent of these developments will be. Some may be passing fads, some may lead to the emergence of new niche markets, but some (such as the saturation of conventional product markets and the commodification of information) most probably will lead to permanent changes in the economy. As was seen in chapter 1 (see also chapter 5), these tendencies have not lead to absolute dematerialization on a large scale, and are unlikely to do so in the future in business-as-usual scenarios. However, they can also be seen as developments that can be *made use of* in active efforts to promote dematerialization.

On the micro-level of individual companies and service offerings, this would imply studying how and why new services are developed, and how and why they are adopted. How do the activities of individual companies influence their customers, suppliers and competitors? What is the relationship between new service development and technological development in the industry? Which services include elements that are conductive to dematerialization, and can they be improved? What kinds of interventions would appear most useful in increasing the dematerialization potential of new services (e.g., technology development, awareness-raising, pricing of production factors, institutional reform)?

3.3 Summary of the evidence and identification of research needs

The idea that new business models (services) can be used to provide desired functions with less natural resource use is, in principle, appealing. Product-based services and results-oriented services combine a functional orientation with an economic logic in which revenues are decoupled from material throughput. The claims are based on a limited number of examples, and mainly common-sense (and in some cases formal) economic or engineering models.

The empirical evidence for these claims is scarce. The existing calculations show that the environmental load can be lower in a service model than in a conventional sales model. However, the extent of demonstrated reductions is in many cases not in the scale of a factor of 4 or 10, and depends heavily on how the service is designed and operated.

Furthermore, the examples illustrate that there are *specific features in each case*. For example, car-sharing does not necessarily reduce the number of new cars manufactured significantly, and laundry services, while more efficient in washing, cannot utilize the free space drying available at home. On the other hand, car-sharing does clearly reduce parking space, and commercial or centralized laundering can save building structures from moisture. There does not seem to be any way to measure the environmental benefits of services in general, and even in specific cases, calculations are complex and surrounded by many uncertainties (Graedel 1998).

There are also some indications that a service mode of operating changes the economic incentives of manufacturers. However, the empirical evidence, once again, is scarce. Although the economic argument applies in principle, real-life situations are much more complex (e.g., the share of natural resource costs in the manufacturer's or service provider's production function varies). Furthermore, producers' and users' relative influence on the durability and use-related resource consumption (and hence, the most efficient distribution of costs) varies from one product group to another.

In terms of *direct eco-efficiency benefits*, the existing evidence seems to support mainly "modest" eco-efficiency claims for services. This would mean that designing entire product-service systems can most probably complement and enhance existing eco-design efforts in many cases, but does not automatically reduce materials use on a factor 10 scale.

Services are probably not the panacea for achieving large-scale dematerialization. It would, however, be perhaps too hasty to dismiss the potential of services for dematerialization on the basis of existing examples. It is worth remembering the terms of the debate that these ideas attempt to address. They attempt to point a way for radical dematerialization (protection of the global environment) with continued economic growth (protection of the economic and social status quo). Furthermore, the ideas speak to a political climate that does not favour strong market interventions (such as heavy taxes on natural resource use), and a culture that does not favour curtailing consumption. They aim to function in an economy in which private, global enterprise controls the development of technology and the material well-being of citizens (e.g., goods, jobs). This is not an easy equation to solve.

Technological developments alone do not seem likely to reduce natural resource use drastically. Many radically more efficient technologies exist, but they are not adopted due to political or economic disincentives in the current market structure. Furthermore, recent studies have indicated that technological improvements within existing industries, and within the framework of the existing production structure, cannot deliver factor 10 improvements, either (e.g., NMR 1999). Schmidt-Bleek (1994) has argued (quite convincingly) that the greatest reductions in materials input per "service" (utility) can be achieved at the final stages of the value chain (e.g., in increasing the efficiency of paper use, rather than in increasing the efficiency of paper manufacturing[83]). New services may be one means to achieve structural change (especially within sectors), and to focus efficiency improvements toward the final stages of the value chain.

Technological efficiency improvements have, until now, been undermined by a continual increase in consumption. Ideas put forth to influence sustainable consumption include suggestions for a broad-scale value change, involving, for example, information campaigns. Economic instruments can be used to influence consumption, but they are often politically difficult. Within the existing political climate, it is difficult to devise effective instruments to influence private consumers in the short term. Services have been viewed as one way to include consumption activities within the environmental management efforts of companies (e.g., Mont 2001)[84] .

Any feasible change should be in the perceived self-interests of large companies; thus, changing industry mindsets and de-linking business performance from natural resource use are central concerns. It is an interesting phenomenon in its own right that manufacturers are getting more involved in services, and perhaps perceiving their business from a new perspective. Thus, the emerging discussion on "new services" may be seen as one possible pathway for ecological restructuring on the micro-level. It may be a means to get companies involved in considering from an environmental perspective not only how they produce, but what they produce. Moreover, if companies become less dependent on natural resource extraction, they may turn to support conservationist measures such as ecological tax reforms.

The previous viewpoints indicate that some kind of a service-orientation may, in any case, be *necessary, if not sufficient*, for reaching a dematerialized economy. From this perspective, ideas about eco-efficient services are a trajectory, rather than a detailed plan. The examples of eco-efficient services do not serve only analytical purposes, but also the rhetorical ones of stimulating and mobilizing key audiences, and introducing a new way of viewing central economic terms such as value, products, business and utility.

Research on eco-efficient services is swiftly accumulating, and the chapters in the present volume aim to contribute to that body of knowledge. On the basis of published research, the following research needs and perspectives can be identified:

1. Direct impacts. While it may be useful to continue calculating the direct impacts of hopefully eco-efficient services, doing this service by service will be a momentous task. Another approach is to try to figure out what kinds of services are most promising from the point of view of dematerialization. Conceptually-based classifications, and the identification of what benefits different kinds of services can deliver can help focus such research, yet are insufficient alone to predict which services actually deliver dematerialization because of the unique processes involved in different kinds of services. An iteration between conceptual and empirical analysis seems the most promising way to discover under which conditions services actually reduce the need for natural resources.

2. Indirect impacts. In addition to, or in place of, direct benefits, developments surrounding a new service-orientation can help to introduce new business logics and new forms of consumption that in the long term may be turned into elements of a sustainable economy. It is also important to explore the ability of such ideas to alter economic logics (e.g., the balance of power between organizations, or within them), and the way in which products, services and value are understood. Do companies start to value existing products if they retain them in their ownership? Do manufacturing companies start to behave differently if they reconceptualize themselves as service providers? Are their interests aligned with their customers' ones? Do consumers consume more or less natural resources if their consumption shifts toward services?

3. Feasibility. Ongoing developments in the economy and within information technology indicate that a focus on services is emerging on its own momentum, but the services provided are not automatically eco-efficient. On the other hand, designers and academics are developing conceptual models for truly eco-efficient (or eco-effective, or sustainable, services). This indicates two pathways for research and development. One is to refine service designs until they are truly eco-efficient or sustainable, and then try to find out whether they are feasible in the market. Another is to look at what kinds of developments are emerging in the market, and try to figure out how they could be utilized or improved from the point of view of dematerialization.

Measuring Dematerialization at the Level of Products

4

Mikko Jalas

Chapter 1 on dematerialization and the macro-economic evidence reviewed the results of Materials Flow Analysis at the level of individual countries. The reviewed studies showed that that the economies have grown faster than the materials requirements of these economies and that this growth has thus resulted in a decrease in the average materials intensity of the economic output. This process was called the delinking of economic growth and materials use. The macro-economic developments are constituted by micro-level changes in products and processes, and thus changes in both the absolute use of materials and in the resource intensity of the economy are dependent on micro-level development. As such, the national, economy-wide statistics only provide a rear-mirror image of the developments in materials use. Micro-level indicators, therefore, add to an understanding of the changes in materials use.

The aim of this chapter is to consider how to measure changes in materials use at the micro-level of products or product-service-systems. Accordingly, the main interests of this discussion are not in a static materials intensity figures, but in the *change and evolution of product systems*. The ratio of value-added and materials requirement, which has been employed in macro-level studies, can also be used to describe changes at the micro-level, often referred to as eco-efficiency[85]. However, there are also other possible approaches to dematerialization at the level of product-systems. These alternative indicators illustrate different aspects of natural resource use, and thus may better serve different interest in the measurement of dematerialization. One of the questions that the following text addresses is the applicability of an eco-efficiency indicator to inform the discussions on structural changes and absolute reductions in materials use.

The notion of eco-efficiency is widely used by very different participants in the environmental discussion, but the methodological discussion on measuring eco-efficiency is scarce. This may be due to the fact that, despite the wide rhetoric use of the concept, there have been relatively few empirical studies on eco-efficiency at the product level (Helminen 2000). Furthermore, even though the existing methodological discussion on measuring eco-efficiency has addressed the question of which units of inputs and outputs to use (e.g. Reijnders 1998; Helminen 2000), different approaches to assessing the *changes* at the product level have received little attention.

This chapter will first look at the alternative approaches to measuring the dematerialization impact of a given product level change. The changes are viewed as exogenous, with no a priori link between the inputs and the outputs of the system. Hence, the interest lies merely in how the different ways of measuring eco-efficiency reveal changes in materials use. After an initial consideration of the conceivable approaches, the three most relevant ones are quantified. Section 4 uses data from an existing Dutch comparison of car ownership and car-sharing to demonstrate the implications of these different approaches. This is followed by a brief consideration of the practical implication of the results.

4.1 The points of reference for dematerialization

Dematerialization as a term has many interpretations, which were touched upon in chapter 1[86]. From the point of view of this chapter, the distinction between absolute and relative changes is essential, although it is by necessity to some extent arbitrary. Both absolute and relative changes have to be assessed against some point of reference. Frequently, absolute dematerialization refers to a change against a firm point of reference such as a physical area (such as a national state), a given population (per capita figures) or a pattern of basic needs such as nutrition or mobility. Relative change, on the other hand, is measured against a preferred output such the as size of the economy, the value-added of a production activity or the function of a product. Thus, in the case of relative dematerialization, both the required materials input of the economic activity and the achieved output of this activity can change and affect the dematerialization of the product or activity.

Another distinction can be made in terms of the level at which dematerialization is measured. Relative dematerialization of a product system can be observed against the product system itself or against a larger entity such as the national economy (e.g. Goedkoop et al. 1999). The former takes place when there is new value-added in the product system or when the materials use is lowered while the value-added stays the same. The latter form of relative dematerialization implies that a product-level change also contributes to relative dematerialization at the macro-level. A more detailed look in the following will show that eco-efficiency at the product level may not always contribute to delinking at the level of the economy.

The distinction between the micro and macro level can also be made pertaining to absolute dematerialization. Figure 4 displays the four categories of dematerialization that are created by the dimensions of absolute vs. relative dematerialization and product-level vs. macro-level reference points. The figure also indicates some of the possible reference points and potential interests served by a particular type of an approach. These interests are further discussed in section 4.4. The vertical distinction in figure 4 between absolute and relative dematerialization has been employed in macro-level studies, which frequently report the materials use in aggregate and per capita figures, but also in respect to the size of the economy (see chapter 1). However, this vertical distinction is more blurred at the level of product systems. Whereas eco-efficiency as a relation of value-added and environmental

	Product-systems	**Macro-level**
Relative dematerialization	*Points of reference:* *Value-added* *Product-unit* *Service-unit (e.g. MIPS)* *Interest:* *Business management and product development*	*Points of reference:* *GDP* *Per capita GDP* *Interest:* *Structural change of the economy* *Monitoring progress along the eKc*
Absolute dematerialization	*Points of reference:* *Product-unit* *Service-unit (e.g, MIPS)* *Set of basic needs (e.g., mobility)* *Time-use for a consumption activity* *Interest:* *Foresight of the process of ecological modernization and future materials requirements* *Sustainable life-styles*	*Points of reference:* *Physical area* *Per capita* *Interest:* *Management of physical carrying capacity* *International equity* *Monitoring the progress along the eKc*

Figure 4: Absolute and relative dematerialization at the level of product-system and at the macro level. For more details on the environmental Kuznets curve (eKc), see chapter 1.

impacts is clearly a measure of relative dematerialization, the approaches that focus on products, or on the ultimate services they yield, can be seen either as approaches to relative or absolute dematerialization. For example, the MIPS-concept (Materials Inputs Per Service) addresses the materials use per a unit of service, such passenger kilometres (Schmidt-Bleek 1994). Depending on the point of view, MIPS can be considered as a measure of either relative or absolute dematerialization. Because the reference of MIPS is a unit of service or utility, instead of a financial value of the output, it may offer a measure of absolute dematerialization from the point of view of a single company. However, as the quantity of the needed services is not fixed, MIPS does not measure absolute dematerialization in a similar manner as, for example, the per capita figures at the macro level. The same applies also to products. For example, the miniaturization of mobile phones clearly represents absolute dematerialization for the developers of the product, but as the phones also get cheaper and hence more wide-spread, such changes are not necessarily reflected in reductions in the aggregate materials use.

Efforts to measure absolute materials requirement at the level of product-systems may focus on a 'stable' set of basic needs. For example, Meijkamp (1998) has studied the *mobility* behaviour of car-sharing members, taking into account the changes in the use of various public and private modes of mobility. He concludes that car-sharing offers possibilities to lower the environmental impacts of mobility. As opposed to the impacts per passenger kilometre of the MIPS-indicator, such a measure of observed behaviour describes the absolute environmental impacts of all mobility-related activities[87]. Another possibility to consider the absolute materials requirements at the micro level is an approach that looks at requirements in terms of consumer time-use. This method decomposes the absolute per capita impacts to the various activities of consumers (see chapter 9).

The horizontal distinction between product systems and macro-level in figure 4 deals with the level of the reference point. The level of product systems - the micro level - is narrower, seeking to make comparisons of functional equivalents. At this level, a single improvement in a product can thus be assessed against an existing product-system with the same functionality or against the value-added of the existing system. The time use approach suggests a comparison of a new temporal activity against an old activity (with the same aim). On the other hand, the macro-level reference implies an assessment of how the product level change contributes to the macro-level materials intensity. As mentioned, in terms of relative dematerialization, these two levels of assessment lead to different and sometimes contradictory results. However, concerning absolute dematerialization, there is no such contradiction. A materials reduction at the micro level always also contributes to the lowering of the aggregate materials use, and, thus, the distinction of micro and macro level absolute dematerialization is less essential. To summarise, from the point of view of assessing product level changes in materials use, the following three aspects of dematerialization are most relevant:

- Relative dematerialization against the product system (D_p)
- Relative dematerialization against the average materials use of national economy (D_M)
- Absolute dematerialization at the product level (D_A)

4.2 Dematerialization as a ratio of outputs to inputs

4.2.1 Dimensions of input and output

The aim of this section is to progress towards quantifying the above-mentioned three aspects of dematerialization, which requires that they are defined more precisely at a conceptual level. In principle, dematerialization can be measured as a ratio of beneficial outputs to required inputs, but in practice the application of such indicators at the product level raises many questions. One of the questions relates to the selection of the output measures. The points of reference listed in figure 4 represent different alternative output measures, in which the outputs of relative dematerialization describe the benefits that are sought by the economic activity, such as the various services needed, financial value, welfare or wellbeing. Of these alternatives, the financial value of the good or service is easiest to define, and will be employed in the following. According to Helminen (2000), this is also a common practice when measuring eco-efficiency. Absolute dematerialization will be considered against a functional equivalent.

When an entire production chain is considered, the value-added of a product is equal to its price. In such a chain, there are ultimately no costs of natural resources, but all costs are either compensation for labour or for capital. Assuming competitive markets, if the product stays the same, the price and the value-added of the product cannot grow unless the costs of the factors of production or the consumer preferences change. Furthermore, productivity improvements that affect all the factors of production proportionally will not result in relative dematerialization because, in competitive markets, also the product price will be lower. Rather, it is only the changes in the share of the non-material and material factors of production that affect the relative materials intensity of the product system. Thus, it is the improvements in the efficiency of materials use or substitutions of labour for materials that create relative dematerialization. Under limited competition, where also profits exist, the growth of the profit is another possibility to achieve relative dematerialization.

Even in competitive markets, the value-added of the product system can increase if the product itself changes. The service discussion includes suggestions that some of the tasks related to product operation may be transferred from the customer or consumer to the manufacturer. For example, chemical leasing may increase the value of the output for the chemical manufacturer as its activities expand beyond the scope of pure manufacturing. Such an extension can also be viewed as one alternative to influence the relative shares of non-material and material inputs of production, if the service component mainly includes the use of labour.

The inputs describe the required factors of production or the negative environmental impacts to be avoided. For example, when assessing the productivity of an operation, the value of the output is placed in relation to the various costs of production such as those of labour and capital, of which capital also includes the internalized costs of the use of natural resources. As a proxy for all environmentally relevant capital, the dematerialization discussion uses the aggregate materials use. As a more limited approach that excludes the externalized environmental impacts, dematerialization can also be measured in terms of the costs related to materials (use). Such ratios of relative dematerialization and eco-efficiency are thus measures of partial productivity that focus on the materials productivity.

In order to achieve analytical clarity in the analysis, the dimensions of input and output should not overlap[88]. For example, if the output measure is the entire value-added of the product or service, which equals the various costs of production (labour and various forms of capital, materials among them), then the inputs should not have any monetary value. Alternatively, as suggested above, the factors of production can be divided into two groups according to their environmental impacts. This approach will be further developed in the following, even though such a distinction is arbitrary.

4.2.2 The qualitative aspect of dematerialization

In figure 5, an environmentally adjusted value-added (va) represents the output, in which the costs of materials are subtracted from the total value-added. It therefore contains the costs of labour and the cost of such capital that is not related to physical inputs from nature. The input measure consists of the costs that were subtracted from the total value-added, and is noted as materials (m). Using these dimensions, a product system P can be described as a vector that has a given environmentally adjusted value-added (va) as an output and a materials requirement (m), which together equal the price and the value-added of the product system[89]. A change in a product system can also be described as a vector, which has a component of non-material factors of production and a materials-use component. The change, thus, has a direction and a length; the direction defines the qualitative contribution of a change and, as will be discussed in the next section, direction and length together define the quantitative contribution of the change.

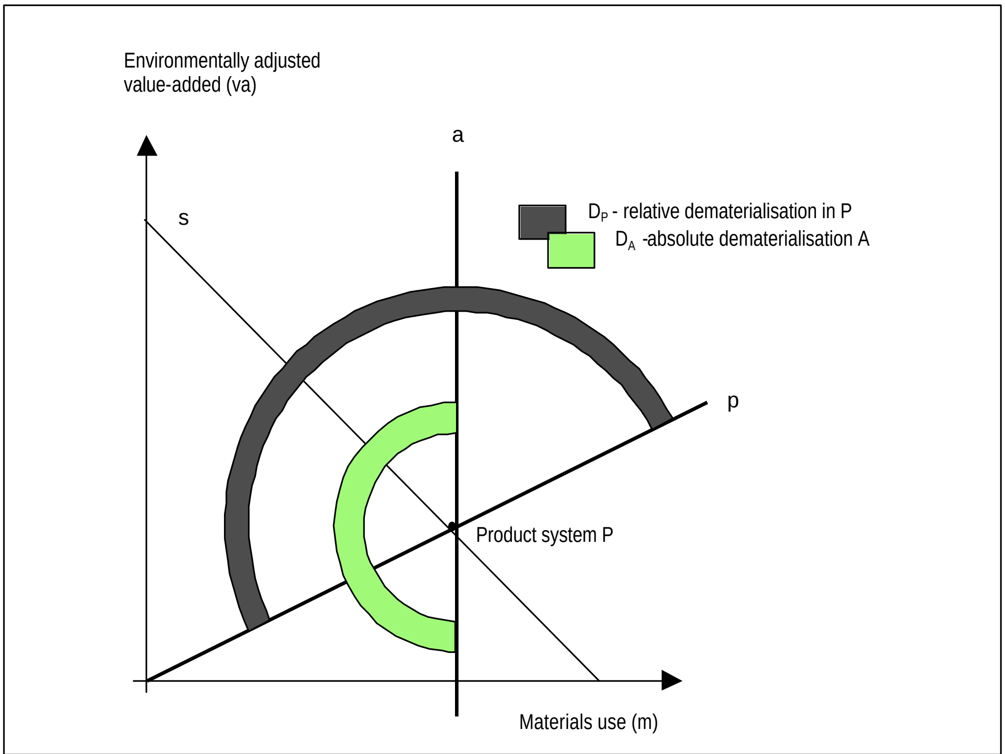


Figure 5. The dematerialization possibilities in a product system P. The initial materials intensity of the product system P is expressed as the slope of line p. The absolute materials requirements of the system P are expressed by line a. The sectors created by lines p and a indicate the directions of such changes that contribute to dematerialization respectively within the product system (D_P) and in absolute terms (D_A). The line s is the isocost of production and thus defines sectors of productivity increases and new value-added (increased costs).

As figure 5 points out, absolute and relative changes in materials use are not mutually exclusive. On the other hand, it is possible to achieve absolute dematerialization without relative dematerialization and relative dematerialization without absolute dematerialization. However, in all cases absolute and relative dematerialization coincide in the upper left corner of figure 5, in which materials inputs decrease and the other inputs increase. The upper left corner is further divided by the line s (isocost). Below this line lays the area of productivity improvements in which labour is substituted for materials. On the other hand, productivity improvements may decrease the need of labour by additional use of energy, automation or other materials intensive (i.e. labour extensive) inputs. Such changes in the product system lie in the lower right corner of figure 5, below the line s.

Productivity improvements depend on innovations and technology development. In the absence of such innovations, the non-material and material factors of production are mere substitutes. For example, an ecological tax reform, in the absence of new innovations, would tend to move product systems towards the upper left corner along the line s. However, because of innovations and technology development, it is also possible to move away from the line s, as suggested above. The lower left corner of figure 5 represents such radical innovative solutions that are able to reduce both the materials and non-materials costs of production.

Such productivity improvements that do not change the relation of materials and non-materials factors of production take place on the line p. These changes do not affect the materials intensity of the system and thus do not result in relative dematerialization. For example, car-sharing, which is considered later in this chapter, is a radical innovation that moves along the line p reducing both the non-material and material costs of mobility.

It can also be noted that the placement of the sector D_P depends of the initial materials intensity of the product system. Thus, the sectors in which absolute and relative dematerialization are mutually exclusive depend on the initial positioning of the product system. The more materials intensive a process is, the more of the absolute materials reductions are such that do not contribute to relative dematerialization. In materials intensive processes, the productivity improvements that take a direction towards the lower left corner may thus result in increased materials intensity although the absolute material requirements are lowered. In terms of relative dematerialization, the materials-intensive processes appear very sensitive to any such changes that lower the use of the non-materials factors of production. However, respectively, there are more opportunities for such value-adding changes that, despite additional materials use, also result in relative dematerialization.

New service components such as maintenance agreements or warranties may be added to existing product systems without any changes in original materials use. Such new additions take a direction towards the upper right corner[90]. New components that only use labour take place along the line a as there are no additional materials requirements. However, if (when) there is also a need for new materials factors of production, the change departs from line a, but may still result in relative dematerialization.

The discussion on the structural change of the economy presumes that in the course of economic development, sectors with low materials intensity, such as the 'service sector', grow and contribute to a delinking of the economy from the materials use. Such an anticipated impact is based on the assumption that the service sector has a *lower-than-average materials intensity*. The same question can be posed for any changes in a product system, even though an individual change in a product system does not itself change the materials intensity of the economy in the way envisioned by the discussion on structural change. Product-level developments can be reviewed and the decisions can be informed by comparing a product-level change with a macro-level reference as was suggested in figure 4.

In the following, the previous figure 5, which presented the concepts of relative (D_P) and absolute dematerialization (D_A), will be complemented with an average resource intensity m, which defines the sector of changes that contribute to relative dematerialization at the macro level (D_M).

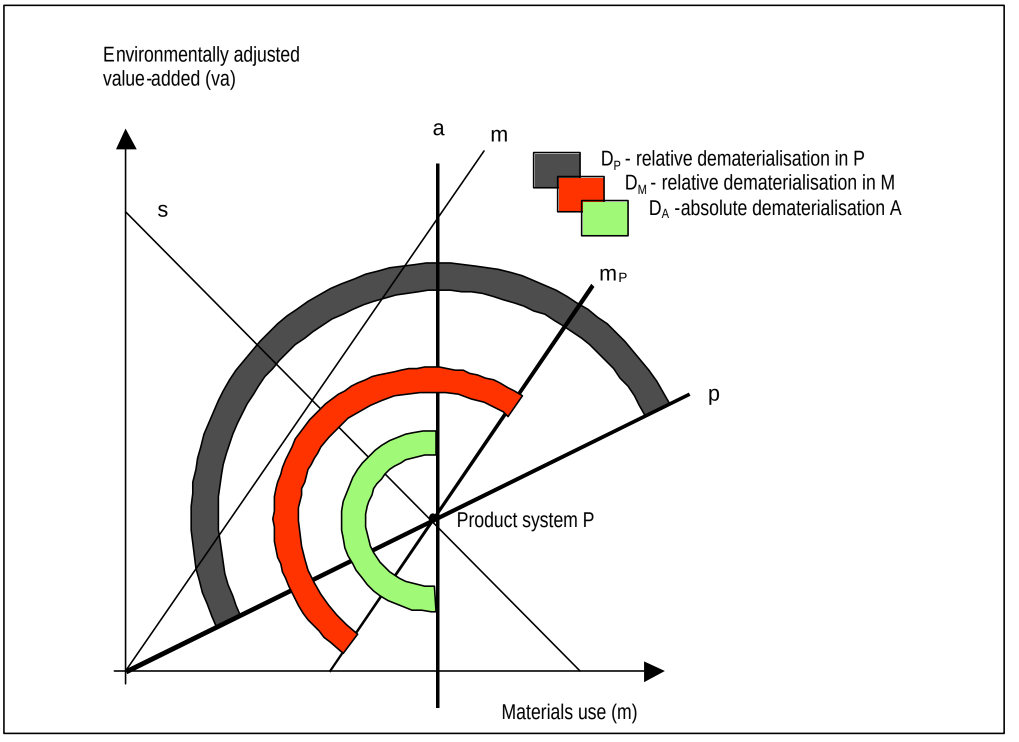


Figure 6. The dematerialization possibilities in a product system P. The initial materials intensity of the product system P is expressed as the slope of line p and the average materials intensity of the economy as the slope of the line m. The line m_P is parallel to m, but runs through the point P. The sectors created by lines p, m_P and a indicate the directions of a changes that contribute to dematerialization respectively within the product system (D_P), within the whole economy (D_M) and in absolute terms (D_A). The line s is the isocost of production and thus defines sectors of productivity increases and new value-added (increased costs).

Relative dematerialization at the macro level, like D_P and D_A, is always present in changes towards the upper left corner. Unlike the sector D_P, the sector D_M in figure 6 does not depend on the initial materials intensity of the system. The two sectors correspond to each other when the product system has the same intensity as the economy (lines p and m overlap), and in such systems the two perspectives of D_P and D_M do not differ. However, the more the intensity of the product system differs from the average intensity, the greater also the difference between the sectors of relative dematerialization within the product system and relative dematerialization at the macro scale.

4.2.3 The quantity of the dematerialization effect

A change in the product level can be presented as a vector with a given direction and length. The magnitude of the change itself is given by the length of the vector. However, the quantitative contributions of a change in each of the three dematerialization perspectives are defined by the projections of the change vector onto such lines that are perpendicular respectively to the lines p, m and a. These projections have their maximum length when the change vector is also perpendicular to the lines p, m and a. On the other hand, if a change takes place along the lines p, m and a, the respective contribution approaches zero. For example, a change that does not affect the relative shares of non-materials and materials inputs, takes place along the line p and thus does not contribute to relative dematerialization although it changes the absolute material requirements. Similarly, a new value-adding component that does not affect the materials requirements of the product system takes place along the line a, and does not contribute to absolute dematerialization.

Changes in product systems thus have a varying efficiency in terms of such goals as lowering the materials intensity of the product system (D_P), contributing to a structural change (D_M) or lowering the absolute materials requirements of the product system (D_A). The components of an efficient combination vary between the different dematerialization aspects, but in principle, all such combinations include a component of reduced materials input and increased non-material input, and as such they are all directed towards the upper left corner of the figures 5 and 6. Figure 7 uses the interpretation that (marginal) changes are most efficient when they are perpendicular to the lines p, m and a, respectively, and presents efficiency paths that are constituted of marginal changes along these normals of p, m and a. These paths are marked E_P, E_M and E_A. As the most efficient ratio for relative dematerialization at the macro level and for absolute dematerialization is constant, the respective efficiency paths are lines. However, E_P settles in an arc[91].

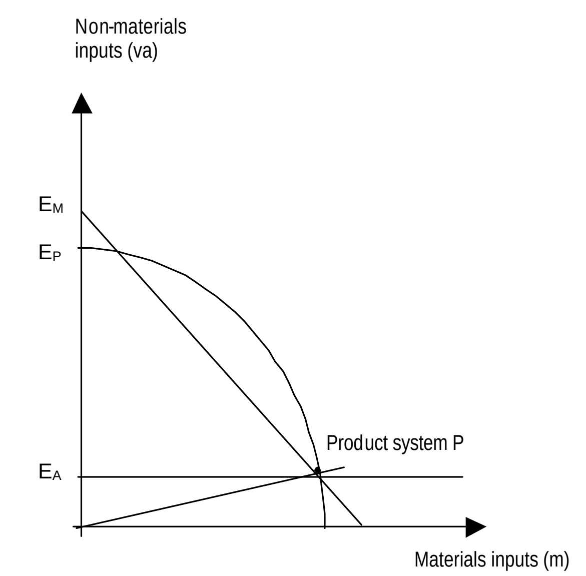


Figure 7. Three strategies of eco-efficiency improvements. E_P corresponds to the set of most effective incremental improvements of the value-added per environmental costs ratio, E_M to the most effective ways to contribute to dematerialization in a larger system M and E_A to achieve absolute dematerialization respectively.

The essential feature of figure 7 is that the paths take different shapes and that their tangents at any point P are not the same. Thus, an improvement appears as more beneficial from one aspect of dematerialization than from another. For example, decision making that takes place narrowly inside a given product system (P) views the path E_P to be most efficient, but leads to inefficient decisions from the point of view of achieving relative dematerialization in a larger system at the macro level (E_M), or absolute dematerialization (E_A). Furthermore, on E_P, there are little incentives for materials reductions in a materials-intensive process. It thus seems, taken this simplistic, commonly used indicator and a competitive environment, that materials-intensive sectors are locked in their position and can merely lower their materials intensity by new value-adding components such as services. On the other hand, on E_P, a very labour-intensive process is hardly credited for further value-added. E_P is, other things equal, the most effective path to lower the materials intensity of a product-system, but an assessment against D_P gives a biased view of the contribution of a product level change towards such goals as lowering the materials intensity of the entire economy or the absolute materials use.

4.2.4 A production function between non-material and material factors

The previous discussion regarded any changes in a product system as possible, and was mainly interested in how product-level changes show in the different approaches towards dematerialization. However, in reality, the factors of production are in relation to each other, and thus all changes, i.e., directions in figures 5 and 6, are not equally feasible. This relation was touched upon in the discussion on productivity improvements vs. mere substitution between non-materials and materials factors of production. It was argued that in the absence of innovations, there is no scope for productivity improvements. Furthermore as such non-innovative systems were supposed to be able to move along the line s (isocost), a perfect substitution between non-material and material inputs was presumed.

In reality, perfect substitutability would be a rare case. Rather, often the factors of production are presumed to have diminishing marginal utility, which implies that, for example, in materials-intensive processes, more materials are needed to substitute for the same non-material input; in materials intensive processes the few labour inputs are very valuable in materials terms. Figure 8. presents the efficiency paths of figure 7 and, in addition, a production function (u) of diminishing marginal utility.

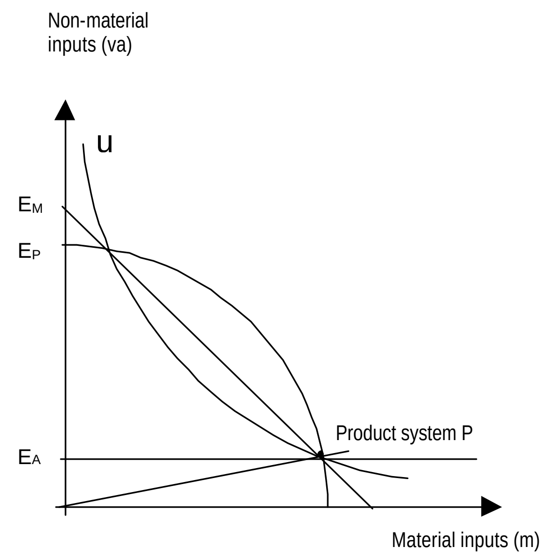


Figure 8. Efficiency paths and a production function u of diminishing marginal utility.

The production function u may better reflect the realistic (cost-effective) possibilities of substitutions between non-materials and materials factors of production. Product systems, which are driven to improve the productivity of materials use, by for example relative price changes, would then be more likely to follow the path similar to u instead of E_p. On E_p, the materials-intensive product systems appear to focus on adding non-materials inputs, whereas the systems with a non-materials bias seek to reduce their material inputs. On the other hand, assuming the diminishing utility of factors of production reverses these tendencies. The materials-intensive systems then make changes, that mainly effect their materials use, whereas the other systems makes moves that mainly imply increases in non-material factors of production. The difference between E_p and u again prompts a question of the applicability of the common eco-efficiency indicator E_p. If product systems evolve and dematerialize themselves along the production function u, both ends of the spectrum appear to be making less progress that the product systems with a closer-to-average materials intensity.

The differences between materials- and labour-intensive processes along the production function u appear more dramatic than they are. Moving on the production function u of figure 8 could imply, for example, a reduction of 10% in materials use and increase of 10% in non-material factors of production regardless of the initial materials intensity[92] . The positions of companies only appear different, because they are viewed from an external point of interest such as structural change of the economy or absolute reduction in societal materials use. However, to a large degree, it is these external interests that motivate the measurement of eco-efficiency.

The general conclusion of figure 8 is that, for purposes such as the reduction of absolute materials use or the delinking of economic growth and materials, it matters how eco-efficiency improvements at the product level are achieved. If a product system moves along the production function u, materials intensive processes need to make large absolute reductions in materials use in order to achieve given eco-efficiency improvement. On the other hand, if they are able to increase the value-added (for example a paper mill shifting to high-quality papers), it is possible to increase eco-efficiency without materials reductions. The delinking effect of a product-level change also depends on how the eco-efficiency improvement is achieved. The contribution peaks when the change takes the direction of E_M. Thus, if the product systems follow the production function u, the systems that are close to the average intensity of the economy, contribute the most to the delinking process. Because of such biases it is evident that any eco-efficiency improvement, i.e., an increase in the ratio of value-added and environmental impacts needs to be considered in terms of changes in each dimension. For the common cause, it matters whether, for example, a factor four improvement has been achieved by doubling the value-added and halving resource use, or by another combination of changes along the dimensions.

4.3 The case of car-sharing

Car-sharing is one of the most often-used examples in the service discussion. Chapter 3 reviewed some of the mechanisms that contribute the environmental benefits of such systems. This discussion often focuses on the absolute dematerialization potential of an innovation, by referring to options of shared product use and longer product life. The changes in the value-added of the production activity, which form the other dimension of dematerialization discussion, have received less attention. This section uses existing Dutch data on a car-sharing system to point out that a single change may provide quantitatively and qualitatively different results in terms of the three perspectives of relative dematerialization within the product system (D_P), relative dematerialization at the macro-level (D_M) and absolute dematerialization (D_A).

Goedkoop et al. (1999) have compared two existing alternative product systems: private car ownership and car-sharing membership. They address both dimensions of the eco-efficiency concept by looking at the cost of using these systems and the environmental impacts of these two product systems. The cost dimension sums up the different cost items and represents the entire value-added of the product system. The figure of the environmental impact is not based on materials requirements, but on an evaluation of characterized emissions and wastes. Some of these impacts are related to internalized materials costs, but some relate to such impacts that are not reflected in the costs of the system.

Goedkoop et al. use secondary data on car ownership and car-sharing[93] . The reliability and validity of the numerical data are hard to estimate. However, the point of this discussion is not so much to assess the dematerialization potential of car-sharing, but rather to demonstrate the implications of the different approaches to measuring dematerialization. Table 7 presents the components of the mobility patters of car ownership and car-sharing with the value-added and the environmental impact of each component.

Table 7. The value-added and the environmental impact of the components of two mobility patters; car ownership and car-sharing (Goedkoop et al. 1999).

System/component	Value-added [DFL]	Environmental impact [mPt]	Eco-efficiency [DFL]/[mPt]
Car ownership /month			
Production	110	120	0,92
Interest	32	7	4,57
Insurance	47	10	4,70
Tax	17	4	4,25
Gasoline use	71	250	0,28
Maintenance	18	12	1,50
Disposal	2	-48	-0,04
Use of public transport	80	45	1,78
Total	**377**	**400**	**0,94**
Car-sharing /month			
Subscription	40	9	4,44
Using the car	43	88	0,49
Driving	48	166	0,29
Use of public transportation	90	50	1,80
Total	**265**	**281**	**0,94** System

According to Goedkoop et al. (1999), car-sharing has both lower environmental impacts and a lower value-added, but the ratio of value-added and environmental impacts of both car ownership and car-sharing is the same. They conclude thus that car-sharing is a cost-effective way to reduce the environmental impacts of mobility, but that it does not carry clear de-linking potential.

This conclusion applies for relative dematerialization at the level of the product system (indicated as D_P in the previous analysis). This product-level conclusion can be complemented by interpreting the data of the study against the other aspects of dematerialization that were put forward in the previous analysis[94]. In order to address the delinking potential at the macro level (D_M), it is necessary to derive an estimate of the average environmental impact of the Dutch economy as measured by Goedkoop et al. (1999). Table 8 compares the eco-efficiency values of the two most significant individual components of table 7 with the materials intensity values reported by Mäenpää et al. (2000). Assuming that the relative impacts are the same for both methods and both countries, it is then possible to derive a rough estimate of the overall eco-efficiency of the Dutch economy that is comparable with the data of Goedkoop et al.

Table 8. A comparison of the eco-efficiency values of Goedkoop et al. (1999) and the materials intensity values of Mäenpää et al (2000).

	Mäenpää et al. (2000) [FIM/kg][a]	Goedkoop et al. (1999) [DFL/mPt][a]	Computational value of average eco-efficiency of the Dutch consumption expenditure [DFL/mPt]
Gasoline use	4,55[b]	0,28	0,23
Car manufacturing	9,09[c]	0,92	0,37
Average of the Finnish household consumption expenditure	3,70		

a Calculated with consumer prices, which include subsidies and taxes

b The use private vehicles

c The purchases of private vehicles

The two computational values of the average environmental impact of the Dutch economy in table 8 differ, but are of the same magnitude. For the purpose of further analysis, an average value of 0,30 DFL / mPt will be used in the following. Based on tables 7 and 8, it appears that both the system of car ownership and car-sharing have almost the same eco-efficiency value, which is higher than that of the whole Dutch economy. These counter-intuitive conclusions are partly explained by the fact that 80% of the costs of the car ownership system are fixed rather than related to fuel consumption (see table 7). Thus, even though car-sharing involves increases in the use of public transportation, its effect remains mainly a scale-effect instead of a structural effect that would show in the eco-efficiency figure. Intuitively, one might also expect car ownership to have a lower eco-efficiency value than the average consumption expenditure. However, this is also explained by the cost structure of car ownership. In addition, it is noteworthy that, since the analysis is based on consumer prices, fuel taxes significantly improve the eco-efficiency of fuel consumption as they add costs without any environmental impacts.

Figure 9 places the results of Goedkoop et al. (1999) into the framework of analysis presented in section 4.2. It shows the aggregate value-added and environmental impacts of both systems of car ownership and car-sharing (see table 7) and the resulting change vector between these systems. Both the relative dematerialization at the product level (D_P) and the absolute environmental gains (D_A) can be observed on the basis of these data. However, because car-sharing does not affect the ratio of value-added and environmental impacts, the change vector of D_P is not visible in figure 9. In addition, the figure employs the rough estimate of the average eco-efficiency ratio of the Dutch consumption expenditure to quantify the relative dematerialization impacts at the level of the economy.

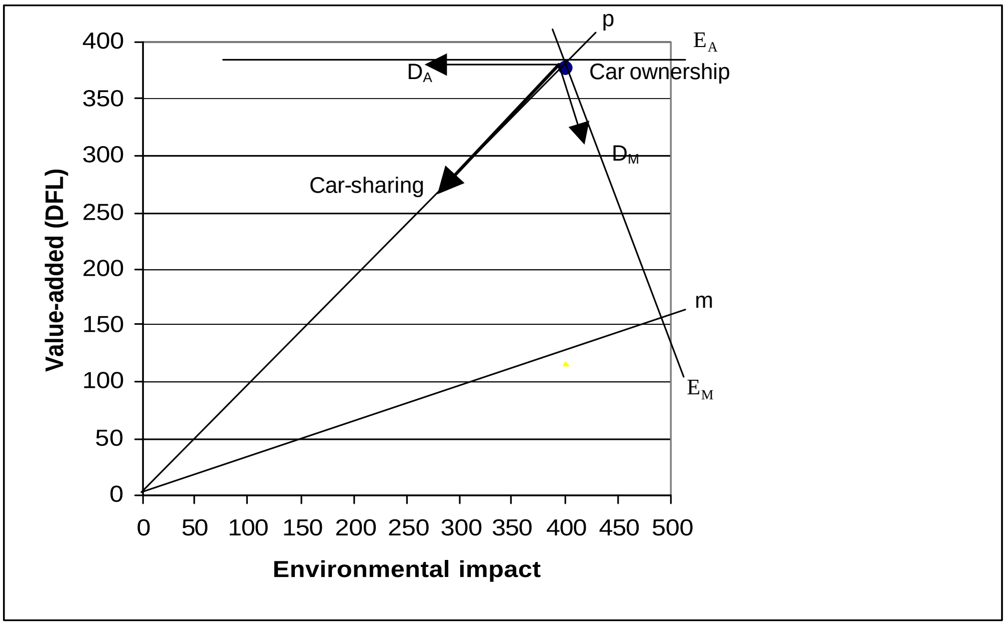


Figure 9. The value-added and environmental impacts of car ownership and car sharing according to Goedkoop et al. (1999) compared with an estimate of the average value-added per environmental impact Bratio of the Netherlands (m). To achieve the vectors D_M and D_A, the change from ownership to sharing is projected on E_M and E_A.

Based on figure 9, it can be concluded that car-sharing as it is presented by Goedkoop et al. (1999) contributes

- positively to the absolute dematerialization of the transport system and the Dutch economy

- insignificantly to the relative dematerialization of the transportation system in reference to value-added
- negatively to the relative dematerialization of the Dutch economy, when using the rough estimate of the average eco-efficiency figure derived from table 8

The reliability of both the data on car-sharing and the estimate of the average Dutch value-added per environmental impacts ratio contain many uncertainties. Thus, the dematerialization effects derived in the example of Dutch car-sharing should be viewed only as indicative. However, the results serve to point out the differences in measuring dematerialization.

4.4 Practical implications for measuring dematerialization and eco-efficiency

Figure 4 identified four different approaches to dematerialization, which also have a different fit with the varying interests of businesses and policy-making. In private enterprises, the relative improvement, i.e., efficiency of materials use, may have an overriding position, but in environmental policy-making, efficiency may be merely instrumental for managing absolute materials use. Clearly, efficient use of resources is a legitimate target, but efficiency does not necessarily contribute to an absolute reduction, let alone by itself assure such development.

4.4.1 Environmental policy-making

The interests of policy-making and business differ in terms of the reference level of relative dematerialization. Policy-making, initially concerned with the state of the environment, needs to have a view on the dematerialization potential that individual product changes offer to reduce the overall environmental impacts. An assessment against the dematerialization strategy E_M informs the policy-maker on how the individual product-level improvements perform in terms of the structure and intensity of the economy in general. Businesses, on the contrary, need information of the performance of their products and services as compared with alternative or previous designs. For them, an assessment against the national economy may only have indirect value as a record of the likely acceptance of such product-level changes.

However, the feasibility of changes and improvements greatly affects the magnitude to which they are undertaken. Therefore, even though some of the business-level incentives may not result in optimal actions from the point of view policy-making, they may provide the path 'of least pain' towards relative and absolute dematerialization also at the macro level. Thus, an analysis of how policy should be used to guide business level activities should also be interested in relative dematerialization at the product level.

4.4.2 Business management and product development

Eco-efficiency as first proposed by the WBCSD was to be an operationalization of sustainable development at the business level. The notion calls for improvements both in terms of economic benefits and environmental impacts (WBCSD 1996). The ratio of value-added and environmental impacts is the most common way to quantify eco-efficiency. However, there has been very little empirical work on eco-efficiency (Helminen 2000).

The lack of empirical analyses of eco-efficiency may be due to the fact that it is often difficult to disentangle the environmentally-driven improvements from other changes in activities. The strategies of companies are affected by the economic, technological and institutional environments in which they operate, and neither the value-added nor the materials use can be decided by the company alone, but the operating environment conditions the changes. Therefore, even if the ultimate aim of a company in terms of materials use was to increase its eco-efficiency, the strategy of how to achieve such a change is likely something else than the theoretical, most effective path of E_p. For example, in the materials-intensive sectors of production it could be relatively easier to lower the materials use than to increase the value-added of the products, even if this was the most efficient ways to improve the eco-efficiency of products. The production function of diminishing marginal utility is an example of such external constraints.

Some of the approaches to measuring dematerialization can be based on company-internal data, but others require information on the price of the product in the market and on the ways the product is used. For example, comparison against a functional unit, such as the MIPS concept, can take place within the design process prior to the existence of the product. It is merely a matter of calculating the materials use of the various alternative ways to provide the same service. The assessment of relative dematerialization against the economic value-added requires, on the contrary, knowledge of the price of the product and, if economy-level impacts are to be considered, of the average performance of the economy.

The measurement of absolute dematerialization also requires market information. As figure 4 proposed, absolute dematerialization can be measured against a firm set of basic needs or against the time-use of consumers. For example, the observed mobility behaviour of car-sharing members indicates absolute changes in the need pattern of mobility. However, such a pattern can not be designed beforehand in product development, but depends on the ways users accept and adopt the concept. The time-use of consumers is also a phenomenon that cannot be designed by the providers of the goods and services. Both of these approaches extend to wide areas of the everyday life of consumers. As such they also cross company borders and expand boundaries, and at least so far, few companies are prepared to address such wide areas of needs and resource use.

4.5 Conclusions

Although what matters from the point of view of the environment is the absolute level of natural resource use, targets for resource intensity have gained increasing interest in policy making (Reijnders 1998, Nord 1998). This reflects policy-makers' preoccupation with economic growth. Accordingly, resource flows and environmental impacts must be managed in relation to economic growth. However, the macro-level development is a consequence of product- or micro-level changes. Therefore, it is also useful to consider the relation of product-level indicators and the macro-level developments.

This chapter has presented a conceptual framework for measuring changes in materials use at the level of product-systems. An effort to bring concepts from the macro-level to the product-level raises questions of the applicability and usefulness of such indicators. The framework that was developed identified three alternative perspectives to product-level changes, which all are informative of the role of such changes in dematerialization. These perspectives were 1) relative dematerialization within the product system, 2) relative dematerialization against the economy in general and 3) absolute dematerialization at the product level.

Eco-efficiency, defined as the ratio of the economic value-added and the environmental consequences of the activity, is one of the most predominant indicators of dematerialization at the product level. This conceptual work pointed out that there are methodological difficulties in using these dimensions, as the value- added and the environmental impacts are not independent of each other. As another approach, it was proposed to divide the costs of production into non-materials costs and environmentally relevant (materials-intensive) costs. In such a framework, reductions in materials use can then take place if non-materials factors of production are substituted for materials use. This simultaneously increases the labour-intensity of the product system. The other possibility to reduce materials intensity is to promote radical innovations that reduce both material use and non-materials factors of production. Such new innovations should make the product level changes cost-effective and attractive to new users. However, they do not change the cost structure of the product system and, thus do not raise the eco-efficiency of the system, as was demonstrated with the example of car-sharing.

Even in absence of any change in the relative prices of materials and non-material factors of production, significant reductions in materials use may take place through radical innovations that improve the productivity of both types of inputs, as was exemplified by the case of car-sharing. However, as there is less scope for relative dematerialization at the product level (eco-efficiency) or at the macro level (delinking), such innovations are hard to combine with economic growth and employment. A tax reform, which changes the relative prices, on the other hand, is conductive to such developments in which both the environmental and economic targets are achievable.

Concerning the applicability of the proposed measures for dematerialization, it is apparent that companies are better equipped to perform analyses of the relative dematerialization at the product level. Such analysis does not extend the scope beyond the information that is available in the value chain of the product. However, it is equally apparent that the ultimate interests behind any ‘policy on materials use’ lays outside such product-level effects. The product-level assessments of relative dematerialization can, nevertheless, be informative also in this respect. Then, if assessing the relation of value-added and materials use, it is not only the change in the ratio that is of interest, but also the contributions of the changes in the two dimensions separately.

Part II
Empirical Studies From Finland

The Role of Dematerialization in Achieving Environmental Goals in the Energy Sector: The Finnish Evidence from 1980 to 2020

5

Raimo Lovio

Potentials for dematerialization are studied in this volume in many articles through cases. In these cases energy saving is a crucial part of dematerialization. This article aims at taking a big picture and looking at the whole energy sector, that is energy production and consumption from the macro perspective. In addition to structural and efficiency development in production, some other factors that effect energy consumption are considered.

Energy production and consumption cause a lot of environmental problems. Especially, the amount of many different types of air emissions - such as carbon dioxide, sulphur dioxide, nitrogen oxide, particle and lead emissions - depends on the volume and nature of the energy sector in a country.

Energy-related environmental problems could be solved by two ways, which for purposes of simplicity are called 'dematerialization' and 'detoxification' in this article. Dematerialization includes all ways to save energy in order to slow down or even stop the increasing use of energy. Dematerialization can be relative, which means that energy consumption per Gross Domestic Product (energy intensity) decreases, or absolute, which means that the absolute amount of energy consumption declines. Detoxification refers here to all measures by which it is possible to reduce emissions per energy consumption unit (including also non-toxic emissions such as carbon dioxide emissions).

The article focuses on two issues. First, the role of dematerialization is compared to that of detoxification in solving energy related environmental problems. More accurately, the question is whether the role of dematerialization is becoming more important than that of detoxification. The second interesting question is how dematerialization is progressing in the energy sector. Is it possible and probable that the growth of energy consumption ends in the near future, for example by 2020, in countries like Finland?

The empirical basis in examining the questions is the Finnish historical data on energy consumption from 1980 to 2000. In addition, focus is placed on the future energy consumption scenarios presented in the National Climate Change Strategy Statement, which was given by the Finnish Government in spring 2001.

5.1 Energy consumption, total material flow and labour input

Energy input is only one factor needed in production. In addition, there are inputs of other natural resources, labour and capital. Here the dissimilar productivity development of different production factors is the most interesting question. It seems to be that at least so far there have been fewer possibilities and/or less eagerness to increase the productivity of energy than that of other production factors.

Material flow analyses (MFA) include energy production and consumption as one component. The share of energy-related components varies a lot depending on how material flow analysis is calculated and which material flows are included (see

Chapter 1 in this volume). For example, in the Finnish material flow analyses energy use is included in material flows through energy fuels (Mäenpää et al. 2000, Hoffrén 2001). According to Mäenpää et al. (2000, 40 - 43), the share of energy fuels in total material requirement (TMR) in Finland has grown from 16 % in 1970 to 18 % in 1996.

Energy savings correlates with savings in other natural resources. A light car uses less fuel than a heavy one. On the other hand, energy input can compensate the use of other natural resources. For example, recycling of paper decreases the use of virgin fibre, but the recycling process necessitates some energy input. Thus, we might consider that the possibilities to save energy are not as viable as the possibilities to spare the use of other natural resources.

Energy input also correlates with labour input. The increase of labour productivity, which has been one of the most important goals of economic policy through decades, has been achieved partly by increasing the use of energy. For example, from 1975 to 1999 in Finland the labour input (total hours worked) decreased by 13 %, whereas the energy input increased by 69 %. In Germany, labour productivity increased by 307 % between 1960 and 1995, whereas the equivalent rate for energy was only 131 %, for natural resources 149 %, and for water 136 % (Bleischwitz 2001: 24).

So, it seems to be evident that savings in energy input are less easily achieved than savings in the use of other natural resources or in labour input. Partly this relates to the relative prices of different production factors. If the relative price of energy to, for example, labour input could be increased through market prices or energy taxes, companies and consumers would feel more motivated to save energy. So far, changes in relative prices have been minor, because willingness to pay energy-related external environmental costs has been low.

5.2 Dematerialization and detoxification in the energy sector

The growth of energy consumption is influenced by three factors: the growth rate of the economy, changes in the structure of the economy and changes in the energy efficiency of different activities. Structural and efficiency changes have been introduced to slow down the growth of energy consumption in order to keep the overall growth rate of the economy high enough to keep the unemployment rate as low as possible. Due to structural and efficiency changes, the energy intensity of the economy decreases. Structural changes can take place at the macro level (the share of the service sector increases) or at the micro level (light industries replace heavy industries). Changes in consumption structure are correlated to changes in production structure but because of foreign trade these changes are not identical. Efficiency improvements can take place in energy production and distribution and in other production and consumption.

The detoxification process of the energy sector can be accelerated in many different ways. First, the energy source breakdown can be changed in favour of less harmful energy sources (for example by replacing fossil fuels by renewable energy sources). Second, the processes of energy production and consumption can be improved so that fewer emissions are generated (for instance by new burning processes). In addition, different kinds of end-of-pipe technologies can be used to decrease the harmfulness of the emissions.

Dematerialization and detoxification can be added into the well-known I=PAT identity by way of a minor reformulation (by leaving Population out and dividing Technology into two coefficients) as follows:

- emission(s) = GDP * E / GDP * emission(s) / E, in which E = energy consumption and GDP = Gross Domestic Product
- for example CO_2 = GDP * E / GDP * CO_2 / E

In this identity the E / GDP coefficient indicates the dematerialization process and the emission(s) / E coefficient detoxification development (e.g., decarbonization).

Various kinds of decomposition methods have been developed in order to separate structure and efficiency gains from each other (see e.g., Sun and Meristö 1999, Hoffrén et al. 2001). However, the borderline between these two is not clear-cut: the effects of structural change within industries due to new product development are difficult to separate. It should also be noted that the total energy consumption is not affected by the GDP alone. For example, in Finland one fifth of the energy is used for space heating, and the annual amount of space heating energy depends also on fluctuations in degree-days (especially on the average winter temperature), and not only on the volume of building space, which correlates with GDP changes.

Therefore, the aim in the following is not to make a simplifying statistical decomposition analysis. Instead, the analysis focuses on drawing a more detailed picture of factors that have affected the use of energy in the recent decades and will continue to do so in the decades to come.

5.3 Dematerialization vs. detoxification in the energy sector in Finland 1980 - 2000

Total energy consumption clearly increased in Finland in the 1980s and 1990s: in the 1980s by 20 % and in the 1990s by 13 %. In spite of the growth, many energy-related air emissions, namely sulphur dioxide and particle emissions, decreased absolutely (see Table 9). In their cases absolute reductions have been achieved due to changes in the energy source breakdown, improvements in burning processes and new end-of-pipe-technologies. Clearly, the role of detoxification has been more important than that of dematerialization in diminishing these environmental problems.

Table 9 also demonstrates that carbon dioxide and nitrogen emissions have not declined in the 1990s. This is because there has been no efficient and economically reasonable end-of-pipe technology available to control the development of these emissions. Especially the carbon dioxide emissions have only been affected by changes in the breakdown of energy sources. In the following, the role of dematerialization in the energy sector will be studied in the light of carbon dioxide emissions.

In 2000 carbon dioxide emissions from Finnish energy production and consumption were at the same level as they were in 1980 and 1990, even though the GDP had grown significantly. CO_2 emissions have not increased because of detoxification: the share of fossil fuels as an energy source has decreased. In addition, dematerialization has played its own role: the energy intensity of the economy has decreased. Table 10 shows, however, that in the 1980s and 1990s the role of detoxification has been more important than that of dematerialization also as to CO_2 emissions: the CO_2 / E coefficient has decreased faster than the E / GDP coefficient.

Table 9. Sulphur dioxide (SO2), particle, nitrogen oxide and carbon dioxide emissions from energy production and consumption and from industrial processes, and lead emissions from road transportation and energy production in Finland 1990 B 2000 (Statistics Finland 2000c, Statistics Finland 2001b).

Year	Lead(1)	SO2 (2)	Particles (3)	NO2 (4)	CO_2 (5)
1990	229		86,4		53,9
1991	184				53,1
1992	133	140,5	**61,4**	42,1	51,5
1993	58	122,5	56,6	32,4	52,2
1994	13	114,6	52,9	24,7	58,5
1995	10	96,6	48,5	19,0	55,1
1996	10	105,1	51,3	22,3	61,6
1997	9	99,3	51,7	24,3	59,8
1998	11	89,6	49,9	32,3	57,4
1999		85,1	50,1	43,1	56,8
2000					54,0

(1) Lead emissions from energy production and road transportation (Luonnonvarat ja ympäristö 2000).
(2) Sulphur Dioxide Emissions from Energy Production and Consumption and from In dustrial Processes, 1000 t SO2 (Statistics Finland 2000d)
(3) Nitrogen Oxide Emissions from Energy Production and Consumption and from In dustrial Processes, 1000 t NO2 (Statistics Finland 2000d).
(4) Particle Emissions from Energy Production and Consumption and from Industrial Processes, 1000 t (Statistics Finland 2000d).
(5) Carbon Dioxide Emissions from Energy Production and Consumption and from In dustrial Processes (total Foss. + Peat), mil. T. CO_2 (Statistics Finland 2000d, KTM 2001a).

Table 10. Average annual changes of GDP, energy consumption, E/GDP and CO_2 /E coefficients in Finland 1981 B 2000.

Average annual change	GDP	Energy Consumption	E/GDP	CO_2 /E
1981 – 1990	+ 3,12 %	+ 1,91 %	- 1,12 %	- 1,83 %
1991 – 2000	+ 2,26 %	+ 1,27 %	- 0,84 %	- 1,17 %
1996 – 2000	+ 5,09 %	+ 1,59 %	- 3,32 %	- 2,19 %

All in all, it can be stated that so far in the Finnish energy sector the role of detoxification has been more important than that of dematerialization in achieving environmental goals concerning air emissions. The question however remains whether the situation in this respect is changing. As an indication of such a potential change, Table 10 shows that the decrease of energy intensity was very fast in the late 1990s, even faster than the decarbonization of energy consumption. Is this change permanent and a sign of transition to a new era in solving energy-related environmental problems?

5.4 Main explanatory factors behind dematerialization in the energy sector in the 1990s

In Finland, the dematerialization process in the energy sector was faster in the 1980s than in the 1990s. In the 1980s energy intensity decreased annually on the average by 1,1 %, but in the 1990s by only 0,8 %. However, the situation in the 1990s varied a lot. In the early 1990s the energy intensity grew, whereas in the late 1990s it decreased by as much as 3,3 % annually. The fluctuation in the development of energy intensity can be explained by changing circumstances in the Finnish economy and policy.

First, the Finnish GDP decreased in the early 1990s due the severe recession, so that the level of 1990 was not reached until 1996. Because only part of the energy consumption is directly affected by short-term changes in the GDP, it is natural that the energy intensity increased during this period. And, for the same reason, when the strong economic growth started again in the late 1990s, energy intensity declined.

The share of manufacturing industries in the Finnish economy increased in the early 1990s because of a clear slump in the construction and service sectors. In addition, the manufacturing industries maintained their high share due to a rapid increase in the export production of telecommunication equipment in the late 1990s. The share of manufacturing industries grew from 26 % in 1990 to 29 % in 1995 and in 2000 it was as high as 30 %.

The third factor behind the fluctuating development of energy intensity in the 1990s was changes in energy prices. In the early 1990s, real prices of fuels were quite stable and even falling. For example, the real world market price for cruel oil was in the middle of the 1990s at the lowest level since the first oil crisis in 1973. In 2000, however, the price of oil leaped up. In the Nordic countries, the price of electricity was also low in the late 1990s because of a large electricity supply based on water resources due to rainy years. Thus, energy saving activities were not supported by the energy price development until the very end of the decade.

Fourth, environmental incentives and policy pressure towards energy savings were not strong in the early 1990s. Many air emissions actually declined; and carbon dioxide emissions were attached political importance only after the Kyoto Protocol in 1997.

All in all, the fast decrease of energy intensity in the late 1990s in Finland can be mainly explained by these four factors, which in the early 1990s did not support energy saving activities but then gained some new power. Hence, the fast drop in energy intensity in the late 1990s should hardly have been possible without the development in the opposite direction in the early 1990s. In order to discover the real trend behind this fluctuation, the issue needs to be approached more carefully by looking at final energy consumption trends by sector (transportation, space heating and industry).

The first clear trend factor is that the growth of energy consumption in transportation changed dramatically from the 1980s to the 1990s. Energy consumption in transportation increased by 44 % in the 1980s, but only by 1 % in the 1990s. In 2000, energy consumption in transportation even decreased by 1 % as a consequence of the rise in oil prices. Behind this dramatic change is the fact that the national stock of automobiles increased very slowly in the 1990s. Furthermore, the fuel efficiency of new cars improved step by step.

Consumption of energy for space heating also grew very slowly in the 1990s. This can be explained by slow growth in the stock of buildings and industrial spaces, improved energy efficiency in new and old buildings and warm winters. For example, in the 1990s in Helsinki degree-days per calendar year were on the average 6 per cent lower than in the 1970s and 1980s. In addition, the year 2000 was very warm in the whole country and therefore energy consumption for space heating decreased by 7 %. Here we can see that in northern countries such as Finland the climate change paradoxically slows down its own cause, the growth of energy consumption, to some extent.

Due to the slow growth of energy consumption in transportation and for space heating the share of energy consumption in industry increased from 45 % in 1990 to 50 % in 2000. The energy consumption in industry grew between 1990 and 2000 by 27 %. On the other hand, during the same time the production volume of the industry grew by 58 per cent! Thus, the energy intensity of manufacturing industries decreased very rapidly. The major reason behind this was a strong structural change. The growth of the Finnish industry was strongest in the manufacturing of electrical and optical equipment - such as telecommunication equipment - and in the manufacturing of machinery and equipment. Energy intensity in these two industries is the lowest among manufacturing industries. For example, it can be calculated that from 1991 to 1999 58 % of the growth of value-added in manufacturing industries in Finland took place in these two industries, and therefore their share in the whole manufacturing value-added increased from 18 % to 35 %. During the same period, the share of the three most energy-intensive manufacturing industries (paper, basic metal and chemicals) declined from 32 % to 29 %. In this way the structure of the Finnish industry changed clearly towards a less energy-intensive direction, although the new light industries mainly replaced traditional industries - such as food and textile industries - which use energy at an average level.

Besides structural gains, also energy efficiency gains have been attained in many areas. A new factor here is the use of information technology and other 'new economy' phenomena (see Romm et al. 1999 and Laitner 2000, and chapter 2 in this volume).

The above evidence indicates that the fast decrease in energy intensity in Finland in the late 1990s (annually 3.3 %) can for the most part be explained by development in the opposite direction in the early 1990s, the warm temperatures of the year 2000 and high price of oil in 2000. However, it also indicates that there are new permanent factors - such as the slow growth of energy consumption in transportation and for space heating and ICT-related structural and efficiency gains - due to which it is very likely that the annual decrease of the energy intensity of the Finnish economy will in the future be higher than only 1 %.

5.5 The future role of dematerialization until 2010

The Finnish Government has agreed to the Kyoto Protocol and the related EU agreement of the goals for different EU countries. According to these agreements, Finland's greenhouse gas emissions should in 2010 be at the same level as where they were in 1990. Plans to reach this goal are presented in the Finnish National Climate Change Strategy Statement, which was given by the Government to the Parliament in Spring 2001 (Kansallinen ilmastostrategia 2001, KTM 2001b).

The strategy includes three scenarios on the development of energy production and consumption from 2000 to 2010 and to 2020. The BAU (business as usual) scenario portrays a development that does not include any new measures to save energy or to change the energy source breakdown. This scenario would mean such a remarkable growth of energy consumption that the limits of the Kyoto Protocol would be exceeded. In turn, the two other scenarios in the strategy document - called KIO1 and KIO2 - would enable compliance with the Kyoto Convention, meaning zero growth in carbon dioxide emissions. This goal will be achieved by promoting energy saving activities by new norms and energy taxes, and by certain new development programmes for renewable energy technologies. In addition, in the KIO1 scenario natural gas would replace the use of coal, whereas in the KIO2 a new nuclear power mill would replace coal.

In the following, the KIO1 scenario will be examined more carefully. This scenario is more optimistic than the other two as to the future development of energy consumption, although the difference is not very big (in the BAU scenario energy consumption would in 2010 be only 7 % higher than in the KIO1 scenario). The KIO1 scenario assumes that the growth rate of the Finnish economy should stay rather high: the average annual growth rate would be 2,8 % until 2010 and even after that as high as 2,1%. Energy consumption is estimated to grow more slowly than before: the average annual growth rate would be 0,8 % until 2010 and after that only 0,4 %. In other words, the dematerialization process is expected to accelerate. It is roughly estimated that the energy intensity would decrease annually by 2 %, instead of 1 %, as was the case in the 1980s and in the 1990s. As a consequence, the zero growth of carbon dioxide emissions would be more dependent on the dematerialization process than on the decarbonization of energy sources: the E/GDP coefficient would now decrease faster than the CO_2 /E coefficient (see Table 11).

Table 11. Annual changes of GDP, energy consumption, E/GDP and CO_2 /E in Finland, historical figures for 1981 – 2000 and figures according to the KIO1 scenario 2001 – 2020*.

Average annual change	GDP	Energy consumption	E/GDP	CO_2/E
1981 – 1990	+ 3,12 %	+ 1,91 %	- 1,12 %	- 1,83 %
1991 – 2000	+ 2,26 %	+ 1,27 %	- 0,84 %	- 1,17 %
1996 – 2000	+ 5,09 %	+ 1,59 %	- 3,32 %	- 2,19 %
2001 – 2010*	+ 2,8 %	+ 0,82 %	- 2,0 %	- 0,8 %
2011 – 2020*	+ 2,1 %	+ 0,36 %	- 1,7 %	- 0,4 %

The KIO1 scenario contains many assumptions. The expected annual growth rate of the GDP is quite high for 2001 - 2010 (2,8 %); it is a little higher than the historical growth rate between 1980 and 2000 (2,7 %). The world market prices for energy are expected to rise slowly. It is possible that the prices will rice faster: at least in 2001 oil prices have been higher than expected in the scenario. Thus, it may be that the scenario overestimates rather than underestimates the future energy consumption.

The previous energy policy statement by the Government was published in 1997 (KTM 1997). This statement also included three scenarios (EMS, EPO1 and EPO2). The EPO1 and EPO2 scenarios were goal-oriented scenarios and the EMS scenario represented the business as usual alternative. When these scenarios were published, the applied data on the energy consumption rate in Finland extended to 1995. Now it can be said that the real energy consumption in 2000 was a little lower than was expected in the optimistic EPO scenarios. The estimate for energy consumption in 2010 in the KIO1 scenario is also a little lower than in the EPO scenario. This means that the KIO1 scenario is essentially the same as the - at least so far realistic - EPO scenario.

In light of these facts the KIO1 scenario seems to be a realistic forecast. The scenario continues the trend of the late 1990s and does not expect any radical changes in the growth type of the Finnish economy due to 'the new economy' or other factors. In fact, in the Finnish National Climate Change Strategy the development of information technology and the new service economy does not play any decisive role. If at least some of the new possibilities offered by information technology and a service-orientation described in the other articles of this volume should materialize, the KIO1 scenario would seem to be an even more realistic scenario. In any case, it seems likely that the role of dematerialization will exceed that of decarbonization during the next decade. However, it may be that the KIO1 scenario underestimates the possibilities to replace the use of coal, oil and peat by renewable energy sources in a longer run.

5.6 Can we forecast absolute dematerialization before 2020?

According to the KIO1 scenario, the dematerialization process will accelerate in the future, and therefore it is interesting to ask whether it is probable that the growth of energy consumption in Finland will end before 2020.

The KIO1 scenario also suggests that energy consumption will grow in the 2010s annually by 0,4 %, which means that the growth of energy consumption would not end before 2020. In this respect, the difference between the KIO1 scenario and the older EPO scenario is interesting. The older EPO scenario expected that the growth of energy consumption would end around 2015, and the total energy consumption would thus stay at the level of 34 Mtoe between 2015 and 2025. According to the KIO1 scenario, the energy consumption would in 2020 be about 34,5 Mtoe. The difference is only minor, but surprisingly the older scenario is somewhat more optimistic than the new one. However, essentially the message of both scenarios is the same: it really seems to be plausible that in countries like Finland with a highly developed industrial structure and almost zero population growth the growth of energy consumption could end by 2020.

Basic trends behind this vision for the future are:

- the anticipated increase of energy prices through world market prices and / or energy taxation;
- efficiency gains in energy production, distribution and consumption in all economic sectors;
- structural change: even though energy-intensive manufacturing industries will not leave industrialized countries for the Third World, as the low-tech labour-intensive industries have done, the growth rate of these industries will remain modest in countries like Finland, where the markets are small and raw materials are already in heavy use; furthermore, needs for new investments in the heavy national infrastructure are minor;
- climate change will strengthen political pressure to decrease the use of fossil fuels in any form.

5.7 Comparisons to the international development and other scenarios

In light of international energy consumption figures, the Finnish development between 1980 and 2000 seems to be typical. According to Sun and Meristö (1999), the annual decrease of energy intensity in the OECD countries between 1960 and 1995 was on the average 0,7 %. The decrease of energy intensity took place in the 1980s and 1990s, since until 1979 the growth rates of energy consumption and GDP essentially remained the same. After the second oil crisis in the early 1980s, energy intensity decreased very fast and then somewhat more slowly between 1986 and 1995. On the average, the annual decrease of energy intensity from 1980 to 1995 was about 1 % (see also von Weitzsäcker et al. 1997: 141 -142).

Romm et al. (1999) have studied the development in the US in more detail. According to the data, energy intensity did not decrease at all from 1950 to 1970. Then a rapid drop took place between 1971 and 1986. The energy intensity decreased from 1970 to 1986 by as much as 30 %, which meant an annual decrease of 2 %. During the next ten years the decline of energy intensity was very modest, clearly less than 1 % annually. Thereafter, the decline has again been fast and of the same level as in Finland.

It would be expedient to compare the KIO1 scenario to the energy scenarios by different 'dematerialization researchers'. Unfortunately, for example, the authors of the so-called factor books have not presented any precise scenarios for future energy consumption. An often-mentioned example from the debate in the US is the soft path forecasting proposed by Amory Lovins in 1976. According to it, the energy consumption in the US should have started to fall in the early 1990s and was expected to be at the same level in 2025 as where it was in 1975 (Hawken et al. 1999: 252). However, the real energy consumption is in fact still growing, although the consumption figure in 2000 was at the same level as the maximum level consumption Lovins estimated for 1990. In a more recent paper, Romm et al. (1999: 7) forecast that energy consumption will grow in the US during the next ten years. However, they estimate that the decrease of energy intensity will be at least 1,5 % annually - "or maybe 2 % or even more". This scenario resembles the assumption of a 2 % decrease in the KIO1 scenario, which illustrates that the KIO1 scenario is not only realistic but also rather ambitious. For example, in Sweden the decline of energy intensity is expected to drop by 1,5 % per year by 2010 (IEA / OECD 1999).

The ambitiousness of the KIO1 scenario becomes even more obvious if it is compared to the basic scenario by the IEA (International Energy Agency) published in 2000 (IEA 2000). According to this rather conservative scenario, the annual growth rate of world energy consumption would be 2 % (the historical figure for 1971 - 97 was 2.2%) and the annual decrease of energy intensity 1,1 % (same as 1971 - 97). For OECD countries IEA forecasts that the growth of energy consumption will be as much as 28 % between 1997 and 2020, whereas the KIO1 scenario forecasts that the growth in Finland will be only 6 % between 1999 and 2020.

In Finland, environmental organizations have presented some alternative energy scenarios. These scenarios have tried to sketch out a future in which energy consumption and especially the use of fossil fuels could decrease essentially in the very near future. For example, as a comment on the previously mentioned EPO scenario, Finnish environmental organizations published an alternative scenario called Renewable Energy Policy. This scenario aimed to outline measures by which it could be possible to end the growth in the use of electricity by 2005 in Finland (Uusiutuva energiapolitiikka 1999). An older scenario called Sustainable Finland (Ulvila and Åkerman 1996: 51) proposed that it would be possible to halve energy consumption in Finland by 2020 if all reasonable measures were to be carried out.

History indicates that the most optimistic ideal 'alternative' scenarios have not come true. On the other hand, history also indicates that in most cases 'mainstream' scenarios tend to overestimate the future consumption of energy. For example, in 1997 some climate change researchers from the VTT (Technical Research Centre of Finland) published a synthesis scenario, which was based on a number of contemporary mainstream scenarios. According to this scenario, energy consumption in 2000 should have been about 1360 PJ (Savolainen and Lehtilä 1997, 22), but in reality it was only 1289 PJ, that is 5 % lower. If history repeats itself, it could turn out a well-informed guess that the real energy consumption in Finland in 2010 will be a little lower than is estimated in the KIO1 scenario.

5.8 Conclusions

It seems evident that we have entered a new era in the sense that the role of dematerialization will become more important than in the past in solving energy-related environmental problems, if new energy technologies which would radically reduce the environmental stress of energy production and consumption are not invented and diffused rapidly throughout the economy (the fewer the new detoxification measures invented, the greater the need for dematerialization).

We can expect that in Finland the annual decrease of energy intensity will be faster during the next decades than it was in the 1990s, very likely at the level of 1,5 - 2,5 %. And this may also mean that the growth of energy consumption will end by 2020. However, it is hard to imagine that energy consumption would decline by factors 1 - 4 before that. This means that an accelerated decrease of decarbonization of energy sources would also be needed to achieve essential reductions in carbon dioxide emissions in the 2010s. One should remember that the use of the most problematic fossil fuels (coal, oil and peat) decreased in Finland already in the 1990s by 8 %. Hence, even though the role of dematerialization will grow in the future, the need for further detoxification remains.

This kind of vision for the future does not include or necessitate any major structural or technological leaps. Such leaps are, however, possible if environmental policy pressure should strengthen and the future energy prices reflect more closely the external costs caused by the energy production and consumption. They would also be made technically and organizationally possible by developing and disseminating the types of new ICT- and service-orientation -based business models that are considered in other chapters of this volume.

According to the International Climate Change Panel (IPCC), many more radical changes which take into account the more extensive global perspective will be needed in the future. If we take this message seriously, it is not reasonable to approach the future of Finnish and global energy after 2010 or at least after 2020 by using scenarios based on today's assumptions. Very probably, the globalizing economy will generate a new kind of global energy policy framework, which will shape the future trends into a new direction.

Dematerialization potential of electronic grocery shopping

6

Anna Kärnä

"Electronic commerce is reshaping manufacturing and distribution systems, product design, and the fundamental relationship of producer to consumer. By linking the world together, the Internet has the potential to vastly improve the efficiency of commerce. In doing so, it could reduce or eliminate the need for products, for warehouses and retail stores, and for the materials, energy, and space they consume. It could curb automobile use, reduce traffic, and enable businesses and consumers to be savvy green shoppers. Electronic commerce could be the technological foundation of an ecologically sustainable society." (Cohen 1999)

There is a growing awareness that the new e-commerce systems are going to have a significant environmental impact. Cohen describes some of the potential environmental gains above. On the other hand, the rebound effects related to e-commerce may also be considerable: efficiency gains achieved in production processes can be offset by the increased consumption of products, materials and energy, growing traffic and the detrimental effect on land use. However, the environmental impacts of e-commerce are still a rather untouched area of detailed research and analysis. One reason for this is that little data has yet accumulated on long-standing business-to-business e-commerce systems, and still less on business-to-consumer (B-to-C) systems.

This chapter will analyse how one area of B-to-C e-commerce, **electronic grocery shopping (EGS),** could potentially change and reduce the material and energy intensity of grocery shopping compared with the prevalent way of buying groceries. Ordering groceries via the Internet combined with a delivery service is considered here as **a new service system** which is based on the use of ICT and in which the grocery buying and delivery process can be organized in a more effective and potentially dematerialised way.

Groceries or daily goods are a promising, but also challenging, product group for e-commerce. Groceries are bought several times a week, and an average purchase consists of many items. On the other hand, groceries are prone to spoil if not handled properly, unlike many other physical products like books or clothing. This sets special requirements on the delivery of products. Electronic grocery trade is currently a very small-scale business, but has been expected to reach 5-10% of the total groceries sales in Finland by 2010. The information technology infrastructure to run successful EGS services already exists, but EGS needs to attract more regular users, which would influence the efficiency of EGS operations and related environmental impacts.

From an environmental perspective, consumers' car trips to supermarkets are a very inefficient way to obtain groceries. EGS provides an incentive to organize deliveries from grocery shops or warehouses to consumers more efficiently and to reduce traffic and related emissions. Currently, various e-grocery delivery models co-exist. Given that major increases in EGS are predicted, the environmental aspects of different EGS models need to be considered early, as they could be significant. Until now, eco-efficiency has not been a central consideration for companies when developing EGS services.

This chapter discusses how the development of electronic grocery shopping services can influence the material and energy intensity of the grocery shopping process. The main questions asked include:

- What kind of environmental aspects can be identified in the existing EGS models when compared to 'traditional' grocery shopping? (**what is the '<u>as-is</u>' situation in the business**)
- How is electronic grocery shopping business predicted to develop by 2010 in Finland and how should it be organized in order to be environmentally effective? (**<u>expected</u> future business development and <u>preferred</u> development from dematerialization perspective)**

To explore these questions, representatives of Finnish EGS service providers and e-commerce developers in the grocery wholesale and retail trade have been interviewed. In addition, a Delphi method-based electronic survey has been conducted among 22 experts, representing practitioners and researchers in the fields of e-commerce, grocery retail trade and environmental and social research.

The next section discusses what kind of a service electronic grocery shopping is, also from the perspective of eco-efficiency and dematerialization. Sections 6.2 and 6.3 review the development of the Finnish grocery trade during the last decades, consumers' grocery buying habits, and the recently emerging EGS market. Consumer experiences of electronic grocery shopping are also discussed. Section 6.4 overviews existing studies on the environmental impacts of electronic grocery shopping. Section 6.5 discusses what kinds of alternatives exist to organize EGS, presents four Finnish EGS services with different operating concepts, and summarizes environmentally relevant aspects at various stages of e-grocery shopping. Section 6.6 presents the results of an expert survey on the anticipated future development of EGS business in Finland by the year 2010 together with a future scenario of an environmentally effective EGS model. Section 6.7 draws conclusions for practice and for future research.

6.1 Electronic grocery shopping: a new service – an eco-efficient service?

Although business-to-business e-commerce is much larger in scale today,[95] there is a growing interest to promote business-to-consumer e-commerce, one area of which is the electronic grocery trade. **Groceries** are daily consumer goods with reasonably low unit prices that are bought repeatedly. Groceries can be roughly divided into perishables and non-perishables; nowadays they also include non-food commodities.[96] **Electronic grocery shopping (EGS, e-grocery)** means ordering a basket of commodities over an electronic network (Internet, telephone, mobile phone, e-mail or fax).[97] Often also a (home) delivery service is connected to the electronic grocery shopping. The electronic grocery shop offers an electronic ordering interface (virtual grocery shop), and normally the retailer or third party takes care of the picking and typically also of the delivery of the goods to the customer (Heikkilä et al. 1998; Raijas 2000b; Jaakkola and Kämäräinen 2000).

Electronic commerce in daily groceries is more demanding than in many other physical products like books or clothing, because the trade of grocery goods is tightly regulated and controlled in terms of preservation and the quality of the delivered goods. Therefore, suitable dedicated delivery systems are needed, particularly delivery equipment with temperature controlled storage. Due to this, grocery trade is also more local than the sales of many other products that are easily accessible throughout the world. Unlike products delivered using digital channels (e.g., software), EGS have to count on physical distribution systems.

On the other hand, there is great potential for EGS, because groceries form the largest business in retailing, consumer's buying patterns are rather stable, and customers may learn to use Internet ordering and delivery services quite quickly because of frequent use. Groceries are suitable for e-commerce because they are products that are bought regularly and without the need to see or test them before the buying decision is made. An additional impetus for EGS may also be that unlike other shopping, grocery shopping is not generally considered as a social and recreational experience by consumers, and not as one requiring extensive information gathering. For many, although not for all, it is a chore and an undesired maintenance activity, not an enjoyable or social one.

In EGS, the consumer's shopping process changes considerably compared with 'traditional' shopping, because the physical logistics stream and information stream related to the ordering, delivery and payment of goods can be separated from each other. Grocery shopping becomes more independent of time and place. Table 12 presents some main differences between the traditional and electronic grocery shopping process.

Table 12. Differences between the traditional store and EGS in place and medium used in the shopping process. (after Heikkilä et al. 1998b).

STEPS IN SHOPPING PROCESS	PLACE		MEDIUM	
	TRADITIONAL STORE	EGS	TRADITIONAL STORE	EGS
Planning	- Home, office, on the way to the store	- Home or office - Ordering point	- Shopping list, ad hoc	- PC: suggestion offered by EGS, recipe, ad hoc
Order	- Store	- Home or office - Pickup point, delivery vehicle, kiosk	- Selection at the store - Orally to the store - (telephone, fax)	- Internet - e-mail
Transport to the store	- Physical	- Virtual	- Private car - Public transportation	- Information network
Picking up	- Store	- Store - Wholesale outlet - Pickup centre, producer's warehouse	- Customer him/herself	- Store or warehouse personnel - 3. party personnel
Payment	- Store	- Delivery van, home - Pickup point, bank	- Cash, credit card, account debit - Cheque	- Credit card, account debit - cash, e-cash
Delivery	- At the cashier of the store	- Home, office - Manned or unmanned pickup point	- Cashier of the store	- Delivery van driver - Customer or personnel at pickup point

It has been proposed that electronic grocery shopping will bring new benefits both for consumers and for the grocery trade. It can provide consumers with considerable ease, timesaving and convenience, as compared to the traditional way, and also enhance the rational management of household purchases. Finns make, on an average, 4-5 trips to the grocery shop each week (LTT 1995), which makes about 250 shopping trips per year. Queuing at the cashier's counter and transport of the products disappear. EGS can also provide consumers with some new services, particularly in various planning related tasks, such as ready-made shopping lists, shopping history data and recipes.

In the grocery trade, the logistics chain is remarkably fragmented between a large number of actors (producers, distributors, points of sale, etc.). Electronic trade may enable producers and retailers to bypass intermediaries, thus leading to supply chain restructuring and to changes in logistics and storage systems. For retailers, developing electronic sales and delivery services fits well with the goal of increasing service orientation in retailing (Cairns 1999; Raijas 2000a). EGS and Internet facilitate the collection of data on consumer habits and purchasing history. The EGS concept also provides an opportunity for new entrepreneurs (e.g., information systems and logistics service providers) to enter the grocery business. It also enables existing grocery retailers to enlarge their business and extend their product range through presentation of a variety of product offerings not available in the physical store.

What kind of a service is EGS? Although supermarket shopping via Internet dates only to the late 1980s in the US and the late 1990s in Finland, home delivery is not a new service. EGS has actually reintroduced an old service, and the new component in the system is the media: the Internet, computers and the required ICT infrastructure with which the orders are made and processed, deliveries organized and payments made. Grocery retailing already relies heavily on the use of developed information systems and technology in transactions in the distribution channel from producers to retailers (e.g., the use of information systems such as Electronic Data Interchange EDI). The new component in EGS is the use of ICT in the consumer-retailer interface.

EGS radically *reorganizes* the grocery shopping process. *EGS shifts the division of labour and responsibility* for the pick-up and delivery of groceries from the consumer to the service provider. Deliveries and reception can be organized in several new ways: pick up, drop-off points, reception boxes, etc. Additional services can be attached to EGS delivery services (e.g., take-back of empty bottles, film processing, laundry services). Taken one step further, in the future EGS entrepreneurs may be more involved in the grocery buying process. They can offer grocery replenishment services where regularly needed products are automatically delivered once a week, or they may even attend to the household planning activity.

If EGS replaced traditional grocery shopping altogether, it could be considered as a result-based service (see Chapter 3), in which the desired outcome would be the acquisition of daily goods. Delivery service represents one form of 'car-sharing', i.e., many shopping baskets are distributed from the supermarket with one vehicle to the households instead of many private cars driving between homes and the supermarket. Also the reception of goods may create incentives for new innovative social arrangements (e.g., reception centres in residential quarters) or extend the service-range of existing entrepreneurs (e.g., post offices, kiosks or gas stations become pick-up points for grocery deliveries).

In grocery retailing, there has been a strong tendency towards building large sales units, which provide cost efficiency for retailers and competitive prices for consumers (see section 6.2). Super- and hypermarkets are, however, based on *substantial self-service* by the consumer: she/he drives to the store, collects the groceries, pays and packs them and drives back home, where the groceries still have to be unpacked. In some sectors of society, this phase of 'mass production' has been already passed. EGS is one promising alternative in grocery retailing to provide more customized services.

Is EGS an eco-efficient service? EGS is a new ICT-based service that could reduce material and energy consumption in the grocery shopping process, especially related to the deliveries of goods. Presented in a pointed way, in the current situation, large trucks deliver goods to the supermarkets where they are put on the shelves for the consumers to pick them up and to deliver them with numerous small cars to homes. In EGS, the supply chain deliveries can be streamlined to operate in a more demand-based manner, and customer deliveries can be organized more centrally and efficiently.

However, there are concerns that e-commerce related home deliveries may constitute an environmental disaster, due to the increasing number of freight trips and overnight deliveries that they generate, with smaller volumes of goods being transported longer distances. The latter concern may be less significant considering groceries because their home deliveries are organised very differently than those of non-food goods (Cairns 1999). E-grocery retailers operate often more *locally* than home delivery companies for non-food goods that operate from more centralised picking-and-packing centres. Unless EGS turns from a local activity into international or global one, grocery related traffic is not expected to increase dramatically, although changes take place in both private car use and the ways in which deliveries are organized.

From the eco-efficiency perspective, a crucial question will be to what extent EGS complements or substitutes 'traditional' grocery shopping. At the current, early phase of EGS development, it complements traditional grocery shopping, and it can be seen as a value-added service provided by grocery retailers or specialized EGS entrepreneurs. It is important that the existing EGS services are developed further taking environmental efficiency more explicitly into account. However, a more decisive factor from environmental perspective may be how many regular users EGS services manage to attract (the penetration rate), and what kind of activities EGS replaces and generates in households and in the grocery supply chain (see section 6.4).

This development can be advanced by active political measures, and EGS can also bring social benefits. The good availability of services and the minimization of environmental impacts caused by increasing traffic are important political aims. The concentration of grocery trade, increased car dependence and disappearance of local services are recent social developments, which increasingly discriminate people living in sparsely populated areas and some consumer segments. This applies not only to grocery retail shops, but also other services, such as postal and bank services. EGS could improve options for those with problems getting to the shops, such as the elderly or disabled, or those living in remote areas (Cairns 1999). Grocery shops as one basic service have a role in keeping city and village centres alive.

6.2 The grocery retail trade in Finland

This section first describes today's grocery supply chain and the players on the Finnish grocery retail market in order to better understand under what kind of circumstances EGS services have recently entered the market. After that, some key data on Finnish consumers' grocery buying habits are presented.

6.2.1 Grocery retail markets

The Finnish grocery retail trade has undergone a strong structural change during the past three decades. The general trend has been the concentration of the grocery retail trade, followed by a reduction in the number of retail outlets and a redistribution of market shares among different outlet types. Grocery trade is very dependent on the large domestic players in the field. The trade is controlled by a few central wholesale companies.[98] In 2000, the total sales of groceries were about 9.9 mrd EUR (Kehittyvä Kauppa 2001). In practice, four grocery trade groups, K-group, S-group, Tradeka / Elanto and Spar share the Finnish grocery markets.[99]

Grocery shops differ very much from each other concerning the size of the store, sales volume, assortment, services and location. Groceries are mainly sold from (Kasso 1994; Koistinen and Vaittinen 1997):

- supermarkets
- hypermarkets
- self-service stores (e.g., Alepa and Siwa chains)
- small local food stores
- department stores
- market halls
- specialized food stores
- kiosks
- gas stations

In 2000, the total number of grocery shops in Finland was about 4300. From the year 1980, the number of grocery shops has decreased by more than half, and it is still expected to drop.[6] During the same period, 60% of the small grocery shops have disappeared, and large stores have been established, although not equally many in number (Raijas 2000b). Grocery shops have more and more concentrated in areas with a high population density. The movement of rural people to towns and cities has created new demand for new large retail outlets and services in areas with growing population density. Retail trade outlets have also moved away from city centres to areas with good connections, mostly along main roads. This has led to a situation in which many sparsely populated areas lack shops altogether.

In 2000, half of the total grocery sales were achieved through the 360 biggest retail outlets (AC Nielsen 2001).[101] The market share of small local food shops has constantly declined, and it has been estimated that in the future, two thirds of the growth in the grocery retail sector comes from the large sales units. One recent tendency is the increasing sales of groceries from small convenience stores such as gas stations and kiosks shops.[102] Their market share is about 10%. They mostly provide replenishment products, but they serve consumers with longer opening hours and often more central locations than the current supermarkets.

The current business strategy in the grocery retail trade is based on an increased construction of large sales units outside city centres. Although large hypermarkets provide retailers with cost efficiency and consumers with cheaper grocery prices, they require increased self-service and mobility by the consumer. The shopping trips of consumers are today longer and the transport costs related to grocery shopping have increased (Raijas 2000a). A positive consequence may be that people decrease their shopping frequency and buy larger amounts of groceries at once, thus reducing the amount of shopping trips. According to a more pessimistic view, super- and hypermarkets increase the total volume of traffic and discriminate against those who don't have a car (Murto 1996).

Based on these developments, the grocery retail trade is facing interesting future challenges. The number of households will increase and their average size will continue to decrease, at the same time with the aging population. The amount of small households of 1-2 persons is already two thirds of all households in Finland and every fourth is a household with elderly.[103] There is a growing need to provide services also for those consumer segments not buying large amounts of groceries (e.g., through better availability of local services and extended service hours). Grocery retailers also need to respond to changing grocery consumption habits. For instance, the market for pre-cooked and ready-to-eat meals is growing, and the organic food industry is one of the fastest growing segments in the retail trade. What kind of an alternative can EGS be for the grocery retail trade, considering the structural changes that have taken place in grocery retailing, the investments made in business development, and the changes in customer demand?

6.2.2 Grocery buying habits

Although the grocery retail trade has undergone a considerable structural change, consumers' grocery buying habits have not changed as significantly (Raijas 2000a). In the year 1999, Finns consumed ca 1850 EUR per person to groceries (Kehittyvä kauppa 2001). Studies on the grocery buying habits of Finns (e.g., LTT Research) indicate, among other things, that:

- The share of total household spending that goes on groceries has diminished by 17% in the past twenty years (being 20% in 1996), whereas spending on transportation, telecommunications, leisure and health has increased (Statistics Finland 2000f; Ministry of Transport 1999b).

- Finns do grocery shopping frequently and buy relatively small purchases at once. The shopping frequency of groceries is on average 4-5 times a week (LTT 1995) and the average purchase is 17- 34 EUR, depending on the size of the retail outlet.

- Finns buy 4.9 million tons of groceries per year, which makes almost 950 kg per person (Finnfood 1999).[104]

- Grocery shopping is concentrated on certain days of the week: almost half of the shopping for groceries is done on Fridays and Saturdays. (Kasso 1994).

- Groceries are more and more often bought from a large sales unit, from a hypermarket or supermarket (LTT 1995). However, a relatively large part of households use the nearest shop to the home as the primary place of shopping, whether it is a supermarket or a local food shop. Therefore, local food shops cannot be characterized primarily as supplement purchase places, neither are hypermarkets places where only large quantities are bought.

- 70-80% of households having a car use it to do grocery shopping trips (LTT 1995). There has been a clear increase in car use related to shopping trips. Whereas in 1975 almost half of the shopping trips were made by foot and 20% by bicycle and only 26% by car, in 1994 over half of the shopping trips were made by car, and 30% by foot and about 10% by bicycle (Raijas 2000c). The possibility to use a car does not seem to influence the amount of grocery shopping trips, but trips to more distant super- and hypermarkets are most often made by car.

- The density of grocery shops in Finland is the third lowest in Europe (Santasalo & Kontio1995). The distance to the nearest grocery shop has grown slightly, being on an average 2.1 km in 1999. On the other hand, 1.6 out of 2.35 million Finnish households live within 1 kilometre's distance from the nearest grocery shop (Nurmela et al. 2000).

- Most of grocery shopping in terms of volume is cash-and-carry. There is little delivery of goods to homes, or mail-order. The share of consumer costs related to the pick-up and transport of groceries from supermarkets to households is estimated to be 1.27 milliard EUR (Timmerbacka et al. 2000).

- Grocery shopping trips are quite a small share (10-25%) of consumers' total mobility (Murto 1996).[105] Altogether, consumers' shopping trips amount to about 10 milliard kilometres annually in Finland (Punakivi 2000).

- The volume of transports of grocery goods between producers and retailers is small compared to the yearly amount of grocery shopping trips made by car. According to a study in the Tampere region (Tampere is the third largest city in Finland), goods transports made only 5-10% of the yearly mileage of grocery shopping trips by car (Murto 1996).

- Households consume a considerable amount of energy yearly for transporting groceries. This energy consumption has almost trebled between 1975 and 1990 in Finland (Kasanen 1993).[106] The growth is due to longer shopping trips and increased car use, also for short trips.

- The share of energy use in grocery transports is almost equally divided between transports from producers to retailers and from retailers to consumers. According to a Swedish estimate, shopping trips of consumers from home to the grocery shop and back consume 2-3 TWh of energy yearly whereas grocery transports between producers and retail stores consume 2-2.5 TWh (Orremo et al. 1999; Bratt and Persson 2001).

- Traffic is responsible for about 75% of CO, and about 50% for HC and NO_x emissions (VTT 1998a). The greenhouse gas emissions from road traffic were 11Mt in 1998 in Finland, from which cars accounted for 6.3 Mt (Siikavirta et al. 2001). However, considering emissions, the share of grocery transports (private shopping trips and transports of trade) of total road traffic is small. The current greenhouse gas emissions from purchase travelling in Finland are estimated to be 1.1 - 1.8 Mt of CO_2, which accounts for 1.5 - 2.5% of Finland's greenhouse gas emissions (Siikavirta et al. 2001).

All in all, the grocery shopping habits of consumers are rather well established, and grocery shopping is a routine activity, which people seldom even consider doing in a new way (Raijas 2000a). Shopping for groceries is generally a repeated activity at regular time intervals. It is often seen as an obligatory mode of shopping, which may often be felt as a burden, as something to be done as quickly as possible and with minimum effort. Grocery shopping also represents buying behaviour based mostly on earlier experience, and minor information search and comparison (Raijas 2000a).

The majority of the consumers' costs of shopping are associated with the shopping trip. During the last decade, consumers' costs of shopping have increased due to the longer shopping trips, increased car use and more leisure time (Raijas 2000a). However, consumers seldom calculate the cost of *time* spent on shopping and transportation or the *fuel consumption or emissions* when using a car. Under these kinds of circumstances the threshold to change over to a new shopping habit is high. Could electronic grocery shopping change consumers' grocery buying habits, and in which direction?

6.3 The emergence of electronic grocery shopping

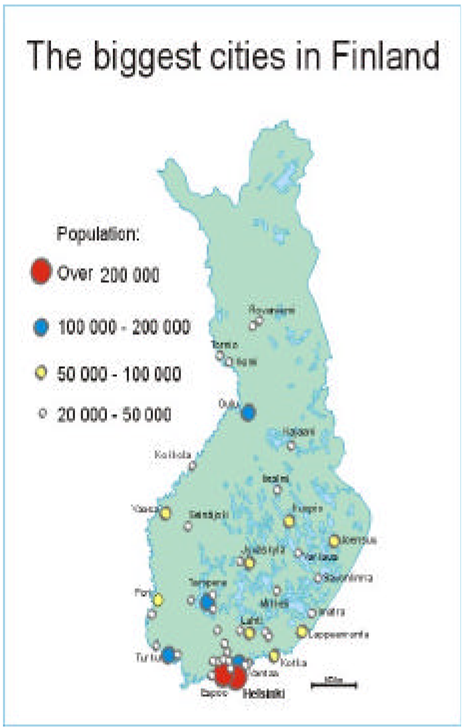
6.3.1 Overview of the Finnish e-grocery business

The emergence of EGS is a result of the development of the Internet and e-commerce. The retail trade infrastructure, the high standard in information technology and on-line access rates suggest that electronic grocery trade might have true potential in Finland.[107] However, B-to-C e-commerce has experienced quite a slow start in Finland. Every sixth Finn has bought products or services via the Internet, at least once (Suomen Gallup 2001). Groceries are, however, not among the products that are first considered as one-line purchases.[108] According to one survey, in early 2000, 9% of respondents planned to buy food or other daily products from the web (Suomen Gallup 1999). They represent a customer base of 350.000 Finns.

At the moment, the share of electronic grocery shopping of all grocery sales in Finland is estimated to be less than 1 %. There are, however, expectations that electronic commerce of grocery goods can reach 5-10% of the total volume of grocery sales in 2010 (Heikkilä et al. 1998a).[109] In October 2001, 19 Finnish on-line grocery shops were found on the Internet.[110] In practice, the number of EGS service providers is smaller, because two EGS service providers operate in several cities. Figure 10 lists Finnish electronic grocery shops together with examples of some other e-stores which sell specialized food products such as herbs, spices and naturally produced products.[111] The latter ones operate nationally, whereas all EGS services are locally organised and offer delivery over a fairly compact area.

In Finnish e-grocery shops, the products are picked from the shelves of an existing supermarket. The only exception is Ruokanet that operates only on the

Internet and picks the products from a wholesale outlet. All e-grocery shops deliver the goods to the customer's home and many also provide a pick-up alternative from the supermarket. The operating model of e-grocery shops is based on the current grocery trade infrastructure, and the supply chain up till the retailer or wholesale outlet remains unchanged.



ELECTRONIC GROCERY SHOPS

- www.ruokavarasto.fi Ruokavarasto (Helsinki, Tampere, Turku, Pori, Rauma, Hämeenlinna, Salo, Lahti and their surroundings)
- www.yhalli.fi K-supermarket Ykköshalli (Vantaa)
- http://nettikauppa.k-supermarket.fi/hertta/ K-supermarket Hertta (Helsinki)
- www.k-market.com/veitikka K-market Veitikka (Oulu)
- www.ruoka.net Ruokanet (Helsinki metropolitan area and Tampere)
- www.s-kanava.net/ Sokos Herkku (Pori)
- www.s-kanava.net/keskimaa S-market Mestarin Herkku, Osuuskauppa Keskimaa (Jyväskylä)
- www.s-kanava.net S-market (Lappeenranta)
- www.ruokarasti.net S-market Ykkösrasti (Kuopio)
- http://www.eurospar.fi/espoontori/ Eurospar (Espoo)
- www.nettimarket.com Nettimarket Turku (Turku)

OTHER E-STORES SELLING SPECIFIC FOOD PRODUCTS

- www.ekoportti.fi Luomupuoti (organic products) Tampere
- www.ryytihyppynen.fi Ryytihyppynen (herbs, spices etc.) Jyväskylä
- www.samsara.fi Samsara (organic products and bakery) Vantaa
- www.ecorner.fi Ecorner (gluten-free food products), Iittala
- www.ruokapohjola.fi Ruokapohjola (organic food, game and fish products) Oulu

Figure 10: Electronic grocery shops and examples of other e-stores selling food products in Finland.[112]

The map indicates that currently, EGS services operate only in the largest cities. In the Helsinki metropolitan area (Helsinki, Espoo, Vantaa), there are five e-grocery shops and in the cities of Tampere, Turku and Pori two in each, as well as one in Oulu. The first two larger-scale EGS businesses, *K-supermarket Ykköshalli and Ruokanet* and have been operating in the Helsinki metropolitan area since 1997 and 1998. Both are examined closer in section 6.5.2. The majority of other e-grocery shops have been established during 1999. What describes the EGS scene in Finland is that many e-grocery services have been local demonstration projects, many of which have not been profitable. Not many e-grocery shops have entered the market recently (Eurospar opened up at the end of year 2000), but some have closed down, instead.[113]

The major grocery retail groups, the S-group and the K-group, have been involved in a number of home shopping experiments.[114] The operating e-grocery services within these groups have been initiated by individual supermarket keepers, and they operate quite independently from the retail trade group. In the S-group, four e-grocery shops operate currently in Pori, Jyväskylä, Lappeenranta and Kuopio. Three of them can be found under the e-commerce portal of S-group called S-kanava (www.s-kanava.net). Two e-grocery shops have discontinued their operations, one in Joensuu and one in Lahti. In addition, a recent pilot has been a *S-box project* in Espoo, which is based on a reception box concept (see section 6.5.2). All in all, the S-group estimates to have about 3000 registered e-grocery customers, of which 1500 are active ones[115] . The K-group operates e-grocery shops in three K-supermarkets in Helsinki, Oulu and Vantaa (see section 6.5.2). The K-group launched its e-commerce portal at the end of 1999 (first known as www.k-netti.com, more recently turned into www.plussa.com), and all three e-grocery shops can be found there. The K-group has also recently focused on developing e-commerce services for its business-to-business customers in grocery wholesale.[116]

Whereas the e-grocery shops of the K-group and S-group are projects by individual and local shopkeepers, *Ruokavarasto* is currently the only grocery chain operating in several cities with an EGS concept. Spar-group is the newest entrant in the EGS market with one supermarket based e-grocery shop opened up in 2000 in Espoo. *Ruokanet*, in turn, is the only e-grocery shop operating solely on the Internet that has outsourced all warehouse and delivery activities. *Ekoportti* is an Internet site for ecological products and services, under which a small e-grocery shop called *Luomupuoti* operates selling organic food (see section 6.5.2).

The large grocery retail groups have plans for how to expand EGS if the demand for EGS services from the market increases. Neither the current market development, nor the focus of strategic business development within the trade groups indicates such immediate pressures.[117] E-grocery business developers in large retail chains expect quite a modest EGS growth within 5-10 years, EGS gaining a market share of 2-5% of grocery sales. The strengths of large grocery retail groups, in terms of enlarging their EGS operations, include an extensive retail outlet network covering the whole country, efficient product supply channels, as well as a ready customer-base and marketing channels.[118] Thus, an interesting question for the future is, will the EGS business development be led by grocery retail trade chains, or will it become more and more a business of individual entrepreneurs specialized in e-business?

6.3.2 Consumer experiences of electronic grocery shopping

Consumer response to on-line grocery shopping has been analysed by Raijas (2000a; 2000b) in Finland and Morganosky and Cude (2000) in the US.[119] The studies indicate very much the same results concerning what kind of people use EGS, why they use it, how on-line shopping has influenced consumers' overall food shopping and how EGS services respond to consumers' expectations.

Raijas has analysed pioneer-users of two EGS services operating in the Helsinki metropolitan area and their shopping habits in spring 1999. *The shopping baskets in the EGS seem to be clearly larger and shopping frequency lower* than in traditional grocery shopping.[120] However, very much the same products are bought on-line than from a 'traditional' grocery shop. These include also fresh products such as fruits and vegetables, as well as frozen food, which have been expected to be not so suitable for current home delivery practices. The studied customers used EGS very seldom, usually 1-2 times per month or even less. The number of regular EGS users is still small and many people have just started to experiment with on-line shopping.

The people buying most from e-grocery shops are women, people in the age group 18-45, families with small children, and high-income people. Customers' reasons for using EGS were the avoidance of grocery picking and delivery, time saving, convenience of ordering and delivery, as well as curiosity to try something new. The overall convenience seems to be more important for EGS customers than the price level or assortment. EGS customers expect to find the same services in an e-grocery shop as in a supermarket.

Two types of consumer groups seeking for different benefits from EGS can be identified: service seekers and price / efficiency seekers (Palmer et al. 2000). Potential early adopters of EGS include, e.g., families with small children, dual career families, elderly and disabled people with physical constraints, wealthy adults seeking for high quality services, the computer literate generation, companies and institutions (Nyman and Raijas 2000; Morganosky and Cude 2000; Heikkilä et al. 1998). The size of these customer segments is, however, limited because only few people can be expected to buy all their groceries on-line. In addition, not all people have access to the Internet.

Empirical studies on the impacts of EGS on the time-use and mobility of consumers seem to be non-existent yet. This is partly because reliable data on the average time that consumers use in daily shopping is difficult to obtain. Morganosky and Cude (2000) found that not all the e-grocery shoppers they studied felt that shopping on-line saves them time, but they expected it to save time as they gain more experience, or that the trade-off is preferable (e.g., not to waste a Saturday morning in the store with children). EGS customers felt that the real time savings were a result of not travelling to and from the store, rather than a decrease in shopping time.[121] According to Cairns (1999), a Dutch survey among customers of one grocery home shopping service revealed that 70% of the respondents believed that EGS was saving them time, but it was not clarified how the gain in time was being spent. Raijas (2000a) has found that electronic grocery shopping seems not be a more planned activity than shopping in a supermarket. These findings raise two questions. What would make people to make large on-line grocery purchases repeatedly? Furthermore, if people learn to use EGS more often, do they learn to concentrate their purchases on the net, and does on-line shopping become a more planned activity?

6.4 Environmental efficiency of electronic grocery shopping: review of the discussion

Research on EGS has been limited since it is a relatively new retail channel. Until now, only a few studies on EGS have been found which also point out environmental aspects. These include three Finnish studies (Murto 1996; Punakivi and Holmström 2000; Siikavirta et al. 2001), two from Sweden (Orremo et al. 1999; Bratt and Persson 2001), one from the Netherlands (Freire 1999) and one from the UK (Cairns 1999). Most of them simulate various home delivery models of EGS and estimate related mileage and traffic emissions, within a certain area or in a country. The Dutch study has applied a life cycle assessment (LCA) method to investigate the environmental impacts of EGS. No empirical studies explicitly examining, for example, the impact of EGS on travel patterns of consumers have been found, but some claims raised in the literature can be presented. In the following, each of the above-mentioned studies is first shortly reviewed, after which some key propositions on the potential direct and indirect environmental impacts of EGS are discussed.

Murto (1996) has simulated changes in mileages and emissions from personal and goods traffic due to different types of grocery shop locations and alternatives in the Tampere region, which is the third largest city in Finland. As one alternative, he examined replacing one grocery-shopping trip per week by EGS and home delivery.[122] The results indicated that *the share of grocery shopping traffic* (personal and professional) *was marginal in relation to the total traffic mileage in the region.* Electronic grocery shopping once a week with home deliveries would decrease the yearly mileage in the region by about 2%.[123] However, EGS and home delivery alternatives seemed to reduce the emissions from personal car traffic considerably.

A more recent study by Punakivi and Holmström (2000) simulated how four alternative e-grocery home delivery models would impact travelling mileage and traffic emissions in the Helsinki metropolitan area. The four home delivery concepts were compared to the ‘traditional’ grocery shopping, store visit by using a car.[124] The simulation showed that the *mileage reduction potential of the overall traffic was between 11-19% depending on the home delivery concept used.*[125] Also the exhaust gas emissions could decrease considerably, depending on the mileage and the type of vehicle used. Vans used for home deliveries were expected to be equipped with diesel engine and consumer’s own cars with catalytic converters. The particle emissions increased radically in home delivery but other emissions (CO, HC and NO_x) decreased by over 75%.

The potential of the same e-grocery home delivery concepts to reduce greenhouse gas emissions has been further studied by Siikavirta et al. (2001), using the same data. *In addition to mileage, the type of the vehicle, its fuel efficiency and the fuel used had a strong effect on greenhouse gas emissions. These emissions could be reduced by 30-90% depending on the home delivery concept compared with traditional grocery shopping*. This corresponds to CO_2 emission reduction of 0.3 - 1.6 Mt, which would reduce emissions in Finland roughly by 0.5 - 2%. The reception box and one weekly delivery showed the highest potential for reducing greenhouse gas emissions.

Orremo et al. (1999) have made calculations on what the consequences for emissions and energy consumption would be if 10, 25 or 50% of the total grocery sales in Sweden were bought electronically. They focused only on the transports between the retailer and consumer, but the effects on transports from producers to retailers were also discussed. Five different logistical models for grocery home deliveries were analysed.[126] These models were applied to different shares of home shopping (10, 25, 50) and to areas with differing population density to find out which model would be the most efficient in each part of the country, so that the whole country would be covered with home delivery services.

The results indicated that the most important factors that determined the extent of the environmental consequences were the size of the delivery area, the proportion of home shopping, the population density within the delivery area, and the logistical model used. Under the right conditions, in densely populated areas where most people in Sweden live, where the delivery van's full capacity can be used and a sensible plan of the routes can be created, there are environmental savings to be achieved with electronic grocery shopping. But if conditions are less favourable, the environmental effects may even increase. In the delivery model that is most frequently used today, i.e., home delivery, the environmental savings were most obvious.[127]

Figure 11 shows how energy consumption decreased at 10, 25 and 50% EGS and home delivery in comparison to traditional shopping when the delivery route was either 50 or 90 km. When all the groceries are transported through the traditional supply chain and consumers make the shopping trips themselves, the energy consumption was estimated to be 3.1 TWh (see horizontal line in figure 11). In home delivery, the energy consumption depends on the route length of the delivery van. The length of the route varies depending on the area (city, densely or loosely populated area). A typical route was estimated to be between 50 and 90 km, the area marked with vertical lines in figure 11. Calculations indicated that*considerable energy savings with even quite long delivery routes could be achieved.*[128] *The larger the share of electronic shopping and the shorter the delivery route, the greater reductions in energy consumption and carbon dioxide and nitrogen oxide emissions were achieved*. If 10% of groceries would be purchased electronically, the transport energy consumption and CO_2 emissions could be lowered by 7% and NO_x emissions by 10%. If EGS increases to 50%, transport energy and CO_2 emissions would both reduce by about 35%, and NO_x emissions by 48%.

Bratt and Persson (2001) simulated, with four scenarios, what would happen to energy consumption and CO_2 emissions in one new Swedish city district in Stockholm with shares of 10, 25 and 50% of EGS. Simulations were made for 2200 and 8000 households. Deliveries were expected to take place from retailers or from e-business warehouses. Four alternatives for reception were considered: reception at intelligent refrigerator-freezers in the residential building's stairwells,[129] directly at the customers door, at local logistical centres where customers pick them up by foot or from where the orders are delivered with electric or other environmentally friendly vans to customers. Deliveries took place once a day to logistical centres and refrigerator-freezers. There were three deliveries per day from each retailer to the customers' door.

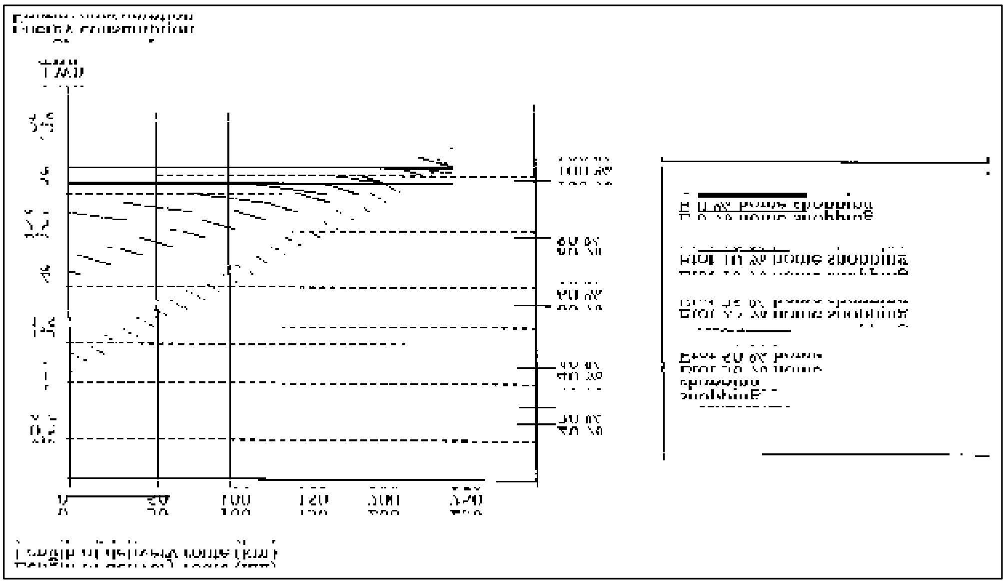


Figure 11. Energy saving potential with 10, 25 and 50 % EGS compared to traditional grocery shopping. (Orremo et al. 1999).

The share of 10% on-line shopping and transport from retailers or e-business warehouses to a local logistics centre would reduce energy consumption by 5-7% and CO_2 emissions by 7-8%. With an increased share (25 or 50%) of on-line shopping, the logistics centre model continued to produce the environmentally best effects, although the other models, refrigerator-freezers in stairwells and home-deliveries were also calculated as decreasing environmental effects. The differences between the various cases were considerably less than with 10% on-line shopping, but they continued to show the same results.

Freire (1999) has compared, using a life-cycle assessment (LCA) method, the environmental burdens of traditional supermarket shopping to the impacts from Internet ordering and home delivery in the Netherlands.[130] Environmental impacts of three scenarios were examined: (1) traditional supermarket shopping by car or bicycle, (2) Internet ordering and home delivery from a special distribution centre, and (3) Internet ordering and home delivery from a supermarket.[131] The focus of the analysis covered the chain from the moment the products leave the central distribution centres to supermarket, until they are stored at home.

The results indicated that in traditional supermarket shopping, transportation by car between home and the supermarket had the highest environmental impacts (more than 46%). Also the supermarket building and its energy consumption was a significant contributor. In home delivery from a distribution centre or from a supermarket, the delivery transport represented the highest burden depending on the type of vehicle used, the distance travelled and the number of deliveries.[132] When all three alternatives were compared, home delivery from a special distribution centre had the highest environmental impact.[133] From the supermarket, the home delivery by a van is more favourable from an environmental perspective than transportation by car, and environmental impacts could be reduced by 20%.

Internet ordering and home delivery did not seem to have significant environmental benefits compared to the traditional supermarket shopping (almost half of which is done by bicycle) in the Netherlands. EGS had slightly larger (5%) environmental impact than traditional shopping. However, in traditional supermarket shopping, the environmental impact varies considerably depending on how the trip is made. *If the trip is made only by car and not by bicycle, the results favour home deliveries both from the supermarket and from the distribution centre.*

Cairns (1999) have analysed the trade-off between the distance travelled by customers if they transport their groceries by car, and the equivalent distance driven by a fleet of vans to deliver the same number of shopping loads within one UK town area.[134] The results indicated that it was far more efficient for a few vans to make several round trips than for a large number of cars to travel individually back and forth to a supermarket. The simulations showed that the delivery van journeys only constituted 23% of the distance previously travelled by cars. *Even with a relatively small number of customers and vans which only carry a few loads of shopping each, 70-80% of vehicle kilometres were likely to be saved if customers no longer travel to the stores by car. If 10-20% of all customers would use home delivery, the traffic reduction could be between 7 and 16%.*

To conclude, electronic ordering of groceries and joint distribution seems to create an opportunity to reduce the amount of total transports related to grocery shopping and associated energy consumption and emissions. Simulations show that home deliveries could reduce traffic mileage by 2 - 19%, energy consumption by 5 - 35% and CO_2 emissions by 7 - 90%, depending on the context. However, many uncertainties still exist related to these calculations and to their generalizability. Some of the uncertainties relate to the emission data used and assumptions made concerning, e.g., the car use for making shopping trips.

These simulations on various home delivery alternatives and their environmental effects provide a starting point for considering the environmental implications of EGS. Some of the *direct effects* of EGS, especially effects on traffic, can already be identified. With increased adoption of EGS, other effects become more visible. Operative models in EGS from order processing to delivery and reception become gradually established. Only then will it be possible to evaluate in more detail what kind of material and energy savings can potentially be achieved in various stages of the EGS process.

The *indirect effects* of EGS are probably more significant than those directly related to the electronic grocery shopping process, from the point of view of the total environmental impacts of EGS. What will be the extent of EGS in twenty years, and does it replace or supplement shopping in retail outlets? How will the e-grocery trade influence the structure of the retail trade in the long run? What other activities will EGS substitute and generate? How will on-line shopping influence buying habits and mobility of consumers? What kinds of people, and how many engage in EGS, how often, for what kind of goods, and under what circumstances?

The impacts of EGS on travel have been widely speculated (e.g., Mokhtarian & Salomon 1997; Cairns 1999; Marker & Goulias 2000; Mokhtarian 2000; Heinonen 2000). Therefore, traffic is used here as an example to demonstrate how difficult it is to estimate the environmental effects in the early phase of EGS business development. EGS may change the behaviour related to how grocery-shopping trips are made and potentially alter activity patterns, the mix of vehicles in traffic, and the spatial and temporal distribution of traffic.

The key question is whether EGS replaces travel or generates it. Replacing store shopping with on-line shopping shifts the travel required for delivery of the purchased goods from the consumer to the service provider, with an uncertain net impact. Provider-side delivery trips may be more efficiently organized than consumer deliveries – or not, depending on both the extent to which the consumer trips are chained to other activities and on the provider-side tradeoffs between efficiency and timelines of delivery. EGS may change the frequency of grocery shopping. EGS customers tend to buy more and shop less often. Both these trends would lead to further traffic reductions. Centralized deliveries can also improve the operational efficiency of traffic by changing the spatial and temporal patterns of traffic, possibly smoothing peak demand periods and locations.

Alternatively, people may be ordering some products such as heavy products on-line but still make a car trip to buy fresh or supplement products, which could mean increased travel. There are also concerns that reduced car use for food shopping may lead to more car use for other journey purposes. It is possible that the time saved by not travelling to the store can be used for additional out-of-home activities requiring travel. In addition, delivery services can be used by non-car owners, who may have previously done their shopping without using a vehicle. The average distance of shopping trips may increase as consumers are able to order deliveries from more distant sources than they would normally be willing to shop at personally. This is expected to happen in the case of non-food goods, but e-grocery services generally operate more locally.

When considered in a larger context, grocery shopping generates only a small portion of all traffic. Therefore, *the overall impacts of EGS on total traffic volumes* may remain minor. According to several commentators, EGS is not likely to have, at least in the current scale of operations, a noticeable effect on total travel reduction or enhancement, as processes cancel each other and there is no overriding effect that clearly dominates.

6.5 E-grocery shops and their environmental efficiency

The first part of this section briefly describes alternative EGS business models and how EGS services can be organized from a business perspective. After that, the operating concepts of four different Finnish EGS businesses are discussed in more detail. The third part identifies and summarises aspects in the EGS shopping process, from ordering to the reception of products, which influence the material and energy consumption related to EGS.

6.5.1 Different e-grocery business models

Currently, e-grocery business is based on two dominant operating models (e.g., Palmer et al. 2000; Kallio et al. 1999; Jaakkola and Kämäräinen 2000; Kämäräinen et al. 2001):

- Electronic service "on the top of" an existing grocery shop
- Virtual e-grocery shop operating only on the Internet

In the first model, products are picked from the shelves of a physical store. The store is used for both EGS and traditional daily shopping. This multipurpose use of stores is often referred to as a *hybrid model* of e-commerce. This model is used, among others, by Tesco in the U.K. The assortment is normally the same or smaller than in the physical store. The underlying product supply and logistics systems are the same for both the physical and electronic store. The concept is easy to implement when sales volumes in EGS are low and electronic grocery shopping is only a value-adding service for the retailers. Investments needed are moderate but this is not a cost-efficient model, because double processes for conventional grocery business and Internet order processing have to be maintained. In the case of higher penetration of EGS, especially picking operations and home deliveries become inefficient because of difficulties in forecasting demand and due to short response times. The second model, the virtual e-grocery shop is specialised in on-line business only. Own or outsourced personnel pick the products from co-operating retail stores or from a dedicated warehouse designed and managed for the purpose of EGS. This warehouse is often a local distribution centre or terminal, where products arrive directly from producers or importers. The products from different suppliers are collected in a terminal organized especially for handling small and pre-packaged batches. Order processing can be to some extent automated, and picking and packing operations are especially designed for serving home delivery (e.g., real-time inventory control on the basis of customer orders). Because products need not be routed through a retail-outlet, the cost of picking-up and possibly also for delivery is lower. The assortment can be larger or more specialized than in a traditional supermarket. This model requires larger investments and a larger customer base. This is how, e.g., Matomera in Sweden operated, but it has recently closed down its operations.

Until now, most e-grocers have operated using the existing supermarket infrastructure. However, if EGS volumes increase, e-grocers are forced to look for more efficient solutions in picking, deliveries and reception of goods. So far, Finnish EGS service providers have not made significant investments in new distribution structure dedicated to deliveries of on-line orders. If the sales volume of EGS does not exceed the forecasted level of 5%, the currently used distribution solutions may work in Finland (Kallio and Kemppainen 2000).

Deliveries in EGS can be organised in different ways and with different time windows (e.g., on which days, at what times, how many delivery rounds per day). The more fixed the delivery windows are, the more efficiently the deliveries can be organized. On the other hand, the more flexible the delivery windows are, the better service it is from the customer's perspective and it may influence the EGS penetration rate considerably. Finding a suitable balance both from the efficiency and service perspective is one of the major challenges currently for EGS business development. Various alternatives for reception of orders exist, although home delivery is the dominant service model. Also reception boxes, pick-up and drop-off point concepts are under development. These are discussed in the following sections in more detail.

Electronic grocery shopping can gradually lead to changes in the logistics in grocery retail trade, such as those illustrated in figure 12. Producers and e-grocery shop-keepers may bypass intermediaries such as wholesalers. On the other hand, new intermediaries such as distribution centers that act as both wholesalers and retailers will enter the market.

- Producers ➔ Wholesaler ➔ Retailer ➔ Consumer
- Producers ➔ Wholesaler ➔ Retailer ➔🡐 Consumer
- Producers ➔ Retailer ➔🡐 Consumer
- Producers ➔ Local distribution centre ➔🡐 Consumer
- Producers ➔ Consumer

Figure 12: Alternative logistics models in e-grocery trade (after Jaakkola & Kämäräinen 2000)

6.5.2 Comparison of four Finnish e-grocery models

In the following, four EGS services (Ykköshalli, Ruokanet, S-box and Ekoportti portal) are described in more detail. They are examples of different e-grocery business models existing in the Finnish market. Ykköshalli's virtual grocery shop operates on the top of an existing supermarket and Ruokanet operates only on the Internet and has outsourced all warehouse, delivery and information technology activities. The unique aspect in the S-box concept is the unmanned reception box for deliveries, and Ekoportti is an Internet sales portal for ecological products and services. One e-shop called Luomupuoti sells organic food products via the Internet site of Ekoportti, and it is examined more closely here.[135]

Supermarket based e-grocery store: Ykköshalli [136]

Ykköshalli is a large supermarket with a turnover of 22 million EUR situated in Myyrmäki at Vantaa, in the greater Helsinki region. The owners who operate as retailers in the K-group, opened the on-line grocery shop in 1997 as a value-added service alongside the existing supermarket. The original idea was to provide customers with better service and with home delivery. In early spring 2001, Ykköshalli had 300 weekly home deliveries, of which 150 are Internet orders.[137] On-line sales represent about 5% of the total grocery sales. The on-line store has 1100 registered users, 300-400 of which are active ones, the majority of them households. Families with small children are currently the largest customer group. The average on-line purchase is 100-118 EUR. Beverages and fruit are among the top on-line sales products.

The virtual grocery shop has the same assortment of about 11000 products as the physical store. Half of the products are supplied by the K-group. On-line purchases are delivered from Tuesday to Friday between 12-20 pm. Normally 20-50 home delivery orders are processed daily, Tuesdays and Fridays being the busiest days. The service fee for the collection and home delivery is 13.5 EUR, and 6.7 EUR if purchases are picked up by the customer from the supermarket. Purchases are paid when received by cash, bank or credit card.

The collection takes place from the shelves of the supermarket, and it is made as much as possible outside the normal opening hours, starting from 6 am. Fresh products and frozen food are collected last, and about half of the orders can be collected outside the opening hours of the supermarket. No scanners are used in the collection due to high investment costs, but the collectors are experienced supermarket staff. Since fall 1999, the supermarket has had a separate cold warehouse to enable more effective fulfilment of on-line orders.

Ykköshalli uses its own van for deliveries. During peak times, extra delivery capacity is acquired from the courier service of the Finnish Post (Keltainen Kuljetus). The orders are delivered in carton boxes incoming to the supermarket with supplied products.[138] Frozen items are delivered in cooler bags with cooler packs inside, or larger amounts in cooler boxes made of styrofoam or PVC. It is estimated that about 3000 kg of groceries are being delivered home daily. The van normally delivers 10 orders per round. On a busy day, 10 rounds are made. One round normally takes one hour, 30 kilometres being a long delivery round. Due to relatively short delivery rounds, no difficulties with the preservation of frozen food have been experienced, although the van does not have any cooling equipment.

The e-grocery shop provides the same price level as in the supermarket, with an additional pick-up and delivery charge. Delivery charges (EUR 13.5) were raised in spring 2001 to correspond better to the real costs of pick-up and delivery. Further development needs, according to the e-grocery shop keeper, include better collection times of orders, more efficient delivery planning (e.g., according to postal codes and weekdays) and electronic payment systems, which would save time in deliveries. Although the year 2001 has brought new customers to the e-grocery shop, and the sales has doubled during each operating year, the overall growth in EGS has been much slower than anticipated by the shopkeeper. As an investment (working hours, time, money and effort put in it), the EGS service has not paid itself back yet.

Virtual e-grocery shop: Ruokanet [139]

The Ruokanet e-grocery shop, launched in 1998, runs all its business operations on the Internet. The business idea has been to develop a dedicated information system with all relevant components needed to run an EGS business and as streamlined operations as possible. The company owns no inventory and has outsourced warehousing, delivery as well as IT operations. It is the only e-grocery shop operating with this concept in Finland. Ruokanet is part of the Janton business group, and an investment company A-Profiili is its largest owner.

In early spring 2001, Ruokanet operated in the Helsinki Metropolitan area and in the cities of Tampere, Turku and Oulu.[140] It employed about 18 people, the majority of them based in Helsinki. Ruokanet purchases the products from K-group's wholesale company Kespro, and Ruokanet also physically operates in the Kespro premises in Helsinki and in Tampere. In Helsinki, the recently opened new Kespro warehouse is 12000 m^2 in size, and provides 14000 sales items. The warehouse operations such as shelving and product coding are designed for the purposes of automated order processing.

In early spring 2001, Ruokanet processed 250-300 on-line orders weekly, corresponding to 1200 monthly deliveries. In the year 2000, the turnover was 1.2 million EUR, and the aim is to double it during 2001. Ruokanet estimates to have a share of 20-30% of the e-grocery sales in Finland. Ruokanet clearly focuses on business customers, SMEs being the largest customer group currently. An average on-line purchase is 110 EUR. Coffee, beverages, bisquits and milk products are among the most popular on-line products.

Deliveries take place from Monday to Friday between 11 am and 19.30 pm. Monday, Tuesday and Friday are the peak days. Orders are collected from the Kespro warehouse by Ruokanet's personnel. Ruokanet delivers all its orders to the customers, no pick-up alternative from the warehouse exist. Delivery and service charge is 13.5 EUR. Payment can be made electronically when ordering the products or by bank or credit card when received.

In spring 2001, orders were delivered in carton boxes, which are leftovers from the warehouse or from the surrounding other stores. A new delivery box with a token was under development. For frozen food, delivery boxes of two sizes made of polyurethane were used. All transports were outsourced to a delivery company, and delivery services are bought according to the exact daily need, thus not leading to overcapacity problems. Diesel vans are used for deliveries, having the capacity of 10-15 orders. Vans are not equipped with refrigerator systems, but this has not caused problems until now, because the longest delivery rounds have been 3 hours. The Ruokanet delivery area covers most parts of the Helsinki metropolitan area.

Ruokanet foresees 2001 to be the first year with operating profit. Although start-up investments have been heavy, no risks are involved in warehousing or product spoilage. The service concept can be easily copied if there is a need to expand operations, and no investments are needed in building warehouses, etc. According to Ruokanet staff, current development needs include more focused product assortment, new ways of ordering (e.g., using mobile phone text messages) as well as new concepts in order reception (e.g., pick-up and reception box alternatives are being studied).

Unmanned reception box concept: the S-Box project [141]

The S-Box project has tested the suitability of an unmanned reception box for the reception of on-line grocery deliveries during the year 2000. The project partners included S-Kanava (e-commerce development unit of S-group), Hollming Oy (reception box manufacturer), TAI Research Centre of Helsinki University of Technology (research partner) and Helsingin Osuuskauppa HOK (grocery retailer).

The deliveries to the reception box started in May 2000 and were run for three months. Reception boxes were assembled in the front-yards of 50 households (detached houses) participating in the project. The households were quite dispersed in the area of Espoo and Kauniainen. The on-line ordering interface was provided by S-group, and the orders were collected and delivered from a S-market in Olari, a supermarket with an assortment of 8000 products. Deliveries took place twice a week, on Tuesdays and Thursdays between 14 and 18 pm. Orders were due before the delivery date by 24 pm. The service charge was 34 EUR per month including collection, deliveries and the rent of the reception box. This meant 8 deliveries per month. In practice, the reception box was free of charge for households during the pilot project. Deliveries were provided by a courier service Suomen Kauppakassi Oy. Delivery boxes of several sizes were used.

The reception boxes were designed and manufactured by Norpe Oy (part of the Hollming group), which is the largest manufacturer of cooling equipment in Scandinavia. The reception box (figure 13) was equipped with three departments (frozen food, cool department and room temperature). The volume of the box was about 200 litres and it weighted 150 kilograms. Because the boxes were assembled outdoors, they were equipped with both cooling and heating. The energy consumption of the box was a few hundred watt-hours.

Figure 13: The reception box used in the S-box project.

As such, the users were satisfied with the functionality of the reception box. The greatest advantage of the box for the retailer was that the time window from order pick-up to the delivery could be reduced, thus reducing the delivery pressure on certain peak hours and days. After the project, the supermarket has actually continued providing grocery delivery service to the reception box households.

This pilot box was quite robust in physical appearance, but the manufacturer has plans to improve its design and increase its functionalities and intelligence (e.g., the box automatically switches to the standard temperature when the freezer temperature is not needed). A disadvantage of the current box concept is that it needs to be bolted into the ground and located close to a power plug. It also has to be reasonably accessible with a delivery van. Another disadvantage is that before such reception boxes reach mass-production phase, the investment costs for individual households are very high. This may lead to different solutions considering the ownership of the box (they may be owned by the retailer or leased by some other service provider). The reception box shifts cooling activities from retailers to households, with an uncertain net impact on energy consumption. From the utilization rate perspective, it remains to be seen, whether several service providers can possibly deliver items to the same box.

Sales portal of ecological products and services on the Internet: Ekoportti [142]

The Ekoportti Internet site was initiated by the the Chydenius Institute in Kokkola together with local entrepreneurs. After it first got financing for the development work from the Ministry of the Environment, the company Ekointernet Oy was established in May 2000 to develop the Internet site further. The site www.ekoportti.fi was launched in September 2000. The company is owned by the entrepreneurs and a small number of private investors. Six persons were more or less involved in the company activities in spring 2001.

Ekoportti aims to be a market place for ecological products and services and it is also a news and discussion forum for ecologically oriented consumers and businesses. The company Ekointernet does not sell any products itself, it only provides sales space on its Internet site. One of the basic ideas behind the site has been to provide a new, more efficient marketing channel for organic food products and local farmers and to improve the visibility of local services.

Luomupuoti is an e-store within Ekoportti selling organic food products from local producers from the Pirkanmaa area (close to the city of Tampere). Pirkanmaa organic food producers established an organic food product wholesale company in 1992 and the company has a retail store in the Tampere market hall, from which the on-line orders are also delivered. Luomupuoti provides an assortment of about 55 products including cereals, preserved and dried vegetables, sweets etc. On-line orders are sent from the Ekoportti's server as an e-mail to the Tampere store. The products are centrally collected from the store and not ordered from individual producers according to demand. Delivery area covers the whole country, and deliveries take place as post packages. The delivery time is 2 to 7 days from the order. The delivery charge is 6 EUR or with post package home delivery 12 EUR. The third alternative is to pick up the ordered products from the shop in Tampere. Payments are made electronically when the order is made on Internet or when the products are picked up from the store.

Although there are 200-300 visitors per day on the Ekoportti site, people seldom use it for making purchases. The volume of on-line orders of organic food products has been really modest.[143] Partly because of this, Ekointernet announced in August 2001 to give up activities related to product sales on its site, at least for the time being. According to the business developer, some of the current obstacles related to selling ecological products on the Internet include that on-line stores do not provide any value-added for customers, because of the same or higher price level than in physical stores and because the on-line assortment is small. Also the delivery times are far too long for attractive on-line business. It has also proven to be difficult to attract small producers to sell their products through a new channel, the Internet. One additional practical problem has been that the payment system is electrical, which reduces the number of producers who can easily be involved in the system.

Currently, Ekointernet seeks for new, larger investors and the business development is more and more focused on providing marketing space for ecologically oriented companies. Slow and sustainable business growth would fit with the ecological ideology of Ekoportti and with that of small local entrepreneurs, but is not in line with the resources needed in developing e-business on Internet. The company is still seeking for the right focus and locality level for its operations.

To conclude from the different EGS business developers' experiences, one of the key aspects many e-grocery shops are currently confronted with is: who are profitable customers for EGS and what should be the range of products and services provided (focus and efficiency)? Many e-grocery shops see the need to reduce their product assortment and to focus more on certain products that sell well. In addition, due to the newness of the business model, credibility creation among customers and suppliers takes time. The establishment of an EGS business is also a considerable information system integration project. The virtual e-grocery shop visible to customers is only a small part of the multi-layered information system needed to run an EGS. Managing the information, cash and logistics flows between product suppliers and the e-grocery shop is a challenge as such. Although the Internet provides a new media to present a lot of product specific information and product images, it takes time and effort to realize these due to the substantial data integration work needed between a large number of products and their numerous suppliers.

6.5.3 Summary of factors in EGS influencing material and energy consumption

The following presents a summary of factors in the EGS process from ordering to the reception of goods that can be expected to influence the material and energy consumption of the process. The identified factors have been brought together from the literature and from EGS practitioners' views. The focus is on considering the shopping process and activities between the e-grocery shop and the consumer, whereas operations in the rest of the grocery supply chain are excluded from the analysis.

Ordering and order processing:

- Equipment needed to make an order (computer, telephone, fax, television) and documents printed (e.g., customer's shopping list).
- Order processing systems in the e-grocery shop: hardware and documents (e.g., pick-up lists, receipts).

Collection of products and product packing:

- Energy consumption of the premises: lighting, heating, cooling, freezing. In a warehouse, energy consumption is normally smaller than in a supermarket.[144]
- Equipment and space needed for product shelving and collection of orders. The need to store incoming products may decrease with an order lead time of one day or less.
- Product packaging. EGS may lead to more standardized package sizes, and to providing only certain product sizes to EGS customers (e.g., ready-packed 6 tomatoes). It can also lead to over-packing. On the other hand, EGS may also lead to simpler product packages and package redesign for efficient deliveries, if the majority of product related-data can be placed on the Internet and the marketing function of packages is decreased.
- Delivery packaging. What kinds of transport boxes or bags are used for the delivery (size, material)? How is the cold-chain for frozen food secured, and how are fresh food products such as salad transported? In Finland, the yearly outdoor temperature variations have to be taken into account.

Deliveries:

- Delivery vehicles. What is the capacity and size of delivery vans? The suitability of vans for deliveries in dense city areas versus in sparsely populated areas? How fully is the capacity used per delivery? What is the number of delivery vehicles needed?
- Car technology and fuel used (diesel, gasoline, ethanol, gas, electric vehicles). Are catalytic converters and other types of exhaust filter systems used?
- Driver training, vehicle design and vehicle maintenance.[145]
- Delivery time and scheduling of deliveries. How many delivery time windows per day are provided to the customers and when do deliveries take place (during peak hours or other time, are night deliveries possible). Customer demand can be influenced by, e.g., specifying different prices for different delivery times such as peak hours to be more expensive.
- Peaks in demand cause problems in planning efficient deliveries. It is difficult to forecast the volume of occasional orders, regular orders and orders related to specific occasions (week-ends, holidays).
- Delivery route optimization. The size of the delivery area and the density of delivery locations. Average delivery chain lengths. Number of deliveries per route. Deliveries in one chain versus reloading needs.
- Who delivers: is it the e-grocery shopkeeper or a specialized delivery company? This can make a large difference to the number of vans on the roads. It is more efficient to have fewer delivery operators with greater consolidation of loads.
- Refrigerated or non-refrigerated transport. Are delivery vans equipped with a cooling system or are products packed in special transport boxes only? The cooling system adds extra weight to the truck, consumes energy and contributes to CFC emissions.
- Drop-off time: is the delivery van running on idle while the ordered goods are delivered to the customers' door or to a reception box?

Reception:

- Home delivery: customer is at home to receive the delivery or goods are delivered to a reception box. The reception box (such as S-box in figure 13) can be installed in the customer's garage or home yard, or it can be a customer-specific locker located in a specific room in the entrance hall of a department house, or in separate small facility in a residential area. There are different kinds of reception boxes entering the market depending, e.g., on the location, size, different temperature zones and electronics of the box. If the reception box is refrigerated, it doubles the number of refrigerator-freezers per household. Another alternative is an insulated and secured delivery box equipped with a docking mechanism. The box containing the goods is delivered to the customer and attached securely in a locking device bolted on the building wall.[146]
- Pick-up points: customer picks up the ordered goods from the e-grocery shop.
- Drop-off points: grocery orders are delivered to a central distribution point close to a customer (e.g., workplace, local shop, community centre, metro, railway or bus station, kiosk, post office or day nursery). There, shared reception boxes or a centralized locker service is organized.

Returns:

- Returns may be due to false pick-ups of products in e-grocery shop, due to damages to the product packaging or due to spoilage of fresh food during the delivery. Returns and related traffic may not be a major concern related to groceries because they are low-price products and are normally replaced by a new item when ordered next time.
- Other services can be attached to home deliveries and to the return-trips of delivery vans (e.g., return of empty bottles, film processing, laundry services).

Other factors influencing the shopping process which may influence the adoption rate of EGS:

- What is the influence of the user interface: sufficient reliability and speed of the connections with the Internet, ease of making an order in the virtual e-grocery shop?
- Interaction possibility with the e-grocer (personal contact) and the feeling of trust in the system (that the e-grocery shop really exists and is reliable) may be important for many customers of an e-grocery shop.
- Flexible ordering possibility 24 hours a day can increase the popularity of EGS.
- The extent to which Internet and EGS can assist in consumption planning by providing customers, e.g., with ready-made shopping lists, automatic ordering and computer search robots, "bots", searching for products according to customized buying criteria.

6.6 Future scenarios on electronic grocery shopping development

A survey based on the Delphi method was conducted to explore how experts and practitioners in the field view the future of EGS. The aim was to identify their views on the development of electronic grocery shopping in Finland by the year 2010, and their views on the implications that EGS can have on material and energy consumption. The aim was to produce a set of scenarios on probable and preferable future development concerning:

- the **expected** EGS business development in Finland to year 2010
- the **preferred** EGS business development: what kind of EGS model(s) would be environmentally effective

The Delphi technique has been principally used in future studies as a method to make future projections and forecasts when assessing new phenomena and their impacts (e.g., in technology foresight). In traditional Delphi, the idea is to get an expert panel estimation of probable future developments when the topic is a complex one, which has many interpretations and is hard to formalize in mathematical models. A series of questionnaires is used to aggregate the judgements or opinions of experts. Individual contributions are then shared with the whole group by using the results from each questionnaire to construct the next questionnaire. The argumentative rounds are usually anonymous, so that the status or background organisation of the experts does not affect others' opinions. The Delphi consists normally of at least two, sometimes even five survey or interview rounds. Normally, 30 to 100 panellists are employed, but smaller panels of 10 to 20 people are also considered as sufficient (Tapio 2000; Mannermaa 1999; Metsämuuronen 1997; Moore 1987).

In this case, a two-rounded survey was carried out between February and April 2001. The first round questionnaire was sent by e-mail to 36 panellists, consisting of representatives of three group of experts:

- experts on environmental and social impacts
- practitioners and researchers of practical aspects of electronic commerce
- practitioners and researchers in the grocery trade

Panellists were selected among researchers identified to be working in the field, and among organizations active in developing or studing electronic commerce or environmental impacts. The aim was to gain the panellists' views as individual professionals, rather than as representatives of a specific interest group. Panellists in the first group included researchers of, e.g., traffic impacts, consumer behaviour, ICT adoption, futures studies and environmental impacts. The second group of panellists included people from e-commerce research institutes, research in the ICT-business and developers of practical e-business solutions. The third group consisted mainly of environmental managers and e-commerce developers in the grocery trade, researchers studying the grocery trade and organizations developing packaging and logistics solutions for the e-business. The majority of those responding to both rounds consisted of researchers, whereas the share of business people responding decreased on the second round.

Table 3: The distribution of respondents in the Delphi panel.

	First round:	Second round:
Experts on environmental and social impacts	10	9
E-commerce experts and practitioners	8	6
Grocery trade experts and practitioners	8	7
Total number of panellists	**26**	**22**

In the first round, questionnaires from 26 panellists were received. In the second round, 22 out of 26 first round panellists returned the questionnaire. In both rounds, the responses were divided quite equally between the three groups, as table 13 shows. In the first round, the data were collected by a fairly open questionnaire. A background information paper was also provided, which included information on EGS business models, the grocery trade and grocery shopping habits, as well as estimates of the impacts of EGS on traffic, energy use, and emissions, and of its business prospects. The panellists were invited to write down qualitative and quantitative assessments of 11 questions, which were divided into three main groups: a) probable development of electronic grocery shopping by the year 2010, b) preferable development of electronic grocery shopping, and c) central environmental aspects in the emerging electronic grocery trade. On the basis of the responses (amounting to about 40 pages of text), a summary report of responses to each question was complied.

In the second round, the questionnaire was fairly structured. The panellist's shared views and more detailed opinions were sought on the following questions:

- The probable share of electronic shopping of the grocery market in the year 2010
- Practical solutions in use in the electronic grocery trade (ordering, picking, delivery)
- The impact of EGS on the consumption of materials and energy (will it increase, decrease, or remain neutral, and why)
- What would be the most effective or efficient model in EGS from the point of view of conserving materials and energy (operating principles, delivery, reception, etc.)?

The questionnaire used on the second round included, in addition to questions, a number of alternative scenarios pertaining to each question. Two to three scenarios were constructed for each question, and these were based on the responses to the first round. The scenarios aimed to encompass the central, frequently recurring arguments used by the panellists to argue for specific trajectories. Panellists were asked to choose the scenario that fit their views best. For each question, respondents were also given the option to present their own, new scenario (i.e., they were not required to choose merely among the given alternatives).

6.6.1 Expected EGS business development

The share of EGS of the grocery retail trade in 2010

Half of the panellists were of the opinion that the most probable share of on-line shopping of the grocery trade would be in the order of 5-10 per cent in the year 2010. On the other hand, many believed its share would be less; 7 panellists estimated the share to be in the order of 1-3 per cent. All in all, quite moderate growth was expected within the coming decade. The developers of e-grocery shopping were the most positive about its growth, expecting a market penetration of 10 to 20 per cent.

The scenario of 5-10% was based on the following kinds of arguments about the future of the grocery trade:

"More entrepreneurs have entered the e-grocery business. The convenience and the variety of services provided by electronic grocery shopping have also improved. Faster network connections and the entry into the market of different kinds of customer terminals will have made the service more versatile and accessible. Delivery logistics will have been made more effective, partly due to the growth of the customer base. Half of all two-income families uses electronic grocery shopping at least sometimes. Electronic grocery shopping is also employed by business customers, busy people whose work is directly or indirectly related to information technology, physically disabled people and some of the elderly households. E-grocery shopping has still not significantly influenced the development of grocery retailing. Small grocery shops, however, are turning more and more into specialty shops (meat, fish, sweets, etc.), in which customers shop for delicacies, fresh food and ready-made meals."

The expectations of a penetration rate of 1-3 per cent were based on the argument that the Finnish market is too small for electronic grocery shopping, which only has a small share of all Finns as its customer base. Some even viewed 3 per cent as a large share. Other factors believed to obstruct the growth of EGS included the conservative operating mode of the retail trade, and the inertia in consumers' purchasing routines.

Alternatives in ordering, pick-up and deliveries

The panellists believed that ordering of groceries in the year 2010 will still be based on orders placed by customers personally. According to the dominant scenario "customers will be aided by a standard shopping list, which can be modified at need. The order can be placed either from home or from work, using a PC, digital TV or a mobile terminal, depending on the possibilities offered by the development of IT equipment by the year 2010, and on the accessibility and convenience of different interfaces in different situations." Fully automated order systems, e.g., on the basis of standard weekly shopping lists, were not expected to be in widespread use by the year 2010.

According to the panellists, in 2010 the picking of electronically ordered groceries will be done in both existing retail outlets and in dedicated distribution warehouses. This means that the model based on the existing infrastructure of grocery retailing will still be in use, but in addition, regional terminals designed specifically for electronic retailing will have also been set up. The panellists held different views on what the dominant mode will be. These differences were more marked within respondent groups than between the different groups of experts. The regional distribution centre model gained slightly more support from the developers of e-grocery services and the retail trade representatives than from others.

Different delivery and reception models were expected to co-exist in the upcoming decade. The panellists expected home delivery directly to the customer to be the dominant mode, but they also believed that pick-up points will have been developed (e.g., local pick-up point on the way home, small local shop, gas station or kiosk). Also unmanned reception or delivery boxes were expected to be in use. Some believed strongly in the future of reception boxes, while others believed in more traditional solutions, such as delivery to or pick up by the consumer personally.

The impact of EGS on material and energy consumption

The impact of EGS on material and energy consumption turned out to be a difficult question to answer on the first round, which was not a surprise as such. After the first round, a list of the most commonly presented arguments for and against was compiled, and from this list, panellists were asked to select the most significant contributors to the total impact.

Eleven experts were of the opinion that electronic grocery shopping would lead to reduced consumption of energy and materials. Seven experts believed it would not reduce or increase energy and materials consumption, irrespective of whether EGS replaces traditional shopping modes or merely complements them. Four of the respondents believed that EGS would increase the consumption of energy and materials.

The majority of the experts in environmental and social impacts were of the opinion that EGS would reduce the consumption of energy and materials in retailing (five out of nine panellists). Three believed the net effect would be neutral, and only one believed EGS would increase the use of energy and materials. Similarly, the majority of e-business representatives (four out of six) believed EGS would conserve energy and materials. Opinions were most divided among the representatives of the grocery trade: one believed it would increase energy and materials consumption, three believed it would conserve energy and materials, while three expected the net impact to be neutral.

The prevailing expert opinion was thus that the net impact would be positive, or at worst neutral, although the same arguments were used to support claims both for and against. Claims for a reduction in energy and materials requirements were most commonly supported by arguments relating to increased efficiency in deliveries, reduced car use by the consumer, and – perhaps somewhat surprisingly – increased efficiency in packaging. The most common arguments included:

- Centrally organized delivery home or into the neighborhood is more energy efficient than shopping trips made by car, assuming that efforts have been made to improve delivery systems
- Electronic shopping reduces shopping trips made by car and hence energy consumption
- Delivery services for products ordered over the Internet can be combined (different service providers utilize the same delivery service), especially as the use of electronic services grows.
- The need to package products will change and decrease. In the electronic grocery shop, packaging does not need to sell the products, but rather to make more efficient use of space when packing the customer's shopping. Sales packaging is reduced, consumer packaging sizes will grow, and transport packaging will be made more efficient.
- Order systems in electronic grocery shopping enable on-demand production, which makes it easier to optimize inventories and reduce product spoilage.
- The number of retail outlets decreases, or retail outlets are replaced by more energy-efficient local distribution centres (lighting, heating, freezer and cooling rooms).

The most important argument supporting the claim that EGS would increase the consumption of energy and materials was that products will be purchased in small batches from an increasing number of physical locations, and that each service provider will have their own delivery models. Improved customer service may also lead to an increased number of delivery times and small-scale special deliveries. Many also believed that reception facilities or reception boxes suitable for cold storage will increase the consumption of materials and energy.

6.6.2 Environmentally effective EGS models

When developing environmentally effective EGS scenarios, the panellists emphasized especially the role of virtual supermarkets, but also pointed at the possibilities for specialized food retailers, including, e.g., services for purchasing "shopping baskets" of organic food. The virtual supermarket would "offer the same assortment of daily goods and other products as physical retail outlets do, or an even broader one. The on-line grocery store offers much more product information than current shops, including nutritional data, data on eco-labelled products, as well as information on local and fair trade products. Data on suitable products and on the best bargains can be sought for and compared from many different on-line grocery shops using search engines. EGS sites can also include other services, such as video rental, photograph development or postal services."

Picking the ordered products from physical retail outlets was not considered an environmentally effective alternative in the future. These activities would be transferred to dedicated regional and local distribution centres, which serve as centralized places for assembling customers' shopping baskets. "Picking is highly automated and deliveries from large suppliers arrive directly into the customers' shopping basket on the day of the delivery, without the need for intermediate warehousing."

Opinions about what would be an environmentally effective delivery model were fairly evenly divided between two alternatives. Fixed delivery times (narrow time-window, e.g., once a week at a specific time in a specific area) was considered slightly better than offering customers more alternatives to select the most suitable delivery times (broad time-window, including, e.g., mornings, weekends and late at night). The narrow time-window was supported especially because it would help increase the efficiency of deliveries by making it easier to plan delivery routes. The broader time-window was supported by claims that it would attract more customers, thus improving the efficiency of the delivery system.

In delivery reception, the unmanned reception box was, perhaps surprisingly, considered the most effective or eco-efficient solution, and clearly a better one than delivering the goods home to the customer personally. The advantage of a pickup point, on the other hand, was that temporary cold storage could be organized more effectively for a larger amount of shopping baskets, and households would not need to invest in a separate reception box.

All in all, the survey produced an interesting set of data, of which only a brief summary can be presented here. The discussion on how such data could be elaborated further and used for more far-reaching conclusions, needs to be continued elsewhere. The responses of the panellists indicated, however, that quite a few different viewpoints exist on future developments. It turned out to be especially difficult for many panellists to identify the environmental impacts of EGS on the first Delphi round. On the second round, the experts' opinions were sought especially on pre-structured alternatives, which on the other hand is the only alternative if one wants to summarize a variety of viewpoints on future developments into a few of the most typical ones. It is worth noting, however, that the viewpoints of the experts did not change much in the second round, and the new information mainly related to providing more detailed scenarios.

Such scenarios of the future development trajectories do not actually provide data on the future, but rather, give an idea of what the expectations of the relevant experts are at the moment, what opportunities can be seen in emerging technologies and solutions, and what the views are on the most probably dominant models in the future. This is also one way to influence the development of EGS, or at least to initiate a broader public discussion on the environmental aspects of this development.[147]

6.7 Conclusions: can EGS be a viable way to achieve dematerialization?

In EGS, the grocery shopping process is organized in a new way, in which Internet use and delivery services are in a central role. EGS is based on a new technological solution, but its adoption requires accompanying social changes. Consumers need to change their daily routines, and the new mode of operating also implies changes in retailing and possibly in the whole food chain. EGS redistributes consumers' time and money spent on acquiring groceries. EGS can lead to changes in energy and material-intensive phases of grocery shopping.

E-grocery trade has not yet significantly altered the grocery business. Today, and in the near future, electronic grocery shopping appears to complement existing forms of grocery retailing, rather than replace them, or stop the increasing concentration of retail outlets. This is mostly due to the heavy investments made by the grocery trade in developing physical retail stores and logistics infrastructures.

The majority of Finnish e-grocery shops currently operate 'on top of' existing supermarket infrastructure, which does not require heavy investments, but will be inefficient if the penetration rate of EGS grows. Modest investments are understandable because the customer-base for EGS is limited in Finland and the country is geographically large. In the early phase of EGS development, efficient operating models fitting the volume of operations are still being sought for. Many EGS businesses are not profitable yet, and several EGS services have also closed down after the first enthusiasm. But for those who succeed in the field, the expected future share of 5-10% of total grocery sales represents a considerable business. Future opportunities for EGS are especially seen in the business-to-business e-grocery trade.

The adoption of EGS by consumers has been slower than anticipated, not only because EGS services have not been marketed very actively. Early adopters have included SMEs and families with small children. EGS is a suitable alternative for those who consider service important, but for many cost-sensitive grocery buyers, EGS service charges are currently too high. In addition, for the majority of consumers, grocery shopping is such a routine activity that new ways of doing it are not even considered. Consumers seldom calculate the cost of time spent on shopping, or the fuel consumption or emissions due to car use for shopping. EGS is not yet considered as an alternative to reduce the environmental burdens associated with daily consumer activities.

Finnish experiences show that although electronic grocery shopping has been proposed to be a promising alternative in scarcely populated areas where there is a shortage of stores and local services, EGS services are currently available only in the largest Finnish cities. In order to be efficient, EGS requires a relatively dense urban structure and a comprehensive customer base. EGS involves *network effects*: home deliveries are very inefficient for an individual customer, but become more efficient the more customers join the service.

EGS and dematerialization. As long as the scale of electronic grocery shopping remains small, it seems that *EGS will not significantly reduce the materials or energy consumed in grocery shopping and deliveries*. EGS is such a new service that it is still difficult to estimate its direct effects, except in terms of what could potentially be best or worst cases. More experience will also be needed before *indirect effects* (such as the impact on consumer behaviour and consumption habits, or on retail trade structure) can be evaluated.

Some of the direct effects of EGS on traffic can already be identified. Simulations have shown that replacing car trips to supermarkets by centralized home deliveries can lead to considerable savings in mileage, energy use and emissions (section 6.4). With an increased use rate of EGS, other effects become more visible when operative models of EGS in order processing, delivery and reception become more established. It seems that in the long run and with a higher penetration rate, EGS could lead to reduced warehousing needs and more co-ordinated traffic flows. Whereas reduction potentials in the energy use are perhaps easier to identify, the impacts of EGS on material use are more complex (how EGS influences product packaging and spoilage, are reception boxes adopted, etc.).

When estimating the net environmental impacts due to *EGS, the indirect effects of EGS adoption become even more significant than the way in which the EGS shopping process is organized*. These indirect effects include, among other things, how many regular users EGS will attract (the penetration rate), to what extent it replaces traditional grocery shopping, and what kind of other activities it potentially substitutes or generates (such as impacts on recreational traffic). It is time to start focusing more research on these impact-creating mechanisms before EGS becomes an everyday activity.

This chapter has identified and discussed some of the direct and indirect environmental implications of EGS development. The aim has been to show that in addition to operative efficiency, economic credibility and customer acceptance, also environmental efficiency needs to be more explicitly considered when developing EGS services of the future. Further research is needed in this area, but future attempts should be more clearly directed at analysing practical experiences and empirical data, especially related to the indirect effects of EGS development. For example, empirical studies on the impacts of EGS on consumer time use and mobility could bring useful new insights into the discussion.

Future scenarios on EGS business development. In this study, an expert panel was used to estimate the most probable development of the EGS business by the year 2010. The panel was also asked to evaluate what kind of operating models in EGS would be most efficient or desirable from an environmental point of view. The most probable development in EGS was seen as moderate growth, with a market share of 5 – 10 per cent or less of total grocery sales. Electronic grocery shopping is not expected to grow explosively, and thus there is still time to influence the operating models adopted, and their ensuing environmental impacts. Panellists expected different EGS models to co-exist: existing retail stores and distribution centres specialized in EGS will operate in EGS business, and alternative reception modes (home delivery, reception box, pick-up points) will be used. The environmental impacts of EGS were considered a complex issue, but the majority of experts believed it likely that EGS could reduce materials and energy use, or would not at least increase them. From an environmental perspective, the most efficient scenario was a model based on local distribution centres, in which many operations are automated, combined with the reception of deliveries using unmanned reception boxes.

Future challenges. Although the electronic grocery trade is faced with several interesting future challenges, three questions are raised here for further discussion, which relate to the social changes needed to promote the adoption of electronic grocery shopping.

1) What would motivate more people to engage in EGS?

Not all Finns have access to e-grocery shops or are willing to use computers and the Internet in their grocery shopping. But for potential customers, the change in the way in which daily goods are bought should be made as easy as possible. It is probably easier to adopt new grocery buying habits and patterns when moving into a new environment, e.g., into a new city district. If EGS is considered when new housing is being built, the marginal costs of adding required features are smaller and different options for the delivery and reception of goods can be carefully considered, in order to better correspond with user needs.

2) What kind of impacts may EGS have on grocery retail trade?

The grocery shop has been a central place where consumers pick up daily goods for only about three decades. Before that, milk was sold in dairy shops and meat in butcher’s shops, i.e., daily products were sold in specialized small shops. In a supermarket, a large variety of products from different suppliers have been put on display in one place. In the future, will e-grocery break this structure again and lead to the system in which products are collected from several suppliers into an electronic shopping basket? In the long run, how will the concept of grocery shop and the product group daily goods be affected? Will physical retail outlets require increasingly less skills and services, as grocery retailing shifts to the Internet? Will retail outlets sell only supplementary goods, or will they specialize in offering specialties?

3) What kind of services are people provided with in the future society?

The development of the EGS business should be considered in connection with the social factors influencing its development. Solutions adopted and political decisions made in transport, environmental and regional policy will also influence the operating conditions for EGS. They also have synergistic impacts on what kind of a service society citizens will be provided with. Finns are generally considered to be early adopters of new ICT-based products and services (e.g., mobile phone penetration). Resources are currently allocated to research in, e.g., telework and telemedicine, but the development of EGS services has gained little public policy attention. The development of EGS services should be considered as one alternative when aiming at reducing both the volume and the effects of motorised traffic, or when making decisions concerning the location of retail facilities and the availability of services.

7 The Potential of ICT-Based Services to Substitute Corporate Travel

Minna Halme

This chapter[148] explores the potential of ICT-solutions to cut down corporate travel, which has been growing exponentially in recent years, and is expected to do so in the future. The growth of corporate travel raises concerns in all three domains of sustainability - environmental, social and economic. Not only is corporate travel considered to be the third largest controllable cost in the corporations, it is also identified as one of the largest producers of greenhouse gas emissions. At the same time corporate travel directly affects the quality of working and private life of corporate employees. In spite of the fact that travelling is expensive, takes employee time and causes significant environmental burden, the attempts to reduce business travel by various substitutes remain largely unsuccessful.

Is it possible to cut travel without compromising corporate competitiveness and quality of working life - and perhaps even improve them? This chapter discusses the potential of ICT-based services to substitute corporate travel. First it examines the motivation of corporate employees to travel or not to travel, and then investigates means with which to incorporate ICT-alternatives to travel into corporate decision-making. Finally the chapter highlights reasons why functional thinking about ICT may not be helpful in the context of travel substitution, and assesses under which conditions and in which situations the potential of ICT-based services is largest.

There are a number of reasons at the background of increased corporate travel. Globalization has brought about mergers of companies into multinational conglomerates that have factories and offices around the world. It has also brought about an international market place; the customers and facilities of single multinational corporations spread across distant parts of the globe. The present magnitude of globalization has been made possible partly due to the fast-growing personal transport sector, above all air traffic. This development generates faster, more convenient, more affordable ways of travelling to an increasing number of destinations. In addition, the opportunities provided by ICT — such as mobile phone services, portable computers and mobile access to the Internet — have liberated the executives and managers from their offices, making it possible for them to be reached without being physical present and allowing them travel more (Himanen et al. 2000). Furthermore, the deregulation of air carriers places them in a more competitive position, and consequently provides business customers with more attractive travel options - better prices and services (through, e.g., the formation of alliances) and special contracts.

The transportation sector of Europe contributes one third of all the CO_2 emissions of the continent. Travelling also results in significant emissions of NO_X, VOC, CO and particle matter (EEA 2000). Business travel constitutes up to 18 percent of the total number of trips (WTO 2000). Despite this, travel is seldom recognized in the corporate sector as an environmental problem. According to World Travel and Tourism Council (WTTC), travel has been constantly increasing, and is expected to grow in the future In 1988-2000 business travel has increased 60 percent world wide. The Finnish trend follows the international development: business travel grew 60 percent during the last twelve years (WTTC 2001). During the last three years, the sales of corporate travel in Finland grew from 740 million EUR to 932 million EUR, i.e. by about 20 percent in two years (Finnish Travel Agencies Association 2000a & 2000b). Business travel is still expected to grow both internationally and in Finland by over 60 percent by the year 2010 (WTTC 2001). As to the means of travelling, air transport remains the dominant mode of transport by 43%. It is followed by 42% of road transport, rail transport with 7%, and sea transport, 8% (WTO 2000).

Yet travelling is frequently - consciously or unconsciously - excluded from environmental management systems or otherwise treated in a way that clearly indicates an attitude "there is no hope" and "maybe sometime later". A Swedish study found that even those corporations that do understand the need to work with the environmental effects of travel appear to address everything from investing into more environmentally friendly city buses to the purchasing of more environmentally benign company cars. They do not deal with the reduction of business travel (Arnfalk 1999, Kogg 2000). A scan of articles in four leading corporate environmental journals[149] brings the same result: company cars get some attention, business travel by air none at all. It seems to be the untouchable holy cow of the corporate sector (Nyström 2000).

Air travel constitutes a major part of all business trips. A particular institutional arrangement promotes this form of travel. Even though the Inter-governmental Panel on Climate Change (IPCC) reported that the aircraft emissions were responsible for 3,5% of the global warming in 1992 with the potential to increase up to 15% in the year 2050 (ENDS 1999b), aviation fuel is currently the only fuel that is exempted from taxation. That gives air carriers the unfair advantage over more environmentally friendly modes of transportation. Air travel remains attractive due to the related hidden subsidies B untaxed fuel and the duty free status of airport goods. According to EU officials (ENDS 1999a), fuel taxation is politically impossible because of the long-standing international agreements on keeping fuel for commercial aviation tax-free.

In the broadest sense, corporate travel can be understood as any work-related travel conducted by corporate members. Usually, however, corporate travel refers to business trips of company people outside of their organization's location. The latter is the scope of this chapter. It is based on interviews with travel managers from ten Finnish companies[150] as well as on secondary data from international corporate travel surveys. Most of the studied companies are from the information and communication industry. The rest represent metal, paper, energy and consulting sectors.

7.1 Current travel management practices in the Finnish companies

It is estimated that in the Western corporate sector, travel costs form the third or fourth largest controllable expense after salaries and IT expenses[151] (Technology Information Communications News 2000, Menzink 1999[152]). In spite of this, travel management tends to remain an operative level task with almost no strategic recognition from the corporate level. In order to explore the reasons for this, we will next look at the division of travel management responsibility in the corporate sector and discuss the motivation to travel or to avoid travelling.

7.1.1 Who is in charge of travel management?

Travel management was organised somewhat variably in the studied companies, but in general it was considered an operative level purchasing function without any strategic recognition. In a couple of the interviewed companies, there was co-operation between travel management and human resource management (HRM). Environmental experts or ICT-specialists did not co-operate with travel management in any of the companies.

7.1.2 Motivation to travel

Looking at individual business enterprises, there are a variety of occasions for travel: customer visits, conferences, merger negotiations, and professional education seminars, among others. Whatever the occasion, the root cause for travelling is knowledge transfer, which requires communication. But aside from the task of knowledge transfer, there are motivational factors like economic incentives, routine, the status related to travelling and the fuzzy motivation of “exciting job content”. The most obvious economic incentives are per diem or travel allowances. For some employees, these constitute a considerable addition to their salary. Routine as a motivation manifests itself through the fact that many companies never question the need of their personnel to travel: “it has always been done” or “our business requires it” are the responses that researchers get when asking about reasons for the flourishing of business travel.

In some companies travelling is a status question, in others it is hard work that the managers and employees would happily reduce (Table 14). The status motive is present in companies in which only a part of the personnel travels. The further you get to travel, the more prestigious your job. However, in companies where most of the staff travels, the status motivation is not present. Due to a somewhat similar motive, travelling opportunity in a job description often makes the job appealing for young newly graduated recruits: “join the navy and see the world”.

Many of us find travelling nice and business people are no exception. A survey among top executives in Sweden revealed that ‘meeting new people’, ‘leisure’ and ‘business travel’ were the respondents’ three top interests (Boson, 1999). Actually, most employees (more than 75 per cent) look forward to, or consider it nice to get out of the office every now and then (MCI, 1999). There are also some factors that cannot be considered primary causes to travel but definitely add to the attractiveness of travelling. ‘Frequent flyer miles’ programmes and non-taxed goods at the airports (Kogg 2000) illustrate this category of factors. When given a choice between immediate departure with an airline that did not provide any bonus points and an extra hour of waiting for the airline that gives a bonus, eighteen out of twenty employees of the major Swedish telecom company Telia flying from Oslo to Stockholm chose the latter (Kogg 2000). Non-taxed goods at the airports as well as the simplicity with which many of the trips are arranged with the assistance of travel agents (Kogg 2000) fell into the same category of factors increasing the appeal of travel.

Naturally, the motivation to travel is associated with the need to get the job done. Paradoxically however, due the simplicity of travel arrangement, corporate staff may experience it easier to travel than to go through the trouble of learning how to use substituting methods. Our empirical findings indicate that sometimes travelling occurs because the employees of companies are not quite familiar with the possibilities for (ICT-assisted) travel substitution or do not feel comfortable about using them, or do not feel encouraged to choose “non-travel” option. In some of the studied companies, technical knowledge for using virtual meetings appears to be scarce.

Table 14: Corporate travel management and the role of IT in meetings of Finnish companies

Enterprise/ Industry	IT-based meeting services in use	Barriers to IT	Role of travel management	Environmental questions regarding travelling	Travelling has status of ordinary work	Advantage of IT-based supple-mentary service
Compaq\ IT	Net-meetings, satellite broadcasts for personnel, video-conferencing	Intrinsic social value of trips, missing personal contact	Takes 5-10% of a secretary's time, routine	Do not count	Status among non-travellers	-
Elisa Communi-cations\ ICT	Video-conferencing especially in regular project meetings	Missing personal contact, deficient picture quality	Routine +	Hotels	Work, no status	More efficient meetings, saving time & money
Fortum\ Energy	Video-conference room [illegible] disassembled due to [illegible]	Missing personal contact	Travel management team of 18 people	Count when suppliers are chosen	Work	
ICL\ IT	Video- and tele-conferencing internally	Missing personal contact, prejudice against technology	Almost a full-time job, fairly routine	Service providers' environmental policy	Work	-
Metso\ Machine construction	Video- and tele-conferencing, mainly replaces domestic travel	Visiting large machines cannot be done via IT-channels	Increased in importance lately, TM reports to administrative manager	Do not count	Work except for young people	-
Outokumpu\ Metal	Video- and tele-conferencing	Missing personal contact	Became a full-time job, recently routine	Do not count	Some status	-
Pöyry\ Consulting	Video- and tele-conferencing	Missing personal contact, especially for sales people	Since 1990s: Reports to vice CEO	Hotels' environmental policy of airline	Work	-
Rautaruukki\ Metal	Video-conferencing replaces a lot of domestic travel	If people do not know each other, or special [illegible]	Routine	Do not count	Some status but keeps decreasing	-
Sonera\ ICT	Net-meetings, video-conferencing in internal use	Missing personal contact, especially for sales people & in first-time [illegible] business	Routine, part of HRM	Hotels	Status for young employees, work for others	-
UPM Kymmene\ Paper	Video-conferencing	Voice & picture problems, customer must be met	Routine	Hotels	Status for those who do not travel much	-

7.1.3 Motivation to avoid travelling

There are also reasons to avoid travelling. In the reality of corporations these relate primarily to costs and travel time. The cost of business travel in Sweden in 1998 was estimated as being about 5,3 milliard EUR, including costs for travelling, transfer, hotels, ordering tickets and managing travel expenses. If the costs for loss of working time are included, these costs exceed 11 milliard EUR (Arnfalk 1999). Although travel costs formed the third or fourth largest cost item in half of the studied Finnish companies[153], only one of the interviewed travel managers mentioned cost and time saving as advantages of using ICT-based travel supplements (Table 14). As to environmental impacts of travelling, they were never spontaneously considered by corporate decision-makers. When asked about environmental aspects of travelling, a number of interviewees mentioned the environmental policy of hotels or airlines as an issue taken into account. The reasoning in corporations - at least among travel managers - was that meeting in person is the best way to do business. According to them, a company cannot compromise on this evan though it requires increased travelling.

In addition, travelling involves social aspects. These were acknowledged by the company interviewees when asked, but they did not constitute a serious concern as of yet. Particularly for employees with an extensive travelling schedule, fatigue and jet-lag is a common problem leading to reduced professional performance. When key personnel such as top managers and specialists within an organization hardly ever are available due to frequent and long-lasting travelling, communication with the rest of the staff naturally suffers, and feelings of frustration and loss of direction may develop within the organization. Regarding the quality of private life, heavy travellers were frequently absent from home, which may also lead to private, social consequences (MCI 1999) like loss of contact with family and friends, divorces, and problems in finding a partner. In a survey at Telia, it was found that as employees for whom travelling originally was a positive factor in the job set up a family, frequent travelling became a negative aspect of the job (Arnfalk 1999).

7.2 Means to reduce corporate travel

Is it possible to cut travel, and at the same time maintain or even improve corporate competitiveness, the level of international communication and co-operation? Let us first have a look at some of the travel reduction options available. We can distinguish different levels at which the options to corporate travel can be approached. These are:

- Substitutes in the form of ICT-assisted measures like video- or audio-conferences
- Planning logistics in the form of route planning or combining trips for different causes together
- Choosing the mode of transport, e.g., taking the train on trips shorter than a one-hour flight.

The first one, ICT-alternatives and their application in the corporate sector, is the interest of this study; we will not address the two latter alternatives. The two latter alternatives reside in the present frame of thinking, and do not really challenge the prevailing knowledge transfer paradigm that sees face-to-face meeting as an efficient way doing business. Of the three alternatives, only ICT-options present a new eco-efficient form of service that could provide gains at the scale of factor 4, or even 10, if applied correctly. However, before discussing the ICT-options, we take a look at how to integrate the consideration of travel reduction into corporate decision-making.

7.3 Corporate travel policy and travel management systems

Although alternatives for travelling exist, the problem of implementing these alternatives still remains. By what means can travel reduction be put into practice? Changing travel habits requires re-organizing some work routines. Even some cultural elements like appreciation of travelling may need to be changed as part of the process of replacing travel with other means of knowledge transfer. A Corporate Travel Management System (CTMS) is one means to implement travel reduction. CTMS is a vehicle with which to reduce travelling by making personnel consider the following options: replacing the trip with a virtual meeting, better planning of travel logistics, or choosing the least costly or environmentally harmful means of transport.

Today, a CTMS is applied only in a few companies. It is somewhat more common to incorporate the travel reduction imperative in corporate travel policy. Some companies have incorporated travel reduction into their environmental policy[154]. Currently travel management systems are used to keep the cost per trip down. However, they could be used for other purposes as well. CTMS could involve steps that make travelling more accountable (e.g. by suggesting an individual or departmental "environmental travel account" consisting of number of trips, their length, cost, used modes of transportation, etc.), more reflective ("have you considered a better option?"), or more controllable (control system by, e.g., assigning responsibility for giving authorization for a trip to someone else than the person travelling).

While the components of the CTMS may vary from corporation to corporation, the total set of logical steps within the system remains the same. Figure 14 presents the travel management cycle of a corporation. *Corporate travel policy* is an essential component of the CTMS that influences various elements of the travel management cycle. It starts with a *trip request*. First of all, the CTMS should make the employee ask the question: should a trip be made at all? Can the purpose of the trip (meeting, sales, service, presentation, conference, display, etc.) be fulfilled in any other way than travelling or having someone else is travel to meet you? Conditions for the face-to-face meetings can be listed in the travel policy. These depend on the type of meeting, and on the technical possibilities available for the travel substitute (for example videoconferencing).

After validation of the reason for the trip, a permission can be granted. After approval of the trip, the trip is organized by the *travel* agents. In the ideal case the agents create the trip profile on the basis of the travel policy. Up until the present, *after-trip experience management* is probably the most rare element in a CTMS. It does, however, provide feedback for improving corporate travel management. Finally, after experience of the travel options has accumulated, the corporation may re-negotiate the travel contracts with the agents and other service providers.

One of the necessary components of an environmentally adapted CTMS is measuring and comparing the environmental impact of different travel services. In order to set up objectives and targets, we need to know where we stand today, and whether we are making progress or not. The lack of such systems is one of the major obstacles to introducing the environmental parameter in the CTMS. In addition, the travel sector does not currently provide any information that can be directly utilized by its customers for environmental purposes. In an effort to tackle these shortcomings, a conceptual model of a system (Travel Emission Tracking System; TETS) has been developed for the Swedish energy company Sydkraft, to collect environmental data from travel providers, and to manage the data within the organization (Shaalan 2000).

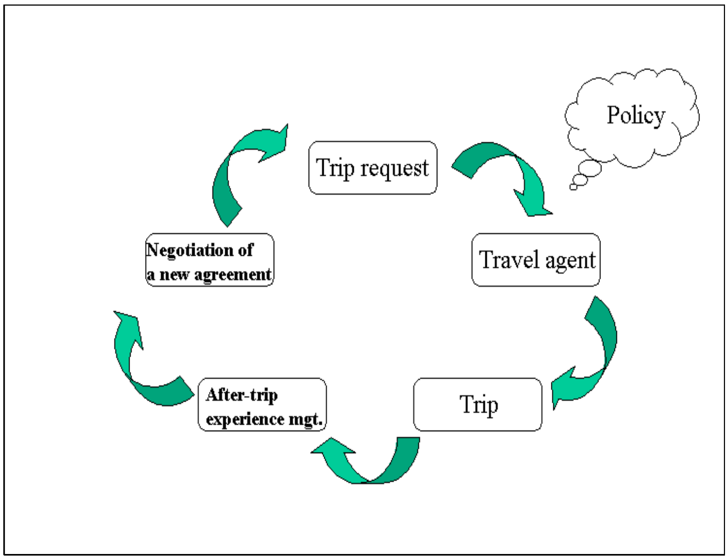


Figure 14. Elements of the travel management cycle

The description of the above-mentioned system is largely based on the system designed and operated by Phillips (Mensink 1999). The internal CTMS is still not a common phenomenon in organizations, at least not to the extent that it is developed in Phillips. In the studied Finnish companies, for instance, there was a travel policy, but no other elements of the system. If environmental considerations were incorporated in the policy at all, this was merely by asking whether suppliers (hotels and air carriers) have an environmental policy.

7.3.1 ICT-assisted methods

What can replace a business trip? "Nothing", is a very common reply, "we have to meet each other". This is very likely true in many cases, but far from all. A number of communication tools are available today, which provide a palette of alternatives that can partly or fully substitute the communication provided by a business trip. The cost for telecommunications is constantly plunging, while at the same time, availability and reliability is improving (Arnfalk 1999). We will next discuss the ICT-based knowledge transfer alternatives with which to replace trips.

The most usual form of communicating without meeting takes place by telephone conversation between two persons. If a meeting with more than two persons is to take place, a *multi user audio conference call* can be used, connecting three or more telephones at the same time. Another option is to connect a conference telephone, a type of telephone with a speaker function that allows a group of persons in one place to communicate via the phone. These two options are called *audio-conferencing*. The big drawback of audio-conferencing is that you cannot see whom you are talking to. This problem is taken care of by *videoconferencing*, in which two or more places are connected via special equipment that allows the participants to both listen to and see each other. Within the concept of videoconferencing, both Desktop systems and Group systems are available.

A Group System is basically a big television and a camera. In addition, electronic whiteboards, document cameras, and computers can be connected to the equipment to complement and enhance the communication. Using this system, several persons can participate at each end. Also here, multi-user conferences can be held. Desk-top or Personal Videoconferencing, usually consists of a computer, equipped with a small camera, microphone, a video- and audio circuit board and a special software. With this equipment, 1-2 persons can communicate at each computer. Multi-user conferences are possible, as several computers can be connected simultaneously.

Furthermore, computers offer a wide range of other means of communication. The most commonly used is e-mail. Currently more than ten milliard e-mails are sent every day, a number that is expected to increase to more than 35 milliard in the year 2005 (IDC 2000).

But computers offer more than the asynchronous communication of e-mail. On-line collaboration makes it possible for a group of persons to simultaneously, remotely edit the same document, draw pictures, give oral and visual presentations, etc. Communication via the Internet offers a nearly unlimited range of options, and this technology is developing very quickly. These are some important ICT-based communication tools available as of autumn 2000. The scene is expected to change considerably in 5-10 years time, providing us with smaller, faster, cheaper, and more versatile communication tools. This will in turn supply us with even better options.

7.3.2 When are the ICT-options viable?

Why are ICT-solutions not adopted with greater eagerness in organizations, if they are as good as their proponents argue? Do they satisfy the requirements that we have on knowledge transfer? In what situation can they be used and when should they be avoided? The answers to these questions depend on what kind of knowledge is to be transferred, what kind people are to meet, how many, for how long, how well do they know each other, etc. Some general findings based on studies by Roberts (2000), Arnfalk (1999) and on the Finnish travel management interviews (Table 14) are summarized below:

- **Sharing the cultural and social context**. ICT-based knowledge transfer will be more successful between agents who share common social, cultural and linguistic characteristics. It is less effective when the agents are from different backgrounds, particularly in the early stages of interaction.
- **Trust**. High levels of face-to-face contact and socialization processes are usually required to establish and reinforce a relationship of trust between agents. Especially for agents from different culture and language backgrounds, face-to-face contact can help to counterbalance the communication difficulties arising due to the difference. Most professionals prefer to have meetings with external business contacts face-to-face, as they are afraid to jeopardize the relationship, trust and feeling of commitment. However, if these meetings occur repeatedly, acceptance for using virtual alternatives grows. As members of the same organization (at least in units in the same country) share a common organizational culture, meetings internally within an organization are also seen as more suitable for virtual meetings. Virtual meetings are unsuitable for making new contacts and acquaintances, but could be satisfactory for persons who know each other well.
- **Type of knowledge**. To what extent does the knowledge to be transferred contain tacit versus codified (explicit) elements?[155] Tacit knowledge is more difficult to transfer since socialization and learning processes require co-presence and co-localization of the transmitter and the receiver (Roberts 2000).
- **Time requirement**. Virtual meetings tend to be tiresome and are best suited for shorter meetings.

In a survey on experiences of group videoconferencing, respondents in different organizations were asked to estimate how much of a ‘real’ meeting their videoconference meetings had been able to replace. The figures varied widely within each organization, from 0 to 100%, but the average perceived ‘degree of substitution’ was roughly 60%. (Arnfalk 1999).

What can companies do to encourage their personnel to use ICT-supported travel alternatives? If such alternatives are actually used, they result in economic gains for the organization (MCI 1999). However, in most cases, the employees using the equipment do not get rewarded for these gains, at least not in a direct way. One way of overcoming this obstacle is to provide the user with some kind of incentive for using, e.g., videoconferencing or audio-conferencing. Possible incentives could be 'meeting allowances', time-off, 'infrequent flyer points', paid dinner with the family, tickets for a theatre performance or simply to show some appreciation and to let the employee know how much money and emissions have been saved in using the travel alternative. Other hindrances are the lack of training in how to use the equipment, poor support and booking facilities, and the lack of someone responsible for the system. In a Swedish study in a large packaging company, it was found that after these latter kind of hindrances were removed even partially, the technology has been used successfully and has gradually increased to cut almost 5% of the company's air travel (Arnfalk 1999).

7.4 Why is the promise of ICT-based travel substitutes materializing slowly?

The previous discussion highlighted a number of organizational aspects regarding the slow adoption of ICT- based travel substitutes. In addition, some societal considerations concerning the evolution of new technologies still call for attention. The idea that ICT-alternatives like tele- and videoconferencing would actually substitute for corporate travel is based on the assumption that business processes actually require a fixed and static number of contacts. Consequently, ICT-alternatives would lead to a reduction in travelling (Geels and Smit 2000). Yet it seems that e-mail, tele- and videoconferences or net-meetings have added an extra mode of contact. In other words, a new technology does not automatically substitute, but often co-exists with, the old one.

When a new technology emerges, we tend to neglect the co-evolution of technology and society. In other words, we forget the generation of new activities that the technology can trigger. We assume that the pool of existing social practices and needs remains unchanged. Counteracting the promise of ICT-solutions that could replace travel, another development is taking place due to which the pool of social practices in business has both been intensified and extended. Wireless communication by mobile phones and the Internet has in part contributed to globalization, which in turn increases the need for knowledge transfer with geographically distant partners. One could expect that this need could be fulfilled with the assistance of yet other technology alternatives, e.g. teleconfrencing and videoconferencing. Instead, international business travel by air has boomed. (Geels and Smit 2000).

Despite the pessimistic undertone of the above speculation, there may be light at the end of the tunnel. A variety of factors may lead to a turning point with regard to wider acceptance of ICT-based knowledge transfer methods. On one hand, the technological development of videoconferencing equipment and other ICT-alternatives is ongoing. The more the alternatives start resembling face-to-face meetings, the more they can be expected to gain in popularity. As the voice and picture synchronization improves, ISDN-connections become faster, smaller equipment appears on the market and can be connected to portable PCs, making it possible to free the video-negotiation from a specific videoconferencing room or location, we can expect increasing use of these appliances. On the other hand, the new generations of users are more accustomed to communicating using ICT-appliances. The children and youth of today talk in chat-rooms, have their own mobile phone text message culture, and many of them live in a virtual reality of computer games. Their capacity for virtual communication is much higher than that of the 30-50 year-olds' generation, who presently dominate business life.

Furthermore, the dominant (and most environmentally harmful) form of business travel, air traffic, is coming closer to its boundaries. Along with traffic growth, the capacity of many central airports is becoming more limited. Construction permits for extended facilities in many cities are difficult to acquire due to resistance from neighbouring inhabitants. While the limits of airport and airspace capacity have come closer, delays have become more usual, causing loss of time of travellers. This may make ICT-based knowledge transfer more tempting to busy business people. It may be that one day soon, when air carriers meet the limits of the flight market, they will find new business opportunities in offering "knowledge transfer services", analogically to construction companies that are moving into facility management markets.

7.5 Challenges for corporate travel management

There is no doubt that videoconferencing and other ICT-alternatives can replace individual trips, but the question remains of whether they will be adopted to such an extent that they actually manage to cut the expected growth of business travel. Although ICT-solutions can replace individual trips, it appears for the moment that they *complement* travel in carrying out a particular *knowledge transfer function* rather than *subtitute* for travel to a significant extent.

The growth forecasts of videoconferencing during the last decade or two have turned out to be overly optimistic. The proponents of ICT-solutions have neglected a number of societal considerations such as the fact that new technology does not automatically substitute but often co-exists with the old one, technology and society co-evolve, and social practices can change (business interactions have intensified and extended). However, ICT-alternatives offer a good potential to complement knowledge transfer on certain occasions. For marketers of ICT-services and other proponents of these alternatives, it would make sense to direct their efforts at the most likely occasions instead of preaching in the name of the overall excellence of tele- and videoconferencing. ICT services have the best potential to replace a trip when: (1) the knowledge to be transferred is codified (explicit), (2) meetings lasts no more than 2-4 hours, and where (3) partners share the same cultural and linguistic background or have learnt to know each other in face-to-face contact and built a sufficient common ground.

Narrow functional thinking - seeing travelling as a purely functional activity of moving from one place to another - keeps limiting the discussion about corporate travel. Corporate travel decisions belong to the category of decisions that are difficult to affect by mere supplying new options for choice. Decisions to travel are defined by a multiplicity of motives, symbolic functions and actions, and are therefore very difficult to control. Depending on her travel preferences, a traveler is able to suggest any convincing reason for travelling or not travelling. The availability of options does not guarantee the best possible choice from an environmental point of view. If changes that effectively reduce corporate travel are to occur, individual (and corporate) values need to shift, not only with respect to corporate travel, but also vis-à-vis the entire quality of working life. At the corporate level, the first step in this direction would be top-management recognition of the impacts of travel (cost, time, environment) and systematic treatment of travel decision by, e.g., a travel management system. If companies are to address the impacts of travelling on quality of life and the environment, they obviously should involve HRM and environmental experts into developing their travel policies and strategies. Furthermore, if a company chooses the strategy of replacing part of its trips with ICT-assisted solutions like audio- and videoconferences, or Internet applications, the need also arises to include

ICT-specialists into the process, and to provide technical support for using the ICT-facilities.

In addition, institutional changes, first and foremost the removal of tax benefits for air fuel are necessary. Moreover, virtual meeting technologies may still have to develop, so that they more accurately reflect the experience of face-to-face contact, before the substitution potential of these technologies is good enough to really offer a genuine alternative to travel. It may also be that the future generation, much more accustomed to ICT since childhood, will find it easier to adopt a substitute to face-to-face contact. These technical and social developments may facilitate the emergence of a critical mass of teleconferencing and videoconferencing users. If the path of these ICT-alternatives follows that of mobile phone and electronic mail penetration - for which the technology was available long before mass adoption occurred - we can expect a growth of virtual meetings in the not-so-distant future.

The Emergence of New Office Services and Their Contribution to Dematerialization

8

Minna Halme
Eva Heiskanen

Offices are a seemingly innocent form of economic activity from a natural resource perspective. More and more people work in them, however (today, about 40 per cent of the workforce)[156] . Office workers consume about as much electricity at work as at home, and their workplaces use half as much space heating as their homes[157] . Offices are increasingly equipped with sophisticated — and rapidly outdated — electronic equipment, using which staff manage to consume more than their weight of office paper each year[158] . Offices also send their staff off on business trips (one-fifth of all international travel), and give them corporate cars to visit their customers with.

Although office work is jokingly called 'paper-pushing', few of the materials used in offices have much to do with the output of office work. Producing documents is not the main reason why we have offices. Mostly, materials are used in offices as a supporting infrastructure, which enables the jobs of administration, communication, and the delivery of financial, legal, and other services.

Offices are a suitable example to explore the propositions of the service hypothesis outlined in chapter 3:

- Services provide functions that can replace materials use: Materials are relatively irrelevant for the output of offices (i.e., they are not incorporated in the output as in a manufacturing company). Thus, we can test the claim that the functions of office equipment and infrastructure can be material-efficiently replaced with services (e.g., videoconference replaces travel, car-sharing replaces the personal company car, digital data replaces paper documents).

- Services counteract product obsolescence and eliminate linear material flows. Office equipment provides an example in which to study whether companies that rent or lease are less prone to "plan" obsolescence into their products, and are better capable of recovering and reusing equipment than suppliers that sell equipment (e.g., PCs, copying machines, furniture).

- Services aggregate materials costs to specialists with the motivation and capability to minimize them. The costs of office facilities and infrastructure are typically small when compared with labour costs, and office users do not usually expend much effort to optimize the use of this infrastructure. Thus, we can test the hypothesis that specialized service providers pay more attention to materials and energy costs, and are better capable of optimizing them (e.g., facility management).

The propositions have some grounding in industrial economics, but the evidence presented is usually anecdotal. As scholars of organizations, we are also alerted to the fact that efficiency (economic or technical) is not the only driver of markets and organizations. In the case of the reorganization of office work through services, relevant issues may include work culture and organizational politics. On the other hand, there may be forces other than efficiency considerations driving the rise of new services and shaping expectations in the market.

Mostly unrelated to environmental concerns, a number of new services have emerged in the business-to-business market, many of these targeted at office customers. This market is currently very new and dynamic, and it is difficult to predict into what shape and size it will stabilize. By exploring this emerging market and the motivations of its players we can, however, start to understand how, where and why new services emerge, or fail to emerge - and what connections this could potentially have with natural resource use. The aims of the present chapter are thus to:

- explore the emerging market for new office services
- identify factors underlying the emergence of these new kinds of services
- evaluate the potential for dematerialization that these services may have in the short and the long term
- identify phenomena that are worth monitoring in the future from the point of view of dematerialization of the economy

In the following, an overview of the market for new office services is presented (section 8.1), followed by more detailed examples of some new services and their market contexts. Section 8.2 explores the motivations and market dynamics underlying the shift toward services. Section 8.3 summarizes the potential of new office services to conserve natural resources. From the perspective of dematerialization, services that should be *increased*, and others that should be *improved*, are identified. Conclusions and suggestions for further research are presented in section 8.4.

8.1 Overview of new office services

This section overviews the different services investigated for this study. These are mostly services that companies have developed on their own accord, without thinking about eco-efficiency or dematerialization. The final part of this section discusses what we have termed "negaservices", i.e., a few newly emerging services that are explicitly designed to save materials or energy. The market overview is interspersed with five more detailed examples.

The data for this study consist of contacts with 42 company representatives (interviews, telephone interviews or e-mail questionnaires) from 29 companies[159]. The companies from which data were collected through personal contacts can be grouped as follows:

- Office equipment manufacturers, dealers and IT-service providers (9 companies)
- Office furniture manufacturers and dealers (7 companies)
- Car-sharing service provider (1 company)
- Facility management providers (4 companies)
- "Negaservices" (5 companies)
- Customer companies[160] (3 companies, 2 of which are also service providers)

Overall, one can observe that a variety of new services have emerged in the industries providing offices with products and services (see table 15).

In the following, the new services will be discussed using the grouping employed in table 15. First, services related to the outsourcing of the ownership or use of office equipment and furniture are presented. Next, services and solutions centering around the digital transfer of information are briefly discussed. Different forms of facility management are presented as their own group, followed by a profile of some newly emerging "negaservices".

Table 15: Overview of new office services

Office infrastructure or activity	services available	examples
IT and other office equipment Furniture Company cars	*services for outsourcing product ownership and use*	leasing, rental, IT-outsourcing, outsourcing of document production, space planning, product take-back, car-sharing
Document production, archiving, information processing Travel and commuting	*digital data transfer and storage*	document digitalization, electronic invoicing, server-based computing and applications telecommunications services
Office building	*facility management*	facility management, property management, design-build-operate business parks, office hotels
Overall natural resource use	*"negaservices"*	Energy service companies (ESCOs) waste counselling, environmental counselling space planning

8.1.1Services for outsourcing product ownership and use

In the following, new services centering around office equipment, furniture and company cars are presented. Some of these are clearly product-based (leasing and car-sharing), but the suppliers' interests in more results-oriented services (e.g., operations-related services) are also discussed in this context. An overview is given in Table 16[161] .

For electrical and electronic office equipment (especially PCs), the shift toward services is most visible in the growth of equipment leasing. Company representatives estimated the share of IT-leasing to be almost 20% of IT acquisitions in Finland, with considerable growth to be expected. Leasing services are provided by a variety of different kinds of companies. Financial service companies, which traditionally dominated the leasing market, offer leasing packages for a variety of products, with a growing focus on PCs. *International computer manufacturers* (whose brands dominate the office IT-market in Finland) offer leases through captive financial services units. Some *IT-service companie*s have specialized in the provision of rental, leasing and other services (see example 2). In addition to leasing, services may include asset management, training, consulting and systems development. Some suppliers provide entire IT-systems (including systems design, equipment and operational support) at fixed monthly rates.

Copying machines are offered in Finland by large international manufacturers or their franchised vendors. Xerox has originally rented all equipment, but today all manufacturers and vendors offer leasing contracts through financial service companies, and some also rent large contracts. Leasing is more traditional for copying machines than for PCs, and it is today the most prevalent form of acquisition, at least for larger companies. The choice between leasing or ownership is mostly related to tax considerations[162] .

Copying machine manufacturers have also started to offer a range of other services. For example, one international manufacturer offers a range of outsourcing services for document management: centralized document production and distribution, document management (e.g., document indexing, archiving, retrieval and distribution), consultancy and network management as well as the production of Internet documents. For example, archives can be transformed from paper into electronic form. Another international manufacturer has focused more on office services, centering around copying services with spin-offs into mailing and secretarial services, in one case even including management of an entire business park. This company also offers recycling services for a variety of electronic equipment.

In contrast to the office equipment market, the office *furniture market* is dominated by domestic companies, and there are a large number of small companies active in the market, as well as 4-5 larger ones. Leasing is a new service in this product group: three of the seven companies interviewed for this study actively marketed leasing services, although the larger companies also offered leasing contracts selectively. Although the role of leasing was viewed as a growing sales channel, few believed that its share of total sales would grow beyond 10 per cent.

It seems that companies in this more traditional industry are however, acknowledging the role of services. Services such as office design, installation and maintenance of furniture, warranties and take-back had gained prominence in the marketing of some of these companies. Of the seven companies, two (one very large and one very small one) had specialized in *space planning*, offering to design and install furniture in a new way that is promised to conserve office space, reduce costs and increase workplace productivity.

Table 16: Product-based services related to equipment, furniture and cars

Product group	Types of services provided
PCs	• share of leasing < 20%, expected to grow in the future • financial and operating leases[163], lease periods usually 2-3 years • service providers: financial service units of original equipment manufacturers, financial service companies, specialized rental companies, IT-service companies - other services: asset management, outsourcing of the entire IT function, take-back and recycling
Copying machines	- leasing prevalent mode of acquisition - financial and operating leases, lease periods usually 3-4 years • other services: operating services, including the outsourcing of the entire document production process, and wide range of office services, product take-back and recycling
Furniture	1. leasing relatively new service, not marketed by all companies, share currently small 2. financial and operating leases, lease periods usually 3 years - other services: design, maintenance, warranties, take-back, space planning
Company cars	• leasing prevalent, but entails no potential environmental benefits • one small company providing car-sharing services • 600 registered business users (spring 2001)

Leasing of company cars is so conventional that it was not considered to merit any further investigation (see, e.g., Interim Report 1999). However, *car-sharing* is a new product-based service, which is offered to companies as well as to private consumers (see example 1). It differs from the other services discussed in this section by having an obvious environmental aspect, although the company providing this service has emphasized cost savings and convenience in its marketing communications. In spring 2001, the car-sharing sharing service had about 600 registered company users (i.e., individual employees), of which about 120 are active users.

There are some obvious environmental benefits to cars-sharing, although these have not been evaluated specifically in the Finnish context (see example 1 and chapters 3 and 4 in this volume). In contrast, the environmental benefits of equipment and furniture leasing are less obvious. In some cases, products can be used by a subsequent user after the first lease period, thus extending product life (see example 2). However, leasing does not always necessarily play a central role in product life extension. Some service providers and manufacturers send end-of-lease equipment to recycling facilities, and in some cases (especially furniture), customers can purchase end-of-lease equipment for themselves at a nominal price. Some of the other services provided by product manufacturers and dealers, such as operations outsourcing and space planning, at perhaps more interesting from the point of view of dematerialization. These issues are discussed in more detail in section 8.3.

Example 1. Innovative mobile technology at CityCarClub

Car-sharing is one of the most often used examples of a product-based eco-efficient service. Car-sharing organisations are usually non-profit organisations, offering the service to private customers. However, the Finnish enterprise CityCarClub (CCC) is somewhat exceptional, because it is a privately owned for-profit firm offering its services not only to private customers but also to organisations. This example focuses on the business market of CCC.

CCC was established in late 1999. In spring 2000 a commercial pilot project was run, and the actual web-based booking was launched in September 2000. CCC's founding and largest owner is a private investor, who, together with three other parties, owns 70% of CCC. The firm currently employs four people, but as it intends to grow, the personnel is expected to double during 2001. The service is provided in partnership with a car dealer, a financial services company and a telecom company. Stockmann Auto provides the cars as well as the service. Ford-Rahoitus finances the cars. Sonera provides the operator services and it has participated in developing the mobile booking technology that CCC applies.

How does car-sharing operate? Typically, the members of a car-sharing organisation enter a deposit when joining the organisation (refundable on exit). When in need of the car, the members book a car (usually by phone), and pick it up themselves. Each individual user is charged a monthly balance, based on two components, hours of use and kilometres driven, with the rate varying by type of car and time of the day. In addition, there is usually a monthly charge (Prettenthaler & Steininger 1999, Karimo & Tarkkala 1999). The CCC car-sharing concept follows this model, except that no deposit is required. Furthermore it involves some IT-innovations which make the use of the car easier for the customer than in the traditional system. First, the car is booked via Internet or phone. The customer does not need a key, because the lock is operated by mobile phone. Thus the customer avoids having to fetch and leave the key in a specific place. Second, for filling the tank, there is a credit card in the car. This removes the need to re-bill fuel costs. All the customer needs for using CCC's service is a mobile phone.

The motivation for using CCC's service: The motivation for the development of car-sharing is two-fold. First, individuals who only have periodic demand for car use can substantially reduce their fixed costs by sharing their car with others in a similar need. In a sense, car-sharing organizations close a gap in the modes of passenger transport (public transport, bus and rental vehicles).

The service of CCC is available for both business and private customers. For the moment, one third of the customers consist of private consumers, while the rest are business employees. Until now the private customers have used the service more intensively. Two-thirds of the charged mileage accumulates from the private segment, and only one third from the business segment. Both customers are important for CCC, as they complement each other by using cars at different hours. CCC aims at a 50%-50% composition of private and business customers. Some business customers, however, prefer to share cars only within their own organization.

The main marketing arguments of CCC are cost savings and ease of use. The service is most suitable for companies in which taxis are used heavily, or which are located in central Helsinki with limited and expensive parking space (savings are also gained in reduced time for searching for parking space). Flexibility is another motive for customers, as different types of cars are available for different needs. This has been an especially appealing factor for small enterprises, which cannot afford several company cars. Another motive is the ease compared to rental cars (less paper work). The concept would also benefit companies in which personnel only needs to use a car now and then. One of CCC's customer firms commented that for staff members who only occasionally need to come to work by car, e.g., to visit a customer, the car-sharing opportunity offered by the employer makes it less necessary to acquire a private car.

According to the managing director and development manager of CCC, environmental considerations have not yet been an important motivation for customers. Consequently CCC does not want to emphasise environmental arguments in marketing. Rather, the company seems to want to distinguish itself from non-profit ideological car-sharing organizations.

Future plans of CCC: CCC intends to expand its operations. In Helsinki, the aim is to reach 30 000 users with 1500 cars. In addition, CCC has plans to sell its innovative technology for booking, billing and using the cars to other car-sharing organizations. With regard to the service concept, the managers of CCC consider their technology a market leader, but they would like to extend the concept to include mobility services of other providers, especially those of the Helsinki Metropolitan Area Transport System. CCC would like to offer service "classes" according to the type of mobility service, for instance "car only", "car plus monthly bus card", etc. (cf. Mobility in Switzerland, Mobility 2001). Both of the above-mentioned factors would improve the service from a customer perspective. If the number of cars increases, they can be made available to customers in more locations. If joint systems with public transportation can be created, the overall costs of mobility for a customer can decrease.

Obstacles to growth: Even though the eco-efficiency benefits of car-sharing are clear - services like the one of CCC offer the potential for cost and time savings, reduce the need of cars and parking space, and cuts down mileage, there are factors that obstruct the growth of the service. The main obstacles appear to be related to status questions and routine. These questions have mainly been discussed in connection with consumer's interests in car-sharing (Prettenthaler and Steininger 1999), but the same questions have their variants in the business customer market. As to status, car has become an increasingly important job benefit. The size and type of company car are easily perceived as an indication of the 'importance' of the person in the organization, i.e. it has value as a status symbol. As to routine, one of the business customers of CCC found that a walking distance of some 200-300 metres from the office to the car may well be too much for some potential users. Larger business customers also need to market the new services within their organization, as the concept is new and relatively little known.

To conclude, the realisation of the eco-efficiency potential of car-sharing depends
- on a number of questions:
- Will awareness of the service among customers increase?
- Will the cost and time savings be considered significant?
- Will car-sharing develop into an image question for corporate environmental profile?
- Will a life style emerge among business people whose identity could be supported by participation in car-sharing (cf. studies on the influence of life style on car-sharing among private people)?

Example 2. Fleet management of IT-equipment at 3 STEP IT

3 STEP IT is a company offering computer rental services that differ in some interesting aspects from mainstream leasing services. The company was originally founded under the name of Computer Rental in 1997. Two of its founders came from the captive rental company of Digital, Declease, after the merger of Digital with Compaq, while one of the founding entrepreneurs had his background in a financial services company. The original business idea of the company was to rent computers, which was and remains a promising new business area. The company grounds its optimism on, e.g., market analysts' estimates that 99% of the US Fortune 100:n companies use leasing as an acquisition strategy. In Europe, leasing has grown more slowly, and in Finland, its market share is estimated as less than 20%. However, IT-leasing is seen by the company as a growth business, as it has continued to grow swiftly even when the growth of IT sales has slowed down.

In spring 2001, the company changed its name to 3 STEP IT. This change of name reflects an expansion in the focus of the services offered by the company. Today, the company's services consist of three types of mutually supporting services: rental, asset management and release. These are packaged under the heading of "life cycle management of IT equipment". The three "steps" consist of the following kinds of services.

(1) The rental service includes all types of IT equipment, and contracts may also incorporate such items as software, furniture or operational support if needed. However, the company sees its core competence as managing IT hardware. Rental terms extend from 12 to 36 months , and may also be constructed as framework contracts allowing for changes in equipment during the rent term. Today, 3 STEP IT has 300 clients, mostly large to medium-sized organizations, including both companies and public sector organizations.

(2) The asset management service helps customers to manage their fleet of IT equipment. It consists of a web-based reporting system including an equipment register, data on programmes, licences, technical features and users, and also helps to keep track of IT-costs. It is, of course, central to operating the service as such, but also provides a service to customers.

(3) Today, the company estimates that the "release" phase may be the one with the most opportunities. In contrast to many other players in the IT-business, the company sees value in used equipment. Due to technological advances and the low cost of new computers, many companies change their workstations every 2 to 3 years. According to 3 STEP IT representatives, computers aged 2 to 3 years can be perfectly serviceable for less demanding users.

Against this background, 3 STEP IT can at least take back used equipment free of charge, or sometimes even pay a small sum for them. This is in contrast with disposal charges of up to a 18 EUR per computer typical in the disposal market. Returned computers are tested, and their hard disks are cleaned and erased, using an inexpensive, but reportedly reliable system developed by a sub-contractor. Computers remarketed in Finland are given a warranty of 3-12 months. Public organizations such as schools are important customers for remarketed computers.

IT leasing is seen as a growing business, as different kinds of organizations start to evaluate their equipment investments more critically, and the market for desktop computers matures. Public organizations and other large customers also seek to structure their inventory of equipment through comprehensive contracts, which allow for improved cost control. 3 STEP IT has been able to capture its share of this growth market. For example, the company turnover grew from 14,4 million EUR in 1999 to 23,7 million in 2000.

The slightly slower growth of IT leasing in Finland (as compared with, e.g., the UK or the US) is believed to be due its poor reputation. Banks have traditionally dominated the market, and their leasing packaged have been viewed as expensive and inflexible. Leasing has been more of a form of financing purchases than a true operating lease. Today, perceptions of leasing are clearly changing. However, some customers are also mistrustful about how end-of-life equipment can be managed in terms of information security. 3 STEP IT has invested efforts in gaining credibility for the system of hard-disk overwriting (the disk is overwritten seven times with random numbers), which according to company representatives is considered one of the safest ways to erase data, yet retain the hard disk for future use.

Leasing is provided by all large computer manufacturers today, but 3 STEP IT representatives believe their own mode of operating entails some advantages. As the company is independent of original equipment manufacturers, it views itself as being closer to the customers' interests: "manufacturers are not interested in the second-hand market for used computers, or in how existing equipment could be utilized as effectively as possible". In the view of 3 STEP IT representatives, companies that rent have more interest in the fit between equipment and customer needs (all changes in contracts entail extra costs). Thus, customer needs are carefully evaluated before contracts are made. On the other hand, company representatives see some possibilities in 'IT cascading': some customers purchase excessively expensive new equipment for their needs, which in the beginning is "too new", and at the end of the ownership period, "too old". In the future, equipment could be 'cascaded' between clients with different demands.

As larger lease terms are upcoming to expire soon, the company has set up or acquired subsidiaries in Finland, Sweden and Britain to develop the remarketing function. As larger numbers of computers start to return, the company believes that they can be sold globally for a profit. In addition to the remarketing of entire computers, the company believes that components can be salvaged as larger batches start to come in. Only a small percentage of returned equipment has to be scrapped.

What is interesting about this company is that it views used IT equipment differently from most of the other companies interviewed for this study. Many other IT manufacturers or service providers saw used equipment mostly as a cost factor that should be dealt with as easily as possible. For example, costs for testing and emptying of hard disks were viewed by some other companies as so prohibitive that scrapping (materials recycling) was the preferred way of dealing with end-of-lease products. In contrast, 3 STEP IT representatives viewed the value of used IT equipment as a business opportunity, and the reuse of existing equipment as the future trend: "the world is so full of products that it's time to think about how they could be utilized more effectively".

8.1.2 Developments in digital data transfer and storage

Information technology enables information to be transferred, processed, retained and retrieved in digital form. Paper-based documents and archives are obviously media for the communication and retention of information, but also meetings and many other forms of office work involve — partly or largely — the processing of information. Services and technologies for IT-based information transfer have developed unrelatedly to eco-efficiency considerations, but many authors are enthusiastic about the possibility to replace physically-based communication with digital information (e.g. Romm et al. 1999), and consider this a promising area for dematerialization.

A variety of products and services have emerged in the market for the electronic management of documents and business data. One example of services for digital data transfer and storage are those provided by Xerox Business Services (XBS). Examples that can reduce the need for paper include the *production of documents on demand*, in which documents are archived electronically, and delivered in electronic form to the site at which they are needed, where the required number of documents can be printed out. Although photocopiers are traditionally heavy "materializers" (i.e., producers of a growing material flow) XBS has also developed services that may to some extent reverse this tendency. Through "reverse copying services", paper-based *documents and entire archives can be transformed into digital form*.

Another application of IT-based document-related service, electronic invoicing, also holds a promise of dematerialization. A number of companies in Finland such as Novo Group, Arthur Andersen and TietoEnator, offer software for electronic invoicing. Electronic invoicing means that invoices can be received electronically, and the whole process of invoice circulation inside an organization, as well as filing, can be dealt with electronically. Electronic processing of invoicing is expected to provide cost savings resulting from faster circulation of invoices[164], saving of working hours and reduction of copying. There are also potential material and energy efficiency benefits: (1) electronic filing reduces the need for filing space[165], (2) paper copies can be reduced, and (3) less mail (internal and external) is sent, needing less transport. An increasing service-orientation can also be seen in the shift from programme vending to *hosted applications*. This means that computer programmes are run on a central server, which users access via the Internet. On the one hand, this can be seen as a return to the ‘computing centres’ of the 1970s, in which mainframe systems were used to run customers’ computational tasks. In the 1980s, due to the advent of the personal computer, more and more data processing activities were done by office customers themselves. Today, hosted applications are in a way reversing this trend: financial, personnel and other management systems are run using web-based interfaces between customers and service providers, operating these large programmes on the servers of application service providers (ASPs). On the other hand, new customer activities, such as websites and e-commerce are often hosted on centralized servers.

Some companies are placing even such activities as e-mail and Intranets on hosted servers, thus reducing the need for maintaining infrastructure on their own premises, and enabling the shared use of high-power, centralized servers. Today, server hosting is provided in Finland by international and domestic companies with different backgrounds, including, e.g., IBM Global Services, Compaq, ICL Invia and Sonera. In principle, the tendency toward server-based computing could mean that customers no longer need to increase their own computing capacity (e.g., continually purchase new equipment) (see e.g., Lewis 2000).

Videoconferencing and distance work are re-emerging on the agenda of some supplier companies (e.g., telecommunications companies) and some customer companies. It is estimated that 10% of the workforce in Finland do distance work occasionally (Heinonen 1998), and some companies have investigated its potential to save energy. For example, the telecommunications company Sonera has launched a programme for evaluating the possibilities and environmental implications of increasing distance work. Distance work also has connections with office space use and space planning (see ReSpace®, example 5). Videoconferencing was discussed in detail in chapter 7.

8.1.3 Facility management expands in scope

Commercial buildings management is a growing service industry in Finland, following developments especially in the US and the UK (see e.g., Jones 2000). Buildings management services can be roughly divided into property management, providing services for property owners, and facility management, which provides services for building users. In the following, the term facility management will be used to include “strategic” facility management, which also includes maintaining and enhancing the value of and returns on real estate property (Rautio 2000). The operation of office hotels and business parks can also be viewed as an extended form of facility management[166]. Two factors have driven the growth of the facility management market: outsourcing and growth in the total value of the sector:

- Traditionally, building owners or long-term tenants have produced facility services in-house, or procured them from a variety of small companies, or used a combination of both. As a focus on core business has emerged, in-house facility management units are being outsourced. For the same reason, customers have started to prefer obtaining a package of services from one service provider, rather than having to co-ordinate a range of contracts with different companies.

- Building owners and users have also started to value the importance of proper maintenance; and modern buildings are such complex entities that they require professional maintenance and service (e.g., centralized monitoring and adjustment of heating, electricity, power and air conditioning). Facility maintenance has also been viewed as a growth industry (e.g. Kaleva 1998).

Service providers have responded by developing an array of service packages, including such items as obtaining tenants and managing rent contracts, managing heating, electricity, power and air conditioning services and maintenance, providing maintenance and repair services, and providing or managing office and other services. A variety of different kinds of companies are moving into this business, including construction companies, traditional facility service companies, real estate dealers and maintenance service companies, as well as some foreign entrants (e.g., Rautio 2000).

From the point of view of dematerialization, perhaps the most interesting cases are those in which *companies with a background in construction or installations enter the facility management market*. Such companies can be assumed to have a core competence in construction and use technology. The facility management units of two large companies in Finland, YIT Rapido and ABB Facility Management, were contacted for this study. The ongoing transition of YIT from a construction company to a provider of real estate and other services is detailed in example 3. An interesting aspect in this development is the development of a "building warranty", i.e., an extension of a construction project with a ten-year facility management contract. Plans are also underway to develop an "energy warranty" using a similar concept.

ABB Facility Management is another interesting company with its background in the service activities of ABB Fläkt, which manufactures and installs ventilation equipment. Since the mid-1990s, the company has been expanding its service function. After winning the call for tenders for the management of ABB's own facilities in 1997, ABB Facility Management has expanded its service into an all-round facility management service, including also some full property management contracts. Today, the company manages 3,5 million square meters of commercial facilities, including those of some of the largest Finnish companies. ABB Facility Management has also experimented with a variety of contract types, including some in which the profits from energy conservation measures are shared between ABB and its clients.

Another interesting aspect is the evolution of facility services into *results-oriented services* that can encompass virtually all support functions related to the use of an office building. Traditionally, these support functions have been managed separately by different members of in-house staff and by a variety of service companies. These activities, which according to one facility manager amount to 6000 EUR per employee, have been traditionally managed without centralized cost control, and have not been optimized as a whole. Traditionally, they have not gained much management attention[167]; it is only recently that some companies have started to appoint corporate real estate managers at high levels. The current popularity of outsourced facility management relates to customers' expectations for increased efficiency through the co-ordination and optimization of support functions. Furthermore, both occupants and service providers have recognized the importance of well-managed facilities for the productivity of staff working in them[168]. Efficiency gains and quality improvements may also translate into materials and energy efficiency (see section 8.3).

In addition to the previous types of services, *business parks and office hotels* have started to proliferate in the commercial real estate market. Both office hotels and business parks have expanded considerably in Finland since the late 1990s. Business parks are targeted at larger customers, and have rapidly become one of the most popular types of new commercial facility constructions among developers (e.g., NCC, YIT, Lemminkäinen). They do not necessarily provide all services themselves, but aim to attract companies that provide services for one another (e.g., copying services, car rental, caterers)[169]. "Outsourced" managers manage all responsibilities related to the property and the operation of the facility (e.g., Rautio 2001). *Office hotels* are targeted at smaller companies or mobile units of international companies. Typically, a wide range of services are provided. In business parks and office hotels, the need for space is reduced by the possibility to use shared conference rooms, halls, lounges and other shared facilities. Furthermore, in office hotels, small occupant companies can share equipment such as copying machines, faxes, and staff facilities.

Example 3. The shift from constructing to maintaining buildings at YIT

The evolution of industrial companies into service providers has gained attention in the "new service" discussion but how this actually happens has not been studied. This example illustrates how one company is making this shift, and how eco-efficiency considerations enter the scene. The focus is on the company's office-related real estate services.

YIT is a company with a long history in industrial and infrastructural engineering and development, which has since the 1980s been primarily a construction company and real estate developer. During the late 1990s, a strong emphasis on services emerged. The company started to develop maintenance services, which by the year 2000 amounted to 22% of turnover at the group level. Today, YIT presents itself as a "versatile service company that offers a wide spectrum of implementation, maintenance and operation services for residential, real estate, industrial and infrastructure investments both in Finland and in the international market. The Group's service spans the entire life cycle of the investment".

Motivations for a shift toward services: The shift toward services is due to two main factors: the sensitivity of the construction industry to economic fluctuations, and the shift of domestic demand from new construction to maintenance of existing investments. The previous economic recession illustrated the combined force of these factors: the construction industry experienced a five-year economic downturn, with new construction dipping at levels unprecedented since 1960s. Although demand started to pick up in the mid-1990s, it seems that the market for new construction is stabilizing in the long term.

On the other hand, industry and real estate owners have started to outsource maintenance operations, and a similar development is expected in the public sector. Consequently, facility management has become an independent and growing business area. "Design-build-operate" contracts are another new rising area in building and infrastructure projects: this means that constructors assume responsibility for maintaining and managing what they have built for a given period of time.

Organizing the shift from products to services at YIT: Today, YIT is in the middle of a shift from product to services. Services gain considerable emphasis in corporate communications, and high hopes are projected for the future. Acquisitions have played a major role in the shift toward a service company. In real estate services, YIT acquired two large companies, one in facility management (turnover EUR 9,5 million) and one in asset management (turnover EUR 2,9 million), as well as a few smaller facility management companies. Restructuring has been used to consolidate the new mode of operating. Business units were restructured according to customer type (industry, residential, real estate), but all including both construction and maintenance operations. For real estate management, a new company, YIT Rapido, was set up. This unit includes the expertise in property and facility management gained through the acquisitions. In addition, new service development has been initiated in the fields of "user services" (technical management, facility services), and "life cycle services" (site auditing, life cycle planning, energy management, and the YIT Building Warranty).

Existing and acquired services have been regrouped and augmented into total services chains. One example is the YIT Building Warranty, a new service aimed at providing customers with brand maintenance for buildings constructed by YIT. This means that YIT offers a ten-year maintenance contract for new buildings it has constructed. In part, this new service is a response to new legislation requiring long-term maintenance plan for new buildings. However, the aim in developing this service has also been to integrate the company's experience in construction and maintenance into a better-quality, lower cost overall product, and to improve life-cycle design and maintenance. For example, durability and ease of maintenance can be taken to when selecting materials and constructions.

The role of eco-efficiency considerations: Cost considerations have been the main force driving reductions in waste and energy consumption. In recent years, the construction industry has also been recognized as an environmentally relevant industry, and a number of national research and development projects have been initiated. However, the industry has not been under strong environmental pressure from customers, and YIT respondents felt that environmental considerations do not, as a rule, influence customers' decisions. While environmental considerations have played a minor role, the importance of life cycle costing has been increasingly acknowledged in the industry. After decades in which the emphasis was on building as much and as quickly as possible, a new emphasis on quality seems to have emerged.

Eco-efficiency has not been the motivation to develop new services, but the environmental relevance of services has been recently recognized in the company. Real estate services have an obvious environmental aspect, as most of the environmental impacts of a building derive from its use phase. In spring 2001, YIT Rapido joined a national training and development project for eco-efficiency innovations called Factor X. For practical reasons, the current pilot project focuses on the eco-efficiency of facility maintenance (e.g., material embedded in service equipment, such as vehicles, tractors and snowploughs, and energy used in their operation (e.g., driving routes, grouping of customers by location). However, the aim is to transfer the lessons learned from the project into other facility management services. Ideas about considering the whole life cycle of a building from an eco-efficiency perspective have been discussed, and some plans are under way to investigate how this could be integrated into the YIT Building Warranty service. More immediately, YIT is exploring the possibilities to launch an energy warranty in connection with the Building Warranty service.

The shift toward services at YIT has not been motivated by eco-efficiency considerations, but it includes some promising elements. YIT is placed as a company so that it could control the material flows of a building from conception throughout its useful life. The company has recognized the need to find a new business strategy, and has launched a strong shift toward services. Quite recently, the company has engaged in small project that has an explicit focus on eco-efficiency. The coming years will show to what extent these developments will lead to reduced natural resource use in the construction and use of buildings.

8.1.4 "Negaservices"

While the previous services are not designed with dematerialization in mind, a few of the new services also explicitly aim to conserve materials or energy. We looked at two energy service companies, waste and environmental counselling, as well as architects developing a novel space management service.

Energy service companies (ESCOs) are the 'original negaservice'. This service is based on the idea that customers do not derive benefits from energy consumption, but the services that energy provides (heat, lighting, etc.). These can be achieved alternatively through energy saving equipment. ESCOs take responsibility for the outcome of energy saving investments by financing (and sometimes, designing and installing) the equipment, and gaining their returns by taking a share of the energy costs saved. Energy service companies have arrived only recently in Finland, although they have existed in the US since the 1970s, and have also appeared in the European market some years ago. Two new companies specialize in energy services in Finland today (see example 4). In addition, some other companies (such as the previously-mentioned ABB Facility Management) are experimenting with the concept.

There appears to be a market for ESCO-type services also in the service sector, which is the special focus of one of the new companies (Espa Ltd.). Energy audits of office buildings found savings potentials amounting to 15-18% in space heating and about 6% in electricity use. Over half of the energy conservation potential in the service sector consisted of projects with a payback period of less than a year (Motiva 2000b). Such projects are not carried out by building owners or occupants due to lack of management attention (e.g., the insignificance of energy costs in the budget), and companies' unwillingness to invest in support functions. This is where energy service companies step in.

Waste counselling is a service offered today by many waste management companies[170], partly due to the fact that municipalities are obliged by law to organize the provision of such services. Thus, it is in a sense a service provided primarily to municipalities (part of waste management companies' contracts with the municipalities), although it is targeted at residents and companies in the municipality. Offices have been the target of waste counselling efforts especially in the Helsinki Metropolitan area, in which office buildings produce 13 000 tons of municipal waste. Mostly, waste counselling has been practised as a demand-side-management strategy to decrease the need for new landfill capacity. However, waste management companies are also exploring the possibility to offer waste counselling as a chargeable service. For example, a national pilot project has recently tested the possibility to extend waste counselling services into a comprehensive materials-efficiency counselling, which also encompasses the materials inputs used by customer companies[171].

Few environmental consultancies have expressed a special interest in office-based customers, although their needs and capabilities differ considerably from industrial operations. *Greenseal Finland* is a company providing environmental counselling specifically for service companies, many of them mainly consisting of office operations. This type of a service is usually employed by companies desiring to set up an environmental programme or an environmental management system. The service consists of assisting in conducting an environmental audit, identifying improvement opportunities, and setting targets together with the customer company's personnel. The benefits (as compared with purely in-house development) include specialist environmental knowledge, systematic procedures, previous experience, as well as the authority associated with an "outside consultant".

Some form of *space planning* is offered by, for example, interior designers and office furniture dealers. In recent years, however, new demands concerning office space have been recognized in the international discussion, especially in the US and the UK, where a variety of "new workplace" programmes have emerged (e.g., Worthington 1997; Bradley and Wooding 2000). These programmes question the capacity of traditional office buildings and designs to respond to the changing needs presented by mobile work, project work and team-work. Holistic space planning, including future needs and the demands of a more flexible workforce, has not, however, been available in Finland. A new service has been recently launched in this field (ReSpace®), aimed at improving both overall efficiency and eco-efficiency (see example 5).

Example 4. Pioneers of energy service contracting in Finland

Energy Service Companies (ESCOs) typically invest their own money in energy-saving projects at their clients' sites, and are paid out of the cost savings that they achieve. The concept was developed in the US in the late 1970s. It is now well-established in many European countries, where it is usually known as Third Party Financing or Contract Energy Management (Butson 1998). An ESCO contracts with energy users to evaluate, design and install capital and operating improvements in existing building facility or industrial process, to reduce energy and operating costs over a contract period. ESCOs finance all project costs and receive payment exclusively from the resultant energy savings. In other words, ESCOs are paid on performance. Therefore they monitor the performance throughout the contract period, and provide training to building operators (Motiva 2000).

ESCOs can be crudely categorized into four groups. A broker-ESCO merely organizes the project and acquires all engineering, contracting and equipment from outside. A consultant-ESCO has all engineering skills in the house, but contracting and equipment are purchased. An "all in house" -ESCO does the engineering, contracting as well as provides at least the most essential equipment itself. The newest form of ESCO in the States is the so-called super-ESCO that provides also the electricity to the customer, taking the role of an energy sales company (acts as a link between an energy company and a customer) (Motiva 2000c). Whatever their type, the key point in ESCO-concept is that the customer company with energy saving potential does not have to invest in its own money.

Energy service contracting in Finland: In Finland, there are two recently established companies focusing on energy service contracting. Espa Ltd. was established by a group that also started a wind energy company some years ago. Its services are directed mainly at service organizations, e.g. hospitals. Inesco Oy, owned by Elektrowatt Ekono Ltd. (belongs to Jaakko Pöyry Group) and Private Energy Market Fund (owned by several investment companies), was started in autumn 2000 and its main markets are industrial facilities and the public and private service sectors. Espa represents a broker-ESCO type; it provides financing and buys everything else (engineering, contracting, equipment) from other companies. Inesco does not represent any pure type in the above categories. On one hand it is a broker-ESCO, but on the other hand it is 50% owned by Elektrowatt-Ekono (an engineering consultancy), and therefore has "all engineering in the house" (e.g., experience in engineering and management of energy-efficiency projects both in energy auditing and investment planning. However, Inesco can buy all engineering from outside if it turns out more inexpensive than the service of the Jaakko Pöyry Group. Both Espa and Inesco arrange financing from the most profitable sources, they are not committed to any particular financier.

Both companies are only in the beginning of their operations. Inesco has completed a pilot project (a heat recovery system for a foundry), a pre-agreement has been made on ten projects, and negotiations with 20 potential customers are on-going. The customers are mainly from the steel, paper and chemical industries, but also service sectors are interested in the concept. Espa, on the other hand, does not employ full-time personnel but is based on voluntary work of its owners (researchers and other experts), who can only devote part of their time for Espa's activities. Until now, Espa has not yet made contracts but is in the negotiation stage with a few customers.

The motivation to set up both Inesco and Espa has been the observation that there is an extensive energy saving potential in a variety of companies and other organizations B according to Energy Information Centre Motiva's energy audits in Finnish companies, the market for energy saving investments is around 100 million FIM in already existing buildings. However, this reduction is not occurring because most of these organizations do not want to invest their time or money into energy saving even though the pay-back time would be only 2-4 years, but rather concentrate on their core business. According to Inesco's estimation, Finland could reduce 1.5-2 of the total of five million tonnes of its CO_2-emissions through ESCO-services.

Energy service contracting in practice: An energy service project begins with identifying a project. The following step is an energy audit, followed by the pre-planning stage. This does not yet guarantee that the project will be conducted. If the project materialises, the costs of audit and planning are paid from future energy saving. (if not, the customer pays the costs). The fourth step is the energy service contract. The details vary depending on the customer. For Inesco, the maximum contract length is five years. A typical contract size is between one or two million FIM.

"Normal rules of competition do not apply": One special feature noticed at Inesco is that it co-operates companies traditionally considered competitors. Engineering companies that make energy audits and thus compete with Elektrowatt-Ekono or equipment providers that compete with Jaakko Pöyry contact Inesco to suggest cooperation when they have noticed an energy saving opportunity, but have not managed to persuade the customer company to invest in it.

Factors influencing the future of energy service contracting: In the Finnish context, there are a number of factors that promote energy service contracting, but also obstacles to it. The major promoting factors are:

- Client does not need to invest own capital and ESCO takes the risk
- The investment does not show in the customer's balance sheet
- ESCO is congruent with the current trend of outsourcing
- Pending opportunity of emissions trading

The main barriers are:

- Energy saving is not core business of enterprises and has therefore low priority
- Low awareness about ESCO-concept decelerates or can hinder closing contracts
- Low cost of energy in Finland

Example 5. ReSpace®, a service innovation to avoid unnecessary construction by Hakanen & Yläoutinen

The previous examples of "new services" have been developed elsewhere (some already decades ago), and what is new is their adoption in the Finnish market. The present example is the only one we found of a purely domestically-developed service. Innovative ideas about office design, space planning, and the requirements of the changing nature of office work have been in the air for some time, and there are individual services available in this area, especially in the US and the UK (e.g. Worthington 1997). The ReSpace concept is however, to our knowledge, unique.

ReSpace® is at present more of a business idea than an operational service. It has been developed by the architects Hakanen & Yläoutinen. One of these architects has a background in environmentally-adapted design, while the other has specialized in the design of office buildings and other business facilities, with a specific focus on corporate image design.

The motivation for developing this service relates to the architects' environmental concern, and the emerging public realization that environmental and economic aims can converge in the long term. Designing buildings has very long-term consequences, and buildings are major consumers of materials and energy. The decreasing life-span of buildings has been recognized as a concern in the industry. Professionals have started to emphasize the need to focus more on the entire building life cycle (life cycle planning). Sustainable buildings and sustainable construction have also become topical, and a market for expertise in the field is emerging.

The idea in ReSpace® is to avoid unnecessary new constructions, and make sure that existing buildings are used and maintained eco-efficiently. Ultimately, the idea is to "build less", which may perhaps be seen as a turnaround in terms of the traditional aspirations of architects. The business idea is meant to function in the following way.

(1) Before starting a design project, the customers' needs for space are evaluated, and various ways for fulfilling these needs are explored. These may include redesign of activities (i.e., "smart" space planning), temporary additional facilities added to the site (e.g., "mobile office containers"), various solutions for mobile work (e.g., office hotels, employees' homes, regional facilities), alternatives for expanding the facilities, and possibilities for acquiring extra space in existing buildings. Furthermore, the service providers can search among existing buildings for facilities that can be renovated or altered to suit the clients' needs.

(2) If all of the previous efforts fail to provide suitable space for the customer's needs, a new construction project has to be started. The design project is conducted according to the principles of environmental and life cycle design. Knowledge of the company is utilized to develop facilities that are as suitable to the work conducted in them as possible, and flexible in terms of future needs. 3D-based concurrent design is used, design documents are available online to all project participants, the design process is totally transparent and design solutions can be tested in virtual reality. Furthermore, the design and construction project is documented in such a way that the documentation can be utilized in the use and maintenance stage (e.g., "what is inside different constructions", "why specific solutions have been chosen"). The first long-term plan for building maintenance is drawn up.

(3) The service also aims to include counselling for space management and maintenance, as well as support services for when the building is in use.

The idea of ReSpace is not for its developers to do all the previously-mentioned things themselves, but to provide customers with an integrated service. Parts of the service will be developed and produced by a network of expert services and databases. All parts of the service are existing services or proven technologies, but they have not previously been offered in the same package.

The role of the architect in this type of a service is much more pro-active than in a conventional design project. "We design what the customer wants or needs, but we also expand their horizons". The architects serve as information brokers, assembling a network of experts in the field. At the moment, Hakanen & Yläoutinen are establishing a network of business partners with expertise and credentials in the field of sustainable construction.

8.2 Why and how are new services appearing?

The services discussed in the previous overview are mostly motivated by other than environmental reasons, although the "negaservices" group includes services explicitly aiming to conserve the environment and natural resources. The present section discusses the motivations for companies to develop and adopt new services, and the market dynamics that underlie their emergence.

8.2.1 Motivations for the provision and adoption of new services

Why are services today of interest in the office supplier industries, and among office-based customers? A number of different reasons can be identified, some quite general (touching most industries), and some quite specific ones (see table 17). Some services are motivated simply by the identification of a new customer need. Others are related to concrete changes in the operating environment (e.g. technological changes). The shift toward services can also in some cases be attributed to changes in how central issues such as 'efficiency' and 'value' are understood (i.e., 'institutional factors'). Environmental considerations have a marginal role in all but a few of the new services.

Table 17: Motivating factors for service provision

Motivation	Examples	Business applications
New market niche	• Energy saving potential, but firms unwilling to invest outside of their core business • Gap between available modes of transport • Changing working patterns (e.g., mobile work) & rising costs of space • Start-up companies cannot invest in impressive office interiors	• ESCO • Car-sharing • Space planning (ReSpace, furniture suppliers) • Furniture leasing, office hotels
Saturation of conventional product markets, intensified competition	• Market growth slows down (or is expected to slow down), companies need new value-adding activities to avoid price competition	• computer manufacturers go into IT-consulting • furniture manufacturers add value through services (leasing, installation, planning, etc.)
Technological advances	• Increasing complexity of office infrastructure and operating technology • Increased speed of technological obsolescence • Improved data transfer networks • Mobile locking technology	• IT-outsourcing, facility management • IT-leasing, IT-outsourcing • Server-based computing • Car-sharing made easy
Capital market incentives	• ROI of services often better than that of capital-intensive manufacturing • ROI favours low level of capital investment	• construction company transforms into service company • customer companies avoid owning unnecessary physical assets
Institutional factors: the spread of new management ideas	• Movement to focus on core competencies • Service orientation grows in popularity, manufacturing perceived as stagnating • Owning becoming unpopular	• IT-outsourcing, outsourcing of facility management, document production, and other support activities • leasing
Environmental considerations	• Primary motivation • Additional benefit	• "Negaservices" • environmentally sound disposal of leased IT equipment

Identification of a new market niche or customer need constitute a motivation for quite a few service providers. Energy service companies and car-sharing are examples of companies that have identified a customer need that is not met in the market, or within current organizations. Changes in office work patterns, due to which office space is often unoccupied for a large part of the day, and changes in the nature of office work (e.g. teamwork, irregular hours), as well as the rising cost of office space have created a market for new office designs. Services have evolved to fill gaps between existing market supply, within in-house customer support functions, or to cater for customers that have special needs (e.g., small start-up companies).

For manufacturing companies, the attractiveness of services is enhanced by saturated markets for manufacturing, which motivates the search for new sources of revenue in the service business. Services are perceived of as a growth market:

> *"Leasing... is used more all the time. We have also gained new customers this way... we have tried to make customers aware that in addition to the copying machine, you can also rent the table under it. It is cheaper than a bank-loan and capital is retained for productive purposes." (furniture manufacturer offering leasing)*

As competition in saturated (or saturating) markets intensifies, companies need to find new ways of competing and adding value for customers if they want to avoid competing with prices. Companies have responded by developing additional services: additional ways of acquiring goods (e.g., leasing), or additional service components to their products. Companies attempt to increase customer loyalty by intensifying their relationship with customers. Thus, even low-tech tasks such as secretarial services may interest manufacturers of high-tech products such as copying machines. Having one's own employee permanently located on the customers' premises enhances customer loyalty, and effective use can be made of employees' time by bundling together a variety of tasks (e.g., copying, mailing, coffee-making).

Technological advances and the increasing complexity of office infrastructure are another set of forces driving the shift toward services. Increased complexity of office infrastructure means that the support staff for office work have to co-ordinate and manage a variety of suppliers and products. Large, multi-unit organizations have, over the years, often grown a complex patchwork of office infrastructure, which no one masters completely. 'Total service' suppliers have found a business opportunity in setting structure to this patchwork:

> *"In 1996 we were supplying parts of our service as independent services, and the contracts were carefully delimited in terms of what our company is responsible for. The customer was forced to fill in the holes between the services and co-ordinate the relationships between service providers." (IT service company)*

As operating and control technologies of office buildings grow more complex, only specialized professionals well experienced in the technology are able to service such systems. On the other hand, involvement with technology also helps to identify customers in need of services for using it:

> *"Even caretakers need to specialize. The old-fashioned building caretaker may be an excellent fellow, but can he master the necessary technology?" (construction company offering facility management)*

> *"We prefer demanding customers, ones for whose business the functionality of the facility is importantYpreferably ones that a use a lot of technology in their buildingsYour installation unit is active in identifying potential customers." (facility management filial of a large technology company)*

On the other hand, the convergence of, e.g., IT technologies makes service production easier to automate and standardize. Automatic monitoring, for e.g., heating, lighting and air-conditioning systems, makes it possible for a centralized service provider to keep track of the systems of many different customers. Services also enable customers to offload technological and other risks. Acquiring IT, for example, involves the risk of making misjudged and expensive investments, which can be avoided through performance-based service contracting. Similarly, problems in getting rid of old equipment can be transferred to service providers:

> *"One of the largest problems in acquiring IT-equipment is getting rid of it. Of course, the customers are also trying to get some structure into the management and acquisition of IT. But their problems in fulfilling environmental requirements and getting rid of old equipment are also transferred to us." (leasing unit of computer company)*

The increasing power of capital markets has made both service providers and their customers try to improve their appearance in the eyes of investors. Indicators such as economic value-added and market value-added have gained a central role in business performance appraisal B even for non-listed companies. Service industries often show a better return on investment than capital-heavy manufacturing. Beyond this, the industry in which a company operates may influence the market value of its shares significantly:

> *"Return on investment is better in the service industry, for instance P/E figures in construction are around 7, installations 11-14, and in services around 20+/- 5... The construction industry is considered risky due to periodic fluctuation, and is valued low. But services are considered to provide a steadier cash flow with less fluctuation. Investors value the stock on the basis of what industry the company is considered to belong to." (construction company with facility management)*

In addition to concrete and specific factors in the operating environment of companies, the current tendency toward service provision seems to be influenced by "institutional factors" (see e.g., DiMaggio and Powell 1991; Scott 1995). These are management ideas that spread across a range of companies, often called management fashions or trends. They may be responses to changes in the business environment (e.g., the importance of information technology) or stakeholder expectations (e.g., capital markets), but as they diffuse among companies, they are increasingly taken for granted as the correct way to do business.

One such tendency that supports a shift toward services is the focus on *core competencies*. This was referred to by both service providers and customers. Focusing on core competencies was connected to both product-based services (e.g., outsourcing of ownership) and results-oriented services (outsourcing of support functions). A trend of trying to avoid investing in equipment (by e.g., leasing) seems to be gaining strength. Partly, this may be due to the aim of improving financial indicators such as return on investment. However, rather than being only a reflection of changes in business performance evaluation, the idea *of 'not owning'* is not only argued for in strictly financial terms:

> *"Specialization is increasing, firms and people want to concentrate on core competencies." (construction company with facility management)*
>
> *"Companies in the "new economy" have discovered that there is no added value in owning products." (computer rental company)*
>
> *"This service is directed at companies that don't want to own anything. They don't have money and even if they do, their ideology is that money should not be invested in owning products." (furniture manufacturer offering leasing service)*

Ideas spread through mimicry within and across industries and country borders. Models developed and tested elsewhere can be adapted to local conditions at relatively low risk. Furthermore, the fact that new services have been adopted most enthusiastically in the United States was frequently highlighted. This serves as information that they are "good for business", and connects them to such values as efficiency and innovativity:

> *"IT-firms are not the only ones [customers], others are also clearly thinking whether it makes sense to invest money in furniture. PC-leasing is coming, leasing cars have already been there for a while." (furniture manufacturer offering leasing service)*

> *"People don't know energy service contracting very well... now we appeal to the fact that the concept is widely used in the States." (energy service company)*

> *"The Finnish thinking is still that independent of what an employee does, she gets the same "tools" (table, chair, filing cabinet, etc). Space planning started in the US in the late 1980s, asking how the efficiency of office operations could be improved. It was realized that square meters cost." (furniture company with space planning)*

In specific cases, changing the division of labour between companies may also help to side-step established organizational hierarchies. Such examples indicate that a service orientation may be supported by other than conventional efficiency considerations:

> *"The starting point is that the IT-management sells the idea to the finance department to get rid of constantly asking for money: all IT-purchases are put under a permanent monthly rent, there is no need to invest." (computer manufacturer offering leasing)*

> *"We have a contract with ABB regarding energy saving... we expect them to be active in developing savings, it's part of the contract that they get half of the savings... it's possible to influence an outsourced facility management contract in a different way [than an in-house unit]." (a customer company in IT-industry)*

Environmental considerations were expressed as a central motive mainly in the "negaservices", but they appear here and there in the motivations for other types of services. For example, facility management services can be used as one means to reach energy conservation targets (especially by customer companies with environmental programmes). IT-services, on the other hand, can be a means to outsource the problem of dealing with end-of-life equipment. Environmental arguments were, however, at most an extra point in the marketing communications of service providers (e.g., after a long list of points, "environmentally sound disposal".) Some of the 'mainstream' service providers did, however, see future opportunities in growing environmental demands:

> *"The most positive thing at the moment is that the product life time can be doubled, or made even threefold (from two to six years), and even after that we can make use of the computer. In 1997 this was not yet interesting, but now a directive is coming along that forces the seller to take back the equipment they have soldY We are trying to make added value out of the remarketing function." (computer rental company)*

Some companies had developed recycling services in anticipation of legislation. This was also one of the motivating factors in developing energy services. The Kyoto agreement aimed at reducing CO_2 emissions world-wide is a driver that both interviewed ESCO firms mentioned. For instance, Inesco's general agreement draft states that Inesco beholds trading rights of 50 percent of the emissions quota, and customer 50 percent in case trading begins.

Even for services with undisputed environmental benefits, few service providers had chosen to found their market strategy solely on environmental grounds. City Car Club, for example, had made a conscious choice not to position their service too much in terms of environmental benefits, and placed much more emphasis on such benefits as cost or convenience. Service providers who were themselves clearly environmentally motivated, still saw their market in a combination of environmental and economic motivations:

> *"In marketing, environmental arguments are not central. But on the other hand, for us [people working for the energy service company] that is the reason why we are doing this. Since people are committed due to environmental reasons, we are able to do this inexpensively." (Energy service company)*

8.2.2 Where do new service companies come from?

There is considerable variation in the origin of the service providers under study. On one hand, there are newly established, fairly small specialized companies, and on the other hand, new services are provided by older companies that have added services to their previous operations. According to their origins, the service providers studied in this chapter can be roughly divided into the following categories:

- New companies (e.g., CityCarClub, ESCO)
- Upward integration in the supply chain (e.g., YIT & ABB facility management, document management by copying machine companies)
- Combining services (e.g., IT-outsourcing, office hotels)
- A company that sells a product offers a leasing or rental option for the same product (furniture and computer suppliers)

The most "novel" service concepts appeared to be provided by the first category of companies, *newly established small companies*. Car-sharing providers and energy service contractors are novel in the sense that they have brought a new service to the market. These are services that were not available for customer companies before these entrepreneurs started to offer the service. New companies can also develop novel ways of designing services, as in the case of 3 STEP IT, which has developed a profitable business out of the management of office IT-hardware during use and re-use - an activity considered secondary by most other players in the field.

The next group, *upward integration* of manufacturers to service provision does not present as novel an approach. From the service provider's point of view, it means changing the business logic. In itself, upward integration does not, however, automatically increase the total volume of services performed within the sector. Rather than a totally new service, the customer is offered a service concept administrated by one external service provider, instead of buying different components of the service from several suppliers[172] or by producing the service in-house[173].

Among the studied companies, there are also firms that *combine services*. Examples of such combinations are office hotels and full property management contracts, which provide a range of services to their customers, doing some themselves and contracting others out. Other examples of combining services relate to the addition of new services to existing ones. For example, the telecommunications company Sonera today provides a range of service "packages" (e.g., intranets, extranets and e-business solutions for customer companies) — services adding value to the original telecommunications equipment, facilities, and services. IT-outsourcing services are also often the result of combining IT-consultancy, software programmes and hardware supplies into a "package" with a fixed monthly rate.

The offering of a leasing *service in addition* to selling the same product is perhaps the least innovative service concept. This type of service is represented for instance by those furniture manufacturers that mainly sell their products, but have recently started to lease office furniture, or some computer manufacturers that lease computers. It seems that for these companies leasing does not really represent a new business philosophy but is rather an additional option to increase their business in a market in which some customers are reluctant to invest in furniture or equipment. At least until the present, few of these companies have significantly altered their product composition or introduced new product strategies as a result of offering these services.

While the categories are not always clear-cut, these approaches illustrate the opportunities that services afford for different kinds of companies. It appears that *small firms are developing specialised service concepts* for which there is potential demand only in a market niche. Presumably these niches are not sufficiently tempting for larger firms, as the demand potential is small. On the other hand, *upward integration and taking responsibility for a total system* (e.g. construction and maintenance, document management) is a feasible strategic alternative for *large manufacturing companies* in industries in which growth has slowed down. In addition to finding new growth opportunities, the advantage of upward integration (i.e. moving closer to customer) provides an opportunity for better control of the supply chain and customer loyalty.

As to companies that combine services, they are able to increase their business by linking new components to their original service. In this way they make use of their existing competence in new service areas. Furthermore, advanced services (e.g. internet solutions and mobile applications) and the “packaging” of services make it possible to improve the margins charged from customers. Thus, their markets are partly totally new ones, partly gained from specialized companies, and partly from their customers’ in-house operations. Companies that simply offer a service (e.g. leasing) option in addition to selling the same product merely combine the product with a financial service, and usually a take-back service.

From this perspective, the emergence of new services can be viewed as one example of the *disintegration of industry boundaries*, which is often linked to the “new economy”, or “network economy” (e.g., Davis and Meyer 1998; Rifkin 2000). When developing a holistic service (e.g., managing an entire office building) a company steps outside of its traditional industry (e.g. construction, copying machine manufacturing). Former products and services need to be “repackaged” to create new ones. Depending on the concept with which a company creates its new service, the task involves either developing new capabilities in the company (training and hiring new personnel) or acquiring them from outside (via networking or acquisitions).

It seems that networking is a popular way of crossing industry borders. For smaller actors with little resources it maybe the only possible strategy, but even for larger companies it is an option involving fewer risks than acquisitions and hiring new personnel. For instance CityCarClub would be unable to offer its car-sharing service without network support from its partners, the financing company and the car sales company that provides the cars. Co-operation in mobile locking technology development was also a necessary element for creating the service in the first place, and later on the R&D partner, Sonera, became a customer of CCC. When larger actors initiate a network, it is likely that the result is a network that resembles a supply chain partnership with one leading actor that contracts with several small suppliers. From the customer’s perspective, e.g., a full facility management service may be an easier concept to handle. A real estate customer basically deals with only one provider from which it procures everything from cleaning to long-term maintenance planning and energy management, compared with the previous arrangement involving direct procurement relationships with several service providers. From the perspective of who actually does the work, the “lead actor-several small suppliers” service concept may entail hardly any changes compared with the model where the building owner or user buys services directly from several suppliers. The service may simply be a re-arrangement of financial relationships. From an efficiency perspective, one can still argue that in a network model with one large lead actor, efficiency gains may accumulate from better co-ordination of activities

8.3 Can the new services conserve natural resources?

As we saw in the previous sections, a shift toward services is *not* simply a matter of replacing products with services. This section explores the extent to which services can conserve natural resources by organizing the use of products more efficiently. We first explore what *direct* potential the new services hold for resource conservation, testing the following assumptions of the "new service discussion":

- A focus on function provides opportunities to replace materials with efficient solutions (document management, space planning, videoconferencing and distance work)
- The transfer of operations to professional service provider promotes materials-efficiency (operations outsourcing, negaservices)
- The transfer of product ownership from customers to suppliers encourages product life extension (leasing, rental)

Next, we consider what measures would be needed to realize this potential. Finally, we will discuss the *indirect* potential of new services to introduce new business logics, and alter the nature of the economy (cf. Stahel 1998; Schmidt-Bleek and Lehner 2000).

8.3.1 Can resource-efficient solutions replace materials use?

Document management, space planning, videoconferencing and distance work are examples of reorganizing office activities in new ways so that materials use is replaced or reduced. They involve services provided by different kinds of companies (e.g., computer programme vendors, photocopying services, furniture manufacturers, architects, telecommunications companies), but typically require quite a lot of reorganizing of work by customers.

Many of these solutions, when used to their full potential, can conserve considerable amounts of natural resources. They also address two of the most important categories of natural resource use by offices: office space and work-related travel. For example:

- Transfer of paper-based data storage into digital form is usually discussed merely in terms of saving paper. While the paperless office has as yet failed to emerge, a breakthrough in new forms of data storage and retrieval may at least conserve filing space in offices. At least in terms of energy consumption, this may be more relevant than the replacement of paper as an information medium[174].

- Space planning can be used to conserve office space directly. Changing forms of work (e.g., teamwork, fieldwork, mobile work) have increased companies' interests in new office designs. According to the experiences of one service provider, new office designs can reduce the need for office space by about 30%, amounting to considerable savings in energy use for space heating.

- There is some degree of renewed interest visible in companies to employ videoconferencing and distance work, especially as awareness of travel costs (both in terms of direct costs and employees' time) increases and technological solutions improve. It has been estimated that at best, the use of distance work and videoconferences could save as much energy as domestic air and rail traffic consume (Himanen et al. 1996).

Increased use of car-sharing could also contribute to decreasing energy consumption for work-related travel, as well as conserve parking-space. Probably, the number of corporate cars could also be reduced (see chapter 3, section 3.2). For corporate customers, a car-sharing service avoids the need to design a system for booking, retrieval, fleet management and invoicing within their organization. In contrast, few such encompassing services are available in, e.g., videoconferencing or distance work (although concepts such as "ReSpace®" could include such services).

There are, however, *limits to a functional approach*. Such limits are visible, for example, in the case of "videoconferencing instead of business travel" (see chapter 7). Obviously, travel involves other functions than the mere transfer of verbal information. Non-verbal information, contextual information and non-task-related information exchange are some of the other forms of information transmitted in face-to-face, physical meetings. Face-to-face meetings also serve to build up trust in business partners. When these other aspects are not critical (as in the case of in-house meetings), videoconferencing is already used to some extent today. In addition to serving various forms of information exchange, business travel also has a number of other functions that it serves for company staff: e.g., amusement, status, variety and personal development. Of course, it also involves a number of dysfunctions, such as rising costs, fatigue and disruption of family life. It seems likely that these other dysfunctions will provide a stronger impetus than environmental concerns to re-evaluate travel management practices.

The limits of functional thinking are also evidenced in the case of office furniture. The furniture supplier companies evaluated the durability of office furniture as corresponding to a much longer period (e.g., 30 years for some pieces) than it is actually used by customers (e.g., 6-8 years according to one estimate). The main reasons for this were changes in organization (new businesses, reorganization, termination) and changes in office technology (e.g., computerization). However, other, less functional reasons were also stressed, such as corporate image, fashion, aesthetics and organizational symbolism. The furniture design managers interviewed believed that efficient solutions are difficult to market because office furniture also has other roles beyond a strictly functional one. For example, product life extension would not work because: "a new director shows that things have changed by refurnishing and throwing all his predecessor's things out". New office space concepts diffuse slowly because of the psychological meaning of office interiors, e.g., "if you have a beech-wood desk, and a high-backed chair and a large office to yourself, then you can feel that you are doing well in your career".

The fact that products serve more than one function need not, however, be seen only as an obstacle to dematerialization. Emerging ideas about office space planning and flexible offices show that changes may be desired in *both functional and non-functional aspects of the physical surroundings*. Although the costs of office space are an important impetus for space planning, planned organizational change is often an equally important goal in such projects. This includes an emphasis on teamwork, flat organizational structures, communication and knowledge management. New space planning concepts aim at flattening organizational hierarchies by doing away with individual offices. This is done, e.g., by providing all staff identical "docking space", as well as a variety of facilities for shared use, and other rooms to be reserved for private use when needed. By taking down the walls between offices, it is expected that the flow of information between staff is improved (see also, e.g., Worthington 1997).

Car-sharing implies a similar "use-when-needed" principle: corporate cars are not given to staff members with a specific status, but used according to need. If this service becomes more prevalent, it may challenge the role of the corporate car as a "reward" and a signifier of status. Similar pressures may accompany an expansion of videoconferencing in place of business travel (see chapter 7). Whether or not planned change is a central goal in adopting eco-efficient solutions, they seem to have implications for organizational hierarchies. The principle of "needs-orientation" implies that office space, corporate cars and other facilities are used by staff members when needed, and not allotted to persons in specific positions. Thus, changes in individual operations may involve changes in the entire organization.

8.3.2 Can professional service provision improve materials efficiency?

There is a clear tendency toward outsourcing office support functions, such as facility management, IT-systems or document production. On the basis of the "eco-efficient services" discussion, such "results-oriented" services could be expected to hold the potential for conserving natural resources due to:

- more professional operation
- scale-related gains
- transfer of the costs of product operation to a specialized service provider, for which these costs are a larger share of total costs, and which have access to the technological means to reduce them.

There are a number of examples in the results-oriented services that can potentially contribute to natural resource conservation, at least in the opinion of the service providers (and in some case, of their customers as well). A preliminary evaluation of which aspects are most relevant for dematerialization is presented in Table 18, but it is important to note that these issues require further examination.

Table 18: Potential for dematerialization of various "results-based" services for offices (preliminary evaluation)

source of potential dematerialization gains			
type of service:	More professional operation	scale-related gains	resource efficiency incentives
facility mgmt	Fair potential where service providers are specialists in building technology	some potential in more efficient use of equipment, gains in technology sourcing	fair potential, if accountability for natural resources is built into contracts
IT-systems outsourcing	Perhaps potential to design better systems, but focus not on natural resources	some potential in server outsourcing fair potential if computing capacity of customers reduced	little potential at present as focus is on human resource costs
document mgmt	Perhaps potential to reduce waste, but may be offset by behavioural changes	some potential in e.g., new document management technology (e.g. digitalization)	some potential due to better cost control and more efficient cost aggregation
ESCO, ReSpace	fair potential	-	fair potential
counselling services	fair potential	-	- (performance contracting not today in use)

The benefits of *more professional operation* are perhaps most evident in facility management, in which modern systems for the monitoring and maintenance of heating, electricity, power and air conditioning do require quite a high level of specialization. A variety of technological solutions can be offered by professional facility management companies, especially ones with in-house competence of the development of such systems. Our study also found some support for this claim in interviews with customers. Facility maintenance is also relevant because it influences space heating and the useful life of buildings, both significant contributors to natural resource use on a national scale.

Some *scale-related gains* were also identified in facility management, but these are not as significant as professional maintenance. Large facility management units can use the same equipment when serving multiple customers, thus reducing the need for site-specific equipment (e.g., tools, vehicles, lawn-mowers), but such gains can be counter-balanced by the impact of increased mobility of service personnel. More importantly, professional service companies have an advantage in sourcing the most advanced technology (e.g., centralized monitoring and control equipment for energy consumption).

The *incentives* for natural resource efficiency depend on the type of facility management contracts. Energy costs are not as a rule a part of the facility management contract, but they can be embedded in service contracts in different ways. A given level of energy use may be *part of the performance targets* set in contracts, or contracts may include *clauses on the sharing of efficiency gains* between customers and service providers. Full property management contracts include accountability for energy costs. Here, the costs of energy may amount to one-third of the total costs of the building property (in contrast to, e.g. about 5% for a typical office building user company)[175]. This can lead to more attention to energy costs, and in combination with more professional knowledge, may lead to considerably more energy-efficient operation. By taking a more active role at the interface between building owners, building users and specialized facility services, professional management contracts may be one avenue for energy conservation in office buildings.

The emerging development toward a "*design-build-operate*" approach in the *construction industry* is another way in which services can provide incentives for efficiency in natural resource use. Designers and constructors gain the incentive to develop buildings that are easy to maintain and cheap to operate if they start assuming the costs of building operation. In the future, this may lead to reduction in the energy consumption of buildings during their use, as well as in the durability of buildings. Furthermore, experiences from building operation can be more readily transferred into the building design process (e.g., the YIT Building Warranty). It is as yet difficult to assess the scale of dematerialization that can be achieved through facility-related services, especially pertaining to building durability, which will only be seen after decades. There are, however, some examples of what can be achieved through *innovative energy contracts*, combined with the capabilities of technologically advanced facility management. Using an innovative ESCO-type contract, ABB Facility Management has managed to reduce the energy consumption of municipal customers by up to 30%.

In the outsourcing of IT-systems more professional operation is a central marketing argument. These services are, however, targeted at reducing the costs of labour (support staff and users) rather than the costs of equipment or materials. Professional systems design can potentially save some materials, as can the fact professional service providers often only replace the malfunctioning parts of workstations rather than the entire workstation[176] . There may be potentially relevant *scale-related gains* in, e.g., the use of hosted servers and application service providers (e.g., outsourcing of servers, use of the service providers' server for maintaining e-mail and web-based systems or computerized management and control systems, e.g. SAP). A number of clients can share the same server, thus reducing the need for multiple, small, distributed servers. If customer applications are run on service-providers' servers, more efficient use can be made of computing resources (e.g., Mathewson 2000).[177]

To fully utilize these gains in terms of natural resources, computing resources at the customer end should be minimized. If programmes are run on a central computer server, personal computers are in principle redundant. They could be replaced by terminal-type solutions ("thin clients"), or existing PCs could be used as terminals. In principle, this could be a very cost-efficient solution, and one that also saves natural resources as a side-benefit (e.g., Mont 2001). The service providers interviewed for this study, however, were somewhat hesitant about such solutions. Mobile interfaces (e.g., "communicators") and special applications are in fact increasing, but customers do not appear enthusiastic about replacing PCs in normal office use, as many customers use *both* hosted applications and PC-based applications. Experiments are, however, ongoing with thin client solutions in both companies and education institutions, and this appears to be a promising area from the point of view of dematerialization: the life of workstations could be prolonged considerably, on the one hand, or if replaced by "smart" terminals, their energy consumption could also be reduced.

Some benefits may also be identified in the outsourcing of document production. According to the service providers, *professional* use makes it possible to utilize advanced features of the technology. Possibilities for, e.g. document digitalization can be increased. A professional printer operator is likely to produce less waste paper, and print-on-demand can cut unnecessary printing. Wastage due to incompetent use can be reduced, and equipment can be serviced professionally and in time, thus extending product life. Potential *scale-related efficiency gains* were also identified, e.g., in the case of centralized printing services, which can reduce the need for personal printers and unit-specific copying machines. In a positive case this would mean that printing and copying equipment are optimal and there is no incentive for over-capacity equipment. However, this is on the assumption that copying services replace (and do not complement) the printers and copying machines of small office work units. It may also be argued that on occasion material consumption may increase: a well-run service may tempt people to copy more as it involves neither their time nor their trouble.

In principle, *cost incentives* should be very relevant in the different types of outsourcing services, as they are mainly argued for in terms of efficiency gains, including extensive references to a variety of different definitions of "total" or "hidden costs". However, it is worth noting that costs for materials and energy are not very central in the total costs of IT-systems or document production. For example, the outsourcing of IT-systems is mainly geared at savings in personnel costs[178]. Thus, the focus in efficiency-seeking is not on natural resources. Moreover, contracts do not, as a rule, include all the energy and materials costs related to systems operation. For example, IT-systems outsourcing contracts exclude energy used by the IT-equipment located on the customers' premises (although energy consumption of centrally located equipment is included). Document management services do include the costs of equipment and paper (but not necessarily that of electricity for operating the equipment). There is, however, evidence that such centralized services at least lead to improved cost monitoring for those costs that are included in the contracts.

The "negaservices" discussed here include the benefits of using *professional capabilities* to improve efficiency in energy and materials use. Energy service contracts also include a strong cost incentive, as ESCOs typically bear the risks of energy saving investments, and extract their payment from the energy saved. Plans for similar performance-based contracts have been discussed in the ReSpace® business idea, but it is not yet clear how they will be implemented in practice.

The other "negaservices" discussed here (waste counselling, environmental counselling) do not today apply any form of sharing risks or gains with their customers. Thus, customers need to be motivated to employ their services, either for environmental reasons, or trusting that the environmental improvements accomplished will be accompanied by financial savings. There does appear to be some interest in applying performance contracting in waste counselling, but this would require data on material and energy flows, and the related savings potentials and costs. Counsellors need to be well acquainted with the customers' business, and need to be able to control the outcome in terms of cost savings. Perhaps some form of performance contracting can be developed, but this will probably take some time.

8.3.3 Does the transfer of product ownership from customers to suppliers create incentives to extend product life?

The transition from selling products to renting them is expected to be beneficial for natural resource use (e.g., Heiskanen and Jalas 2000). It is assumed that when ownership is transferred from customers to suppliers, products become a cost factor, rather than a source of revenues, for service providers (e.g., Stahel 1998). Thus, we would expect companies providing rental and leasing services to manage their products during and after use as valuable assets (e.g., extending product life), and be interested in improving their durability.

There are few companies offering product rental, but quite a few providing operating leases. These services for furniture and office equipment are both relatively new in Finland, so their final impact cannot be evaluated (not many lease terms have expired yet, and leasing is small-scale in most companies). As yet, there does not appear to be a tight connection between leasing and product life extension, an observation supported by findings from a recent US study by Fishbein et al. (2000). Table 19 gives an overview of the current situation, based on interviews with a sample of the largest companies. The rows in the table indicate how prevalent different modes of operating are, while the columns show connections between leasing and various end-of-life operations.

Table 19: Connections between leasing, end-of-life management, remarketing and refurbishing

	furniture manufacturers and dealers							Office equipment suppliers/service providers					
	1	2	3	4	5	6	7	1	2	3	4	5	6
leasing provided	on re-quest	on re-quest	yes	yes	yes	yes	plans	yes	yes	yes	yes	yes	yes
take-back for leased products	no	no	yes	yes	yes	yes	plans	on re-quest	yes	yes	yes	yes	yes
recycling of leased products	plans	plans	no	no	no	no	plans	some	not domi nant	not domi nant	yes	not domi nant	yes
remarketing of leased products	some	some	plans	plans	plans	plans	plans	some	yes	yes	no	yes	small share
systematic refurbishing	no	no	no	no	some	no	plans	no	yes	yes	some	yes	very small share

While some type of operating lease is often used, the *lease periods are usually short* (2-3 years for PCs, 3 years for furniture, 3-4 years for copying machines). At the end of the lease term, office equipment is usually returned to the lessor, but furniture can - and probably will - be purchased by the customers at the nominal cost of 1% of the total contract offered by service providers, taking into account that its useful life is many times longer than the lease period.

Reclaimed products are returned to the service provider. Hence, they most probably are *dealt with more systematically at the end of the lease period*. They avoid being stored or dumped (storing old PCs, for example, only makes them increasingly obsolete as time goes by, and takes up storage space). Today, companies taking back leased products usually either sell them in the second-hand market (in Finland or elsewhere in Western Europe, but often also in Eastern Europe), or send them to recycling facilities. Take-back services are, however, offered by many manufacturers also for products that have been sold. So, while take-back is usually offered to leasing customers, it may be offered to other customers as well.

Of the companies interviewed for our study, only one manufacturing company and one independent service provider *systematically refurbished* end-of-lease PCs (conditioning, remanufacturing) and viewed them as valuable assets. One of the copying machine companies had a comprehensive system for remanufacturing photocopiers, while the other company recycled most of the reclaimed products as materials. In the office furniture industry, only one manufacturer had an agreement with a professional furniture repair company, and this was largely unconnected to their leasing service, but part of a take-back service for any old office furniture their customers might like to dispose of.

In view of the presently available data, leasing *does not as a rule have any connection with product durability*. Only one manufacturer (copying machines) stated that their products are designed to facilitate reconditioning and product-life extension. The obsolescence of office IT equipment was viewed as totally dependent on technological developments and the development of software. Even in copying machines, where leasing is traditional, products are becoming obsolete more swiftly due to technological development. No difference could be observed between furniture manufacturers that actively marketed leasing, and those that did not, in terms of how frequently new product models were introduced, or for how long spare pieces for older series were kept available.

Company representatives were also asked their *opinion* of whether leasing could, today or in the future, contribute to better end-of-life management, utilization by consecutive users, conditioning and remanufacturing, and product durability. Respondents in the various industries mostly agreed with the connection between leasing and improved end-of-life management, although many pointed out that requirements for extended producer responsibility will take care of end-of-life products in any case. Most office equipment suppliers also acknowledged that there is, or can be, a link between leasing and product refurbishing. In contrast, most of the office furniture suppliers were sceptical about refurbishing, referring to how expensive such labour-intensive processes are.

Few believed that leasing could increase product durability or influence product design. Some of the furniture company representatives actually thought it might decrease product life by making it cheaper and easier to acquire new furniture. Many were of the opinion that increasing product life is not in the interests of product manufacturers. However, there were a few companies that recognized some potential in a “fleet manager” approach to enhance product durability. It may be that part of the lack of this connection is due to the fact that leasing is such a small-scale activity for most companies, which was actually referred to by one respondent (“...at least yet it hasn’t inspired us to launch leasing-oriented product development projects”). Product development is still mainly targeted at developing new features, which is incompatible with a true “fleet manager” logic.

8.3.4 Under what conditions can the new services promote dematerialization?

The previous sections have discussed a number of new services that have recently appeared in the Finnish market, and attempted to identify their potential to conserve natural resources. The evaluation is very preliminary, as the services are quite new. Data on natural resource use are not readily available, some parts of the systems are still unknown (e.g., what will actually happen to end-of-lease furniture, or how the new services will influence customer behaviour[179]), and the systems will probably change in any case as they mature. Taking into account these provisions, one can however identify services that should be *increased* and others that should be *improved.* Some examples in our pool of services have a clearer profile in terms of their capacity in saving resources. For instance, the environmental benefits of car-sharing, tele- and videoconferencing and “negaservices” like energy service contracting are quite easy to see. There are many kinds of environmental benefits to car-sharing (see chapter 3). As to energy service contracting, its very aim is to reduce energy consumption B ESCO firms make their profit through energy saving of the customer companies. Videoconferencing can replace travelling, and anything that conserves office space (e.g., space planning, distance work) reduces the consumption of natural resources. Consequently we can argue that crucial for the realisation of the material and energy saving potential of these services is their *demand among the customers*. Penetration of these services will depend on customer awareness of them, the capacity of customers to learn new routines, and cost savings or other benefits perceived by customers. Networking, gaining legitimacy and finding promising "lead users" (i.e., users with specific reasons to adopt the service, and which help to expand the volume of the business enough to secure resources for further development) seem to be important aspects in this process.

Services for outsourcing the ownership of goods, or for outsourcing entire activities are less clear in their implications. Their resource conservation benefits *depend on how they are, or potentially can be, organized*. *Leasing* can in some cases improve the operation of second-hand markets. Thus it extends the life of existing office equipment, but it is unclear to what extent this actually reduces the demand for new products. Another outlet for end-of-lease products is materials recovery, which is an improvement over landfilling. This is a central consideration in the US (e.g., Fishbein et al. 2000), but does not imply such benefits in Europe, as extended producer responsibility is becoming the norm in any case.

If leasing is to turn into a true "fleet manager" strategy, large numbers of products should be actually returned after the lease period and refurbishing activities should be expanded and improved. A few computer manufacturers seem to be developing remanufacturing activities at some sites, but the capacity of many of the existing operations does not seem to be close to the new manufacturing capacity of the companies. The practices of copying machine manufacturers vary greatly. There is no systematic and large-scale refurbishing of office furniture in Finland. Ultimately, in order to reduce the need for new equipment, products should be designed with a view to durability or upgrading and remanufacturing, and a clear organizational link should be established between service marketing and product design (e.g., Fishbein et al. 2000). Such "missing links" may emerge on their own accord when (if) operational leases become more widespread[180]. Factors such as how extended producer responsibility is designed and implemented may also influence the economics of remanufacturing.

It is perhaps more interesting from the point of view of dematerialization that original equipment manufacturers, as well as a variety of service providers, are developing different kinds of *results-oriented services*. For example, the provision of computer programmes run on centrally located servers (hosted applications) holds the potential to reduce customers' need for computer capacity. Ultimately, this could end the office PC replacement cycle, and considerably cut demand for new desktop computers.

What is the benefit of an external service? In principle, many of the services discussed here could be (and sometimes are) produced by an in-house service unit. Companies do employ specialized staff for, e.g., copying services and facility management. Our interviews, however, indicate that in-house support services gain less *management attention* than the same activities do in a specialist company. Specialized service providers also benefit from scale-related gains (e.g., using the same equipment for multiple customers). Perhaps most importantly, unspecialized customer companies lack the *influence on technological development* that companies within the industry have. For example, their influence on the development of IT-systems or the design of buildings is limited.

The capacity of results-oriented services to actually conserve natural resources depends on *three* factors. One is the previously-mentioned superior ability of the service provider to design and control the system that they operate (e.g., the office building, the IT-system or the document system). The second is the extent to which *contracts include the costs of natural resources* such as energy and materials. The third is the *relevance of these costs in the cost* structure of the service provider.

Some examples of innovative cost incentives were identified, e.g., in some types of facility management contracts. The dematerialization potential of facility management could be improved by increasing the number of contracts that include building energy use. The involvement of construction and installation companies with facility management also seems promising, as this can lead to better facility design (see, e.g. Douglas 1996). Many results-oriented (e.g. outsourcing) services do not include the full costs of natural resource use (e.g., equipment energy use). Moreover, it is worth noting that the costs of natural resources, even if they are all aggregated to the service provider, may not turn out to be so high that they lead to the optimal solution from the perspective of natural resource consumption. For example, the costs of IT energy use are negligible when compared with the costs of the related labour. Hence, the capacity of such services to conserve natural resources requires that natural resources gain attention beyond their significance in terms of costs.

Many of the companies providing new services were *not aware of the environmental* aspects of their services, and even some companies with systematic environmental management programmes did not apply them to their services. The interviews and contacts for this study also indicated that there is an *information gap* between the environmental co-ordinators and the service development personnel. Environmental managers usually knew little about their services, and service development personnel had not realized that their services could include environmental benefits. Data on aspects such as materials and energy consumption in service provision had not been collected. The eco-efficiency potential of services could be improved by improved measuring and monitoring of services from a natural resource perspective, and the introduction of environmental concerns into service design. This would lay the foundation *for using environmental arguments* in the marketing of services with a potential to conserve natural resources.

In most cases, customers seem to be equally unaware of the eco-efficiency considerations in service contracting. Alternative ways of fulfilling functions are not usually considered in office purchasing, even where environmental criteria are otherwise in use. Environmental aspects are usually not emphasized in service contracting, although there are some exceptions such as facility management contracts, which may include energy-savings criteria or incentives, or IT-leasing, in which take-back of products may be required.

All in all, both customers and service providers operate in fields that are not generally perceived of as environmentally relevant, and that have not been subjected to environmental policy measures (cf.. Salzman 2000). Some recent developments indicate that this may be changing in Finland (see, e.g. KTI 2000). For example, the national energy saving agreements between industries and the Ministry of Trade and Industry have recently been joined by a programme for facilities (KRESS), which aims, e.g., to reduce specific heat consumption by 5% as well as to stabilize and start to reduce electricity consumption in commercial facilities by the year 2005[181] . Incentives for energy conservation in facility management contracts are a topical issue in this programme. Guidelines on energy efficiency in public procurement also recommend that energy conservation should be included in facility management contracts, either through performance targets or through rewards (KTM 2000).

8.3.5 Does the shift toward services indicate that a new business logic is emerging?

Many of the services discussed here are so new that it is impossible to say what shape, form and size they will settle down to. They are, however, also interesting also from another perspective: do they indicate that a new business logic is emerging? Are companies questioning their existing products? Will their focus shift from production to use? Does their new mode of operating align their interests with those of their customers? And finally: will the new modes of operating have a broader impact within their own line of business and in other industries? These questions are explored below.

Are companies questioning their existing products? One of the arguments implicit in much of the discussion on eco-efficient services is that companies start to view their business differently. They realize that it is not the products that customers need, but the utility derived from their products. They no longer mass-produce more and more industrial products, but look toward their customers and try to solve their problems (e.g. Schmidt-Bleek and Lehner 2000).

On a discursive level, our examples lend evidence to this kind of a shift. It is difficult to say whether companies are really and truly questioning their products, but at least they are distancing themselves from them in their self-presentations. The former construction company YIT now calls itself a "versatile service company". Office furniture manufacturers provide "dynamic interior solutions". One large computer service company first crystallized its business idea as "providing IT straight from the plug", then as providing "information from the plug" and their most recent vision is to deliver their customers "competitiveness from the plug". It is easy to shrug off such self-presentations as normal corporate image management, but such rhetorics may also have some influence. Perhaps customers, continually bombarded by advertising about superior service, actually start to demand it. Perhaps new recruits actually take the slogans seriously. Perhaps the service-related functions within the company gain more prestige, and can access more corporate resources. It is too early to say what influence service-centred self-presentations will have, but it is an aspect worth studying and monitoring.

Will companies' focus shift from production to use? The shift toward services is expected to herald a new business logic by turning product manufacturers into fleet managers that try to maximize the utility gained from their products, rather than push new products onto the market. Thus, the throughput economy turns into a circular economy (e.g., Stahel 1998). Our examples give rise to some observations that support these ideas, but also to other ones that set them in question.

The fact that new services are proliferating in the office supply industries indicates that at least business customers are willing to relinquish product ownership, and to transfer activities to professional service providers. A culture of ownership (with the customers), or a productionist logic (with the suppliers) does not seem to be a central impediment to changing the shape of the market.

It is, however, not self-evident that the new services increase the share of use-related services in the economy, and decrease the share of production. Yes, manufacturing companies are going upward in the value chain. They are focusing on product use-related services, rather than merely selling new products. But where does their business come from? As noted in section 8.2.2, many of the services such as facility management or IT-outsourcing mean that service providers (often former manufacturing companies) assume tasks previously performed by their customers. Does this mean that they manufacture fewer products? Does this mean that the total market for services increases? Perhaps yes, in the long run: for example, if the same company manufactures ventilation equipment and services it, and if the superior service provided by this company extends the life of the equipment, then (all other things remaining constant), less equipment is needed, and more services are used. However, it is far too early to say whether this is the case in general.

A related development is that large companies are moving into areas which have formerly been dominated by small businesses, such as facilities management, cleaning, consultancy, etc. While this may improve the efficiency of natural resource use (professionalization, technical capabilities, scale-related benefits), it may also reduce the role of human (employment) labour in carrying out these tasks.[182]

Does the new mode of operating align suppliers' interests with those of their customers? Authors in the new service discussion argue that the new service economy is a customized economy, in which there is no waste. Everything is produced according to the customers' requirements and only when needed (e.g., Schmidt-Bleek and Lehner 2000).

Our examples indicate that there are in fact many different modes of operating (see section 8.2.2). Manufacturers expand their business toward customers, and offer entire life-cycle services ("design-build-operate"). At the other extreme, we have extremely specialized services such as ESCOs, which only do one thing for the customer. Both argue that their mode of operating is efficient for the customer. Both claim to be aligned with customer interests: independent services because they are not committed to any specific technology, and life-cycle services because they have the means and incentives to design products for optimal use. In the eco-efficient service discussion, it often is claimed that the environmental potential of services is not realized if service provision is not integrated with product design (Mont 2000; Heiskanen and Jalas 2000;Fishbein et al. 2000). This seems to be the case in, e.g., many of the leasing services offered today in the market. However, even if provided by manufacturers, it is not obvious that leasing leads to remanufacturing and increased product durability. If manufacturers are committed to continual new product development, and see their core competence in technological renewal, they may view obsolete products as extremely peripheral to their business. A smaller rental company, in contrast, viewing the management of existing products as its core business, may find the reuse of old products much more attractive and interesting - even if the initial margins are in fact the same for both companies. We cannot resolve this question, but suggest that this issue should be monitored as the service markets evolve.

Will the new modes of operating have a broader impact within their own line of business and in other industries? The services explored in this chapter are today newly emerging. Their role in their market is in some cases microscopic, and at best, only a fraction. The discussion in section 8.2.1, however, indicated that there is some kind of a mimicry effect, so that the central ideas of these services spread within and beyond sectors. How far they will spread, and for how long, remains a question. There are some relatively objective foundations to these ideas, such as saturating demand. However, there are many different kind of market conditions on which managers can focus their attention (e.g., instead of on saturating demand in Europe, one can focus on the rapidly growing demand in newly industrializing countries). And there are a variety of management responses to specific problems, some of which become topical at a given time. Thus, it is not obvious that the current focus on services constitutes an irreversible shift in the economy. From a policy perspective, this would mean that the time-window for riding on the current trend (e.g., by trying to introduce more eco-efficiency considerations into new service development) may not remain open for ever.

Whether the new services are spearheads of new developments is especially interesting in the case of the more innovative services, such as car-sharing or ESCOs, which are today very small-scale and practised by tiny companies. This could occur in two ways. Small companies innovate, and larger companies may enter the industry (either by developing competing services, or by buying up the smaller companies) after the possibilities and risks have been established. It is interesting to see whether, for example, car manufacturers or dealers decide to go into car-sharing services (cf. e.g., Prettenhalter and Steininger 1999).

On the other hand, innovative services may introduce the market to a new mode of operating. ESCOs, for example, are in many ways the archetype of an eco-efficient service. While the potential market for energy services as defined today may not be gigantic, it is interesting to see whether the elements of energy services can be applied in other fields. There are some positive indications among our examples. Some facility management contracts are experimenting with ESCO-type elements such as the sharing of the risks and profits of energy conservation investments.

It has also been suggested that an ESCO-type approach could be applied in waste minimization or material flow management (e.g. Zundel 1995). This issue was discussed with some of the other nega-service companies contacted for our study. The response was mixed: some companies were enthusiastic about the concept in principle, and considered that performance contracting could potentially take them further than, e.g., mere counselling or design contracts. On the other hand, people doing counselling work in practice also pointed to the problems of such an approach. If a service company assumes the risks of a conservation project, it should be able to assess the scope of financial savings that can be gained, and should be able to control the customer's activities so that the savings are actually accomplished. These are issues that should be tested and developed if the scope of ESCO-type performance contracts is to be expanded.

All in all, one can conclude that there are some elements of a new logic, but whether they will come together to actually form an entire new logic that supports dematerialization is still a very open question. Very few companies are actively pursuing a "circular economy" or a "customized, zero-waste economy" - and these are goals that individual companies most probably could not accomplish on their own, in any case.

8.4 Conclusions

We have studied services provided to offices that deliver the use of products, entire results, or traditional functions in new ways. Our interest has not been in identifying "success stories" or in making suggestions about the "ideal eco-efficient service". Rather, we have chosen to explore what companies are doing in this field on their own accord.

Offices were taken as an example for investigating business-to-business services because they are an increasingly typical type of workplace, and because the materials and infrastructure used have little relation to the actual, intangible output of office work. However, the examples studied here have implications beyond this sector in two ways. Firstly, many of the new solutions explored for this study (e.g., car-sharing, leasing, facility management) are applicable in other fields as well (e.g., other businesses, schools and other public facilities, or private households). Secondly, the case study approach has helped to identify more general features in how reorganizing the ownership and use of goods through services can contribute to natural resource conservation.

Two groups of emerging services were identified. In the first group, the eco-efficiency potential is obvious. This group includes what we have termed "negaservices", services such as ESCOs and waste counselling that explicitly aim to conserve natural resources. It also includes a more heterogeneous set of solutions such as car-sharing, videoconferencing, telework, space planning and electronic archiving, which are not designed to conserve natural resources, but obviously do so if their full capacity is utilized.

From the point of view of dematerialization, the problem with these services or solutions is that they are not in extensive use. A relevant indicator to monitor in this context is the rate at which these types of services start to be adopted into mainstream business activities. This does not necessarily mean their market share, but also what kind of networks they manage to establish, and what kind of "lead users" they manage to gain.

The second group consists of services that may conserve natural resources if they are organized in an effective way. Product rental and leasing often include take-back and recycling or second-hand sales, but not necessarily refurbishing or upgrading, and hardly ever altered product designs. These latter elements should be improved if a rental strategy is expected to actually reduce the demand for new products.

Results-oriented services such as facility management or IT-systems outsourcing can bring savings through more professional operation and efficiencies of scale. As energy costs are relevant in facilities, they are today increasingly built into maintenance contracts, which increases their eco-efficiency potential. These costs are not relevant in, e.g., IT-systems, and thus service providers lack the incentive to apply solutions that could conserve materials and energy.

Providers and users of office services operate in lines of business that are usually not considered environmentally sensitive. Thus, systematic environmental optimization efforts are still relatively scarce. Even among companies with systematic environmental management practices, few have yet recognized the environmental relevance of services. Environmental concerns are usually not yet taken into account in the management and design of services, and customers usually fail to consider them in their purchasing or contracting functions. There are indications that this is changing especially in facility management, which may be a promising sign that such perceptions can change fairly rapidly. This is a development that could be supported to enhance the dematerialization potential of these services.

Frequently, authors in the eco-efficient services discussion view new service development as an extension of product eco-design (see, e.g., Charter 2001). They suggest that the awareness of designers should be raised to reconsider the service delivered by their products (e.g., Schmidt-Bleek 1994). The examples in the present study raise some questions about the central role of the product designer. The services discussed here have been developed in a variety of contexts, but none primarily in product development departments. The sources of our new services included marketing departments, independently-minded business units, top-level strategic planning, and innovative new companies. Thus, awaress-raising efforts should also include other company functions than product design. Ultimately, however, a service strategy should also influence product design, so communication and co-operation between functions should be encouraged.

A further issue is whether these new services are signs of a broader change in business logics. There are indications that some “old” ideas are dying out on their own accord. Customer companies are questioning the value of owning products, and manufacturers are increasingly presenting themselves are providers of services or solutions. It is too early to say whether this means that we are entering the “new service economy” (as described in the environmentally-informed literature), or whether it merely means that the boundaries between organizations and industries are shifting.

Whether or not a totally new business logic emerges - one that is decoupled from natural resource use - is an issue that cannot be answered yet. It is, however, an issue worth monitoring by following how these fields evolve. One concrete indicator could be whether activities are merely transferred from one organization to another, or whether the shift actually increases the volume of service activities in the sector at the expense of manufacturing.

Efficiency considerations are central to the adoption of new services, but what is viewed as efficient is often a matter of perception. Small, innovative services companies, such as ESCOs, car-sharing, or ReSpace® do not today have a significant impact on the economy. However, their significance may lie elsewhere. They act as spearheads, which introduce and test new business ideas in niche markets that are not yet large enough to tempt larger companies. If successful, they may catalyse the adoption of these ideas in larger companies, or more extensively within the industry. It is worth keeping an eye on these kinds of services. Will large companies follow suit? Are the ideas applied in other fields?

A Time Use Perspective on the Materials Intensity of Consumption

9

Mikko Jalas

9.1 Introduction

The current discussion on eco-efficiency often calls for improvements in the efficiency of consumption. Such ideas are manifested in the claims that it is not the products that consumers want, but the services that the products yield (e.g. Schmidt-Bleek 1994; Meijkamp 1998). These thoughts reflect the earlier discussions on the ultimate source of utility taken up by, for example, Lancaster (1966), who proposed that preferences are expressed in terms of product characteristics, which are available in different combinations from different products. Consumption, according to Lancaster, requires information and managerial skills in order to find the efficient product combinations that reflect the consumer preferences for specific characteristics. As such, this discussion is relevant also for the present debate on eco-efficiency, in which both producers and consumers are urged to question the products as the ultimate source of utility and welfare (Lintott 1998).

The debate on eco-efficiency has also been extended to consider the practical implications of such aspirations. From a manufacturer's point of view such an approach shifts the focus from the physical products to the services the products provide, often referred to as service-orientation. It also puts forward the notion of manufacturers as managers of a product fleet (Stahel 1994b). In more traditional terms, leasing and renting are appearing as alternative business models to product sales (Interim Report 1999). While these changes are seldom environmentally driven, there is in any case a trend in the European and US markets of manufacturers and new service providers getting involved in product ownership and operation (White et al. 1999, Heiskanen and Jalas 2000, Mont 2001).

The trends identified and coined as service-orientation or servicizing are more obvious in business-to business relationships than in consumer products. However, various renting and leasing agreements, maintenance agreements and extended warranties all tend to shift the responsibility for products and technology from private consumers to the organized businesses. Thus, such an orientation also implies an increased market bias in the catering for consumers' needs. Car-sharing schemes, which are gaining wide popularity in Europe, are often mentioned as an example of such a shift in responsibilities (Prettenthaler and Steininger 1999).

The important premise of the service discussion is that the preferences of consumers can be known and reacted upon by the producers in their search for more efficient ways of providing utility for consumers. Unlike, for example, Lancaster (1966), the current discussion regards the producers as having a key role in the improving the efficiency of consumption. In practice, product designers are called on to forget incremental product development and devise totally new eco-efficient ways to fulfill consumer needs (e.g. Schmidt-Bleek 1994). Thus, the discussion on the (in)efficiency of consumption focuses on objective, universal needs or product characteristics in contrast to the subjective consumer preferences of standard economics. As such, the discussion takes a rather single-sighted stand on the nature of consumption, although the dichotomy between universal and subjective needs is well established in the literature. For example, Max-Neef (1992) has proposed a distinction between pre-systematic universal needs and needs which can only be understood as part of a dynamic system with no hierarchical linearities. Csikszenmihalyi

(2000) suggests a dichotomy of existential and experiential needs, of which the former are more universal and hierarchical, and experiential needs in turn more subjective. The point of view claiming limited universality is supported by consumer research in other disciplines charging that needs are culturally defined (Douglas and Isherwood 1980) and that welfare is relative (Easterlin 1972).

The focus of the eco-efficiency discussion does not match the reality of ever diversifying and escalating material consumption, and to fill the gap, the discussion frequently mentions so-called rebound effects that undermine efficiency improvements (e.g. Meijkamp 1998). However, being preoccupied with a functional view on consumption the discussion has not concentrated on understanding the phenomenon.

The concept of *rebound effect* was initially taken into use to describe the price elasticity of energy demand, which implies that a part of the efficiency gains are translated into additional demand (Khazzoom 1980, ref Binswanger 2001). This early notion of rebound effects referred to the substitution effect between different energy-related services such as mobility. For example, improved fuel efficiency of cars increases the substitution of car-use for other modes of transport. In addition to substitution effects, also so-called income-effects contribute to total rebound effect. Thus, for example, the new combination of the modes of mobility creates savings and allows increased mobility among other increases in consumption (Binswanger 2001).

Most of the discussion on rebound effects has regarded consumption as limited by the purchasing power of the consumer. However, as consumption is embedded in everyday life, it also has as a temporal dimension. This chapter introduces a time use perspective on consumption, which addresses the temporal conditions of escalating consumption. It further argues that service-orientation entails the possibility of a time use rebound effect when the productive activities of consumers are transferred to markets in order to promote eco-efficiency. Such a point of view has only rarely been brought up in the eco-efficiency discussion (see e.g. Binswanger 2001), and has not been studied empirically. The aim of the present chapter is firstly to propose that financial and temporal constraints should be viewed as separate and to demonstrate the role of a time use approach in articulating sustainable lifestyles. Secondly, empirical data on the energy requirements of selected household activities are used to consider the circumstances under which new consumer services may contribute to the reduction of aggregate energy use.

The structure of this chapter is as follows. Section 9.2 reviews three alternative approaches to describe a sustainable life-style - a functional approach, an approach based on purchasing power and thirdly a time use approach. Section 9.3.1 describes the method of decomposing private final energy use into temporal activities and the energy intensity of these activities. The data and the results of the empirical analysis are presented and discussed in section 9.3.2. Section 9.4 introduces a model of the time use rebound effects, which is then applied to the energy intensity data in section 9.5. Finally, section 9.6 concludes with methodological reflections and with a more general discussion of the role of new consumer services.

9.2 Approaches to sustainable lifestyles

In the context of this chapter, a sustainable life-style can be defined as a dynamic pattern of consumption activities, in which the related materials use is stable regardless of possible changes in welfare. From the materials-use point of view, all approaches to articulate a sustainable life-style can be by definition reduced to a simple notion of not increasing natural resource consumption. However, this notion can be formulated in different ways that enable the analyst to take different points of view on such developments as the service-orientation.

The appropriateness of a given approach towards articulating sustainable lifestyles depends on our understanding of consumption. On the one hand, consumption partly serves basic, existential needs (e.g. Max-Neef 1992). On the other hand, many authors regard consumption as a temporal process with intrinsic value. For example, Firat and Dholakia (1998) lay out a picture of consumption changing from modern goal-oriented instrumental consumption into playful activity, which is an arena for creativity and for the construction of identities. As a consequence, they argue, consumption becomes more diversified and the hegemony of markets in defining consumption will be reduced. Csikzsenmihalyi (2000) provides a more negative account of consumers, who increasingly find themselves with nothing do, and whose consumption is more and more driven by the markets. Whichever the case, such divergent modes of consumption also call for different, complementary approaches towards the notion of sustainable consumption. The following text considers a functional approach, a budget constraint -approach and finally, in more detail, a time use approach.

9.2.1 The functional approach

The eco-efficiency discussion focuses on the functions or services that the products yield (e.g. Meijkamp 1998) and implicitly assumes that the needs that these services aim to satisfy are stable and that they can be conveyed to the developers of technology (Heiskanen and Pantzar 1997). For example, in this discussion the need for mobility is often addressed (purposefully) ignoring any non-functional meanings of private cars. Assuming such transparency of consumption, the discussion often also presumes that an increased market bias in the provision for such needs would bring about efficiency gains.

The applicability of such an approach is, however, limited as the needs of consumers may be obscured for many reasons. Firstly, the developers of any technology rely on a limited understanding of the circumstances of use and of the functional results that the technology should enable. Secondly, the users, when enacting technologies, constitute new meanings for them (Orlikowski 2000). Thus, the use of technology in a specific context neither follows the intended purpose deterministically nor is it independent of that purpose. Along this continuum, the functional approach represents a view of needs and the context of use as being open to the developers of technology. While such universal needs certainly exist, it is, nevertheless, questionable whether this approach can be extended to cover the whole assortment of consumption, which, according to Firat and Dholakia (1998), also stages artful self-reflection.

9.2.2 The budget constraint -approach

The breakthrough of the neo-classical school of thought brought about a new theory of value, utility and needs. Whereas the classical theorists regarded value as objective and dependent on the factors of production, the prevailing neo-classical theory regards preferences as individual. Accordingly, utility is subjective and it can not be measured as such, but it is reflected in prices. The numerous studies that have focused on the resource or the energy-intensity of various consumer expenditure categories reflect this idea of the subjectivity of needs (e.g. Biesiot and Mol 1995; Nurmela 1996). When the marginal utility of each unit of purchasing power is the same in all consumption categories, the resource use per economic output is a figure that allows comparisons of consumption categories with widely different functional aims.

However, there are at least two distinct difficulties in approaching sustainable lifestyles with a budget constraint approach. Firstly, it juxtaposes consumers as having an incentive to increase consumption in the name of greater welfare, and as having an incentive to limit consumption in the name of saving resources (Lintott 1998). Thus, under productivity improvements and economic growth, sustainable lifestyles would imply such continuous change in individual preferences that compensate for the additional materials requirements of economic growth (Cogoy 2000). The second reason is that money does not have equal value for all and everywhere (Sen 1992: 29), and thus the management of materials use in respect to purchasing power does not maximize welfare.

9.2.3 The time use -approach

The time use -approach shares the basic assumption of the budget constraint approach that needs are not fixed but subjective and individual. The second, distinctive premise is that the approach considers the temporal constraints on consumption rather than the budget constraint. The following part of this section argues for three distinct assumptions that motivate the proposed analysis of the time use dimension of consumption:

1) *the temporal dimension of consumption provides additional understanding of the potential changes in consumption,*
2) *the distinction between gainful work and leisure is becoming increasingly blurred and,*
3) *the individual decision of the quantity of one's labour input is restricted by social and economic institutions.*

Theoretical approaches to the role of time use have been developed within the field of household economics. Becker (1965) has argued that Economic Man not only expresses preferences between different commodities within a budget constraint, but also between commodities and leisure time. Such an analysis combines the constraints of time and money and treats them as interchangeable. Recently, Cogoy (1995; 1999) has pointed out that although Becker has not recognized it, time-allocation also has environmental implications. According to these authors, markets goods are not sources of utility per se, but need to be combined with consumer time use (labour). Consequently, it is argued that changes in consumption can better be understood, if the temporal limits of consumption are attended to (Mogensen 1990; Cogoy 1995 and 1999; Godbey 1996).

However, the theory of household economics, which presumes rational goal-oriented consumption, does not reflect the present understanding in consumer research. Csikszenmihalyi (2000) points out that consumers increasingly find themselves lacking things to do. Consumption of material goods is, then, used to fill the day and create meaningful passages of time. Bluntly, preferences and utility exist more and more in respect to time. As the ends of consumption transform from physical outcomes into temporal activities, the resource intensity of consumption should also be evaluated with respect to time. Furthermore, as the ends of consumption become more blurred, a distinction between gainful unpaid housework, on the one hand, and meaningful leisure time, on the other, becomes more problematic. For example, Cogoy (1999) uses cooking as an example of an instrumental activity that is guided by other aims such as having a nice meal. However, surveys of time use preferences show that both women and men, on an average, prefer such activities as cooking and cleaning to watching TV, which is, nevertheless, hardly instrumental, but rather a form of ultimate leisure time (Körmendi 1990, Godbey 1996).

Time use does not seem to change as swiftly as other aspects in society (Mogensen 1990, p. 31), which points to a considerable rigidity in time use probably caused by social and economic institutions. Indeed, the fact that productivity gains are utilized to increase additional materials consumption instead of leisure time is a commonly expressed concern of the literature dealing with the environmental aspects of consumption (e.g. Röpke 1999b, Sanne 2000). According to Röpke, the explanations draw on economic, socio-psychological and socio-technical factors. Not only consumption, but also work, carries social and personal meanings, which may contribute to a ‘work and spend’ -bias. Furthermore, as many of the benefits of consumption are relative to the other consumers, individual consumers may opt for increasing their material wealth (Röpke, 1999b). Empirical support for the impact of socio-technical factors has been provided by authors like Cross (1993) and Schor (1991), who claim that labour markets and production technology maintain the cycle of ‘work and spend’. Thus, under a constant productivity growth and rising affluence in industrialised societies, consumption in these countries may be more and more limited by time rather than by money (Godbey 1996).

Within the time use approach, a sustainable lifestyle can be described as a requirement of no increase in the materials-intensity of everyday life. On an aggregate level this notion is not very informative. However, a decomposition of materials requirements into different temporal activities allows better understanding of the conditions under which the changes in aggregate materials use do occur. For example, it has been claimed that increasing telecommunication expenditure is a sign of dematerialization. Nevertheless, as the growth of telecommunications also gives rise to economic growth, the effect remains unclear. The increased use of mobile phones or the Internet could be assessed from the time-use point of view. How much time is used in the activity? Is the new activity concurrent with some previously existing activity, such as travelling? Or has it acquired a time slot from some other activities, and what were their resource intensities?

The recent discussion on rebound effects does recognize the time constraint as a separate source of rebound effects (Binswanger 2001). However, empirical research specifically on time use and the environmental impacts of consumption appears to be limited. On the one hand, the time use research has not directly addressed the environmental impacts of the time use patterns (Harvey 1998). On the other hand, research that addresses the materials basis of the economy has not focused on the temporal aspect of consumption, either. As a notable exception, Schipper et al. (1989) have used time use surveys, consumer expenditure data and data on appliance ownership to study consumer lifestyles.

As Schipper et al. (1989) note, including time use forces the analyst to consider at the same time both what people might do differently in the future and what they might not do as a consequence of their new activities. These consequent new activities or changes in the time budget are in the following referred as *time use rebound effects*. In most of the previous considerations of the rebound effects, time use has only had a peripheral position, if any. For example, Goedkoop et al. (1999) propose in a market study of new eco-efficient services that the resource consumption of the time-sharing of luxury yachts be compared with the average environmental impacts of leisure time activities. However, they do not elaborate on the idea as they do with purchasing power rebound effects. As such, the earlier notions of time use rebound effect do not point out the strength of the approach, which, in essence, is that it allows the analysis of aggregate resource use without defining a set of basic needs or taking an exogenous size and structure of the economy.

9.3 An empirical analysis of the energy intensity of consumption activities

Households contribute to energy consumption by the direct purchases of energy carries such as electricity, oil, gas and other fuels. However, they also affect energy demand by purchasing other goods and services. Such embodied energy use is referred to as indirect energy consumption. Both direct and indirect flows are significant. In 1990, the share of the direct energy consumption of Finnish households was 46% (Nurmela 1993). The energy use of households, both direct and indirect together, denoted as private final energy consumption[183], accounted for 44% of the total energy consumption of Finland in 1988 (Nurmela 1996: 78).

9.3.1 Methods and data

The following analysis combines Finnish data on the direct and the indirect energy consumption of households with time use data, and focuses on how the energy use is distributed between different consumption activities outside the working hours. Accordingly, the daily energy requirements can be decomposed into the temporal activities and into their energy intensities in the following manner.

$$E_{tot} = \sum_{i=1}^{n} \sum_{j=1}^{m} t_i \times c_{i,j} \, e_j / t_i$$

Where time t_i refers to the duration of the activity i, cost $c_{i,j}$ to the j consumption expenditure categories related to the activity i and e_j to the energy intensity of the consumption category j. The duration of the activities (i =1 ... n) sum up to 24 hours and the expenditures c (j =1 ... m) to the average daily consumption expenditure.

The analysis was conducted for two-person households in Finland and was based on data from Statistics Finland from 1987-1990. Two-person households were selected because, among the types of households, they account for the largest share of population (Nurmela 1993). The following four data items are combined to produce the figures on the energy intensities of household activities:

Item 1: The household expenditure survey, 1990.
The household expenditure data are from a representative survey from 1990 (Statistics Finland 1992), which provides a disaggregated record of the expenditure of two-person households in Finland.

Item 2: Input-output table of the Finnish economy and the derived energy intensities of final consumption expenditure in 1990.
The energy intensities of final consumption expenditure can be calculated using national statistics and an input-output energy analysis, which is an application of economic input-output analysis developed by Leontief (1941, see Biesiot and Moll (1995) for a description of the method). The present work makes use of the reported energy intensities of the Finnish economy in 1990 (Nurmela, 1993). The accuracy of the input-output method depends on the number of sectors that the economic activity is divided into (Wilting and Biesiot, 1998). In a study of the energy intensities of the economy of the Netherlands, Biesiot and Moll (1995) have used a model with 60 sectors. Nurmela (1996) reports data on 82 sectors of the Finnish economy.

Item 3. Direct energy use of households
Direct energy consumption data have been reported by Nurmela (1996). He has used the data of the Finnish household survey 1990 to estimate the direct energy use of different types of households, and secondary sources to estimate the distribution of the use between different domestic activities.

Item 4. Time use survey from 1987-1988.
The time use data have been collected from a statistical sample via diaries and interviews in the Finnish time use survey in 1987-88 (Statistics Finland 1991). The data used in the present study consist of the aggregate annual time use of the men and women living in two-person households.

The combination of items 1 and 2 reveals the indirect energy use of the various expenditure categories of households. In order to study the energy intensities of activities, both the indirect and the direct energy use, item 3, must be allocated to specific households activities. As these two data sources are typically collected separately, such allocation of consumer expenditure to specific activities is based on a qualified guess. The allocation is relatively straightforward for some expenditure categories. For example, expenditure on books, newspapers and magazines is allocated to the activity of reading. However, items such as housing, furniture and tools are connected to a variety of different activities, and therefore were not allocated to any activity. Also the allocation of such direct energy consumption as heating is difficult. Brodersen (1990) has performed a similar re-categorization of Danish consumer expenditure data to match the time use data and, to maintain reliability, has chosen to only work with aggregate time use categories, such as leisure time and unpaid household work. Despite this, Brodersen does not allocate housing, heating and furniture to any activities, either. The present analysis has aimed to focus on individual activities. In order to maintain the reliability of the analysis, activities, for which there were not sufficient allocation criteria, have been left out of the scope of the analysis. Consequently, the analysis does not cover the total energy use of the household. Section 9.3.2 reviews the coverage and the potential errors of the analysis. For details on the allocation, see appendix 1.

9.4 Energy intensities of selected domestic activities

Table 20 presents the energy requirements and the time use of selected activities of a two-person household in Finland in 1987-1990. The total energy requirement of a given task is the sum of the direct energy use for performing the activity and the indirect energy use of producing the goods and services that are needed in the activity. The energy intensity of an activity is the relation of the energy use and the duration of the activity.

Table 20: Energy demand, consumer expenditure and time use of selected household activities in a two-person household in Finland in 1987-90. See appendix 1 for more detailed information on each activity and the sources of the data.

Activity	Direct energy demand of the activity [kWh/a]	Consumer expenditure in 1990 [FIM/a]	Indirect energy demand [kWh/a]	Time use of a two person household[h/a]	Energy intensity of the activity [kWh/h]
Washing and ironing	457	292	86	106	**5,1**
Cleaning and organizing	a	a	a	300	**0,42**
Cooking	1543	904	323	525	**3,6**
Dishwashing	457	140	41	181	**2,8**
Driving to shop for daily goods	a	a	a	161	**28**
Eating in restaurants		1609	320	31	**10**
Culture and sports events		330	69	57	**1,2**
Reading		3016	907	751	**1,2**
Using home electronics	686	854	174	1531	**0,56**
Taking a sauna	925			125	**7,4**
Average of the above activities					**3,9**
Average of non-contracted time	50679			15051	**3,4**

[a] The intensity is an estimate - see appendix 1.

Table 20 includes domestic activities and activities that take place outside the home. Driving and eating in restaurants have high energy intensities, whereas cultural and sports events have clearly lower energy intensities. Similarly, also domestic activities include ones with both higher and lower energy intensities than average. Schipper et al. (1989) claim that a shift of activities from home to other places may significantly increase the total energy consumption. This is supported by the present data especially when such activities involve long driving distances. However, also the opposite is possible as domestic activities such cooking, washing and taking a sauna have clearly higher energy intensities than for example cultural and sports events.

It is necessary to emphasize that the data in table 20 are mainly presented to demonstrate a method for the time use approach. There are methodological difficulties within the present data in terms of allocating all relevant energy use to the right activities. The activities that are presented in appendix 1 occupy 27% of the average 24-hour daily time-budget. Sleep, which involves practically no energy consumption because domestic heating is not allocated to any activities, occupies 35% of the time budget, and work, for which no final consumption is allocated, occupies 14% of the time budget (Statistics Finland 1991). The remaining 24% of time use is unaccounted for in this analysis. These activities were left out of the analysis, because there were no sufficient grounds to allocate energy consumption to these activities. For example, various daily maintenance activities occupy 2,5 % of the time-budget, but they also involve the utilization of such a variety of market goods that allocation is not possible using the present data.

The energy requirements for the activities in appendix 1 cover 20% of the total direct and indirect energy consumption of a two-person household reported by Nurmela (1996). Following Nurmela (1993, 1996) domestic heating and lighting energy also amounts to 20% of the total final private energy consumption. Transportation services, which are not included in the present analysis except for daily shopping trips, account for another 29% of the total energy use. Thus, when summed up these activities together account for 69% of the total private energy consumption, while 31% is associated with other activities. Some of the energy consumption that is not covered by the analysis does relate to the activities under scrutiny. For example, the use of detergents and other consumables such as water is not included in the analysis, even though the tasks of washing clearly require these consumables. The remaining unallocated energy use relates to the 24% of the time use that is not covered by the analysis, for example to holidays and vacations. However, such data gaps do not impair the comparison of the selected activities[184].

The approach of combining time use data, consumer expenditure data and energy intensities per economic output is novel. Thus, there are no previous results that would allow direct comparison with the present findings. However, it is possible to compare the present data with previous research on the energy intensity of consumption activities.

Eating in restaurants seems to score high. Mäntylä and Alppivuori have estimated the total energy consumption of visits to restaurants, bars and cafes in Finland in 1990 to be 1085 GWh excluding the travelling-related energy consumption (1996: 20). Using the method and data of the present study - consumer expenditure and energy intensity of restaurant services - gives a total figure of 1355 GWh. However, as this analysis uses a figure that has been achieved by an all-inclusive input-output energy analysis, it is to be expected to be higher than the estimate of Mäntylä and Alppivuori, which only considers the most significant direct and indirect energy uses. Thus, the energy intensity of restaurant eating is well in line with the results of Mäntylä and Alppivuori.

Private car-use is often regarded one of the most energy intensive activities. Is it viable, then, that driving would only have a factor 2,8 higher energy intensity than eating in restaurants as indicated in table 20? This result is influenced by the assumption made for the average speed: a low speed in city traffic of 30 km/h obviously results in a relatively low intensity for driving. Secondly, driving is an activity in which most of the energy consumption takes place along with the activity, and is thus readily observable. Restaurant meals, on the contrary, include a variety of significant indirect energy consumption items such as the food production chain, the construction and facility maintenance activities, equipment manufacturing and the energy content of packaging waste. As such, restaurant meals condense indirect energy consumption that is spread over a large area in society into a tight temporal act of consumption.

Schipper et al. (1989) have studied the energy intensities of various consumer activities. They concluded, for example, that the energy intensity of driving is roughly eight times higher than that of using commercial services, which differs from the ratio of driving and restaurant meals obtained in this study. However, their methodology does not allocate all final energy consumption to the consumption activities. In their analysis, for example, such an indirect effects as the food production chain do not show in the energy intensity of the final consumption act of having restaurant meals. Furthermore, Schipper et al. do not present their comparison specifically for restaurants, but also include various other service buildings such as retail stores, lodging and places of cultural events. According to their data, restaurant spaces have a twice as high a specific energy use as the average for buildings for commercial services.

The activities that take place outside the home require some means of transportation between the residence and the service location. Some of this transportation includes the use of private vehicles, which has a high energy intensity as shown in table 20. Thus, such activities as attending to cultural events that have a low energy intensity as such, have higher energy intensity when the necessary transportation is taken into consideration. However, the energy requirement of transportation is not predominant. Mäntylä and Alppivuori (1996: 20, 25) estimate that transport constitutes 30% of the total energy consumption of restaurant visits and that transport and lodging together constitute 21% of the total energy consumption of theatre visits. This energy consumption is not included in the figures in table 20 as the time use data of travelling are not specific enough.

9.5 A model of time use rebound effect

Section 9.2.3 on the time use approach was based on a view of consumption as a process that requires physical inputs and time. In table 20, the physical inputs were represented by the energy requirement of an activity, and the time requirement by data from the time use survey. Using these two dimensions, any consumption activity can be presented as a vector in a system of coordinates set by energy requirements and time use.

The time use rebound effect was defined as the new activities a consumer engages in as a result of a less environmentally harmful product or service being substituted for an existing activity. Figure 15 uses two hypothetical examples from the eco-efficiency literature to illustrate the time use rebound effects that are associated with the initial efficiency measures. In the figure, the rebound-activity is presumed to have the same energy intensity as the average non-contracted time, i.e., all time outside market employment and the related travelling.

In example 1, a delivery service is substituted for the consumer activity of shopping for food (Cairns 1999, Goedkoop et al. 1999). The time used in the activity is reduced as the consumer only has to select the goods, for example via the Internet, whereas a commercial service provider performs the delivery. The energy demand of the delivery is also lowered, because multiple customers can be served by the same delivery service (Goedkoop et al. 1999). The rebound-activity is the activity the consumer engages in instead of the time spent on shopping trips. Thus, the intensity of the net outcome is a time-weighted average of the reduced shopping activity and the new activity that the consumer has engaged in.

In example 2, a commercial car service and repair shop is substituted for the work of a handyman. Graedel (1998) uses this example to argue that commercial services bring about efficiency gains. Following Graedel, the energy demand in example 2 is

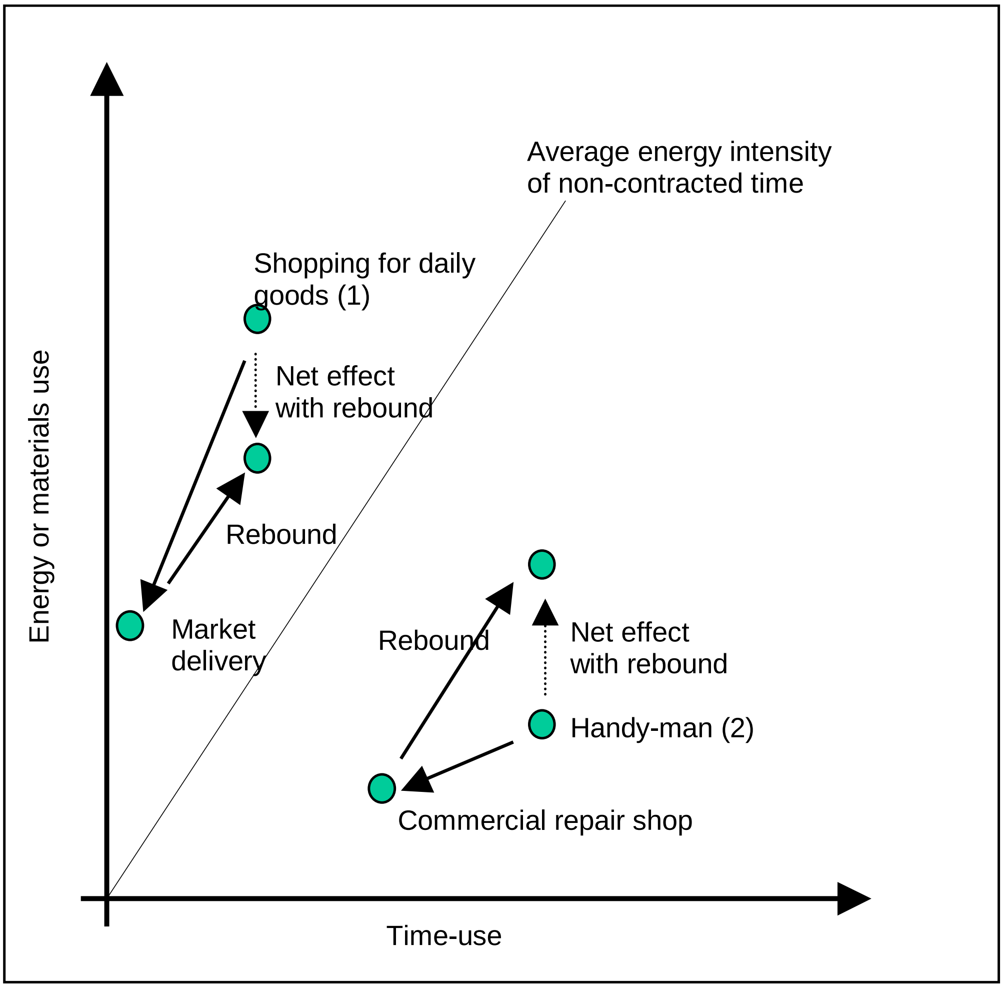


Figure 15. Theoretical model of time use rebound effect and two hypothetical examples. See also Goedkoop et al. (1999) for a general graphical presentation of rebound effects.

reduced due to the higher rate of utilization of existing tools. However, if one takes into consideration the activity that occupies the time that is saved by commercial services, there is a net increase in the energy demand.

A more general interpretation of figure 15 is that a change towards the lower right-hand sector that is created by the line of the average energy intensity leads to net decrease in the energy demand (example 1). Respectively, a change towards the upper left-hand sector (example 2) results in a net increase of the energy demand. The effect on net energy demand thus does not depend on the initial energy intensity of the activity, but on the direction of the change. However, if the original activity has a high energy-intensity, there is more "room" for such changes that lower the net energy demand.

A specific case in the model is when an activity is scaled down, i.e., there is a change towards the origin. In this case, if the initial activity is located above the line of average intensity, a scaling down results in a lower net energy demand. Respectively, a scaling down of activities located below the line of average increases the net energy demand.

9.6 An application of the model

The present data do not allow considerations of which type of activities would constitute the rebound effects. However, the assumption that the rebound effect has the average intensity of all activities allows the consideration of potential scale effects

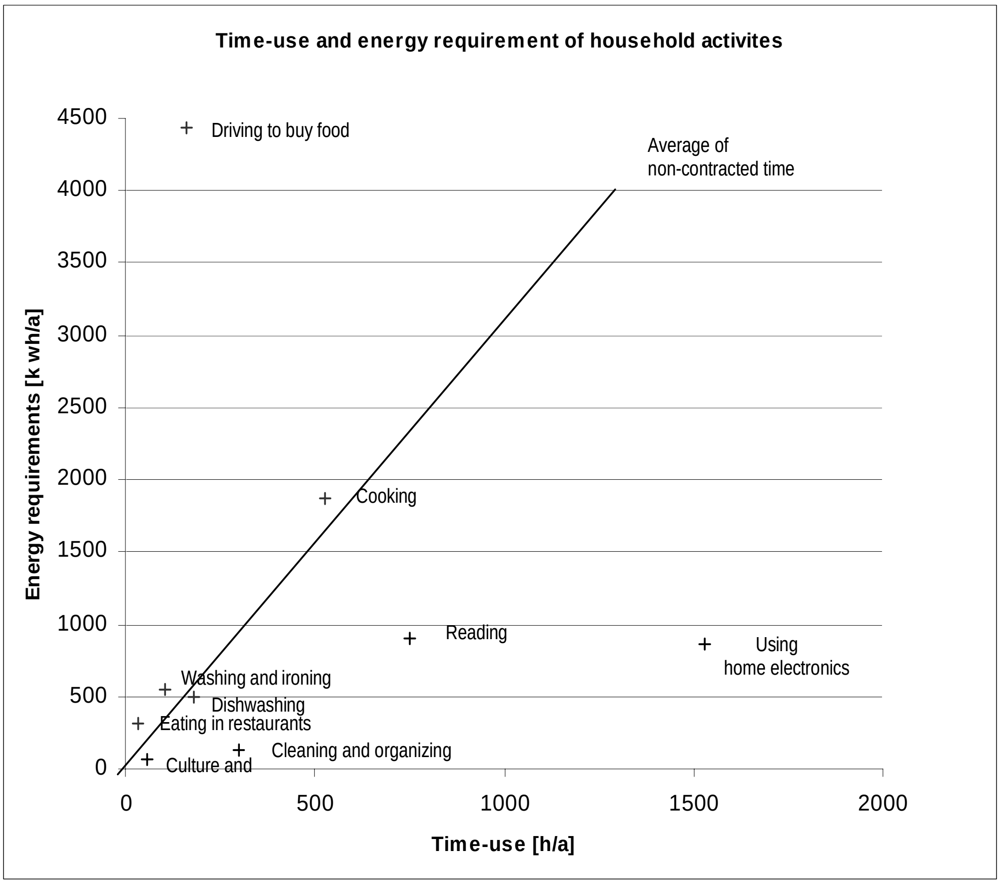


Figure 16. Energy intensities of selected household activities of two-person households in Finland in 1987-90.

in the existing activities. Figure 16 plots some of the data of table 20 into the conceptual model of time use rebound presented in figure 15.

As noted earlier, scaling down activities with lower-than-average energy-intensity increases the total energy requirement. According to figure 16, such activities include attending cultural events, reading, the use of home electronics, washing dishes and cleaning and organizing. Respectively, for the activities that have higher than average energy-intensity, scaling down lowers the total energy requirement. These activities were found to include driving to buy daily goods, eating in restaurants and taking a sauna. Activities such as cooking and washing clothes are close to the average energy intensity.

Figure 16 can be used also to consider the service debate more generally. The discussion postulates that services that are produced by households could be produced in the markets more effectively from the materials-use point of view. However, as these changes also affect the time use of consumers, they have a time use rebound effect. For example, commercial laundry services may be more effective when viewed as such (Goedkoop et al. 1999; VROM 1993), but their net effect depends on the new activities the consumer engages in due to the additional leisure time gained.

The use of the Internet provides another example. As the operation of computer equipment has a similar (low) energy-intensity as the use of home electronics, it seems that increasing time spent on the Internet would have the potential to reduce the overall energy consumption. However, Nurmela et al. (2000) report that heavy Internet users (over 5 hours per week) have reduced time spent on watching TV and for ‘general hanging around’. In the light of this, there may not be significant changes in energy consumption, as Internet usage has not replaced any activities with a high energy-intensity such as driving.

Restaurant meals have been presumed to provide an efficiency gain when compared with preparing food at home. For example, a document commissioned by the Dutch Ministry for Housing, Spatial planning and the Environment states that “Eating in restaurants ... leads to greater efficiency in the storage, preparation and cooking of food” (VROM 1993: 29, 41). Although not well grounded, this claim is in line with the assumption of the service discussion in general. The results of the present work suggest, however, that while there may be efficiency gains available for providing meals, restaurant *eating* at present may not contribute to sustainable lifestyles. Combining all food-related activities that were presented in table 20 together and calculating an aggregate intensity for meals prepared at home gives an intensity of 7,7 kWh / h (see appendix 1 for details). Eating in restaurant has a higher intensity of 10 kWh / h and thus the assumed efficiency gains are compensated by the time use rebound effects. This is also supported by Mäntylä and Alppivuori, who conclude that home meals (per meal, without a temporal specification) only require 40-60% of the energy required by meals at restaurants (Mäntylä and Alppivuori 1994: 22).

9.7 Conclusion

Despite the methodological difficulties in combining the energy data and the results of the time use surveys, some tentative conclusions can be made of the potential of eco-efficient services within the realm of households. Firstly, there is a time use rebound effect in any such efficiency measures that transfer household activities to markets and thereby contribute to a market bias in delivering welfare. Because of this temporal rebound effect and the consequent new consumption activities, some of the efficiency gains will be lost. The type of such activities can not be defined with the present data and thus also the net effect of any particular service remains unknown. However, a comparison of, for example, home meals and restaurant eating points out that the benefits of a market bias are far from self-evident.

From a methodological point of view, the time use approach is complementary to the other approaches used in the eco-efficiency discussion. The time use approach allows one to study the total materials requirement and the concept of sustainable lifestyles in an analytical way, while still not presuming a predefined set of needs or a given size the economy. However, also the nature of the questions asked changes. Within the efficiency discussion it would be common to ask whether, for example, the high energy intensity of restaurant meals is due to the saved time or the less efficient use of energy. Such a question, however, presumes a functional reason against which it would be possible to assess the saving of time or the use of energy. From the point of view of the time use approach, consumer preferences are expressed as time use and, thus, all activities are equally good ways of spending time from the point of view of the analyst. The reason for engaging in specific activities is outside the scope of the time use approach.

A non-functional view according to which the outcomes of the processes are not of interest is of course an analytical concept that has its limits in practical applications. Food, for example, clearly is a basic need that can not be replaced by other activities. Thus, the food-related time can not be reduced freely although it has a high materials-intensity, as the outcome of food preparation, namely nutrition, is needed. And even if ready-made meals do shorten the time spent on food preparation, they do not lower the indirect energy demand of the food industry (Schipper 1989). However, it is equally obvious that consumption is not only driven by such basic needs. Indeed, it can be argued that much of the present consumption in the wealthy industrial societies serves culturally defined needs or individual and relative needs of play and self-reflection that all are only remotely connected to such subsistence needs as nutrition.

Gershuny (1999) has suggested that household time use surveys can provide valuable information on the economy of producing end-services. This chapter further suggests that the surveys are important in understanding the role of marketed services in the quest for dematerialization. However, it is only by forgoing the assumption of perfect substitution that one can gain more insight on the nature of time use rebound effects and on the dynamics that are implicit in the energy consumption of household activities. Furthermore, it is also necessary to move beyond the aggregate level of time use surveys and focus on the individual processes of substitution in everyday life. Multiple avenues exist for gaining further knowledge on the relation of different activities. To mention a few, a time-geographical approach addresses the temporal and physical interrelations of tasks (Ellegård 1999) and the hierarchical clustering of activities can be used to study the substitutability and similarity of tasks (Cermak, 1996). Studies of time use preferences (e.g. Körmendi 1990; Vilhelmson 1997) are, as well, informative in respect to potential changes in the time budgets. When such theoretical understanding and empirical data on changes in the time budget become available, the method demonstrated here can provide valuable new understanding concerning the potential of market-based services to contribute to sustainable lifestyles.

Appendix 1: The specification of the data used in the calculation of the energy intensities of the activities presented in table 20

	Annual consumer expenditure (Statistics Finland 1992)	Expenditure code of the included items (Statistics Finland 1992)	Energy intensity of the consumer expenditure (Nurmela 1993)	Category of the energy intensity data (Nurmela 1993)	The direct energy use of the activity[185] or indirect of the purchase [186]	Source of the figure of the direct energy consumption	The average time use of two-person household[187]	Activity codes of the included time use items.	Energy/ time
	FIM/a		GJ/100FIM		kWh/a		h/a		KWh/h
Washing and ironing					457,10	Nurmela 1996, p.146 and p.148	106	222	5,14
Washing machine etc.	292	42011-42018 Detergents not included	0,1062	53 Household equipment	86,14				
Cleaning and organizing					95,85[188]	Estimate	300	221	0,42
Vacuum cleaner	101	42019 Vacuum cleaner	0,1062	53 Household equipment	29,80				
Meals at home[189]									8,36
Cooking					1542,72	[Nurmela 1996, p. 147-148	525	211-213	3,55
Preserving					971,34	Nurmela 1996, p. 147-148	23	214	42,00
Eating (inc. snacks)							835	321, 326	
Kitchen equipment	502	42000-42010 Kitchen equipment, except for dishwasher 42003	0,1062	53 Household equipment	148,09				
Dishes & tableware	402	4300 Tableware	0,1565	54 Durable kitchenware	174,76				
Dishwashing					457,10[190]	Nurmela 1996, p. 147-148	181	215	2,75
Dishwasher	140	42003 Dishwasher	0,1062	53 Household equipment	41,30				
Food (indirect)	17460	10-11 Food			8086,20[191]	Nurmela 1993, p19-21	85	271	94,95
Driving (acquisition of daily goods)					3756,8[192]	Mäntylä and Alppivuori 1996, p. 119	161	209	27,60
Vehicles (indirect)					674,83	Mäntylä and Alppivuori 1996, p. 119			
Eating in	1609	13 Meals in restaurants	0,0717	80	320,46		31	323	10,18

[185] Nurmela (1996:148) gives the total electricity demand and its distribution within household activities. The factor for primary energy demand of electricity production 1,91 has been calculated from Mäenpää (1998: 32).
[186] The indirect energy consumption is the product of consumer expenditure and the energy intensity of the manufacturing sector.
[187] The data do not originate from the same households. Therefore the data on men and women living in two-person households are combined to form meta-data of the time use of a two-person households. There were 2255 diary days of men (base 708825) and 2150 days of women (base 634184) from two-person households. (Statistics Finland, 1991, tables C3.A (men) and C.3B (women)).
[188] An estimate of 1 kW vacuum cleaner being used for 15% of the time
[189] An aggregate figure for rows from Cooking to Vehicles.
[190] Water supposed to be warmed by a dishwasher, no additional energy for using pre-warmed water is taken into account.
[191] Nurmela (1993: 19-21) the energy content of the foodstuff of a two-person household
[192] 0,78 kWh/km in city traffic (Mäntylä and Alppivuori, 1996). Own estimate of 30km/h average speed.

restaurants[193]		and cafés,		Restaurants, cafés and hotels					
Culture and sports events	330	720 Entrance fees, excluding 72004 discos and dances	0,0757	74 Recreation, culture and free-time education	69,39		57	441-444, 451-453	1,23
Reading							751	711-715	1,21
Books	3016	73 Books and magazines	0,1083	75 Books, magazines and newspapers	907,31				
Using home electronics					685,65	Nurmela 1996, p. 147-148	1531	721-741	0,56
Equipment	854	711 Radio and TV	0,0733	71 Radio and TV equipment	173,88				
Sauna					924,78[194]	Nurmela 1996, p. 149-150, data for a three person household	125	332	7,38
Average of the activities under study					18032		4711		3,83
Average of non-contracted time					50679,92[195]	Nurmela 1993, p. 15 and 19.	15051		3,37
Work and travel							2469	101-145	
Sleep							6065	311-314	
Total							17520		

[193] The expenditure figure does not include drinks, and the time-use figure excludes time in bars and discos.
[194] Heating warm water is not taken into account
[195] The average total final energy consumption of a two person Finnish household excluding domestic heating and lighting.

Notes

[1] Environmental shares refers to the fair share of natural resources (including environmental carrying capacity) that would be available to each person in the world if these resources were distributed equitably (e.g. Ulvila and Åkerman 1996).
[2] Of course, services enabling the shared use of goods, and the delivery of 'results' have existed before, also (e.g., public transportation, car-rental, restaurants). However, the concern about natural resource use and the possibilities of ICT can generate new services (e.g. car-sharing) and give existing services (e.g., laundries) new meanings.
[3] See chapter 8.
[4] This juxtaposition illustrates the disciplinary incompatibilities of natural sciences and economics by pointing out that the natural sciences often focus at the natural systems and specifically on the natural or environmental capital, while economists focus on the human systems and welfare without any bias between different forms of capital be they human made or natural (Verbruggen 1998).
[5] Simon Kuznets pointed out in 1954 the inverted U-shape of the relationship between the level of economic development and the degree of income inequality (Kuznets 1955). The hypothesis of environmental Kuznets curve was brought to prominence by the World Bank report on Development and the Environment (1992).
[6] Cleveland and Ruth (1999) and Wernick et al. (1989) also refer to the unattended effects of the mining side-rock of rare metals. However, the side-rock is included as a hidden flow in Materials Flow Analysis.
[7] A distinction between absolute and relative changes is used by much of the literature (e.g. Jänicke et al. (1989) use concepts of absolute and relative structural change). However, there are different concepts to specify absolute and relative changes. de Bruyn (2000), for example, uses notions of strong and weak delinking. Dematerialization has also been used in a variety of meanings, which are further discussed in chapter 4.
[8] De Bruyn (2000) labels the signs of first order derivative of materials use weak (+) and strong (-) delinking (or dematerialization) and a positive second order derivative as relative relinking.
[9] The introduction of IPAT is generally credited to Paul Ehrlich. Chertow (2001) provides a good overview of the history of the IPAT equation and shows that it involves a heated debate over the role of technology as a source and cure for environmental problems.
[10] Poland, Hungary, Spain, Norway, Finland, Japan, Yugoslavia, Greece, Sweden, US, France, West Germany, Italy, Denmark, UK, Switzerland, Belgium, the Netherlands, Turkey.
[11] It is of course conceivable that consumption is actually oriented towards more materials-intensive goods, instead of, for example of services, but that the technological improvements have been able to reverse this into a lower materials intensity of the economy. Decomposition analysis of the Finnish economy, however, shows that both structural change and technological improvements have contributed to a lower materials intensity of the economy (Mäenpää et al. 2000; Hoffrén et al. 2001).
[12] The figures are based on the data of the country reports of Matthews et al. (2000). The CO_2 emissions from biomass burning have not been included as it is regarded as CO_2 neutral. The data of the countries differ in respect to how CO2 emissions from domestic and international bunkers have been taken into account. However, for each country the three reference years 1975, 1985 and 1996 have been calculated with the same method.
[13] There are many possible explanations for the figure 2 in addition to those put forward by the eKc-discussion. First of all, it may be due to a classification of previous waste into secondary materials, which pile up into stocks along with limited demand for these materials. Furthermore, an increase in the incineration of such waste that contains carbon may shift mass from the non CO_2 emissions to the CO_2 emissions. The growth of CO_2 emissions and the lowering other DPO may also be connected through recycling. High rates of recycling may require more energy than the use of virgin material sources. A shift from other energy sources to fossil fuels would also affect these figures. However, for example the mining side-rocks of uranium or lignite are not included in the DPO figure. Finally, it should be remembered that DPO figures of the five countries of figure 2 do not reflect any changes in the structure of their imports and exports.

[14] The share of exports of the Finnish GDP rose from 21% in 1970 to 40% in 1997.
[15] The DMI figures include a double-accounting effect of international trade. It is difficult to estimate the difference between the DMI and the TMC figures, but the fact that DMI includes, for example, both the imports of fossil fuels and the (mainly) exported timber harvest overestimates the Finnish materials use.
[16] Both Mäenpää et al. (2000) and Jespersen (1999) are based on input-output tables, which assume same level of technology. If the imports are manufactured with lower level technology than the exports, this raises the relative intensity of the imports.
[17] According to the SNA1993 (System of National Accounts), public spending is divided to individual and collective spending. The first refers to items that could in principle be transferred to the market actors whereas the latter refers to spending on such public goods as defence. Individual public spending is the publicly paid share of the cost of publicly provided individual services.
[18] This argument was first put forward by Baumol (1967) by pointing out that many services such as entertainment only have a labour-input, which does not allow any productivity improvements to occur.
[19]The output of the Finnish private healthcare sector has remained constant (1995 prices) from 1975 to 1998. However, the private education services have doubled their output in the same time frame (Statistics Finland 2000a).
[20] This is likely due to the hidden material flows of building telecommunications infrastructure.
[21] There are few environmentally concerned policies that strictly call for economic growth as a solution. However, the three dimensional concept of sustainable development makes this situation much more likely. It has been claimed that social sustainability is a prerequisite of ecological sustainability, and that it is dependent on economic growth. Such links between economic and environmental wellbeing points out that it is not the mere per capita GDP that is of interest, but also its distribution.
[22] Various definitions with slightly differing emphases can be found for ICT and the ICT industry. Here the information and communication technology is understood as consisting of equipment, software and the assisting infrastructure needed to produce ICT products and services (see also glossary in the summary of this report).
[23] For example, in Finland, Japan and the US the ICT sector has in recent years been the industry with highest growth rates both in volume and in productivity.This will be discussed in more detail in section 3 of this chapter.
[24] ICT-producing industries are generally considered less-energy intensive than process and heavy industries such as pulp and paper, steel or chemicals producing industries (e.g., Romm et al. 1999).
[25] In Europe, the eEeurope initiative, for example, launched by the European Commission in 1999, aims at accelerating the uptake of digital technologies across Europe in order to increase economic growth and employment, among other things. It does not refer to the environmental aspects of this development at all (eEurope 2000). In Finland, the national Information Society Strategy from 1995 was revised in 1998, see http://194.100.30.11/tietoyhteiskunta//english/st5/eng01.htm. Sustainable development is the main strategical aim of the new strategy, and an action plan suggested in the report is now being realised as the KESTY programme of the Environmental Cluster Research Programme.
[26] Further initiatives have also been made by Information Society Forum's working group 4 on Sustainable Development, the Institute for Prospective Technological Studies (IPTS, Seville), Eurescom, ETNO, the World Future Studies Federation, European Commission's Cellule de Prospective, and the European Environmental Agency in Copenhagen (ACTS 1998a).
[27] An early attempt to assess the direct and indirect environmental impacts of Nokia's business operations and products has been made by Lankoski (2001).
[28] The pre-study of Kahilainen (2000) for the KESTY programme provides a good overview of activities in Finland to enhance information society on the one hand, and sustainable development on the other.
[29] This report will analyse in more detail electronic grocery shopping (chapter 6) and the ways in which ICT can influence and reduce corporate travel (chapter 7).
[30] Until now, few detailed energy or environmental analyses of the impact of electronic commerce have been carried out. Some predictions have been made based on empirical energy data on ITC equipment and infrastructure (e.g., Kawamoto et al. 2000). Also the impacts due to potential changes in business practices driven by electronic commerce have been modelled (Caudill et al. 2000). The existing literature in the area is more on the level of hypothesizing environmental impacts, and these hypotheses still need to be studied more closely and tested empirically (NYAS 2000).
[31] ACTS (Advanced Communications Technologies and Services) was an EU research effort during 1994 - 1998 to support the early deployment and effective use of advanced communications services. Around 200 projects were executed covering a wide range of novel technologies, applications and services. Working groups of ACTS projects have produced, among other things, a guideline "Sustainable Development Impact Assessment", which addresses the potential impact of

ICT on sustainability. Full texts of ACTS guidelines can be found at http://www.infowin.org/ACTS/ANALYSYS/CENCERTATION/glindex.htm

[32] According to the ACTS (1998a) definition, a rebound effect is a situation where the savings per unit of good or service are encountered by a higher number of units consumed. Different types of rebound-effects are discussed in Chapter 9, and our definition for rebound effects can be found in the glossary of Chapter 1. The rebound effects specifically related to the ICT sector and ICT use is discussed in more detail by Plepys (2001).

[33]This development has been enhanced by a synergy effect caused by also other factors than the direct impacts of ICT and digital technology on data transfer and communication. These other factors include the globalisation of trade, increased competition, liberation of financial markets, deregulation, increased flexibility on the labour market and the goal of stability in economic policy, which all have created favourable circumstances for investments and growth (Hämäläinen 2001).

[34] The key activities of the ICT sector (ICT manufacturing and telecom services, software and IT services) generated a turnover of EUR 17.5 billion in 1998. In 2000, the company Nokia alone accounted for 4.6% of the Finnish GNP and its share of total exports was ca. 20% (Ali-Yrkkö 2001).

[35] Virme, M. (2001). Interview information from Markku Virme, Finnish Post, 08.08.2001.

[36] Average cost savings for companies from using an e-letter are estimated to be FIM 1.30 per letter in first class mail (Finnish Post 2001). Yearly, around 800million business letters coming from IT systems of companies are posted in Finland, such as letters related to invoicing, salaries, collection of charges (Virme 2001). Finnish Post has estimated the CO2 emissions for a traditional letter to be 34 g from sender to receiver. Emissions for e-letter have not been estimated but they are smaller because of shorter delivery distance of the physical letter.

[37] According to the same study, the use of SOLO, the Internet banking service of Nordea (former Merita), a large Finnish bank, saved 12.4 GWh energy in 2000, which roughly equals the yearly energy consumption of 600 electric heated one-family houses (Pesonen 2001). At the same time with electronic banking services development, an extensive restructuring of the bank sector has taken place in Finland, which both led to increased productivity of the sector. During the 1990s the amount of bank offices and personnel has diminished by 50% in Finland (Finnish Bankers Association 2001). Energy savings due to the reduced need for office space may be considerable. On the other hand, the longer distances to bank offices increase personal transport to banks and, hence, the associated energy consumption. Also the information infrastructure needed to run electronic banking services (PCs, servers, cables, etc.) both at homes, offices and banks contributes to total material and energy consumption.

[38] In the US, accumulated case evidence suggests that in the IT-producing industries the rate of increase in gross product originating, or value added, per worker (GPO/W) has been extraordinarily rapid in 1990-1997. However, in many IT-using industries, especially IT-using service industries (such as security and commodity brokers, legal services, health services), the measured GPO/W growth has declined despite massive IT investments (the so called "productivity paradox"). Those service industries making more intensive use of IT inputs appear to have had more modest results than other service industries. The US Department of Commerce report (Henry et al. 1999) discusses these findings in more detail as well as the difficulties in measuring the effect of ICT investments on productivity in the service industry.

[39] For a good review and more details on the subject, see http://enduse.lbl.gov/projects/infotech.html

[40] Energy efficiency gains are achieved by the application of a variety of energy saving measures (such as more energy-efficient lighting through sensors and control systems, or computer-controlled adjustable speed drives for motors) or by gains in total factor productivity (Romm et al. 1999).

[41] Chapter 1 of this report reviews the on-going discussion on eco-efficient services and the role of services in achieving dematerialization. There are different perceptions on how and what kind of services can provide environmental savings. Heiskanen and Jalas (2000) have reviewed the on-going discussion on eco-efficient services and identified in this context four different perspectives: non-material services, result-oriented services, product-based services and eco-design with a service approach.

[42] Brezet et al. (2000) discuss the mobile phone development as an example of this. Instead of automatically applying multifunctional and technically continuously more complex mobile-computer-telephones and the related advanced infrastructure as standard components, a streamlined, energy-efficient mobile phone with only the basic function of verbal communication as its core component would fulfil the needs of many mobile phone users.

[43] Electronic grocery shopping services, business travel and office services are examples of areas where ICT use can make operations more efficient and which hold potential for environmental improvements. These are analysed more closely in Chapters 6, 7 and 8 of this report.

[44] The distribution costs of an Internet based magazine, for example, do not essentially depend on the total volume of circulation; it can be distributed to 100 or 100000 households with nearly the same costs (Hetemäki 2000).
[45] The Internet allows customers to share information with each other. On the Amazon.com web site, readers can write book reviews for the benefit of prospective buyers, and buyers can use lists of other books purchased by readers of the same title (Cohen 1999).
[46] Another example are such products as small appliances run on computer chips. Consumers may be able to download software upgrades that make their appliances work more efficiently for a longer time. This may also enable producers to monitor a product's performance in order to improve its design and to provide re-sellers with information on how much a product was used.
[47] Such green comparison shopping search engines or sites do not exist yet for consumers, although at least one, www.GreenOrder.com is making strides in the business-to-business sector.
[48] One example of substitution effects is how electronic mail has reduced the volume of corporate letter correspondence. The voice mail services provided by operators and producers of professional digital telephone exchange equipment are making answering machines increasingly useless. A third example are banks, where paying bills electronically via the Internet has to some extent replaced the need to use physical money and reduced the need for personnel and facilities.
[49] For example, the car manufacturer, Ford, has predicted that the company can improve the management of its raw materials by 30% due to better demand and supply chain co-ordination by using electronic commerce practices. Currently raw materials are bought in pre-agreed amounts and depend on bulk production runs. A simple change in demand can cause a large overestimate in the demand for raw material, resulting in more waste. Internet-based electronic commerce practices make it possible to forecast demand more accurately, strengthen the links between firms in the supply chain and speed order processing (NYAS 2000). In the case of surplus products and materials, the Internet is a fairly new but active channel for companies to match supply better with demand. Examples of this development include last-minute free flight seats traded on the Internet or industrial secondary material markets that are based on Internet sites helping companies find buyers for materials they no longer need.
[50] Dell computers, for example, can now be assembled according to the customer's exact specifications, and car manufacturers are developing web sites that allow customers to specify the features they want in their cars. Levis jeans can be cut to the customer's personal measurements, and CDs can be made to order, with music tracks selected by the purchaser. Detergents can be customized according to the cleaning needs of particular workplaces or formulated based on the water quality of different regions. Pesticides can be customized according to the insect population of specific localities and they are delivered with site-specific instructions on when to apply them. Lawn care products that fit the nutritional needs of different growing environments have been developed, and cosmetics and personal hygiene products can be formulated to avoid a particular allergen or exposure to particular chemicals (e.g., Cohen 1999; Fishbein 2000).
[51] Whereas the company Amazon had 93.000 square feet of space when it began selling books in 1995, now it has 2.7 million square feet of facilities across the US (Fishbein 2000).
[52] The additional volume of delivered items generated by electronic commerce in Germany was estimated at 25 million articles in 1999 and 45 million in 2000 (Fichter 2000).
[53] Moving a package by air rather than by rail can increase the energy use by a factor of 30 (Fishbein 2000). It has been estimated that a next-day delivery for a single package in the US is thirty times less energy-efficient than delivering it by regular mail. Air-shipped next-day deliveries may be five times as fuel-inefficient as deliveries by trucks (NYAS 2000).
[54] In the US, commercial buildings consume more than 30% of total energy consumption and 60% of total electricity consumption (Cohen 1999).
[55] An estimate for the ratio of commercial building energy consumption per book sold in a traditional store versus an online store is 16 to 1 (Romm et al. 1999).
[56] The development of ICT may slow down the demand for current paper qualities but on the other hand it may lead to the development and adoption of new paper qualities, such as those suitable for digital printing. Hetemäki (2000) estimates that after 2005 electronic books may begin to replace traditional paper books, and electronic paper and ink may become more widely used.
[57] Borders, a major US bookstore chain, plans to establish print-on-demand centres in its stores. This would enable customers to print out-of-stock books in about 15 minutes. Borders will benefit from this by eliminating the need to stock less popular titles that take up shelf space and remain unsold for long periods of time (Fishbein 2000).

[58] It must be noted, though, that these technological developments do not reach everyone. Two-thirds of the world population still do not have access to basic telephony, either fixed or mobile, for economic reasons (Pestel and Johnston 2000).
[59] Here, the societal embedding of a technology means co-evolution of technology and society, i.e., a learning process occurs in which the technology is further developed, more applications are "discovered" and new meanings are attributed and articulated. It takes time to struggle out of the grip of the old meanings of technology.
[60] For example, LP-records, clock cards and typewriters are not dominant technology solutions anymore. On the other hand, the pace at which mobile phones have been adopted in Finland has been extremely rapid. In contrast, the pace at which the digital television seems to be replacing "normal" television is much slower than expected.
[61] This categorization is perhaps not the most analytically clear one in a substantive sense, but it illustrates the different ways in which services are conceptualized in the ongoing discussion. Thus, it is useful for understanding the expectations toward services in different constituencies, and illuminating the many different meaning that are used when speaking of eco-efficient or potentially dematerializing services.
[62] In this classification, it is difficult to place some traditional services, such as public transport or restaurants and catering. They may be viewed as non-material services, insofar as they do not directly replace products. However, they may also represent one form of results-oriented services, when, e.g. public transport is marketed as an alternative for private transport through a "mobility service".
[63] There are many examples of companies that have limited their eco-design efforts to improving existing design concepts, although more radical ideas have been identified in the design process. See, e.g. Roy (1999).
[64] A detail perhaps worth noting is that companies in the traditional service sectors are also at present significantly more backward in adoption environmental management efforts than manufacturing companies (Welford et al. 1998). Furthermore, Saltzman (2000) has noted that such sectors have not been subjected to environmental legislation, which would be difficult due to the non-point-source nature of their environmental impacts.
[65] For example, according to Nurmela (1996), services that consume below 0.1 GJ/100 marks include telecommunication services, restaurants, hotels, medical services, recreational services as well as cultural services and adult eduction.
[66] At present, approximately 200 car-sharing organizations operate in Europe, but only a few are large-scale commercial activities (Sperling et al. 1999; Sperling and Shaheen 2000).
[67] This assumption, however, overlooks other factors influencing product life, such as non-usage related wear (e.g., for cars, rust), and various forms of obsolescence (economic, psychological, infrastructural).
[68] The reduction per service unit is impressive, but the example may sound trivial. The authors believe, however, that there are dozens of household and garden products that can be pooled in a similar manner, and indicate that this could be organized through residential services (e.g., caretakers).
[69] This report also includes a number of other calculations on the contribution of services and resource-efficient solutions to the reduction of natural resource use in Finland.
[70] If one wants to try to find a more general mechanism here, the conservation of space could perhaps be viewed as an instantiation of the broader idea of a "lean economy" (e.g. Heiskanen and Jalas 2000), in which a shift toward services helps to minimize inventories and infrastructure (see also Hawken et al. 1999).
[71] Of course, it is impossible to prove that consumers or small-scale users are always, or even in general, incompetent, careless and unaware of costs. However, e.g., Kempton's (1985) US studies indicate that ordinary consumers do not know much about how their electrical appliances work, or how energy can be conserved. A recent Finnish study by Aalto (2000) indicates that Finnish consumers do not know the pH of their tap water and hence overdose detergents, and also actually fail to wash full loads although they report doing so.
[72] In Finland, only about 10% of all households own a tumble-dryer or a drying cabinet. On an average, owners use these appliances to dry half of the laundry in winter, and about one-fourth of the laundry in summer (Aalto 2000).
[73] These findings gain some support from a study on the environmental impacts of textile services in Finland and Sweden (Kalliala 1997). 40-45% of the energy used in the commercial laundering process was used for tumble-drying. The measured average energy consumption of three commercial laundries was 8,5 MJ/kg as compared with a household average of 2,5 MJ/kg. The figure for commercial laundries was, however, for hotel laundry washed at 70^0C (and includes 15-30% energy for ironing processes), whereas the figure for household laundry is probably based on lower average washing temperatures. Furthermore, there was considerable variation in the energy consumption between laundries. A further

point is that the commercial laundries use mostly primary fuels (e.g., fuel oil and natural gas), while household washing machines operate on electricity (thus implying losses in energy conversion). The study does not provide data on resource consumption for producing the washing equipment. However, it is noted that the commercial laundries used less washing chemicals (17 g/kg) than households on an average (28 g/kg).

[74] For example, Mäki (1999) has calculated that the replacement of all incandescent light-bulbs in Finland with fluorescent bulbs would reduce national energy consumption by 1.6%.

[75] Home deliveries by grocery retailers are evaluated in chapter 7 (Dematerialization potential of the electronic grocery trade).

[76] Restaurant meals are investigated in chapter 9 (A time-use perspective on the materials intensity of consumption)

[77] Facility management, hosted servers and ESCOs are investigated in chapter 8 (The emergence of new office servicesY).

[78] This is often presented as an example of leasing, although some authors report that the company has had difficulties in applying the leasing concept (Fishbein 2000; Ehrenfeld & Brezet 2001). Insofar as it works, the provision of modular carpeting, and replacement of worn carpeting tiles when needed, can be more readily conceptualized as a results-oriented service.

[79] Jackson (1996) and Schmidt-Bleek and Lehner (2000) view the shift toward services as a necessary reversal of the separation between manufacturers and consumers, which occurred at the onset of industrialization, leading to a productionist economy.

[80] For example, user-specific billing of heating costs has been suggested as energy saving measure - which means that energy costs are disaggregated from the “total service” provided by the landlord. This kind of shift B widely discussed but not much adopted in Finland - would be the opposite of a shift toward results-based services. However, the evidence in terms of energy conservation does not seem to clearly support this kind of de-servicizing, either (Melasniemi-Uutela 1996).

[81] One example of this is a service called myHome, launched by Unilever in the UK. It provides cleaning and laundry services to well-to-do consumers, and is viewed by commentators as an attempt to escape the intensive price competition of branded products by gaining a foothold in the high-margin home service business (see, e.g., Tomkins 2000).

[82] The service, developed as the outcome of an strategic, environment-oriented planning exercise, consists of rental of equipment, training of staff, supplies and maintenance to professional service providers (laundry, cleaning, etc.). While Electrolux provides this package as a service, the processes that it consists of appear very similar to the “services” are provided by large companies (e.g., catering chains) to their franchising agents.

[83] For example, paper users can improve the efficiency of paper use in the order of a factor 4 by reducing their originals to half the size and copying on both sides of the paper (four sheets on one), whereas gains of a similar order are not to be expected in paper manufacturing (Nord 1999).

[84] The fact that consumer behaviour is strongly influenced by market supply, advertising, the retail environment, infrastructure and cultural factors have been identified as problems in promoting more sustainable lifestyles. In spite of a high level of environmental consciousness in surveys, most consumers have been slow to change their lifestyles. Services are one way to influence consumption without relying on the environmental awareness and capability of private consumers. Eco-efficient services can be seen as an alternative (and competitor?) to the original, deep-green ideas about self-sufficiency and voluntary simplicity. The influence of services on consumer lifestyles is discussed in chapter 9.

[85] The eco-efficiency term has been brought to prominence by the World Business Council for Sustainable Development (WBCSD) as a way to describe sustainable development at the company level. According to WBCSD, eco-efficiency is reached by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing the ecological impacts and resource intensity throughout the life cycle, to a level at least in line with the earth’s carrying capacity (WBCSD 1996). This rather ambiguous definition has been operationalised by suggesting to measure eco-efficiency, for example, as the ratio of value added and environmental impacts.

[86] Hermann et al. (1989), Romm et al. (1999) and Kahilainen (2000) use dematerialization as the absolute reduction of materials use in specific products or in given applications. In the same vein, Farla and Blok (2000) define dematerialization as the absolute reduction of materials requirement per a unit of physical production at a level of a subsector of the economy, and Dobers and Wolff build scenarios of the dematerialization of value-chains. Hoffren et al. (2001) use the term as the intensity of materials use within a sector. Furthermore, Labys and Waddell (1989) and de Bruyn (2000) use dematerialization to refer to the lowering intensity of use of a single material at the level of the economy. Finally, Hinterberger and Luks (1998) and Cleveland and Ruth (1999) use dematerialization as the lowering of the materials

intensity of the whole economy. Dematerialization is thus an overarching term for the efficiency or intensity of materials use and is used in multiple meanings even by the same authors. However, to distinguish, dematerialization often refers to more limited phenomena than the delinking (or decoupling) of the economy and materials use in general. The notion of dematerialization also distances itself from the mere economic value of the output and addresses also physical outcomes such as products or services.

[87] Such an approach requires a definition of the activities that are considered to be related to the particular set of basic needs. Meijkamp (1998), for example, has included all activities of physical travel such as walking and bicycling, but not any communication activities such as the using telephones and the Internet.

[88] If the dimensions do not overlap, any change in the output/input relation is, in principle, possible. However, if they do overlap, it is not possible for one dimension to change in a two-factor model without a change in the other - for example, for the value-added to increase while the materials use would stay the same. In this sense, the common operationalisation of eco-efficiency as a relation of value-added and environmental impacts is less applicable, unless the environmental impacts refer to such environmental externalities that are outside the price mechanisms and are not included in the value-added.

[89] The vector $p = (p_{va}, p_m)$

[90] Chapter 3 considered the various mechanisms through which such services can bring about efficiency gains in product use. In this chapter these potential gains are not taken into consideration, and thus new service components are only considered in terms of the additional requirements for the factors of production.

[91] For E_P $(va)^2 + (m)^2 = (va_P)^2 + (m_P)^2$

For E_M $va = -1/(va_M/m_M)m + (va_P + m_P/(va_M/m_M))$

F or E_A $va = va_P$

In which P (va, me) is the initial product system with a given environmentally adjusted value-added (va) and materials costs (m) and M (va, m) is the materials intensity of the economy with respective aggregate figures.

[92] The notion of Weitzäcker et al. (1997) calls for a factor four improvement by doubling wealth and halving resource use. While this is most probably meant as a metaphor to point out the two dimensions of the discussion of materials intensity, it is interesting to note that such a metaphor calls for changes along a production function such as the one in figure 8.

[93] Goedkoop et al. build their analysis of car-sharing on the empirical documentation of mobility patterns by Meijkamp (1998). Their data on the value-added and the environmental impacts stems from a variety of other secondary sources.

[94] Also Goedkoop et al. note that the results should be analysed from different perspectives. According to them further conclusions require, for example, knowledge of how the money saved by car-sharing members will be used. The analysis of D_M in this work essentially assumes that the money is spend so that it does not change the structure of the economy (spread evenly among various consumption expenditure categories).

[95] In 1998, B-to-B transactions accounted for 84% of all Internet transactions in the USA (IPTS-ESTO 2000). No reliable statistics on the actual volume of B-to-C trade over the Internet are available.

[96] Perishables are the commodities with shortest shelf life (e.g., bread, vegetables, fruits, some dairy products, fish). Semi-perishables have longer shelf life (ready-made, processed food, frozen food, etc.) Non-perishables include canned and dried foodstuff and beverages. Non-food commodities include household products, cosmetics, magazines, tobacco, etc.

[97] Also terms such as virtual shopping, teleshopping and on-line shopping have been used to describe the process of buying products through electronic networks.

[98] About 80% of the grocery sales in Finland is controlled by the three largest grocery retail groups. This is the fourth highest figure in the European markets (Päivittäistavarakauppa 2000; AC Nielsen 1999).

[99] The market shares of different grocery trade groups were divided in 2000 as follows: K-group (37.6%), S-group (28.9%), Tradeka and Elanto (12.4%), Spar-group (9.1%), and others (12.0%). (Kehittyvä Kauppa 2001).

[100] Between 1985 and 1999, the amount of grocery shops in Finland has fallen from almost 8.500 to about 4.500 (Päivittäistavarakauppa 2000).

[101] Although there were not so many hypermarkets in Finland (only 95 in 1999), their market share is already as much as 21% (Raijas 2000b).

[102] These include, for example, R-kiosks, Neste Quick Shops, Shell Selects and Esso Snack & Shops.

[103] There were about 2.35 million households in Finland in 1999, and the average size of a household was 2.16 persons which is an European average (Nurmela et al. 2000). In 2010, 17% of the Finnish

population is over 65 years old, and in 2030, the amount is expected to be 26% (Statistics Finland 2000e).

[104] In Sweden, the corresponding figures are 7 million tons per year, and 700-800 kg per person (Orremo et al. 1999).

[105] According to a study on passenger transport in 1998-1999, the daily mileage of each Finn is on average 45 km, of which shopping trips make 6.2 kilometres and 13.8% (Ministry of Transport 1999a).

[106] The energy consumption related to the acquisition of groceries (including grocery production, transports to the stores and shopping trips) was estimated to be ca 14 % of total energy consumption of Finnish households in early 1990s (Heiskanen 1995).

[107] Almost 50% of the Finns aged 15-79 years have an access to Internet from home, work or from the place where they study, according to a market gallup (Suomen Gallup 1999). According to a more recent study by Statistics Finland, one third of Finns has on-line access possibility (Nurmela et al. 2000). In Europe, on average 12% of households are connected to the Internet which represents about 20% of the population with online access (e-Europe 2000).

[108] Among top ten on-line products that Finns buy are, e.g., books, music (CDs), computer accessories, clothing and software (Suomen Gallup 2001).

[109] 1% would mean the sales of about 100 million EUR, corresponding the yearly grocery sales volume of one large city in Finland. In Sweden, 0.8% of all daily household goods is purchased on the net, the estimate being 10-20% in the near future (Bratt and Persson 2001; Orremo et al. 1999). Retailers and suppliers in the grocery industry estimate that the market share of e-grocery will be between 5 and 10 % in Europe in 2005. In the US, the estimates for the online grocery market growth are more or less at the same level as in Europe. Forrester Research estimates that the market share of e-grocery in the USA will be 3.2% in the year 2004 (Punakivi 2000).

[110] In Sweden, there are about 60 e-grocery shops operating (Orremo et al. 1999).

[111] Also some other than the listed entrepreneurs exist on Internet selling organic food products and herbs.

[112] Map source: Ministry of Transport and Communications, http://www.mintc.fi/www/sivut/english/facilities/asuk1.htm

[113] In 2001, e-grocery shops that have closed down include PKO Kotiostopalvelu in Joensuu, which operated for several years as a small local experiment and lisinet in Lappeenranta which was merged with Ruokavarasto.

[114] In addition, the largest Finnish department store Stockmann provides home delivery service for food products but is not running an e-grocery shop.

[115] Interview information from Lohi Jari, S-Kanava Oy, 09.02.2001.

[116] Interview information from Rajala Niila and Haukka Timo, Kesko e-commerce unit, 13.02.2001.

[117] For example, K-group put 1.7 million EUR on developing its e-commerce activities in 1999. At the same time, 156 million EUR were invested in developing physical stores (Luotonen 2000). Currently, the development of EGS services for consumers is not the top priority in e-business development units of large grocery trade groups. E-business development is more focused on other product groups and customer segments such as business customers. In the grocery supply side, large grocery retail groups are actively joining international e-trade based purchasing networks.

[118] Interview information from Rajala Niila and Haukka Timo, Kesko e-commerce unit, 13.02.2001 and Lohi Jari, S-Kanava Oy, 09.02.2001.

[119] In the US study, data were collected from 243 consumers who bought groceries from one Internet shopping service operating in StLouis market area plus three other areas in Missouri.

[120] The average EGS basket was over 85 EUR. According to Raijas, reasons why the grocery shopping baskets are considerably larger in EGS include that the shopping frequency in traditional grocery shops is much higher and therefore, the shopping baskets are smaller. In addition, often grocery shopping for the weekend is made on-line, which is the time when shopping baskets are larger also in supermarkets. Furthermore, e-grocery shops deliver only shopping baskets over 17 EUR, and the acquisition of volume products or heavy items which people are not willing to carry themselves is concentrated on EGS (Raijas 2000a). In Sweden, the EGS baskets have been on average 119-142 EUR (Orremo et al. 1999).

[121] According to Peapod, the average time spent by its customers on grocery shopping on Internet is 37 minutes (Jaakkola and Kämäräinen 2000).

[122] Other alternatives were: (1) four new hypermarkets would be built outside the city and (2) existing hypermarkets would be shut down and replaced by 10 good quality local supermarkets at central places within densely populated areas. It was further assumed that in the EGS alternative, grocery transports to stores by the trade and industry would reduce by 25%. 17.000 shopping bags were delivered per

day. One delivery van took 30 bags in a day, an in average, 500 delivery vans were needed for home deliveries.

[123] The alternative of increasing more local supermarkets close to households would reduce the yearly car mileage used to grocery shopping most, by ca 25%.

[124] First home delivery model was based on delivery during same day, attended reception (customer at home), and there were 3 delivery time windows per day between 17-21 hours. The next two models were based on next day delivery, another with attended reception (1 hour delivery time between 12-21), another with an unattended reception box (between 8-18). Fourth model was a reception box, delivery once a week on a fixed customer chosen day (delivery between 8-18). The fourth one was seen as the most effective model from the e-grocer's point of view because orders could be sorted by postal code and divided evenly on all the delivery days. The simulation was done for orders from 1450 households from the Helsinki metropolitan area. Real grocery shopping basket data were used in the analysis. Orders were delivered from a single distribution centre to the households, located in a suburban area next to an existing store, which was one of the five stores from which the shopping basket and customer data was collected. The test area (135 km^2) covered partly the Helsinki metropolitan area. The total number of households in this area is about 89.000, and the number of inhabitants about 202.000.

[125] Goods traffic, purchase travelling, travelling to school and work as well as business and leisure time traffic were included in the concept of overall traffic.

[126] These models were: 1) from store to home, 2) from warehouse to home, 3) from warehouse to workplace, 4) from warehouse to a pick-up point and 5) from warehouse to a distribution point from which groceries are delivered within a geographically larger area. It was assumed that the average shopping basket was 3.5 larger than in traditional shopping, and that one delivery van took 25 orders per route. The delivery route was expected to be between 50 and 90 km.

[127] In other models, some emissions could increase, e.g., depending on the choice of the transport van type or geographical distances.

[128] At 10% home shopping the decrease in energy consumption was 5-7% that makes ca 0.2 TWh. At 25 and 50% home shopping the energy consumption reduced even more (with 50% home shopping energy savings were up to 25-35% which makes 0.8-1.1 TWh). When the route exceeded 185 km, the energy consumption for the delivery van was greater than that of traditional shopping.

[129] These intelligent refrigerator-freezers had a built-in control for minimizing the operational time and they were estimated to use less than half the energy-consumption than best available household fridge-freezers. The assumed fridge-freezers currently exist only as prototypes.

[130] The SimaPro software and IVAM database were used to perform the LCA analysis. Products were only considered on a weight basis (25 kg of goods) and assumed to be the same when buying traditionally or on Internet. Technical data and assumptions made for the LCA calculations are discussed in more detail in the report of Freire (1999).

[131] In the Netherlands, 47% of the population does their weekly shopping by car and the rest using other transports, mainly by bicycle (Freire 1999).

[132] The vehicle used for home deliveries was expected to be a 1 tonne van doing 10 deliveries per circuit, maximum circuit distance being 25 km. If the truck for home delivery was changed to a 16-tonne one, the environmental burden would decrease considerably, by 58%.

[133] This was because it was assumed that the distribution centre was located at a 27 km distance from the delivery circuit whereas the supermarket was located within the delivery circuit. Therefore, the distribution van drove considerably more kilometres and the required cooling period was longer for the delivered goods. Also the cooling unit of the refrigerated van (its weight and energy usage) contributed significantly to the total environmental impact of home delivery. However, the total environmental burden of the central distribution centre model was lower than in traditional supermarket shopping, if the distance from the distribution centre was reduced by half.

[134] This was simulated in the case of a simplified representation of a UK town Witney, which has a population of about 7.000. Real data about the shopping behaviour of residents was used in the analysis in combination with the simplified road network. It was assumed that a home delivery service would be provided by a central supermarket in town and that 1% of households who shopped there (distributed randomly) decided to use the home delivery service. Home delivery operated using vans which could each carry 8 loads of shopping. The simulations showed that the delivery van journeys only constituted 23% of the distance previously travelled by cars.

[135] Data in this section is mostly based on interviews with EGS service providers or persons who have been otherwise involved in developing these services. Altogether nine persons were interviewed during February and March 2001.

[136] Interview information from Sihvonen Harri and Malmström Jarmo, K-SupermarketYkköshalli, 14.02.2001.
[137] Home delivery orders are received via Internet orders, but also by e-mail from 100 households with elderly (a special arrangement between a home care company, the city of Helsinki and Ykköshalli) and by telephone or fax (about 50 orders weekly).
[138] In addition, reusable textile bags of 40 litres are used for the weekly 100 deliveries to households with elderly people.
[139]Interview information from Stenberg Jyri and Surma-Aho Timo, Ruoka.net, 08.02.2001.
[140] Since then, the operations in Turku and Oulu have been closed down.
[141] Kervinen (2000); Interview information from Tanskanen Kari, Yrjölä Hannu, Punakivi Mikko and Kämäräinen Vesa, Helsinki University of Technology, TAI Research Centre, 13.11.2000; Lohi Jari, S-Kanava Oy, 09.02.2001.
[142]Susiluoma, H. (2001). Interview information from Susiluoma Heikki, Ekoportti.fi, 09.04.2001; http://www.ekoportti.fi
[143] In the beginning, there were two other entrepreneurs selling food products via Luomupuoti (Osuuskunta Luomubotnia and ÄitiMaa).
[144] According to a Finnish study by Kasanen (1993), in the period of 1975-1990, the Finnish grocery wholesale units consumed about 16 - 18 toe energy. The majority of this was heat energy, the rest was electricity for lighting and equipment use. Also the energy consumption of grocery shops (sales and warehouse premises) has increased to 83 toe in year 1990. Less than half was heat energy, the rest electricity.
[145] One survey of over 3500 vehicles in 300 fleets revealed that the best vehicle fleets managed to travel almost double the distance of the worst vehicle fleets on a given amount of fuel (Cairns 1999).
[146] For example, the company Homeport in the UK provides such delivery boxes, see www.homeporthome.com/.
[147] An attempt in the same direction has been made in an EU project SusHouse (Strategies Towards the Sustainable Household), in which shopping, cooking and eating was one area in which experts from different stakeholder groups developed in workshops scenarios for sustainable shopping, cooking and eating for 2050 based on a Factor 20 reduction in associated environmental impacts. The aim was an interactive construction and assessment of sustainable normative scenarios in five European countries. One of the developed scenarios was called Virtual Shopping (Young et al. 2000). It produced, to some extent, similar expectations of future developments as this expert survey.
[148] A considerable part of this chapter is based the paper of Fadeeva, Halme and Arnfalk (2001) presented at the Ninth International Greening of Industry Network Conference SUSTAINABILITY AT THE MILLENIUM: Globalization, Competitiveness, & the Public Trust, Bangkok, Thailand, January 21-25, 2001.
[149] Business Strategy and the Environment, Sustainable Development, Eco-Management and Auditing and European Environment, 1998-2000.
[150] We would like to thank a master's student, Saija Sandström, at Helsinki School of Economics who conducted the interviews.
[151] In five out of the ten Finnish corporations that we interviewed for this study, travel costs formed the third or fourth highest cost item.
[152] This information is based upon the lecture of Herman Mensink, the director of Europe, Middle East & Africa at ACTE (Association of Corporate Travel Executives, http://www.acte.org) at Erasmus University, Rotterdam in the fall 1999. The origin of information is American Express Corporate Services and published under the titles: Global T&E Expense management survey, European Corporate Travel Index and American Corporate Travel Index.
[153] Salaries, IT-expenses (and marketing costs at one company) were higher costs.
[154] For instance the insurance company Teollisuusvakuutus in Finland lists distance work, car pooling, favouring public transport, and tele- and videoconferencing in its environmental programme.
[155] Knowledge can be codified if it can be recorded in the form of symbols (e.g. writing or drawing) or embodied in a tangible form (e.g. machinery or tools). Tacit knowledge is non-codified knowledge, encompassing skills or crafts. It also involves the cognitive dimension consisting of mental models and beliefs that cannot be translated into an explicit form (Nonaka 1994). Often even knowledge that we consider explicit contains tacit elements that make it more difficult for the information recipient to interpret the way the information transmitter expects. (Roberts 2000).
[156]This is an estimate based on occupational statistics (Statistics Finland 2001c), assuming that occupations represented by the classifications 0-09, 15,17,18,20-29 and 30-33 consist of people mainly working in offices.

[157] In Finland, office buildings consume about one-fifth of the heating energy (about 3200 GWh) and a similar share of the electricity (about 1400 GWh) consumed by the service sector (Motiva 2000a). According to a Dutch study reported in van den Hoed (1997), heating, lighting, paper use and business travel and commuting are the most energy-consuming functions in offices.
[158] This figure is estimated on the basis of Nissinen (1993), environmental reviews conducted by students at the Helsinki School of Economics during 1997-2000 in different organizations, as well as data from the Helsinki Metropolitan Area Waste Management Facility.
[159] In addition, company Internet sites and the business press were consulted, and experts in the field were interviewed (e.g., co-ordinators of national development projects). Data were also collected in connection with workshops held for waste counsellors and purchasing managers.
[160] I.e., companies that use at least some of the services investigated.
[161] This section is based on interviews with/e-mail questionnaires to 7 furniture manufacturers or dealers, four of the largest international computer manufacturers operating in Finland, two IT-service providers and the Finnish units of two copying machine manufacturers. The websites of these and other companies operating in the business were also referenced, and a few financial services companies were contacted to complement the data provided on their websites.
[162] For companies that have a considerable stock of inventory in any case (e.g., industrial companies), the benefits of being able to adjust the depreciation period in their book-keeping outweigh the benefits of leasing, making purchasing the preferable option.
[163] Fishbein (2000) emphasizes the difference between financial and operating leases. In the US, a financial lease means that the lessor automatically gains ownership of the product after the lease term (as in hire-purchase). The distinction is not as clear in Finland (see Taloustieto 1995): a financial lease here means that financial service companies purchase a product, and rent it to their customers on a long-term (e.g., 36 months) basis. Operating leases in Finland mean leases provided by manufacturers or dealers. Apart from this distinction, the possibilities to purchase the products after the lease term vary: sometimes this option is not available at all, sometimes products can be purchased for a nominal price, in which case the lease is similar to a hire-purchase contract.
[164] Making use of cash discounts and avoiding penal interest.
[165] For instance, Helsinki School of Economics participates in a pilot project of electronic invoicing. HSE files 12.000 invoices annually and it is required by law to keep the archives for six years. Compared to the previous situation, invoices of one year will only take one CD-ROM worth of space in the new system. In addition, the different departments and units of HSE no longer will have to take their own copies invoices, because responsible persons within departments and units will have code that entitles them to access the electronic archives.
[166] This section is based on interviews with representatives of two facility management companies (YIT Rapido and ABB Facility Management), one business park manager (Spektri), one office hotel manager (Petrasol) as well as one expert from the trade association of the construction industry (Rakli). Furthermore, the business press, ongoing public development projects (e.g., Rakli, Tekes) and company websites were extensively referenced.
[167] E.g., a study by the energy counselling centre Motiva indicates that even in new buildings, with advanced technology to conserve energy, the technology is not used properly due to the incompetence of staff. Some of the equipment may even be installed, but never turned on due to confusion in responsibilities between the different parties (installers, maintenance companies, users) involved (Heikkonen 2000).
[168] This increased interest is visible in, e.g., the recent future vision paper of the construction industry (see Rakli 2001) as well as in recent Tekes projects such as Rembrand (Real Estate Management Branding, see Rembrand 2001).
[169] One example is the oldest Finnish business park, Spektri in Espoo, developed by Puolimatka/NCC in the mid-1980s. The individual buildings that it is made up of are owned by different investors. Provisions have been made for changing customer requirements by the design of adjustable space (walls and connections can be shifted). One "outsourced" property manager from ABB manages the entire property, and is fully accountable to the owners. As it has been in operation for a number of years, it provides some indication of how well such a concept works in Finland. According to the manager, energy costs are monitored very closely, and specialist competence has been applied to optimize energy use.
[170] According to a renet survey, 37% of Finnish municipalities had included waste counselling in their contracts with waste management operators (Kuntaliitto 2000). Most, but not all, are owned by the municipalities or regional co-operative organizations. It is not known how extensively waste counselling focuses on offices. In 1998, about 10% of the municipalities organized waste counselling for companies in the area (Kuntaliitto 1999), but this has probably grown since then.

[171] See Finnish Environmental Institute, http://www.vyh.fi/tutkimus/eu/matnep/matnep.htm
[172] E.g. cleaning from a cleaning firm, maintenance from a maintenance firm.
[173] E.g. lobby service, copying service, document management, facility maintenance, IT-support
[174] A reduction in 10 kilos of paper conserves about 500 MJ of energy in paper production (Nissinen 1993), but if these papers are filed for 10 years, one can estimate that they expend at least 670 MJ of energy in office space heating (assuming an archive density of about 100 kgs of paper/m2, and a specific energy consumption of 670 MJ/m^2, on the basis of VTT (1998b) and Motiva 2000a)
[175] These figures came up in our interviews pertaining to individual companies: the first was brought up as the reason why energy costs are significant in a property management contract, while the other was the reason why energy costs are not relevant for a consultancy and accountancy firm. However, the share of energy costs in facility operation is in line with national statistics (e.g. VTT 1998b).
[176] Specialist knowledge could also in principle be used to reduce the energy consumption of equipment and paper usage through improved systems configuration.Today, such aspects are not dealt with in these contracts, so they are not at the focus of attention.
[177] Unfortunately, the companies interviewed had no data available on what this means in terms of energy consumption per service unit, e.g., does placing a large number of large servers centrally increase the need for cooling ventilation when compared with placing small servers so dispersedly that the can utilize free air cooling..
[178] For example, the "total cost of ownership" charts that the service providers publish usually consist of about 40% hardware and software costs, and more than 60% use-related costs, such as user operations, downtime, administration and operations. Energy costs do not feature as a seperate cost category.
[179] Examples such as e-mail and the Internet indicate that new technologies change the way we work, and although they improve efficiency, they also have also had unanticipated consequences, such as increased paper use. Similar concerns may be raised in connection with the new services discussed here. For example, well-run services may encourage unnecessary use. Leasing services may stimulate customers to acquire new products (e.g., impressive furniture) even if the old ones are serviceable. Thus, the eco-efficiency of the new services should also be evaluated in natural settings, in which potential changes in customer behaviour and office work can also be taken into account.
[180] US-based companies do appear to have some extent of remanufacturing activity especially in the States (e.g. Fishbein et al. 2000), which may be due to the more extensive share of leasing there. Some also have remanufacturing plants in Europe, but the practices appear to vary by geographic area.
[181] The programme includes other targets as well. The aim is to reduce specific energy consumption by 10% by the year 2010, and have 80% of the building area audited and continually monitored for energy consumption by the year 2005. By May 2001, organizations accounting for more than 65% of the commercial building space in Finland had signed the agreement. For more details, see http://www.rakli.fi/kehitys/KRESS/index.htm
[182] Here, also, the social aspects of these developments are worth investigating. Will the large companies push the small operators out of the business, and what does this mean in terms of employment and income distribution? How do employees experience outsourcing: do they loose their jobs and their benefits (as employee representatives often see the issue) or can they gain more challenging and upwardly mobile tasks in companies specializing in their field of expertise (as managers often claim)?
[183] This includes the minor contribution of private non-profit organizations.
[184] The assumption that heating energy is not dependent on short time activities enables the comparison of indoor and outdoor activities without any consideration of heating. The tasks relating to washing do not include detergents, but the detergents only stand for a small share of the total energy demand of washing clothes.
[185] Nurmela (1996:148) gives the total electricity demand and its distribution within household activities. The factor for primary energy demand of electricity production 1,91 has been calculated from Mäenpää (1998: 32).
[186] The indirect energy consumption is the product of consumer expenditure and the energy intensity of the manufacturing sector.
[187] The data do not originate from the same households. Therefore the data on men and women living in two-person households are combined to form meta-data of the time use of a two-person households. There were 2255 diary days of men (base 708825) and 2150 days of women (base 634184) from two-person households. (Statistics Finland, 1991, tables C3.A (men) and C.3B (women)).
[188] An estimate of 1 kW vacuum cleaner being used for 15% of the time
[189] An aggregate figure for rows from Cooking to Vehicles.

[190] Water supposed to be warmed by a dishwasher, no additional energy for using pre-warmed water is taken into account.
[191] Nurmela (1993: 19-21) the energy content of the foodstuff of a two-person household
[192] 0,78 kWh/km in city traffic (Mäntylä and Alppivuori, 1996). Own estimate of 30km/h average speed.
[193] The expenditure figure does not include drinks, and the time-use figure excludes time in bars and discos.
[194] Heating warm water is not taken into account
[195] The average total final energy consumption of a two person Finnish household excluding domestic heating and lighting.

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Documentation page

Publisher	Ministry of the Environment	Date November 2001
Author(s)	Eva Heiskanen, Minna Halme, Mikko Jalas, Anna Kärnä, Raimo Lovio	
Title of publication	Dematerialization: The Potential of ICT and Services	
Parts of publication/ other project publications		
Abstract	The project relates to the topical discussion on eco-efficiency and the replacement of products with services or solutions. The aim has been to overview the potential of services and information and communication technology (ICT) to reduce natural resource use and materials-intensity in the Finnish economy. The emphasis has been on service or ICT innovations that could potentially increase the efficiency of product use or replace activities that consume significant amounts of natural resources (e.g., rental, shared use, outsourcing, e-business, videoconferencing). Issues explored include the reduction of the materials and energy intensity of the national economy (statistical analyses and reviews), the potential of ICT and service innovations (literature reviews) as well as the adoption processes and consequences of new innovations (case studies, expert Delphi study). In addition, modelling is used to explore the connections between microeconomic phenomena, such as eco-efficient services, and the national economy. The potential rebound-effects of services are investigated using a novel approach exploring their impacts on consumer time-use and lifestyles (statistical data). The four main conclusions are as follows. (1) Services and ICT help to reduce the natural resource dependency of the economy, but it is unlikely that they will automatically lead to significant reductions in total natural resource use. (2) ICT and services do, however, have three important roles in reducing natural resource use: they can increase the efficiency of individual processes, they can alter the structure of value chains (helping to direct efficiency improvements closer to the consumption stage), and some services can provide an avenue for less materials-intensive growth. (3) Services and ICT are thus necessary, but not sufficient, means to reduce natural resource use while maintaining economic growth. (4) The market for service and ICT innovations is so new that the final impacts on natural resource use cannot be evaluated. Yet this early stage also provides the opportunity to influence the course of events, e.g., by integrating environmental concerns into early stages in service and technology development.	
Keywords	materials, energy, economy, dematerialization, services, information, technology	
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Kuvailulehti

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Tekijä(t)	Eva Heiskanen, Minna Halme, Mikko Jalas, Anna Kärnä, Raimo Lovio	
Julkaisun nimi	Dematerialization: The Potential of ICT and Services Dematerialisaatio: tieto- ja viestintäteknologian ja palvelujen mahdollisuudet	
Julkaisun osat/ muut saman projektin tuottamat julkaisut		
Tiivistelmä	Tutkimuskokonaisuus liittyy ajankohtaiseen keskusteluun ekotehokkuudesta ja tuotteiden korvaamisesta palveluilla tai ratkaisuilla. Tavoitteena on ollut kartoittaa palvelujen sekä tieto- ja viestintäteknologian (ICT) mahdollisuuksia vähentää luonnonvarojen kulutusta ja talouden materiaali-intensiteettiä Suomessa. Erityisenä mielenkiinnon kohteena ovat olleet palvelu- tai ICT-innovaatiot, joiden uskotaan voivan tehostaa tuotteiden käyttöä tai korvata luonnonvaroja kuluttavia prosesseja (esim. vuokraus, yhteiskäyttö, toimintojen ulkoistus, elektroninen kauppa, videoneuvottelut). Tarkasteltavia aiheita ovat mm. kansantalouden materiaali- ja energiariippuvuuden vähentäminen (tilastokatsauksia), uusien ICT- ja palveluinnovaatioiden mahdollisuudet (kirjallisuuskatsauksia) sekä uusien innovaatioiden omaksuminen ja sen vaikutukset (case-tutkimuksia, asiantuntija-Delphi). Lisäksi mallinnetaan mikrotalouden ilmiöiden, kuten ekotehokkaiden palvelujen, yhteyksiä makrotalouteen. Palvelujen mahdollisia "rebound-vaikutuksia" tarkastellaan uudenlaisella tavalla kuluttajien ajankäytön ja elämäntapakysymysten näkökulmasta (tilastoaineisto). Tutkimuksen neljä tärkeintä johtopäätöstä ovat seuraavat. (1) Palvelut ja ICT vähentävät talouden luonnonvarariippuvuutta, mutta ne eivät todennäköisesti tule automaattisesti vähentämään luonnonvarojen kokonaiskulutusta. (2) ICT:llä ja palveluilla on kuitenkin kolme tärkeää roolia luonnonvarojen kokonaiskulutuksen vähentämisessä: niillä voidaan tehostaa yksittäisiä prosesseja, ne muuttavat arvoketjujen rakennetta (tehostamistoimia voidaan kohdistaa lähemmäksi kulutusta) ja jotkut palvelut tarjoavat väylän vähän luonnonvaroja kuluttavalle talouskasvulle. (3) Palvelut ja ICT ovat siis välttämättömiä, mutta eivät riittäviä, keinoja luonnonvarojen kulutuksen vähentämiselle, jos talouskasvusta ei haluta tinkiä. (4) Uusi palveluihin ja ICT:n perustuva liiketoiminta on niin alkuvaiheessa, että lopullisia vaikutuksia on mahdotonta arvioida. Varhaisvaihe tarjoaa kuitenkin myös mahdollisuuksia vaikuttaa kehityksen kulkuun mm. tuomalla ympäristönäkökulmia mukaan palvelujen ja uusien ratkaisujen kehitystyöhön.	
Asiasanat	materiaalit, energia, talous, dematerialisaatio, palvelut, tietotekniikka	
Julkaisusarjan nimi	Suomen ympäristö 533	
Julkaisun teema	Ympäristönsuojelu	
Projektihankkeen nimi ja projektinumero		
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Presentationsblad

Utgivare	Miljöministeriet	Datum November 2001
Författare	Eva Heiskanen, Minna Halme, Mikko Jalas, Anna Kärnä, Raimo Lovio	
Publikationens titel	Dematerialization: The Potential of ICT and Services Dematerialisation: möjligheterna av infårmations- och kommunikationsteknologi och service	
Publikationens delar/ andra publikationer inom samma projekt		
Sammandrag	Undersökningshelheten anknyter sig till den aktuella debatten om ekoeffektivitet och ersättning av produkter med service eller lösningar. Målsättningen har varit, att kartlägga servicens, samt kommunikations- och informationsteknologins (ICT) möjligheter att minska förbrukningen av naturtillgångarna och ekonomins materialintensitet i Finland. Föremål för särskilt intresse har varit service- eller ICT-innovationerna, som man tror kunna rationalisera förbrukningen av produkter eller ersätta processer som sliter på naturtillgångarna (t.ex. arrendering, kollektiv disposition, lägga ut verksamheten på entreprenad, elektronisk handel, videokonferenser). Ämnen som granskas är bl.a. minskandet av nationalekonomins material- och energi-beroende (statistiköversikter), de nya ICT- och serviceinnovationernas möjligheter (litteraturöversikter), samt att tillägna sig nya innovationer och deras verkan (case-studies, expert-Delphi). Ytterligare gör man upp modeller för mikroekonomiska fenomen ss. den ekoeffektiva servicens anknytning till makroekonomin. Möjliga 'rebound-effekter' som servicer kan framkalla granskas genom att undersöka deras verkningar på konsumenternas tidsanvändning och livsstil (statistikundersökning). Undersökningens fyra viktigaste slutsatser är följande. (1) Servicen och ICT minskar ekonomins beroende av naturtillgångarna, men det kommer högst sannolikt inte att automatiskt minska på helhetsförbrukningen av naturtillgångarna. (2) ICT och servicen spelar dock tre viktiga roller i minskandet av naturtillgångarnas helhetsförbrukning: med dem kan man effektivera enskilda processer, de förändrar värdekedjornas struktur (rationaliseringsåtgärder kan fokuseras närmare konsumtionen) och en del av servicen erbjuder en passage till en tillväxt som mindre sliter på naturtillgångarna. (3) Således är servicen och ICT nödvändiga, men inte tillräckliga åtgärder för att minska exploateringen av naturtillgångarna, såvitt man inte vill pruta på ekonomins tillväxt. (4) Den nya affärsverksamheten som grundar sig på service och ICT är ännu så i sitt begynnelseskede, att slutgiltiga verkningar är omöjligt att evaluera. Förstadiet erbjuder dock även möjligheter att påverka utvecklingens gång, bl.a. genom att införa miljöaspekter i utvecklingsarbetet av servicen och de nya lösningarna.	
Nyckelord	material, energi, ekonomi, dematerialisation, service, tjänster, informations teknologi	
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