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The future impact of ICT on environmental sustainability

Second Interim Report

"Script"

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EXECUTIVE SUMMARY

In the script the following ten key trends in ICT with low uncertainty have been identified:

1. Moore's law continues for 10-15 years
2. Increasing context sensitivity
3. Wireless and mobile networks spread and converge
4. Widespread broadband access
5. Embedded computing and extension of networks into daily appliances
6. Growth of ICT markets
7. Ongoing built-up of ICT infrastructure
8. Parallel development of licensed and free software
9. Improved reliability of authentification systems
10. Improvement of existing ICT services and new location based services

The scope of the investigation covers the following 10 fields and 7 indicators:

	freight transport volume	**passenger transport volume**	**modal split**	**energy consumption**	**Share of renewables**	**GHG emissions**	**Daily waste**
First order							
ICT industry				x(i)			
ICT use				x(d, t)			x(d, t)
Second and third order							
E-business	x	x		x(i, t)			x(d, t)
Telework and virtual meetings		x		x(d, t)			
Virtual goods							x(d, t)
Waste management							x(d, t)
Intelligent transport systems	x	x	x				
Energy supply				x(d, t, i)	x	x	
Facility management				x(d, t)			
Production process management				x(d,t)			

d: domestic, i: industry, t: tertiary

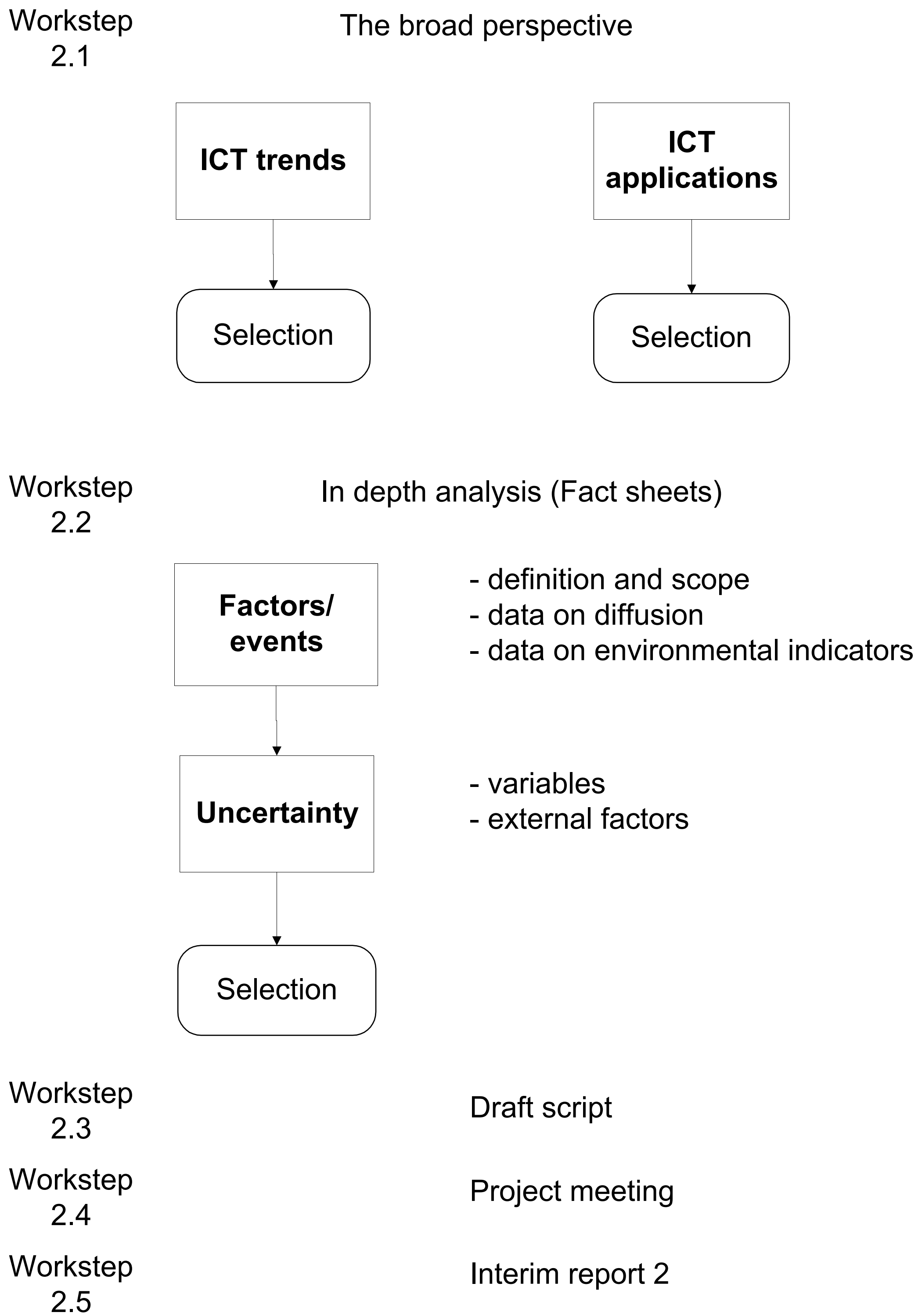
For each of the 10 fields a fact sheet of the following structure has been prepared:

- definition and scope
- data on diffusion
- data on environmental indicators
- variables
- external factors

These fact sheets, exploring important factors and uncertainties are the basis for the scenario-building and modelling and also contain information in which areas policy can steer towards environmental sustainability.

PREFACE

The aim of task 2 is to lay the entire data basis for the project. The following figure shows the worksteps of the call for tender and how they are considered in the script:



Workstep 2.1:
The aim of workstep 2.1 is to give a broad perspective of the future trends and developments of ICT. On the one hand technological and economic developments in the ICT sector have been identified, on the other hand a synopsis of ICT-applications relevant to the environmental indicators has been compiled.
The technological and economic developments in the ICT sector (chapter 2) have been analysed by evaluating existing studies on the future course of ICT. Main data sources are IPTS Technology maps and material of the eEurope 2002 and eEurope 2005 initiatives. Six main areas mainly addressed in these reports are investigated: microelectronics, new functions, networks, ICT devices and infrastructure, software and knowledge management and, finally, services and applications. ICT trends and developments in these areas have been analysed by estimating the expected time horizons and giving a rationale for the uncertainty.
Ten key trends with low uncertainty have been selected. In order to give one of several inputs for the scenario building additionally other key factors/events for the development of ICT were identified in a brainstorming in an in-house workshop at IZT. They have been classified by their estimated probability and impact on diffusion of ICT.
A broad overview of ICT-applications discussed in scientific literature with regard to their environmental impact is given in the synopsis (chapter 3). Based upon the principal sustainability strategies and the chosen sector/indicator-combinations (1st interim report) the ICT-applications have been clustered into the following fields: virtual goods, virtual mobility, e-business, intelligent transport systems, energy demand, energy supply and waste management. The principal second order effects of these strategies on the environmental indicators have been assessed to identify key interactions of ICT-applications and the indicators. The same has been carried out for the first order effects of ICT industry and ICT use. Third order effects are dealt with in the in-depth analysis (Workstep 2.2). Main data sources evaluated include two studies carried out for the European Union: The “Atlas-Project” (ATLAS 1997) and “Telematic applications for sustainable energy management” (IZT, ETSU 1999). Furthermore various studies prepared by the project partners and other research institutions were analysed to close data gaps. The potential effects on the environmental indicators are screened. A selection for the in-depth analysis was carried out by a semi-quantitative assessment of the impact on the environmental indicators. Additionally the quality of data is characterised briefly to give an impression in which fields the data basis is still insufficient. This has to be taken into account for political action. The selected ICT-applications are analysed in detail in workstep 2.2.

Workstep 2.2:
Workstep 2.2 contains an in-depth analysis of factors and events. In each of the fact sheets derived from workstep 2.1 a scope of the areas investigated is defined. Then data on diffusion of the ICT-applications and the factors/events that influence their uptake in the EU have been gathered and structured. Data for main environmental effects identified in workstep 2.1 have been compiled from many different single studies and analysed. For both the diffusion of the ICT-applications and environmental effects most relevant variables have been extracted. The degree of uncertainty has been estimated for each of the variables. Furthermore the relation of external factors to variables is assessed and explained in the form of a rationale. The selection is preliminary, as Forum for the Future will add and drop some additional variables for building the scenarios.

Workstep 2.3:
Data from 2.1 and 2.2 have been condensed into a draft script.

Workstep 2.4:
A discussion of the draft script has taken place on 22 April 2003 in Barcelona.

Workstep 2.5:
The 2nd interim report documents the data basis for project, results of workstep 2.4 and additional comprehensive comments by IPTS on the draft script.

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1 INTRODUCTION

The main goal of the project is to identify corridors of the influence of ICT on the environmental indicators. The study has an explorative character as there are no quantitative studies for the EU yet. Geographical coverage is EU15 plus Accession Countries. The time horizon is 2020.

In task 1 sector/indicator-combinations which are expected to be most sensitive to ICT have been selected. The selected sector/indicator-combinations of the first interim report are compiled below:

Table 1-1: Sector-indicator combinations from 1st interim report

	GHG	Energy/ GDP	Transport/ GDP	Modal split	Urban Air Quality	Municipal waste	Share of Renewables
Transport	+	?	xxx	?	+		
Industry	+	xxx			+	xxx	
Domestic		xxx				xxx	
Agriculture		+			+		
Energy industry	xxx				+		
Tertiary		xxx				xxx	

xxx: chosen sector/indicator-combination, + high impact, but not chosen, ? choice to be discussed

The in-depth analysis of intelligent transport systems (chapter 5.7) has led to the choice of the modal split as additional transport indicator. Energy consumption will be derived from transport volume and modal split by using typical energy demand coefficients. The in-depth analysis of the energy industry (supply) has also led to the choice of the indicator share of renewables.

Task 2 shall lay the entire data basis for the project: scenario-building (task 3), modelling (task 4) and policy recommendations (task 5).

A further selection of key trends, applications and the analysis of variables and factors is necessary to give a coherent and consistent picture of the future impact of ICT on the environmental indicators. Many studies have been written on the environmental impact of ICT. The primary focus is on the principal studies discussed among scientists and own research. Furthermore relevant reports for/of the European Union are included.

In chapter 2 the **methodological framework** is described. A main distinction between variables and factors is made.

Extensive research has been carried out about **technological and economic developments** of ICT, which are dealt with in chapter 3. Based upon Technology maps published by IPTS and material of the eEurope initiative the uncertainties of single future developments until 2020 have been assessed in the form of a brief rationale. 10 key trends with low uncertainty and high impact have been extracted. In contrast, other ICT future courses which might slow down or accelerate the uptake of ICT have been identified in a brainstorming at IZT and classified according to their estimated probability. The chapter serves as an input for the assessment of the variables in chapter 5 and for the scenarios (task 3).

The **synopsis of ICT-applications** (chapter 4) has been shaped according to basic sustainability strategies to minimise redundancies. The pool of applications screened in the 1st interim report has been extended by a study for the European Commission on telematic applications (IZT, ETSU 1999), energy supply and demand (ATLAS 1997), Romm et al. (1999), studies on e-business (IZT, SFZ, Borderstep 2001; IZT, Borderstep 2002) and various other smaller sources. Followed by a brief description of the application the effects on the environmental indicators are assessed, reflecting the studies cited above. Additionally the quality of data has been characterised roughly. The selection of the most relevant applications has led to a more precise definition of areas to be analysed in detail.

Chapter 5 contains the **in-depth analysis for the selected ICT-applications**. Data for diffusion on the EU-level is gathered if possible, whereas the environmental effects mostly refer to single case studies. The identification of variables and factors which are decisive for the uptake of the ICT-applications and the environmental effects is based upon the analysis of the data, the trends in selected fields of ICT (chapter 3) as well as the socio-economic context (chapter 2.2).

The script will be the basis for the development of the scenarios and the modelling. Some policy options have also been identified. Intensive co-operation in the scenario-building and modelling tasks is necessary. The data basis will be further refined in the project process.

2 METHODOLOGICAL FRAMEWORK

The aim of the methodological framework is to determine principal variables which are investigated and external factors, which affect the variables. Furthermore the environmental effects have to be structured to refine the complex system in such a manner that scenarios can be built, quantitative effects modelled and policy recommendations drawn.

The scenario building and modelling of the future impact of ICT on environmental sustainability requires some basic thoughts about the system boundaries. There are baseline scenarios for household waste generation (ETSO 2003), transport (CEMT/CM(2001)4) and energy consumption (NTUA 1999) in the EU until 2020. To assess the impact of ICT on baseline projections factors and variables have to be defined. For the purpose of this project factors and variables are defined as follows:

- **Factors** are over-arching and define the scenarios (e.g. demographic change)
- **Variables** are smaller scale and can be quantified or qualified (e.g. households broadband access). They are the same within each scenario, but change in different ways according to factors.

The future impact of ICT on the environmental indicators depends on the innovation and diffusion of ICT and on the specific environmental effects.

Innovation and diffusion of ICT take place in a socio-economic context. The innovation and diffusion of ICT will be conceived as variables, whereas the socio-economic context is treated as a factor, which is in compliance with the long-term scenarios for household waste, transport and energy mentioned above.

The effects of ICT on the environment can be broken down as growth, structural and technology effects. Another approach is to describe the environmental effects by first, second and third order. As the data and empirical evidence for the first approach are poor (Digital Europe 2003) the second methodology is chosen.

Attention has to be drawn to the external factors and the variables which determine the uptake of ICT for the assessment of the future trends and developments of the ICT sector in chapter 3, the in-depth analysis in chapter 5 and especially the estimation of the diffusion velocity of ICT in task 4.

2.1 Innovation and diffusion of ICT

The main aim of this subchapter is to give an overview on how innovation and diffusion of ICT are influenced and embedded in the socio-economic context. These aspects have to be considered when data from other studies are evaluated, especially technology maps (chapter 3) and the uptake of ICT-applications (chapter 5).

Innovation can be conceived as a dynamic process with the stages sensitisation, invention, selection/acceptance and realisation.

- This simplified system takes place in a socio-economic environment that is influenced by current and future market expectations, culture and policy frameworks. The company itself has a certain economic performance, culture and policy. The ICT bubble of 2001 collapsed because overestimated future market expectations were revised.
- Creative heads try to invent the future. The innovation process can take place within a company or within networks. ICT encourages innovation networks. Computer aided design and modelling are state-of-the-art tools.
- There is a bulk of ICT inventions that will never be realised. They may not fit into the companies strategy or cost-/benefit analysis leads to a negative decision.
- Once the invention is accepted, further human resources, financial and technological capital are invested to push the invention towards market maturity. The development of both software and hardware often requires tremendous efforts.

Innovation cycles of ICT have become shorter and shorter. The use of ICT has accelerated the innovation cycles of other products and services respectively. The innovations range from incremental (e.g. process optimisation, product design) to break-through innovations (e.g. new system solutions). The question how the innovation processes can be steered towards sustainability is investigated in current research (SUMMER 2002). First assessments indicate that the innovation process with open results is in conflict with the normative “hindering” concept of sustainability.

Diffusion of ICT has been overestimated by many experts in the last years. Examples include e-learning and telework. Will e-commerce be the next one? A paper from Lennstrand (1998) from Stockholm University investigates eight key factors that can cause such a misjudgement:

1. Supply versus demand perspective

In diffusion estimations often the supply side of technology development is not coupled with consumers needs and behaviour. Many ICT-applications destined to conquer big markets stay niche applications.

2. Technological optimism

Management culture tends to stress the positive and to ignore the negative aspects of new technologies. The past is stereotyped, the present is challenging and the future will be bright.

3. Technological performance characteristics

Moore’s law describes an exponential increase in chip performance over time. Very often it is neglected that this is not necessarily combined with any important demand-side benefits.

4. Market inquiries and research

Most of the market inquiries on ICT are commissioned by players who have significant economic interest in a positive sketch of the future of ICT (e.g. primary data in Romm et al 1999 and ABARE 2001).

5. Diffusion models

Most common diffusion models (Rogers, Bass) assume that diffusion mainly depends on communication and follows an S-curve. However, with regard to ICT, four assumptions of these models may lead to wrong prognosis:

(a) Diffusion of an innovation is independent of all other innovations
(b) Nature of an innovation does not change over time
(c) Diffusion of an innovation is not influenced by marketing strategies
(d) There is only one single adoption by each unit

How these assumptions do not apply to reality has been shown for the household possession of computers[1], the diffusion of the internet[2] and mobile phones[3].

6. The human bias towards optimism

There are hints that many people tend to adopt new technologies in order to express modernity. This can lead to the misinterpretation that technical development is a self-generating process which cannot be steered.

7. Technological development

The rapid development of new technologies can be an obstacle for the creation of applications, because it is difficult to consolidate the knowledge, while the technological context changes rapidly.

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[1] Growth rates for multimedia computers vary considerably by the assumptions what will happen to the old computers in households (d). Computer sales increased substantially in Sweden due to new tax rules that encouraged companies to offer their employees the opportunity to buy/rent a home computer (a).

[2] Further adoption of the internet requires new households to get computerised (a). Other technological solutions (e.g. digital TV, cheap networks computers) can radically change diffusion patterns (b).

[3] Cellular phones were introduced in may countries with market-skimming pricing. The industries pricing strategy determines the shape of the S-curve (c).

8. Killer applications

Killer applications can break up a market and can be identified easily ex post. They are characterised by that people find an initial use in their daily lives. Difficult products and enabling technologies are far less accepted.

All but the last factor lead to an overestimation of ICT diffusion.

2.2 The socio-economic context

Economic, social and technological drivers will change the values of the environmental indicators. According to OECD (2001) the main factors are: demographic and labour force developments, globalisation, trade and investment, economic development, consumption patterns and technological change. The assessment of the uptake of ICT has to consider socio-economic developments, which can't be studied in detail, as well. The relationship of these external factors and key variables has to be clarified to make implicit assumptions transparent (chapter 5). **ICT** as part of the technological change highly **affect** globalisation, trade and investment, economic development, labour force and consumption patterns. The direct impact on demographic developments is assumed to be relatively small, but ICT enable also the development of other new technologies. Innovation and diffusion of **ICT are also influenced** by the socio-economic context. For the Baseline Scenario for Transport in Europe (CEMT/CM(2001)4) a general framework for consistency has been developed. It includes macroeconomic variables (GDP, structural change, demographic projections, age pyramid structure), regional growth and trends in transport prices and costs (crude oil, taxes, public policy). For the development of ICT such a framework has to be developed as well. Other external factors might be added depending on the analysis of variables in the fact sheets for ICT-applications in chapter 5.

For a baseline scenario these macroeconomic variables might be sufficient. But they rather reflect the "mainstream" of indicators and developments. Use of virtual meetings for example rose sharply by the fear of air travelling after 11th September 2001. To gain alternative pictures of the future the concept of "wild cards" gives valuable hints. Wild cards can change the mainstream assumptions suddenly and have a high impact on the indicators. An overview of typical "mainstream" indicators in baseline scenarios and "wild cards", mostly derived from Steinmüller (1999) is given in the following table.

Table 2-1: "Mainstream" indicators and "wild cards" for the socio-economic context

	Mainstream	**Wild cards**
Demography	- population size - population structure (by age, sex) - population distribution (urban and rural)	- mass exodus from Third World countries to the European Union - life expectancy attains 100 years on average - cloning of humans
Society/ Policy	- household consumption (income and expenditure) - lifestyles - environmental policy - tax policy	- the end of the nation state - permanent social unrest and riots (ethnic, social) - Russia becomes a member of the EU
Economy	- trade (import and export) - investment - labour force - GDP and GVA of sectors - Costs for transportation, energy and waste	- big businesses replaced by small businesses - financial crisis reduces investments and household expenditure - Economic performance of East Asia surmounts EU and the USA
Technology	- biotechnologies - nanotechnologies and material Sciences	- breakthrough of renewable energy and/or nuclear fission - biodegradable packaging

Source: own compilation

The indicators and events listed above are driven by very complex factors. ICT is just one of them. To illustrate the complex relationships two examples, one for the “mainstream” and one for “will cards” are given.

- The influence of ICT on GDP is highlighted in politics and research. However the effects are not well understood, as many factors that contribute to GDP growth interfere, such as liberalisation of markets, competition from other economic blocks and financial markets. Even short term estimations of GDP often fail due to the complexity. Despite the fact that ICT influences many of the indicators and events listed above the specific impact of ICT can hardly be determined.
- The environmental indicators may be influenced by breakthroughs in other technologies. If there is a breakthrough in nuclear fission incentives to reduce energy consumption might be substantially reduced and the impact of ICT on energy consumption could disappear from the political agenda.

To reduce the complexity of the whole system analysed and taking into account the poor knowledge about the specific interactions of ICT the socio-economic context is treated as an external factor.

2.3 Environmental effects

Declining prices of ICT in Europe have lead to a mass use of a key technology, whose potential is far from having been fully exploited yet. The ICT sector is not just an industry like the steel industry or the transport sector but radically changes the way how people and machines communicate, business is carried out and alters the relations of space and time. ICT pervades all other sectors. ICT has the character of an integrated and enabling technology, thus it will be more and more difficult to reflect the specific contribution of ICT to macroeconomic phenomena or environmental indicators.

In principle there are two approaches to assess the environmental effects of ICT. In the widely disputed studies on the macroeconomic effects (Romm et al. 1999, ABARE 2001, Digital Europe 2003) it is distinguished between a growth effect, structural effect and a technology effect. On the other hand there is the concept of first, second and third order effects of ICT on the environment. The second approach is increasingly adopted in science (FFF 2000, EMPA, IZT 2003). For the structure of the whole project it has to be decided which way to choose.

The mainly discussed studies which cover growth, structural and technology effects of ICT on the environment have to be evaluated, in order to prove whether it is a suitable approach.

A scenario for internet and global warming has been built by **Romm et al. (1999)**. It is rough due to incomplete data. In 1997 and 1998 the US economy grew by 8 % whereas energy demand grew by only 1 %. Energy prices were low. Without structural changes a growth of 6 % would have been expected. The structural change through ICT to more light-weight businesses (ICT industry, services) is assumed to be responsible for 1/3 of the energy reduction effect. Efficiency gains in other industries contributed 2/3. The growth effect is not quantified. How these figure were generated is not explained in the report.

The consequences of ICT uptake for the energy industry have been assessed by **ABARE (2001)**. The energy industry is influenced by the three effects also covered by Romm et al. (1999) and direct impacts of increased use of ICT in energy industries. In a complex model energy intensity of the world economic output has been estimated to fall by 1 % per year between 1995 and 2010. If the uptake of e-business is 50 % faster, GDP will grow by 3,9 %/a and energy consumption by 1,5 %/a. Potential energy efficiency gains have been approximated by energy efficiency improvements that are uniform across sectors. However the data provided are highly speculative and were published during the internet bubble.

According to the project **Digital Europe (2003)** environmental effects of ICT can be decomposed into:

- growth effect: expressed as GDP
- structural change effect: expressed as GVA_{Sector}/GDP
- technology effect: expressed as environmental effect/GVA_{Sector}

Additionally the domestic sector has to be taken into account. As a data basis NAMEA (National Accounts Matrix including Environmental Accounts) supplied by Eurostat was used. The data comprised primary energy use, CO_2-emissions and GVA for Germany, Italy and UK. Most of the data is too old to give an impression of the current impact of ICT.[4]
The technology effect accounted for a reduction of CO_2-emissions in Italy and Germany of about 60 million tons each, in UK only 20 million tons were achieved. The structural change effect in the UK led to reduction of CO_2-emissions by 60 million tons, whereas the structural change effect in Italy and Germany led to small increases. Growth effects have been monitored in all three countries, from almost 30 million tons in Germany over almost 40 million tons in Italy to almost 80 million tons in UK. Private households showed small growth in CO_2-emissions in all three countries.
The study concludes that "Nevertheless, in all three economies the ICT sector did not play a crucial role with regards to development of CO_2 emissions" (Digital Europe 2003, p. 32).

The evaluation of the studies can be summarised in the following way:

- Data for decomposition analysis is insufficient.
- Although there is a growth and a structural change effect the specific contribution of ICT cannot be proved.
- The environmental effects due to ICT cannot be sufficiently understood from this perspective.

For this GDP and structural changes are treated as external variables in this study. The main focus is on the technology effect, which can be addressed by the concept of first, second and third order effects.

The first, second and third order effects can be defined as (FFF 2002):

First order effects	The impacts and opportunities created by the physical existence of ICT and the processes involved.
Second order effects	The impacts and opportunities created by the ongoing use and application of ICT.
Third order effects	The impacts and opportunities created by the aggregated effects of large numbers of people using ICT over the medium to long term.

The first order effects of ICT have been analysed for long and are addressed by the industry and politics to a high degree. Main fields analysed are energy consumption in production and use of ICT and end-of-life waste. The secondary effects can be either positive or negative. Depending on the ICT-application there is intensive research (e.g. on telework) or poor knowledge (e.g. on in-car navigation systems). The third order effects are not well understood. They can be either treated in general, or related to applications studied in detail. In the second case third order effects compensate to a certain degree secondary effects. It is assumed that this way is better understood and better accessible for policy action, than the general perspective.
Romm et al. (1999) emphasise that the second and third order effects of ICT outweigh the first order effects with the exception of households and maybe transport. From a policy perspective the ICT industry and the ICT usage patterns are highly important, how small or big the first order effects might be, and will therefore be addressed in this project as well.

For the in-depth analysis in chapter 5 the effects are considered in the following way:

- separate fact sheets for the first order effects of ICT
- second order effects and third order effects of ICT-applications are treated within each fact sheet

The selection of ICT-applications for in-depth analysis is carried out in chapter 4. The analysis of key trends within the ICT sector in chapter 3 is significant for all the environmental effects studied in chapter 5.

[4] e.g. GVA for Germany is from 1995 and 1997; CO2-emissions for Italy cover the period from 1990-1992.

3 KEY TRENDS IN SELECTED FIELDS OF ICT

The main aim of this chapter is to analyse trends and developments in ICT and assess possible extrapolations for the time horizon of 2020 (Workstep 2.1). As near-term trends like growing performance and continued affordability seem to prevail, the medium and long-term effects can only be guessed roughly. Key trends and uncertainties identified in this chapter will be also considered in the in depth analysis of chapter 5.

The technological and economic developments in the ICT sector have been analysed by evaluating existing studies on the future course of ICT. Main data sources are IPTS Technology maps and material of the eEurope 2002 and eEurope 2005 initiatives. From the bulk of data sources they have been chosen as they aggregate the knowledge of many detailed studies carried out on technological and economic developments of the ICT sector.

The IPTS time maps on the future of ICT for the fields of ubiquitous computing and knowledge management (IPTS 1999) are based upon Delphi-Studies. It is realistic to assume that the people asked do not have a common broad understanding on the factors that influence the market success of ICT. However, as shown in chapter 2.1, innovation and diffusion processes are so complex matters that a generic assessment is impossible. Keeping in mind the principal uncertainties of the methodology the IPTS technology maps are nevertheless assumed to be the most suitable data source, as a practical way through the jungle of information has to be found.

The eEurope initiative bundles the activities and measurement of key indicators, which are considered to be most relevant for the building of a digital society in the European Union. Other rather short term developments are published annually by the European Information Technology Observatory. This comprehensive data source is useful for the modelling of ICT penetration.

Information and communication technology (ICT) can be grouped into three segments (Call for tender):

- ICT equipment (computer hardware, end user communication equipment, office equipment, data communication and network equipment)
- software products
- ICT services and carriers

All categories will be covered by the six fields examined in this chapter:

- Microelectronics
- New functions
- Networks
- ICT devices and interfaces
- Software and knowledge management
- Services and applications

A breakdown of the ver heterogeneous category ICT equipment into microelectronics, new functions, networks as well as ICT devices and interfaces has been carried out according to the EMPA, IZT (2003) approach in the project on the precautionary principle for pervasive computing. Knowledge management, as one of the main fields in the IPTS Technology maps, has been added to the software product sector as the application is closely related to software. Main services have been derived from the eEurope initiative which mainly focuses on the internet and from a study of IZT on m-commerce. The carriers are addressed under networks as the actors coincide to a high degree.

ICT trends and developments have been analysed by characterising the expected time horizon and giving a rationale for the estimated uncertainty, taking into account the time horizon of 2020. Ten key trends with low uncertainty have been selected from the areas studies above. To give an impression of alternative future courses of the total ICT-sector in a brainstorming factors and events have been identified which might influence the uptake of ICT to a high degree. These factors/events have been characterised by their probability and impact on ICT diffusion in an internal workshop at IZT. They serve as one of several inputs for the scenario building (task 3).

This chapter is more technology oriented than economy oriented, because the diffusion of ICT-applications, to a high degree drive by market forces, will be studied in detail in chapter 5.

3.1 Microelectronics

The increased performance per given size and declining prices are the major prerequisites for the widespread diffusion of ICT and may lead to what is called pervasive computing or ubiquitous computing. Chips can be integrated into an increasing portfolio of devices becoming therefore invisible.

According to **Moore's law** memory capacity of chips is doubled every 18 months. The chips' performance develops at a comparable speed. This trend is supposed to last for at least 10-15 more years and to be highly certain (ETH 2002, EMPA, IZT 2003).

Moore's law will probably come to an end if the structure density is **below 50 nm**, because quantum effects play a major role on this scale. On the other hand this may enable the construction of quantum computers. Quantum computers are able to calculate parallel at the same time instead of sequentially. This would lead to a push in computer's performance. Quantum computers might be built on the basis of III/V-semiconductors like GaAs or InP.

High performance switching elements made from non-linear optical material might start between 2007-2011. Molecular computing IMP 91 and neurochips are expected for 2010-2012 but whether they can be realised efficiently is highly uncertain (IPTS 1999).

On the other hand there is growing research in materials which aim more at a reduction of prices than on improvements of performance. Breakthroughs are reported for **Polytronics** based on organic material. It is expected that a limited share of silicium-chips can be replaced but polymer chips will render more mass applications possible. They are printable on almost every physical good (EMPA, IZT 2003).

The following table summarises the estimated developments in microelectronics.

Table 3-1: Future uncertainties for developments in microelectronic materials

	Time horizon	Uncertainty	Rationale
Moore's law	continued until at least 2013-2018	low	extrapolation of trends until quantum effects occur
Polytronics	Breakthrough 2003-2005 with very fast diffusion	middle	Polytronics will cannibalise a small proportion of Si-technology but Smart labels will diffuse rapidly
Quantum computing	2006-2008	high	Invention and commercial applicability unknown
Molecular computing and Neurochips	2010-2012	high	Invention and commercial applicability unknown
Optical computing and storage	2005-2011	middle	Optical storage and computing are close to the breakthrough
Biochips and quantum semiconductors	beyond 2015	high	Invention and commercial applicability unknown
"E-Grains"	2010-2012	middle	First military experiments successful, many applications possible

3.2 New functions

Biotechnology, surface sciences, Nanotechnology and microsystem technologies give new impulses for basic functions of ICT. In the context of pervasive computing context sensitivity might play a major role.

Tiny **sensors**, data processing units and actors build microsystems. Sensors measure temperature, electromagnetic waves (IR, light, ...), surface tension, ions, gases etc.. The miniaturisation of the components will foster context sensitive microsystem applications. Special attention is justified for the development of biometric identification. For the breakthrough research focusses on price reduction, miniaturisation, microintegration and continuous measurements. New materials include piezoelectronic ceramics, specialised semiconductors and biological materials (EMPA, IZT 2003). Nanotechnology will probably be pushed to a high extent by fullerenes and nano carbon tubes. Mass synthesizing technology for fullerene carbon compounds is expected for 2006-2009. Industrial and home sensor/actuator networks are expected to be on the market between 2004-2008 (IPTS 1999). The diffusion pattern are unknown.

The development of smart labels for the **identification** of objects and other information has gone far. Smart label can be realised in the form of a printed transponder. Passive smart labels send at Radio frequency and therefore seamless interaction with reading/writing-devices is possible. Increased price reduction might lead to a replacement of the common barcode-system, which might lead to deep changes on all movements of goods (logistics, shopping, ...).

The **localisation** of people who use a mobile phone is easy, but inaccurate. The resolution of Global Satellite Navigation Systems will be significantly enhanced by the set-up of Galileo in 2008. As GPS faces competition from Galileo the artificially reduced accuracy might be loosened to have an advantage. It is estimated that GPS/Galileo-receivers will have the size of a credit card in the future (ETH 2002).

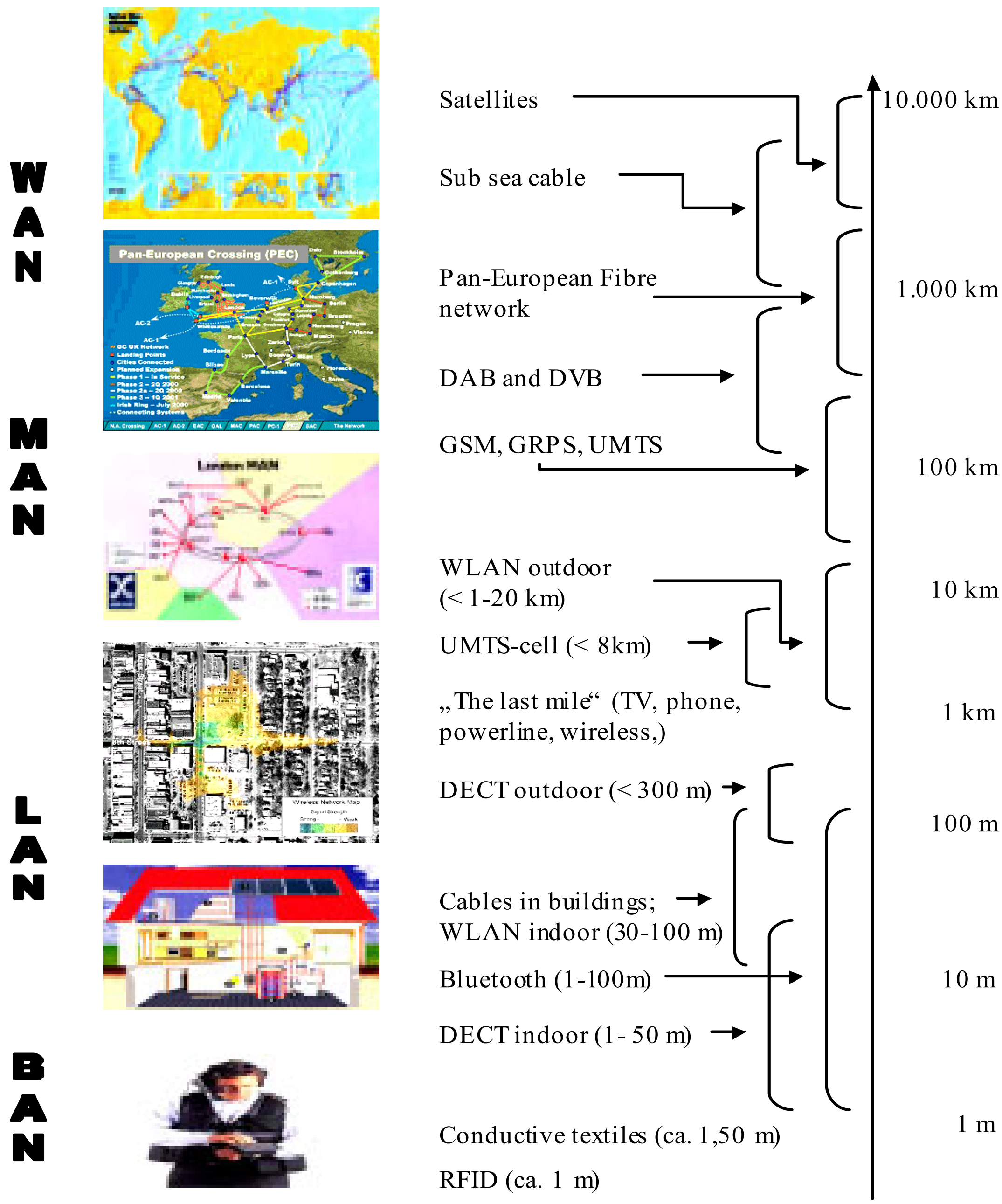
Table 3-2: Future uncertainties for new functions of microelectronics

	Time horizon	Uncertainty	Rationale
Miniaturised and cheap sensor/actor-systems	2004-2008	middle	Technology already exists, there are heavy downsizing and cost reduction activities
Mass synthesizing technology	2006-2009	high	Fullerenes and nano carbon tubes will give a bulk of new sensor/actor possibilities, economic performance highly uncertain
Sensor/actor-networks	2004-2008	middle	Sensor/Actor networks may first find use in industry, public acceptance might be low.
Smart Label diffusion	2003-2006	low	Smart label technology advances and has enormous advantages
Galileo/improved GPS	2005-2010	low	Extensive investment in technology has started.

3.3 Networks

The benefits from ICT are bound to a high extent to networkability. The following figure illustrates the scales of different ICT nets:

Figure 3-1: The scale of ICT networks



Source: EMPA, IZT 2003

On all of the scales of nets (Wide Area Networks, Metropolitan Area Networks, Local Area Networks and Body Area Networks) there are important developments for the future impact of ICT. In WAN space for satellites has become scarce. Software has improved the utilisation of existing optical fiber-networks significantly. Outside Europe new sub-sea cables are lied down to the oceans ground whereas in Europe the high speed and high capacity Pan-European networks and MANs expand. Digital Radio (DAB) and Digital TV (DVB) as well as Mobile phone networks will grow rapidly in the next years. LANs are based upon the WLAN standard or they are fixed to wires and can connect ICT-devices from areas to single rooms in buildings. In BAN data can be transmitted wireless (e.g. Bluetooth) or via conductive textiles.

A further expansion, especially of wireless nets, on all scales and increased interoperability is expected until 2020. Media convergence and the support of different standards seems to be a quite stable trend.

Major developments on the **WAN** scale are the set-up of Galileo-satellites starting from 2008 and capacity increases of optical fiber networks between major centers of the information and service society in Europe like London, Paris, Amsterdam, Frankfurt and Zurich.

As DVB and DAB have already been introduced in many European countries to supply a wider range of programmes and services, a dense coverage over all of Europe seems to be just a question of time. Mobile telephone nets based upon GSM technology have spread in Europe very fast. Telecommunication service providers have spent a lot of money on the concessions and build-up of UMTS technology, which offers broadband capacity for services like video-transmission. But it is unclear to what extent the customers will accept the services offered as GSM already supplies a high performance and other broadband wireless technologies like WLANs can be easily accessed via Laptop in big cities, once basic infrastructure has been set up (e.g. London, San Francisco, Aachen).

Fourth generation mobile communication nets may provide 10 Mbps but they will be offered only in hot spots with many users on a small space (e.g. airports, office centers). The Digital Inter Relay Communication (DIRC) is based upon the peer-to-peer principle. Contrary to GSM and UMTS there are no BTS (Basis Transmission Stations) but all senders are also receivers. To have a high coverage many participants are necessary. The DIRC-net is highly redundant.

On the **LAN** scale the standards of IEEE 802.11b (WLAN), DECT and Bluetooth have lead to an integration into many end devices. The price for Bluetooth chips is estimated to drop rapidly. Forrester Research estimates that in 2006 235 mln. Bluetooth-devices will be on the market in Europe. 73 % of all mobile phones and 44 % of all PDA will support the Bluetooth standard. DMAP is based upon the DECT standard, established in more than 100 countries, and integrates speech services. It aims at connecting web-phones, web-pads, digital cameras, scanner, modems, PC-cards, web-TV, set-top boxes and so on. LAN and WLAN spread rapidly in companies and, more slowly, in the domestic sector. In the USA according to Meta Group 6 % of the companies already use a WLAN. A big obstacle is the poor protection from hackers' attacks. It is supposed to be overrun by the future standard 802.IX which entails user identification and authentification. Frost and Sullivan expect that airports, stations and hotels will be increasingly equipped with wireless nets. They expect more than 37.000 hot spots. The share of Bluetooth is expected to be 35 % whereas WLAN and DECT/DMAP will account for 20-50 % each. Other fixed line broadband access possibilities (e.g. DSL) are covered by the eEurope benchmarking indicators.

Mobile phones are already equipped with bluetooth headsets and wearables are especially interesting for workers who need their hand for other purposes (call centers, construction sites, ...). The uptake patterns have to be guessed with caution because people may refuse nets to close to their bodies.

Table 3-3: Future uncertainties for networks

	Time horizon	Uncertainty	Rationale
Galileo/improved GPS	2005-2010	low	Extensive investment in technology has started
Urban broadband cable > 34 Mbps	2006-2010	middle	Many projects have already progressed (e.g. interroute)
Widespread use of real time voice and TV services over IP	2004-2006	middle	The services already exist but quality is poor
ipv6-Internet	starting from 2005	low	IETF estimated in 1994, that ipv4 addresses will be exhausted by the year 2008 +/- 3
DAB and DVB full population coverage	2004-2006	low	DAB and DVB pushed by European initiatives (e.g. EUREKA)
GSM to GRPS	2003-2005	middle	investments in UMTS threatened by GSM and GRPS
UMTS (2Mbps) full population coverage	2005-2008	middle	First phones available 2003; coverage depends on license (e.g Germany: 50 % of population by 2005)
4th Generation	2005-2008	middle	demand is not sure
DIRC	2010	high	needs many participants to work sufficiently
> 30.000 WLAN hot spots	2006	low	estimated by Forrester Research
Crash proof WLANs	2007-2009	middle	Hackers' abilities unknown
Broadband access uptake	2005	low	Most homes will have IP access > 2 Mbps. Target of eEurope
Homes have universal information bus	2006-2008	middle	Smart homes may be accepted only in small groups, new installation is limited
Personal Mobile >10 Mbps	2006-2008	high	The need for applications needing that much speed is unlikely
GPS in all cars	2004-2006	low	nowadays almost all middle and upper class cars are equipped with GPS
RFID at the body	2003-2010	high	Might depend on our knowledge about electromagnetic waves smog
Conductive Textiles	2008-2010	high	commercial applicability unknown

3.4 ICT devices and interfaces

ICT started with big mainframe computers. In the 1980s markets for PCs grew rapidly. In the end of the 1990s mobile computers and telecommunication equipment boomed. At the threshold to the new millennium embedded computing has accelerated fast.

Several product classes can be separated, the first nine classes usually included if the ICT hardware is addressed (A.D. Little 2002; modified):

1. **Big computers (Servers, Data storage, supercomputers)**

The growing internet requires huge server farms and data storage computers, whereas supercomputers might be replaced by distributed computing.

2. **Personal computers and workstations (Desktop PC and monitors, Laptop, workstations)**

In the Desktop Monitor market there is a shift from CRT to LCD. Laptops usually have an LCD screen as well. Projection displays may replace monitors in the future. Workstations have become popular in the public. The functions of a PC might be merged with TV or other devices. The same applies to monitors for PC and TV.

3. **Peripheral equipment (printers, scanners, copiers, multifunctional devices)**

There is a certain trend towards multifunctional devices integrating printing, copying and scanning and other functions. All this hard-copy peripheral equipment makes only use in an information society that requires paper.

4. **Fixed telecommunication equipment (phone, fax, answering machine)**

As traditional phones are still used widely because of the favourable costs, fax-machines face competition from PC-fax and answering machines might be replaced by virtual ones.

5. **Mobile devices and power supply (mobile phone, PDA/handheld, cordless phone, accumulator, net plug)**

High performance batteries (500 Wh/kg) are expected for 2008-2010. Low-energy PCs that will run a year on a button battery may be reality between 2011 and 2014 (IPTS 1999).

6. **Telephone network equipment (Cell site equipment, fiber optic terminals, public analogue network, private branch exchanges)**

The telephone network equipment will remain vital for the information society and develop parallel.

7. **Computer network equipment (LAN switches, routers, hubs, WAN switches, remote access servers, cable modem termination systems)**

The market for computer network equipment will rise continuously.

8. **Uninterruptable power supplies (UPS)**

Accumulators for uninterruptable power supplies are the fastest growing segment of lead acid batteries.

9. **Other (Point-of-sale terminals, automated teller machines ATM, aperture terminals, typewriters, dictation equipment, voice mail systems, handheld calculators)**

No general trend can be given.

10. **Consumer electronics (TV, audio and video, game consoles)**

Consumer goods might be interoperable with other ICT goods. The most important application on the rise seems to be digital TV. Some analogue TV require a Set-top box to receive digital TV, others can take advantage of digital cable transmission or satellite TV.

11. **Embedded ICT (packaging, cars, electronic equipment, machines)**

The last point indicates that ICT increasingly has a pervasive character. Smart label may be printed on every package sold, in upper class cars there are already up to 30 microprocessors, TV, refrigerator and washing machine increasingly have internet access and displays.

Additionally there is increased **machine-to-machine** communication. Affective robots may operate from 2004-2006 on, almost every home or service task might be undertaken by robots from 2009-2014 (IPTS 1999).

The conventional human interfaces of a computer are the keyboard and the mouse for input and the display for output. Devices like handhelds have become so small that they must be operated using a pen. Touch screens have integrated input and output functions. Increasingly important developments are mainly:

- **voice recognition and information (e.g. in cars)**
- **new display technologies (LCD, OLED, Plasma, projection, e-paper)**

Full voice machine interaction will come between 2004 and 2007. Holodeck meeting rooms and holographic displays may be reality between 2011 and 2015 (IPTS 1999). Data gloves haven't conquered markets yet, the same applies to head-mounted displays and retina-displays. Extensive research is carried out in the field of virtual reality for games and computer aided design.

Table 3-4: Future uncertainties for ICT devices and interfaces

	Time horizon	Uncertainty	Rationale
supercomputers replaced by distributed computing	2007-2010	high	secure nets and economic models are required
All in one screen (TV, PC)	2006-2008	middle	there is TV over IP but quality is poor. LCD has a limited visibility
CRT almost phased out	2005-2006	low	LCD prices will drop further and CRT has only advantages for video games, projection displays become cheaper
High performance batteries for mobile devices	2008-2010	middle	high incentives for companies to develop high performance batteries.
virtual answering machine standard	2005-2007	middle	virtual answering machines are on the market but continuos costs and fear of lacking data security block the spread
server farms, computer network and telecommunication equipment, UPS double	2006	low	according to political goals and unused potentials communication infrastructure will grow at a fast pace
home and service robots prevail	2009-2014	high	customer acceptance is very insecure
Smart label take up	2005-2008	middle	cost reduction is probable, the extent determines the overall applicability on billions of goods
Internet and displays in electronic devices standard	2006	low	trend can be seen for decades (starting from radios over automated machines to washing machines)
full voice machine interaction	2004-2007	middle	there are still some technical problems to be solved
e-paper becomes amass application	2010-2012	high	there are still severe technical problems to be solved
Holodeck meeting rooms and holographic displays	2011-2015	high	there are still severe technical problems to be solved
Hydraulic chair for virtual reality games	2004-2006	middle	the market size is unknown, but it might be attractive for the event-oriented
3-dimensional printer	2012-2015	high	A significant consumer benefit is not in sight

3.5 Software and knowledge management

The field of information processing and knowledge management has three main components:

In the field of **software engineering** software certification systems are expected from 2003 to 2006, which has been fuelled by the TCPA chip and licensing efforts by software and hardware producers. Production of software is still rather a craft than an industry. Formal software modelling and reusable software components and libraries are of growing interest. Self-learning software and quick and error free software inspection will start at the beginning of the next decade (IPTS 1999).
The way software and other information goods are produced might change dramatically. On the one hand there is **commercial software** which has to be paid, on the other hand there is a growing **free software** movement. Free software under the General Public License is software which can be used, copied, distributed and modified for free. For this it has the character of a public good. There are many public software projects in the internet and also many companies such as IBM have appreciated the advantages of free software. Among the advantages are fun, self-fulfillment, transparency, better software (the producer and many others test it and bring in

their experience) and new creative co-operative work. The principle of free software is applied to a increasing number of projects like common writing of texts, designing a CPU or even a car (Oekonux 2002).

Data mining and warehousing includes data capture and retrieval as well as security matters. Main breakthroughs are expected for 2005-2010. Agents and avatars are destined to help the ICT user in navigating through the complex cyberspace. On the basis of Java such agent systems for the internet are already available. Avatars are a form of visualisation for agents. They may incorporate behaviour rules and shall be able to organise trips or to take part in an auction. Job-agents and shopping-agents count among the most important applications. The spread might be hindered due to privacy problems and maybe irreversability (EMPA, IZT 2003).

The field of **Artificial Intelligence** is very heterogeneous (IPTS 1999). Telecommunication in Europe could be boosted by translation machines. Auto transcription devices for 200 € are already on the market but insufficient. Real-time continuous speech translation might come between 2009 an 2012. Other dimensions of AI include distributed intelligence and pattern recognition.

Table 3-5: Future uncertainties for information processing and knowledge management

	Time horizon	Uncertainty	Rationale
Software certification systems	2003-2006	low	Efforts are strengthened by software companies (e.g. Microsoft)
Free software widely used	2005-2010	middle	Parallel a growing amount of people is dissatisfied with quality and prices of software and makes its own software (e.g. Linux)
Re-usable software components	2004-2009	middle	Although there is a big demand heterogeneity of concepts are a severe obstacle
Self-learning software	2009-2011	middle	Technologically possible but difficult to implement
Reliable authentification of ID for contracts	2003-2006	low	Important EU-activity to foster e-commerce
Global distributed networks with personal ID	2007-2011	high	Business models and organisation unclear
Large scale data retrieval	2005-2007	middle	Growing demand but rarely effective
Advanced security technology	2008-2010	middle	Big issue, but hackers will remain active
Software agents	2003-2007	low	Already in use, but of limited benefit
Self operation: navigation planning and reasoning	2003-2008	high	Involves deep changes in peoples way of living
Natural language text translation	2003-2006	low	Already existent but of poor quality
Real-time continuous speech translation	2009-2012	middle	Might foster international communication but very difficult to implement
Language and voice recognition for end users	2007-2011	low	Technological difficulties should be overcome
Expert systems might surpass human logic and learning	2009-2012	high	Mankind has no clear conception if that should happen
True AI: computer understands its role in the world	beyond 2015	high	Mankind has no clear conception if that should happen
Context sensitive pattern recognition error rate <1%	beyond 2015	high	depends on the heterogeneity of patterns in the far future

3.6 Services and applications

There are many existing ICT services both for the internet and mobile telecommunications. The internet offers a wide range of services like e-mail, mailing lists, download and sending of files, tele-operation and –administration, chat and discussion groups, MUD, www, search engines, real time video and audio, voice over IP, access to databases and so on. Mobile services include phone, organiser, SMS, e-mail and MMS. In the future Location Based Services (LBS) will play an important role.

There are many ICT services which are already widely used. The eEurope initiative (eEurope 2002) has set up an action plan for a digital European society. The main objectives have been clustered into:

1. A cheaper, faster, secure internet

a) Cheaper and faster Internet access
b) Faster Internet for researchers and students
c) Secure networks and smart cards

2. Investing in people and skills

a) European youth into the digital age
b) Working in the knowledge based economy
c) Participation for all in the knowledge based economy

3. Stimulate the use of the internet

a) Accelerating e-commerce
b) Government online: electronic access to public services
c) Health online
d) European digital content for global networks
e) Intelligent transport systems

The progress of the action plan of the eEurope initiative shall be monitored by benchmarking indicators. The proposed list of eEurope 2005 benchmarking indicators covers these fields:

Internet indicators

A Citizens' access to and use of the internet
B Enterprises' access to and use of ICT
C Internet access costs

Modern online public services

D e-government
E e-learning
F e-health

A dynamic e-business environment

G Buying and selling online
H e-business readiness

A secure information infrastructure

I Internet users' experience and usage regarding ICT security

Broadband

J Broadband penetration

Broadband access and secure information infrastructure are not ICT services but main prerequisites that citizens, enterprises and governments use the ICT services.
It is very probable that the objectives covered in the eEurope initiative will be approached, because there is a political will behind.

A broad view on services by function is given by IZT, SFZ, IAT (2001). It is less policy oriented, but reflects main markets, which are already used to different degrees.

- Finance: payments, insurance
- Commerce: buying and selling, auction
- Information: news, customised information
- Entertainment: music, video, quiz, bets and games
- Shopping: buying and price comparison
- Health and wellness: Consulting, control of patients

- Learning: knowledge, education for children, guidance
- Work: contact with clients, data bases
- Multimedia communication: for families, communities, individual
- Public services: e-government and information about public services
- Telematics : logistics, navigation, control of homes
- Application service provision online: software, products
- Other: security, exchange stocks, contact markets, job markets

These services are often combined to get the most benefit. Location based services LBS (e.g. direction in cities, local tourist information, automated localisation in case of emergency) lie cross to all of the services mentioned above. LBS have a big economic potential and are expected to grow with the set-up of Galileo in 2008.

As these services already exist to a high degree no general assessment of the certainty is undertaken. Many more services exist, those with an assumed high impact on the environmental indicators are listed in chapter 4. The character of ICT will lead to many new services which we can't imagine today. The diffusion patterns are estimated in chapter 5 for the applications selected in chapter 4.

3.7 Conclusion

Ten key trends in ICT technology with low uncertainty can be extracted:

1. Moore's law continues for 10-15 years

Moore's law will prevail for the next decade fostering a technology driven push of ICT

2. Increasing context sensitivity

The developments in material sciences and micro-integration will enable new functionality of microelectronics with a considerable surplus.

3. Wireless and mobile networks spread and converge

Investment in mobile infrastructure has been undertaken in the European Union. Companies which have a license develop services to get a return on investment. Media-convergence is a key trend.

4. Widespread broadband access

Widespread broadband access is a key indicator of the eEurope initiative and will lead to a growth of data transfer.

5. Embedded computing and extension of networks into daily appliances

With the ipv6 protocol and the miniaturisation of ICT the prerequisites are given for pervasive and embedded computing.

6. Growth of ICT markets

The efforts of the European Union, nations and companies for a further spread of ICT are uninterrupted. As price reductions continue customers' cost/benefit considerations will contribute to this development. Innovation cycles become shorter and shorter. Supply and demand of multifunctional devices is growing.

7. Ongoing built-up of ICT infrastructure

To meet growing demands ICT infrastructure has to be developed further. UMTS and Galileo are only two examples which will be realised in the near future.

8. Parallel development of licensed and free software

An alliance of software and hardware producers recently introduced the TCPA chip, which is destined to allow only licensed software to be installed and run on the hardware. On the other hand free software is still available and might lead to a prospering co-evolution.

9. Improved reliability of authentification systems

To foster e-business the European Union takes many measures to guarantee safe and reliable authentification systems.

10. Improvement of existing ICT services and new location based services

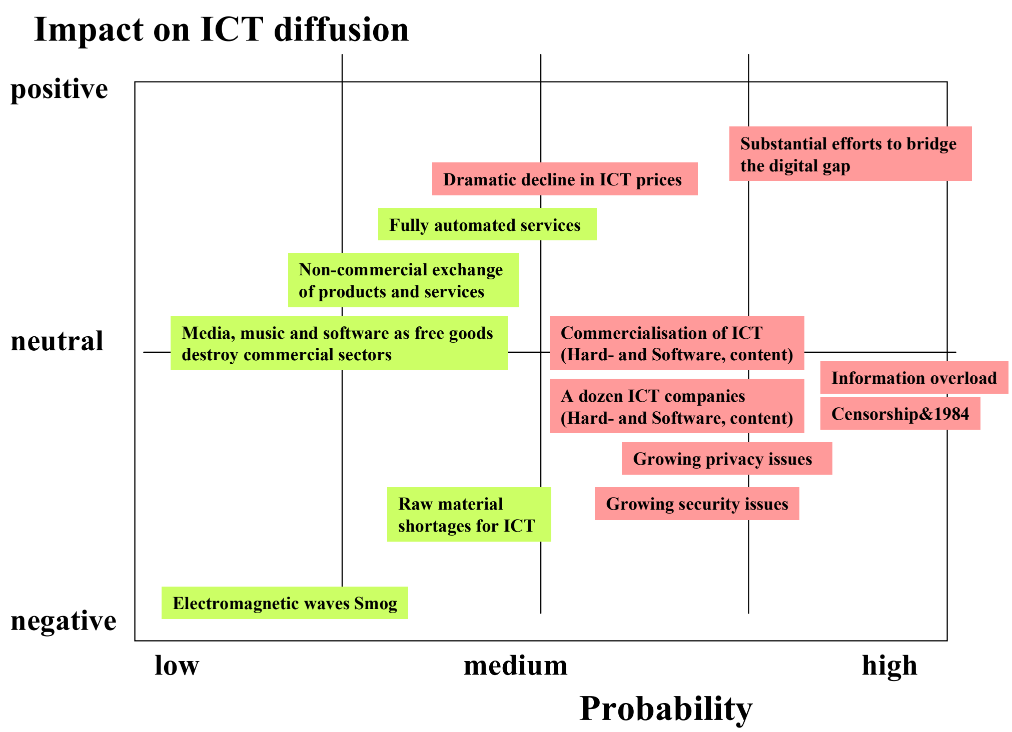
Tough competition in the ICT sector incites service suppliers to improve their services. An emerging service with high market potential are LBS.

Digression: Alternative future courses of the ICT sector

The general spread of ICT at a moderate speed is considered as a stable trend. But other developments until 2020 are possible. ICT spread may be much faster or slower. The classification as a trend is not discrete, but embedded in a continuum of more or less probable events with more or less impact on the diffusion of ICT.

In a brainstorming at IZT some basic events have been identified which might influence the total future course of ICT. Many more events can occur. The rough characterisation of probability and impact is seen as one of several inputs which can be reflected in the scenarios (task 3).

Figure 3-2: Alternative future courses of ICT



Source: Brainstorming in IZT

A key occurrence for the uptake of ICT with low probability could be a scientific proof for adverse effects of electromagnetic waves by ICT on human health. ICT uptake already was delayed by shortages of the mineral coltan, containing tantal, which is used e.g. in mobile phones or game consoles. Resources, away from civil war areas, have been mobilised and to a certain extent substitutes have been found. On the other hand there are many severe obstacles with a much higher probability. People tend to stay robust against information overload and control but privacy and security issues are severe obstacles for a further uptake of ICT, especially if pervasive computing is taken into account.

On the other hand there are visions with more or less probability which may push uptake of ICT even faster. Maybe in the future services will be fully automated, but dramatic decline in ICT-prices and political action to bridge the digital gap are far more probable.

4 SYNOPSIS

The synopsis should give a broad overview on the influence of ICT on the environmental indicators (workstep 2.1). The main aim is to select ICT-applications which will be analysed in detail in chapter 5. The selection is carried out in three stages:
1. Shaping of the synopsis
2. Synopsis of ICT-applications
3. Selection of ICT-applications for in depth-analysis

The first stage aims at identifying the most important effects of ICT with regard to the environmental indicators. In the second stage a large amount of ICT-applications is screened according to their assumed impact on the environmental indicators. The main selection criteria is the estimated quantitative relevance of the environmental effects. Additionally the quality of knowledge has been assessed, which is important for further policy action.

4.1 Shaping the synopsis

The synopsis should identify the areas of ICT which will have the highest impact on the selected indicators. Therefore it is asked, where the hot spots are which contribute to the environmental indicators. The breakdown of the environmental indicators in the first interim report has to be further specified. In a second step the first order effects of ICT have been assessed in a qualitative manner on the environmental indicators. The same has been carried out for the secondary and tertiary effects of principal strategies which are discussed in research literature.

4.1.1 Where are the environmental hot spots?

Energy consumption is mostly determined by the following purposes in the different sectors (COM(2001) 226 final) and ATLAS (1997)):
- Domestic: heating, warm water, electricity
- Tertiary: heating, warm water, electricity
- Industry: production processes

Greenhouse gas emissions of the energy supply industries are positively influenced by the **share of renewables**, nuclear power, co-generation of heat and power and natural gas, whereas coal and oil have negative impacts on GHG. The overall supply efficiency also plays a key role (EEA 2002).

The main purposes that contribute to **transport volume** by **modal split** are (CEMT/CM(2001)4 and BMVBW (2000)):

Passenger transport
- commuting (MIV, rail, public transport)
- business (MIV, air)
- leisure (MIV)
- tourism (MIV, air)

Freight transport
- Vehicles machines, (semi-)finished products (truck, train)
- Minerals (truck)
- Food and feed (truck)

Additionally inland water ways are important on the EU level, especially for minerals, but play a minor role in Germany.

Waste from daily household and commercial activities mainly consists of the following fractions (ETSO 2003).
- Organic
- Paper and cardboard
- Plastics

By function in the household the most important waste contributors are:

- Feeding
- Recreation
- Infotainment

Paper and cardboard as well as glass is collected separately to a high degree, organic waste is composted to some extent in areas with gardens. Light weight packaging is increasingly collected separately in some countries, but still to a small degree in the EU.

Urban air quality differs locally to a high extent. For this no further breakdown makes sense. Effects will be discussed qualitatively. It highly depends on transport and energy conversion emission patterns.

4.1.2 First order effects of ICT industry and use

The first order effects of ICT industry and use have been discussed in literature for long. Both contribute to energy consumption, and the latter also to waste from daily household and commercial activities. Although the contributions to the indicators are only in the magnitude of a percent these areas are covered, first because this might change dramatically until 2020 and second there are important fields of action for EU policy.

Key effects to be studied in detail (chapter 4 and 5) are written in bold letters.

a) ICT industry

The ICT industry is defined in OECD definitions and comprises a large variety of sub-sectors. The main effect discussed in scientific reports is energy consumption.

Table 4-1: Effects of ICT industry on the environmental indicators

Environmental indicator	**Effect**
Energy consumption	**Production of ICT goods and provision of services requires energy.**
Waste from daily activities	not applicable, see "ICT use"
Transport volume	unknown, assumed to be hardly affected
Share of renewables	see "ICT use"
Modal split	unknown, assumed to be hardly affected
GHG	Can be derived from energy consumption and share of renewables, but there are some process related GHG emissions as well (e.g. CFC)
Urban air quality	unknown, assumed to be hardly affected

b) ICT use

The use of ICT is related to the ICT-applications. Primary effects discussed are mainly the electricity consumption of devices and infrastructure, but also waste from daily household and commercial activities is affected.

Table 4-2: Effects of ICT use on the environmental indicators

Environmental indicator	**Effect**
Energy consumption	**Most of ICT need active energy supply, mostly electricity**
Waste from daily activities	**Fast growth of traditional ICT waste (PCs, mobile phones etc.), waste streams might change their character with embedded ICT (e.g. wearables, furniture) and smart label (e.g. on packaging) might affect recycling processes.**
Transport volume	unknown, assumed to be hardly affected
Share of renewables	can be influenced to some degree by ICT industry, e.g. with renewables for mobile phones (devices and infrastructure)
Modal split	unknown, assumed to be hardly affected
GHG	Can be derived from energy consumption
Urban air quality	unknown, assumed to be hardly affected

As the synopsis is carried out for applications only, it was decided to prepare these two fact sheets on primary effects without further selection, but with intensive review of the scientific literature and scenarios.

4.1.3 Second and third order effects of ICT-applications

The aim of this sub-chapter is to clarify the main effects of principal ICT-application strategies. In the following section, there will be a screening of ICT-applications with respect of their influence on the most relevant areas described in this paragraph.

Principle basic sustainability strategies for ICT-applications can be grasped in the following terms, taking the environmental indicators into account (e.g. FFF 2002, Digital Europe 2003):

- dematerialisation/virtual goods
- virtual mobility
- e-business/e-commerce/internet
- traffic management/telematics/intelligent transport systems
- waste management
- energy management (supply and demand)

The second order effects on the environmental indicators are described in a qualitative way, to identify the key indicators which are affected by ICT. Other indicators can often be derived from the key indicator, e.g. GHG emissions from transport volume by calculating with emission factors. The rationale is expressed for positive effects, but third order effects might result in an overall negative effect. For this case the rationale has to be converted.

a) dematerialisation/virtual goods

Almost all information based products can be digitised in principle. Examples include audio, video, text and other code, such as software. The term virtual good is used in this study. Mainly waste from daily activities is influenced.

Table 4-3: Effects of virtual goods on the environmental indicators

Environmental indicator	Effect
Waste from daily activities	**Digitisation of information can replace physical products such as paper and CDs.**
Energy consumption	If less physical products are needed, they don't have to be produced in industry. The use of digital media in the domestic and tertiary sector requires energy (first order).
Transport volume	Products which are distributed electronically don't have to be transported physically. Both freight and passenger transport are affected.
Share of renewables	unknown, assumed to be hardly affected
Modal split	unknown, assumed to be hardly affected
GHG	Can be derived from energy consumption, transport volume and waste from daily activities by using emission factors.
Urban air quality	More emissions from power stations and less emissions from paper industry might locally occur.

b) Virtual mobility

Virtual mobility can reduce physical transport. Electronic delivery of digital goods has a potential to cut down freight transport. On the other hand electronic delivery of physical goods is just one kind of electronic service which can be provided electronically. The use of digital services (e.g. internet-shopping, virtual meetings) may reduce passenger transport volume.

Table 4-4: Effects of virtual mobility on the environmental indicators

Environmental indicator	Effect
Transport volume	**Products which are distributed electronically don't have to be transported physically. Services can be used electronically. Both freight and passenger transport are affected.**
Energy consumption	Virtual mobility increases energy consumption of ICT in the domestic and tertiary sector, which provides the services (first order)
Modal split	unknown, assumed to be hardly affected
Urban air quality	Less road transport may improve Urban Air Quality
Waste from daily activities	see "virtual goods"
GHG	Can be derived from energy consumption, transport volume and waste from daily activities by using emission factors.
Share of renewables	unknown, assumed to be hardly affected

c) e-business/e-commerce/internet use

The section e-business/e-commerce/internet use is usually structured by business, consumer and government interaction. A main effect is a better matching of supply and demand at very low transaction costs. The term e-business is used in this study. As the whole economy is affected many environmental indicators are influenced.

Table 4-5: Effects of e-business on the environmental indicators

Environmental indicator	Effect
Energy consumption	**E-business facilitates a better matching of supply and demand. For this overproduction in the industry, inventories in warehouses and retail stores can be reduced. Less overproduction means less energy in industry and space in warehouses and retail stores has not to be heated or even built.**
Transport volume	**E-business highly affects transport. On the one hand it makes transport more efficient, on the other hand transport distances become longer. The overall effect is important but unknown.**
Modal split	**In B2C e-commerce home deliveries lead to increased freight and less passenger transport. Just in time deliveries favour road and air transport.**
Urban air quality	unknown, assumed to be mainly affected by modal split and transport volume
Waste from daily activities	**Smaller amounts, more often delivered ("atomisation") might increase packaging waste. Better matching of supply and demand in the area of feed might reduce the amounts of feed (including packaging) thrown away.**
GHG	Can be derived from energy consumption, share of renewables transport volume, modal split and waste from daily activities by using emission factors.
Share of renewables	see "energy supply"

d) traffic or mobility management/intelligent transport systems/telematics

Traffic management/intelligent transport systems/telematics aim at increasing the capacity of vehicles and transport infrastructure as well as optimising the modal split. The term intelligent transport systems is used in this study. This area is closely related to e-business.

Table 4-6: Effects of intelligent transport systems on the environmental indicators

Environmental indicator	Effect
Transport volume	**Increased capacity usage of vehicles and infrastructure directly affects passenger and freight transport volume**
Modal split	**Some telematic applications aim at changing the modal split directly**
Energy consumption	Can be derived from transport volume and modal split by using energy consumption factors
Urban air quality	Overall effect unknown as a lot of transport is supposed to be shifted, some local experiences have been documented
Waste from daily activities	assumed to be hardly affected
GHG	Can be derived from transport volume and modal split by using emission factors
Share of renewables	assumed to be hardly affected

e) waste management

Waste management aims at increasing the collection rates of waste and better separation of fractions in order to reduce the amounts of waste which have to be incinerated/landfilled.

Table 4-7: Effects of ICT supported waste-management on the environmental indicators

Environmental indicator	Effect
Waste from daily activities	**The amount and the downstream phase can be affected by ICT**
Energy consumption	Energy consumption is affected indirectly because less waste and more recycling save energy for the processing of primary resources in industry
Transport volume	Waste logistics might change by changing mass streams, but the effect is considered to be small
Modal split	assumed to be hardly affected
Urban air quality	assumed to be hardly affected
GHG	Emissions from waste on landfills, depending on the carbon content, are difficult to determine. GHG emissions from industry can be derived from energy consumption
Share of renewables	assumed to be hardly affected

f) Energy demand

Energy demand of the industry, tertiary and domestic sector can be minimised by using ICT. The energy demand of transport is assumed to be mainly dependent on transport volume and can be derived indirectly.

Table 4-8: Effects of ICT-supported energy demand management systems on the environmental indicators

Environmental indicator	Effect
Energy consumption	**ICT-applications can reduce energy consumption of buildings and industrial processes/machinery directly**
Transport volume	unknown, assumed to be hardly affected
Modal split	unknown, assumed to be hardly affected
Urban air quality	Might lead to less emissions in living and commercial areas and in the vicinity of other energy conversion installations
Waste from daily activities	assumed to be hardly affected
GHG	Can be derived from energy consumption and share of renewables by using emission factors
Share of renewables	see “energy supply”

g) Energy supply

Energy supply of the domestic, tertiary and industry sector overlaps with the areas of energy demand and e-business. Some ICT-applications also affect the supply of fuels for transport.

Table 4-9: Effects of ICT-supported energy supply management systems on the environmental indicators

Environmental indicator	Effect
Energy consumption	**ICT-applications change the efficiency and ways of energy supply by better matching of supply and demand and related price effects**
Share of renewables	**The share of renewables can be directly addressed by ICT or is indirectly affected by ICT based markets for energy/GHG**
Transport volume	unknown, assumed to be hardly affected
Modal split	unknown, assumed to be hardly affected
Urban air quality	Might lead to less emissions in commercial areas and in the vicinity of other energy conversion installations
Waste from daily activities	assumed to be hardly affected
GHG	Can be derived from energy consumption and share of renewables by using emission factors

The indicator/ICT-application combinations will be analysed in detail in the synopsis.

4.2 Synopsis of applications

The structure of the synopsis is oriented at the principal strategies described in the previous section. To identify high potential effects on the environmental indicators the ICT-applications have been specified. The screening of environmental effects is based upon the assessments in different studies. Furthermore the status of knowledge is described in a brief rationale. The selection of ICT-applications for in-depth analysis has been made according to an assessment of the impact on the environmental indicators (see previous section) and the quality of knowledge. The quality of knowledge is assessed roughly, in order to enable an assessment of the maturity for policy action (chapter 5).

4.2.1 E-business

E-business is used as a term for commercial market transactions by using interactive media (e.g. Internet, Digital TV) for supply, order and/or use (E-commerce) plus e-based and/or e-supported activities within a company (e.g. telework, teleconferencing, ...).

Although virtual mobility, trade with virtual goods and electricity also belong to e-business, they are treated in extra chapters, because the character of these activities and goods is different from physical goods. In this section the effects of e-business in the exchange of physical goods is examined.

Three main fields are intensively discussed:

- Optimisation of value chains
- Customer relationship
- Internet support for product use and recycling

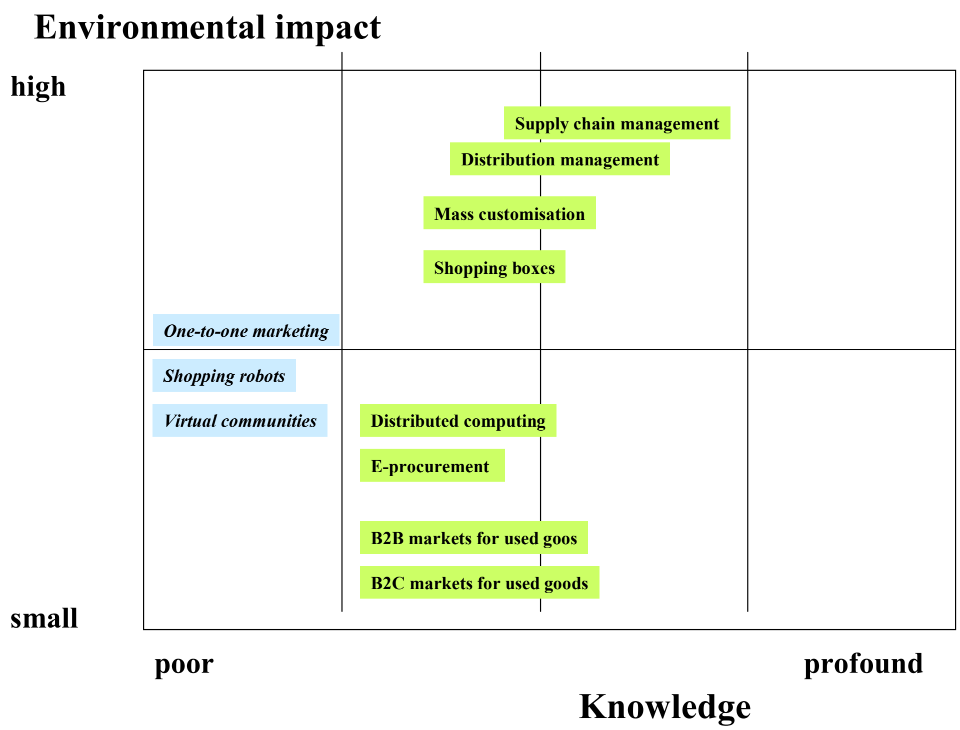
E-business is usually structured by pair-wise combination of business, government and consumer. Main effects on the environmental indicators are located in the B2B and B2C e-business (Digital Europe 2003), which are mainly focussed in the synopsis.

Table 4-10: Synopsis of e-business applications

ICT-application	Description	Effects on environmental indicators	Quality of data
Optimisation of value chains			
Supply Chain Management	Integrated corporate activities for supply with raw-materials and semi-finished goods, including information and money flows	Increase in resource productivity, stages of the supply chain skipped, but global supply patterns favoured (IZT, Borderstep 2002), Amounts of waste (e.g. food chain) might be reduced	many effects well understood, few quantitative and representative data
E-procurement	Supply of offices with ICT, paper and so on	see supply chain management	No specific data known (IZT, Borderstep 2002)
Inventory management	ICT based inventory optimisation	Usually integrated in supply and distribution management	
Distribution management	Optimisation of logistics to wholesalers, retail or customers (e.g. UPS)	Transport optimisation, stages of the distribution chain skipped but global distribution patterns favoured, atomisation of deliveries (IZT 2002)	Main effects and factors understood, few quantitative and representative data
Distributed computing	Outsourcing of data services and global work across different time zones	Increase in resource productivity (Jain, Wullert 2002)	Hardly any secondary effects known
Customer relationship			
Shopping-Boxes	Pick-up-points (e.g. petrol stations, kiosks, stations or living areas).	Improved transport efficiency, but returns have to be considered (IZT, Borderstep 2002)	Main effects and factors understood, few quantitative and representative data
Shopping-Robots	Shop-Robots are looking in the web for products	Might be used for procurement	Effects unclear
Built-to-order/ Print-on-demand/ Mass Customisation	Customer specific (mass) production	Reduction of inventories, avoidance of overproduction (IZT, Borderstep 2002)	Main effects and factors understood, few quantitative and representative data
One-to-One-Marketing	Customer specific communication	Might lead to a better matching of needs and lead to less overproduction	Effects unclear
Virtual Communities	Communities in cyberspace with a common interest (e.g. power shopping, sustainable products)	Easy identification of customers' needs and product/service requirements (Schneidewind 2002)	Effects unclear
Internet support for product use and recycling			
B2B-Internetplatform for used machines and plants	Commerce with used but superfluous goods	Extension of lifetime, but esp. long-term products affected (IZT, Borderstep 2002)	insufficient knowledge on effects
B2C and C2C-markets for used goods	e.g. e-auction	Extension of lifetime, but medium and long-term products affected (IZT, Borderstep 2002)	insufficient knowledge on effects

The following figure shows the estimated impact on the environmental indicators and an assessment of the quality of knowledge:

Figure 4-1: Environmental impact and quality of knowledge for e-business



Source: own assessments, italics (poor knowledge): effects unclear

The internet support for product use and recycling is useful for medium- and long-living products. As they are not an important fraction in "waste from daily household and commercial activities" they are not further regarded. Nevertheless production of these goods from primary resources might be avoided to some degree and leads to a decrease of energy intensity of the industry. Case studies surveyed by IZT, Borderstep (2002) unveiled that B2B-platforms for used machinery and plants rather tend to be exportation portals to less developed economies in South America and Asia. The sheer heterogeneity of products exchanged in online markets (B2C and B2B) makes it impossible to assess any effect on substitution of primary raw material and related energy savings. Research on this subject seems to be interesting.

The effects of customer relationship management and consumer activities in the internet are far from being quantifiable. Distributed computing might have important first order environmental effects, but second order effects are assumed to be relatively small. One key effect which is discussed is mass-customisation which reduces errors, inventories and overproduction. The inclusion of these stages into supply chain management, which is well established in big companies, will lead to an even more efficient demand chain management. There is a consensus among experts (e.g. Romm et al. 1999, ABARE 2001, IZT, Borderstep 2002) that supply and distribution chain management are the key for understanding some of the environmental effects of the new economy. Reduction of overproduction and inventory space as well as transport optimisation are the most important effects.

With regard to environmental impact and knowledge the fact sheet for e-business covers:

- B2B and B2C e-business
- Commerce with physical goods
- Supply and distribution chain management, incl. mass customisation & home deliveries
- Effects on waste from daily household and commercial activities, energy consumption, transport volume and modal split

4.2.2 Virtual mobility

The substitution of travel through ICT based communication is called virtual mobility. A lot of passenger transport is due to commuting and business travel which are captured in the segment of work. Shopping and the use of services are the second segment, leisure and engagement travel being the third. On the other hand it is assumed that sophisticated travel information and booking systems encourage leisure and holiday travel, but this aspect is covered under intelligent transport systems.

The main effect of virtual mobility is the reduction of passenger transport. On the other hand there are changes in the energy demand of the domestic and the tertiary sector.

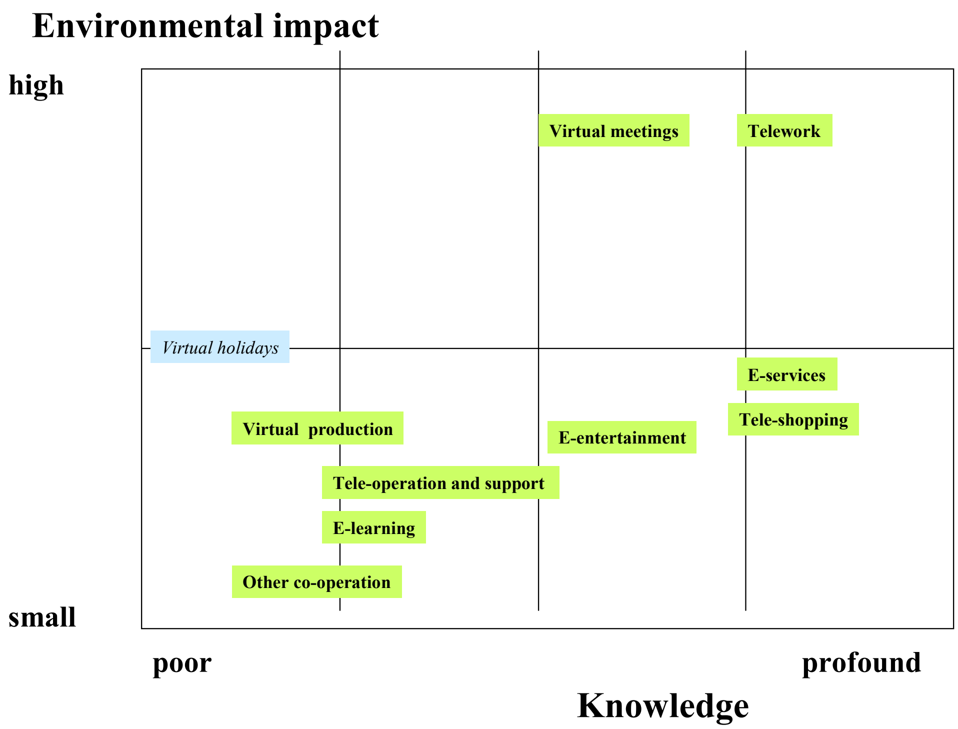
Table 4-11: Synopsis of virtual mobility applications

ICT-application	Description	Effects on environmental indicators	Quality of data
Work			
Telework	Self-employed work at home or dependent work away from office	Potential for reduction of commuting transport (Arnfalk 2002)	well investigated
Virtual meetings	Use of audio and video technology	Potential for reduction of business travel (Siemens reports up to 8%)	first studies available, but macro-effects not well known
Other co-operation	Groupware decision support, common work space and XXL-screens	Effects probably small compared to those above	insufficient knowledge on effects
Shopping and services			
Tele-shopping	Electronic shopping in the internet or mobile	Passenger transport reduced by a maximum of 1% for shopping of daily needed goods (Vogt et al. 2002)	In-depth studies available
Tele-operation and -support	Support for physical goods online (installation, maintenance and repair) or tele-operation of e.g. a washing machine	Small proportion of physical transport affected	few and poor data
e-banking, e-government, e-health and social services	Online services	instead of travel and paperwork, transport reduction potential small because usually combined with other shopping activities (IZT, Borderstep, SFZ 2001)	In-depth studies available
e-learning	Long distance learning like university	Growing importance on a global scale, one movement to another city can be replaced, but only a small amount of transport affected	few and poor data
Leisure, holiday and engagement			
e-entertainment	Virtual reality, MUD and online chat	Might replace physical transport for personal communication, but a small overall potential (Zoche et al. 2002)	In-depth studies available
Virtual production	People produce digitised goods like music, software, independent information (commercial and non-commercial)	Might reduce passenger transport as people do creative things in their free time; probably limited to small groups	insufficient knowledge on effects

Virtual holiday	People don't have the need for holiday travel, because virtual reality is satisfactory	highly speculative application	insufficient knowledge on effects

The following figure shows the estimated impact on the environmental indicators and an assessment of the quality of knowledge:

Figure 4-2: Environmental impact and quality of knowledge for virtual mobility



Source: own assessments, italics (poor knowledge): effects unclear

Scientific discussion has shown that the extent of virtual mobility depends highly on framework conditions like transport prices. Intensive research has been carried out in the field of telework and virtual meetings (e.g. Arnfalk 2002), showing that the significant potentials for transport reduction can be exploited to a high degree under certain conditions.

The effects of ICT based shopping, entertainment and services on passenger transport have been overestimated for long, but they are now quite well investigated. People seem to have almost constant time budgets for physical shopping and doing their things. Very often different service and shopping activities are combined, as a consequence the substitution of a single service doesn't contribute significantly to transport reduction.

Certain potentials for the substitution of leisure, holiday and engagement related travel exist, but they seem to be limited to Internet-addicts and niche groups. Leisure activities and engagement are still carried out to meet physically with people.

With regard to environmental impact and knowledge the fact sheet for virtual mobility covers:

- Telework and virtual meetings
- Effects on energy consumption and passenger transport volume

4.2.3 Virtual goods

ICT enable the virtualisation of all information based goods. Main product categories affected are print, audio, video and software. The exchange media are above all the internet and mobile networks. Location based services might foster the amounts of virtual goods traded, but the development is just beginning.

The key effects expected is a potential for waste reduction and indirectly the reduction of energy consumption in the industry, as the production of physical goods might be avoided. The exchange of virtual goods might also replace some physical travel and deliveries, but total effects are small (see the above section). On the other hand energy demand of the tertiary and domestic sectors may rise.

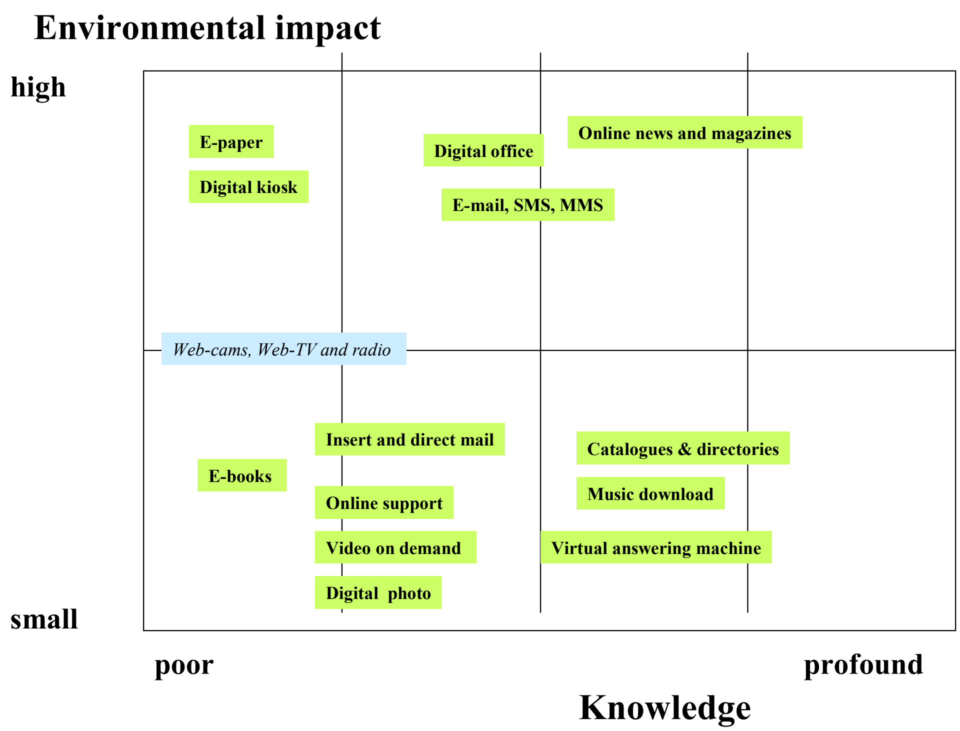
Table 4-12: Synopsis of virtual goods

ICT-application	Description	Effects on environmental indicators	Quality of data
Print			
Online-news and magazines	Widespread use	High potential for paper-reduction, transformation of media markets, (Romm et al. 1999), Dematerialisation and rematerialsation	in depth study available, few quantitative and representative data
Catalogues, directories and information-based books	Selective information	Effects depend on frequency of use, small net effect (Hilty, Hischier 2002)	in depth study available
Digital office	Media interoperability, skipping prints (e.g. scan, process, display, digital archive)	Some best cases but in general paper demand induced by download and print culture (IZT, Borderstep, 2002)	effects known, few quantitative and representative data
Insert and direct mail	Direct advertisement via mails and pop-ups	Small potential (Romm et al. 1999), people increasingly angry	few and poor data
e-mail, SMS, MMS	Key uses of Internet and mobile phones	Letters and post cards replaced (Romm et al. 1999), but high induction effects	single studies available, but no representative data
Online-support	Support for physical goods online (installation, maintenance and repair)	Manuals replaced, but small net effect (Romm et al. 1999)	few and poor data
E-Books	Spread via internet and read on a display	Effects depend on frequency, power consumption, reprint, ...	few and poor data
E-Paper	Paper-like electronic material	Potential advantages compared to paper	speculative
Digital kiosk	Printing of selected articles only	Not in operation but potential for newspaper reduction	effects unknown
Audio			
Music	e.g. MP3-download	Dematerialisation and rematerialsation (Digital Europe 2003)	in depth study available
Virtual answering machine	Central mailbox for voice-mail, e-mail, fax and SMS	27 times less energy than conventional answering machine (GESI 2002)	in depth knowledge available
Video			
Digital photos	Digital cameras and integrated function	Less paper for fewer films developed (EMPA, IZT 2003)	few and poor data
Video on demand	Download of videos	Dematerialisation and rematerialsation	few and poor data
Web-cams, Web-TV and radio	Visual media over IP	substitutes TV- and radio-operation	no studies known
Software	Software downloads	Dematerialisation and	few and poor data

	(new, upgrades, ...)	rematerialsation (Romm et al. 1999)	

The following figure shows the estimated impact on the environmental indicators and an assessment of the quality of knowledge:

Figure 4-3: Environmental impact and quality of knowledge for virtual goods



Source: own assessments, italics (poor knowledge): effects unclear

With regard to the environmental indicator "waste from daily household and commercial activities" the share of CDs, video-tapes and other storage systems is small. Taking rematerialisation and induction effects into account, the reduction potential seems to be negligible.

Regarding the amounts of paper newspaper and cut-size paper are the most important fractions. The crisis of print newspaper in many European countries is in part caused by competition of online media. The vision of a paperless office is fostered by large companies like IBM and Hewlett Packard, on the other hand SME, tertiary and domestic sector are more characterised by induction than substitution effects. Postal letter deliveries in some countries also decline due to competition by electronic messaging, especially by e-mail. New technologies like digital kiosk and e-paper may have an important impact on paper waste, but knowledge is still poor.

With regard to environmental impact and knowledge the fact sheet for virtual goods covers:

- Online news and magazines, digital office and e-messaging
- New technologies (e-paper, digital kiosk)
- Effects on waste from daily household and commercial activities

4.2.4 Energy demand management

ICT-applications for energy demand management have been discussed for long. Main fields of action, according to the shares in total energy demand, are the manufacturing industry, buildings and transport. The estimation of the effects and developments is mainly based on the study "Telematic Applications for Sustainable Energy Management" carried out by IZT, ETSU (1999) and on the ATLAS project (1998).

According to the fields of action main environmental indicators addressed are energy consumption of the industry, domestic and tertiary sector as well as transport. Direct energy consumption of transport is dominated by road vehicles. Despite technological efficiency increases fuel consumption has increased in road transport over the last 10 years. Total energy consumption is mainly affected by transport volume which is covered in the next section. Although there are some direct energy saving potentials in the vehicle sector they are not investigated further. Therefore energy consumption of the transportation sector will be derived from travel volume and modal split.

Table 4-13: Synopsis of ICT-applications for energy demand management in the manufacturing industry

ICT-application	Description	Effects on environmental indicators	Quality of data
Process simulation and planning	Heat and mass balances to model chemical processes to change design, collaborative work, AI, sharing best practices; demand for open standard	Potentials for energy up to 20-30 %, for paper factory 25 % less waste (IZT, ETSU 1999), 2-6 % on average	difficult to separate from process and plant control management systems, potentials speculative
Computer integrated manufacturing	Input, processing and output integrated in enterprise resource planning ERP systems or separate	Potential for steel industry but unlikely as long as energy prices are low	few and poor data
Process and plant control, management systems	Monitoring of outputs, discharges and emissions of plants and factories, demand for open standard	20 % use no management system (IZT, ETSU 1999), Energy saving of 5-10 % for sites (ATLAS 1997)	speculative potentials
Virtual factory	Better understanding of material and energy flows with augmented reality	Add on to process simulation and control	few and poor data
Automated speed drives	ICT controlled motors	Largest single application that contributes to energy efficiency in industry (ATLAS 1997)	speculative potentials
Smart label in production	Optimised logistics and control of process flows	Efficiency gains	few and poor data

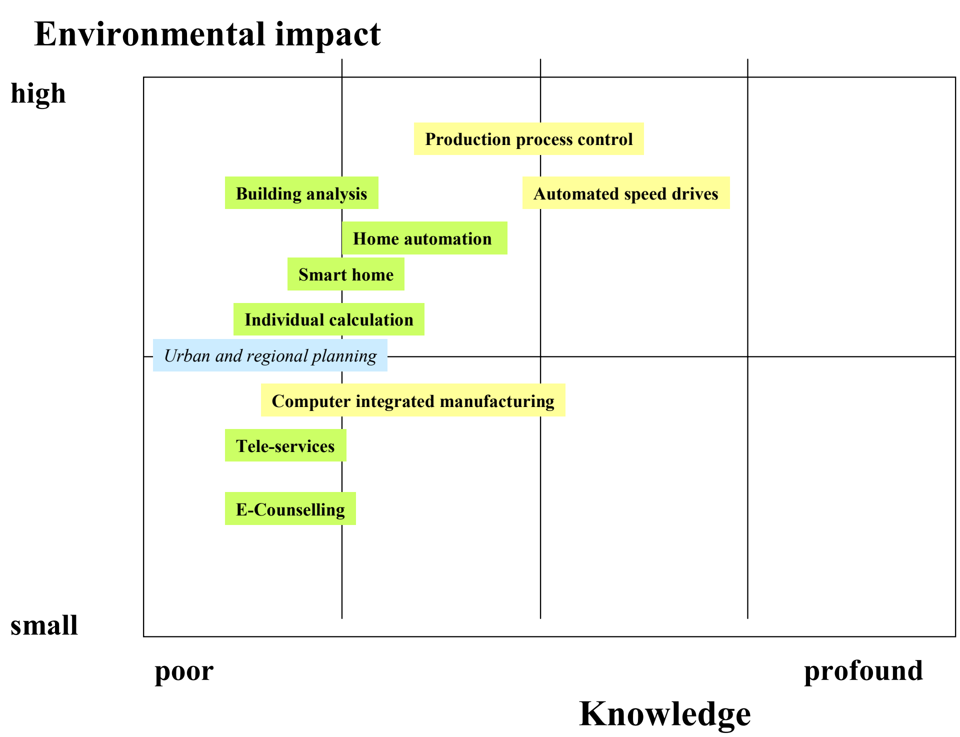
Table 4-14: Synopsis of ICT-applications for energy demand management in buildings

ICT-application	Description	Effects on environmental indicators	Quality of data
Building analysis	Analyse energy performance for building stock, refurbishment simulation and new buildings (data bases, thermograph, simulation)	90 % of buildings used in 2010 already exist, data bases for best practices set-up, simulation on the increase, thermography underdeveloped (IZT, ETSU 1999)	few quantitative and representative data
Urban and regional planning	Environmental Information Systems provide transmission, processing and display of energy relevant data for energy saving optimisation, reduction of building space, short distances	In single regions/cities in use, spacial effects very uncertain (IZT, ETSU 1999)	effects hardly understood
Automation and co-ordination of building maintenance	Controlling and regulating equipment for public, commercial and private buildings (heating, ventilation, air-conditioning, lighting)	Expenditure is high, so mostly used in large buildings (offices, hospitals, airports, ...), private small (ATLAS 1997)	potentials speculative

Smart home	Full integration of ICT, facility management and electronic devices (e.g. fridge)	Cost savings of 15-20 % by avoiding peaks and optimising heating systems (IZT, ETSU 1999), new: context sensitivity (EMPA, IZT 2003)	potentials speculative
Individual calculation	Incentive for efficient use of energy (electricity, water, heating, cooling, ventilation)	Differences around 1/3, pilot projects (IZT, ETSU 1999)	only single case studies known
Tele-services	Tele-maintenance and –management allow outsourcing	Considerable growth expected (IZT, ETSU 1999)	few and poor data
Counselling of house owners and tenants	Information, checks and calculation tools offered by municipalities and consumer organisations	Acceptance unknown, considerable need for training of developers (IZT, ETSU 1999)	few and poor data

Other measures for energy efficiency described in the ATLAS project (1998) have only poor relation to ICT.
The following figure shows the estimated impact on the environmental indicators and an assessment of the quality of knowledge:

Figure 4-4: Environmental impact and quality of knowledge for energy consumption of manufacturing industry and buildings



Source: own assessments, italics (poor knowledge): effects unclear, green: buildings, yellow: industry

The complex field of energy management is broken down by the categories manufacturing industry and buildings.
In large companies of the manufacturing industry ICT is widely used. Significant further energy saving potentials are assumed in the field of production process control and automated speed drives. Computer integrated manufacturing has to be analysed sector-specifically and is coupled closely to process integration. The ICT effect is difficult to determine. The concept of a context-sensitive virtual factory and smart label are other important ICT-applications, which will be covered under production process control. Further reduction of implementation costs and the

introduction of new production lines will make ICT for production process control more attractive.
The field of buildings comprises the sectors industry, tertiary and domestic. As most of the building which will be used in 2020 are already built, the improvement of energy efficiency of existing buildings should be focussed on. Building analysis, individual calculation and management of heat, warm water, ventilation and air-condition as well as light might lead to a significant reduction of the energy demand of by buildings. Electricity consumption plays a minor, but growing role and is mainly a first order effect of ICT which will be covered in a separate fact sheet.
In general quality of data evaluated is quite low, but the heterogeneity of industries and buildings required the evaluation of aggregated sources, which give overviews over the whole sectors.

With regard to environmental impact and knowledge the fact sheet for industry covers:

- Cross-sector perspective: production process control and automated speed drives
- Sector-specific perspective: closer look on energy saving potentials in energy intensive industries
- Effects on energy consumption

With regard to environmental impact and knowledge the fact sheet for buildings covers:

- building analysis, individual calculation as well as home automation and smart home
- Effects on energy consumption

4.2.5 Energy supply management

The field of energy supply covers the whole upstream chain starting from energy usage. Main fields covered are exploration and mining of raw materials, processing, conversion into the desired form of energy (e.g. electricity) and distribution between all stages.

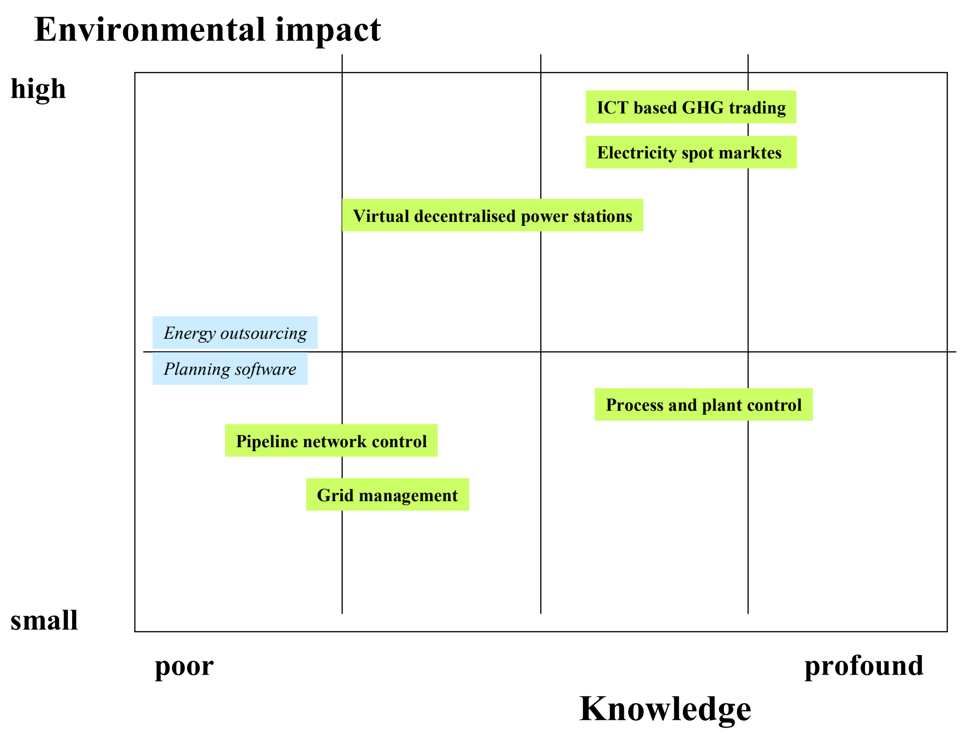
Table 4-15: Synopsis of ICT-applications for energy supply

ICT-application	Description	Effects on environmental indicators	Quality of data
Planning software	Forecasting, resource data basis, supply and demand analysis, CAD and plant modelling	Common standard (IZT, ETSU 1999), effects difficult to determine	poor knowledge
Process and plant control	Monitoring of outputs, discharges and emissions of power stations, refineries, ...	Large plants already fitted with process control tools (IZT, ETSU 1999)	monitored to a high degree
Pipeline network control	Control and remote sensing for oil and gas pipeline leak detection	Leakage still a big problem in Russia, maybe in some acceding countries (e.g. Romania)	nor quantitative and representative data available
Grid management	Real time information for network integration and control	Common standard (IZT, ETSU 1999), small effects assumed	few data available
Electricity spot markets	Real time pricing for electricity	Reduction of peak demands; affects energy mix, price reduction (TAB 2002)	some high quality empirical data available for single markets
Decentralised virtual power stations	Integration of decentralised small renewables and co-generation facilities	Support of renewables and co-generation (Siemens), framework conditions crucial	only pilot studies

Satellite supported wind and solar energy prognosis	Forecasts for radiation intensity and wind velocity to maximise renewables share	Support of renewables, but small net effect	only pilot studies for direct integration in virtual decentralised power stations
Energy outsourcing	External energy supply of the manufacturing industry	Use of economies of scale gives incentives for energy saving measures (ABARE 2001)	effects of ICT on energy outsourcing have not been explained
ICT based GHG emission trading	Within companies (e.g. BP) or between companies (Kyoto mechanism)	Efficiency rises and changes in energy mix	Many reliable studies available

The following figure shows the estimated impact on the environmental indicators and an assessment of the quality of knowledge:

Figure 4-5: Environmental impact and quality of knowledge for energy supply



Source: own assessments, italics (poor knowledge): effects unclear

Although discussed as an ICT impact in some studies, energy outsourcing is considered to be influenced to a low degree by ICT. Energy contracting has been carried out for long and usage of economies of scale is a requirement due to increased competition.

In the energy industry many ICT-applications like planning software and grid management are state-of-the-art. Key ICT-based applications with high impact and profound knowledge are Greenhouse Gas emission trading and electricity spot markets which rise efficiency and lead to a changed energy mix. Furthermore virtual power stations can contribute to the integration of renewables and CHP into the electricity grid.

With regard to environmental impact and knowledge the fact sheet for energy supply covers:

- GHG emission trading, electricity spot markets and virtual decentralised power stations
- Effects on energy consumption, share of renewables as well as GHG emissions.

4.2.6 Intelligent transport systems

Dozens of telematic applications for mobility and traffic management have been discussed and partly implemented in the last years. They mainly aim at giving travel information and monitoring as well as optimising traffic flows. The assessments below are mainly based on the study “Telematic Applications for Sustainable Energy Management” carried out by IZT, ETSU (1999).

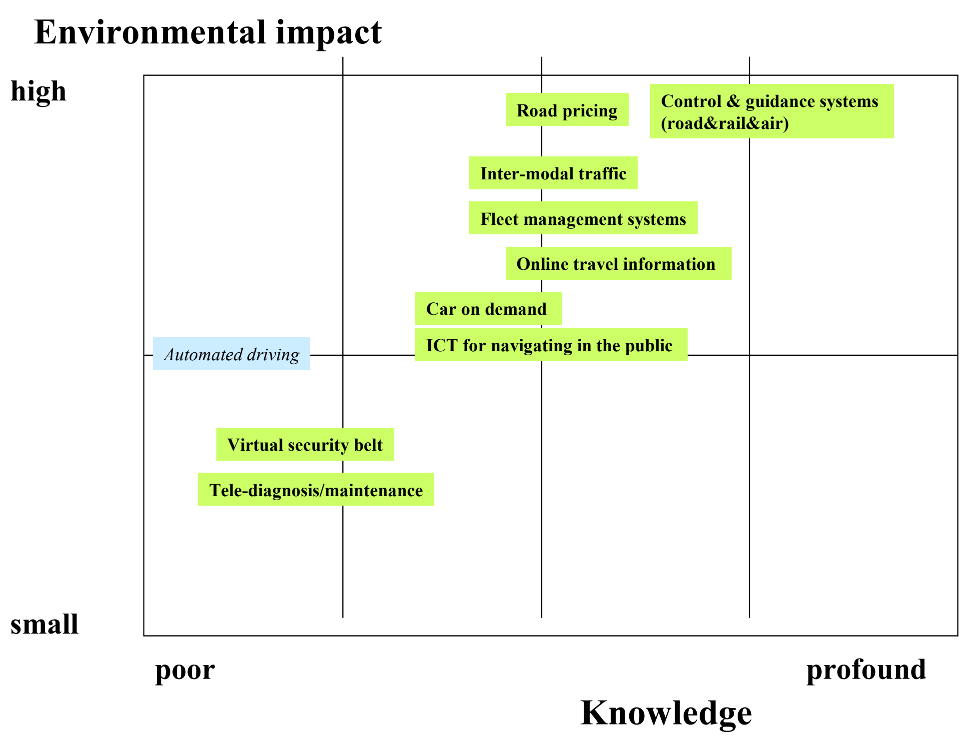
The biggest part of transport volume (passenger and freight) is caused by road traffic, which should therefore be highlighted. Additionally travel information for all means of transport is vulnerable to deep changes which will affect the total level of mobility.

ICT-application	Description	Effects on environmental indicators	Quality of data
Monitoring and information systems			
Traffic monitoring systems	Information about traffic flows and patterns, infrastructure conditions, weather, incidents, etc. (air, land, sea)	In use in all European countries especially for road and air, becoming more sophisticated	lack of quantitative data
Advanced information systems for public transport	Information on time-tables, tariffs, delays connections, alternatives	Potential for better pre-trip and on the way information, booking; in future mobile (PTA)	scattered information, poor knowledge of effects
Integrated traffic information systems	Interface management for inter-modal transport for individuals and commercial users, common data pools and information processing	Development potential, growing complexity (eEurope 2002)	overall potentials difficult to estimate
e-tourism	Travel information online	Seems to stimulate mobility need (Zoche et al. 2002)	in-depth study available
Road			
Advances speed control and management systems	Maximising capacity/efficiency of transportation infrastructure by harmonising traffic flows	Many pilot projects for advanced speed control and detection (eEurope)	good empirical data
Automated driving	Velocity and direction	Higher capacity use, effects unclear	poor knowledge about effects
Drivers assistance systems	Intelligent tempomats, adaptive gear-and power management, street signals on display	Reduction of fuel consumption and incidents (17%)	Few independent data sources
Road traffic management (access and area control)	Control and limitation of access of additional vehicles (congested sections, inner cities)	Growing complexity, potential for energy savings	Many case studies evaluated
Freight and fleet management applications	Optimising routes and capacity of a single carrier (digital maps, navigation systems)	Lower energy consumption due to higher capacity usage and shorter distances (treated under e-business)	few up to date data available for the public
Freight capacity pooling	Multitude of carriers	High potential but obstacles because of competition (revenue sharing), (treated under e-business)	few up to date data available for the public
Car pooling	Capacity pooling for private and business travel, matching supply and demand	Huge potential for optimisation of occupancy and distances	no quantitative and representative data available
Car sharing	Many people share a common	Aim is reduction of cars	good data sources

	pool of cars	needed, but lower mileage	available
Demand management	Road pricing, variable in time and place	Significant benefits, pilot projects	Many case studies evaluated
In-car navigation systems	Dynamic routing	Reduction of transport volume by 15% (Schenker)	few up to date data available for the public
Tele-diagnosis/-maintenance	Remote control	Higher reliability and optimisation of model series	effects highly speculative
Virtual security belt	Sensors for distance keeping	Less incidents and congestion	Few independent data sources
Rail			
Virtual train coupling	Optimising distances	High potential	Potentials speculative
Driving advice systems for energy optimisation	Real-time advice (e.g. signals in 3 km)	unknown	Potentials speculative
Full automated driving	No driver interaction in regular operation	Increase in transport capacity by up to 100%	Potentials speculative
Computer controlled drive in stations	Minimising braking and acceleration	Energy saving potential of 20%	Potentials speculative

The following figure shows the estimated impact on the environmental indicators and an assessment of the quality of knowledge for main application fields:

Figure 4-6: Environmental impact and quality of knowledge for intelligent transport systems



Source: own assessments, italics (poor knowledge): effects unclear

There is plenty of profound knowledge about the effects of intelligent transport systems. High effects on transport volume and modal split are expected especially for control & guidance systems for road, rail and air. But there is also a lot of in-depth knowledge for inter-modal

traffic, fleet management systems, online travel information, and to a lesser degree for car on demand and ICT for the purpose of navigation in the public.
The European Union has set-up ambitious goals for the transportation sector in the eEurope initiative:

- "50% of Europe's major towns and cities ought to be provided with traffic and travel information services,
- 50% of Europe's major motorways ought to be equipped with systems to manage traffic and to detect accidents and congestion, [...]
- legislative initiatives should be taken to promote the Single European Sky, mobile communications for trains, maritime information and control systems, and Galileo."

The most important impact is expected for road transport (eEurope 2002). The potential of Intelligent Transport Systems (ITS) has been estimated to reduce journey times of up to 20 % and to increase network capacity by 5-10 %. Safety will improve by 10-15 %. ITS include telematic systems for data collection, travel control and/or road information centres. Basis traffic management plans, pre- or on-trip information, freight management services (e.g. for inter-modal traffic) and electronic road-charging systems shall be introduced with priority. In-car navigation systems will become a standard in cars and trucks probably soon. The deployment of Galileo will enable many sophisticated LBS.
With regard to environmental impact and knowledge the fact sheet for energy supply covers:

- Intelligent transport systems for road, air and rail as well as travel information
- Effects on transport volume and modal split

4.2.7 Waste management

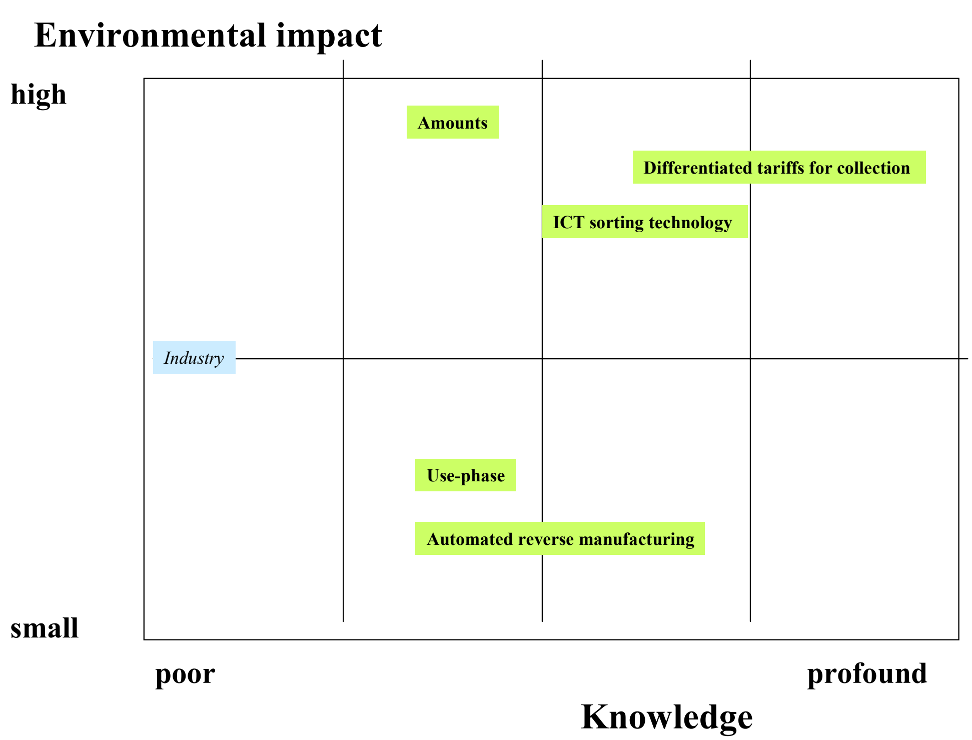
Although ICT waste is growing significantly it has just a small share of "waste from daily household and commercial activities". Main fractions of this category are bagged waste (feed/organic, packaging) and to a lesser degree glass and paper.
ICT and its applications on the one hand affect the amount of waste from daily household and commercial activities, on the other hand the amounts collected and recycled.

ICT-application	**Description**	**Effects on environmental indicators**	**Quality of data**
Amount of waste			
Smart fridge	Information about decay and automated ordering	feed and packaging waste might decline by improved consumption	see e-business-chapter
Virtual goods	see extra chapter	see extra chapter	see extra chapter
ICT waste	see ICT use chapter	see ICT use chapter	highly speculative future projections
EE-appliances	e.g. one-way digital camera and handy	Declining lifetimes	poor knowledge
Mechanical products	e.g. clothing	Declining lifetimes	no empirical data yet
Smart label for daily goods	Finding of lost or stolen goods	Products don't need to be bought again	no valuable studies known
Industry			
Package design	Minimisation with ICT tools	Waste reduction potentials unknown	ICT influence highly speculative
Life Cycle management	LCA software, waste scenarios	High impact assumed (e.g. packaging LCAs as basis for legislation), but very soft correlation to measures	ICT influence highly speculative
Smart Label	for product recycling information	Registering used products, mainly valuable for medium and long-living	no study known

		goods (e.g. for WEEE)	
Use phase			
Leasing, pooling, sharing, upgrading, refurbishment, renting, take-back, consulting	Most services make only sense for long lived products	only consulting e.g. on packaging has a significant potential, but ICT based is not probable	many studies available
Downstream			
Differentiated tariffs for waste collection	ICT based measurement of waste amounts enables pricing systems with incentives	Significant changes in waste streams reported from Denmark	single in-depth analysis
Retro-logistic	See above (fleet management, ...)	Already optimised	see intelligent transport systems
Reverse Manufacturing	Only useful for long-lived goods	Not applicable	single pilot projects
ICT sorting technology	IR and other sorting technologies may lead to clean fractions	Less waste landfilled/burned	scattered information
Smart Label in packaging recycling	Smart labels on packages may spoil the quality of secondary raw materials	Adverse effect	No empirical evidence up to now

The following figure shows the estimated impact on the environmental indicators and an assessment of the quality of knowledge:

Figure 4-7: Environmental impact and quality of knowledge for waste management



Source: own assessments, italics (poor knowledge): effects unclear

The amount of waste is dominated by the fractions organic/food and packaging in the bagged fraction. The amount of food/organic can be significantly reduced by supply chain and demand chain management and will therefore be derived from the e-business fact sheet. The amounts of paper and ICT waste can be collected from the separate fact sheets for virtual goods and ICT use. However there is no profound knowledge on the future amounts of waste, which take into account the various influences of ICT.
The future potential of ICT for further optimisation of packaging is considered to be very speculative. Extension of the use-phase and reverse manufacturing mainly apply to long-living goods which are just a small fraction of waste from daily household and commercial activities.
Main effects by ICT in the downstream phase are expected for differentiated tariffs for waste collection. They will give an incentive to reduce total amounts of waste as well as for separate collection of packaging, especially plastics. ICT based sorting technology enables separation of fractions which can be recycled. On the other hand pervasive usage of Smart Labels on packaging might lead to quality problems in the recycling processes, especially in the case of glass.

With regard to environmental impact and knowledge the fact sheet for waste management covers:

- Differentiated tariffs for collection and ICT sorting technology
- Effects on waste from daily household and commercial activities
- Amounts of waste are derived from the e-business, virtual goods and ICT use chapter.

4.3 Conclusion

The following table summarises the scope of the in-depth analysis of ICT-applications in brief. The fact sheets envisaged are found in the first column. The main effects of the selected applications on the environmental indicators are indicated in the other columns:

Table 4-16: Scope of the in-depth analysis

	freight transport	**passenger transport**	**modal split**	**energy consumption**	**Share of renewables**	**GHG emission**	**Daily waste**
First order							
ICT industry				x(i)			
ICT use				x(d, t)			x(d, t)
Second and third order							
E-business	x	x		x(i, t)			x(d, t)
Telework & virtual meetings		x		x(d, t)			
Virtual goods							x(d, t)
Waste management							x(d, t)
Intelligent transport systems	x	x	x				
Energy supply				x(d, t, i)	x	x	
Facility management				x(d, t)			
Production process management				x(d,t)			

i: industry, d: domestic, t: tertiary

Energy consumption of transport can be derived from transport volume and modal split by applying specific consumption factors.
In general GHG emissions can be calculated from the energy consumption or transport volume by multiplication with emission factors, taking into account the energy mix and modal split.
Urban air quality is discussed qualitatively taking into account local aspects.

5 FACT SHEETS

The 10 areas identified in chapter 4 are analysed in detail in the framework of fact sheets. This chapter refers to workstep 2.2, in which factors/events that influence the uptake of ICT-applications and the environmental indicators are studied and main uncertainties elaborated.

The fact sheets have the following structure:

1. Definition and scope
2. Data for diffusion
3. Data for environmental indicators
4. Variables
5. External factors

Each fact sheet shall be readable separately.

A pre-test for the workflow between the different tasks was carried out for the effects of home-based telework on passenger transport, which has led to the structure of the fact sheets.
The definition and scope indicates the coverage of the fact sheet. The data for diffusion and environmental indicators are on the one hand the data base for the modelling (Task 4), on the other hand main factors/events and their uncertainties can be derived from the analysis of studies. and condensed to variables and factors.[5] These variables and factors serve as a main input for the scenario building (task 3).
In defining the variables the available data was considered and a unit was chosen. The effect of the variables on diffusion and environmental effects are described by a rationale.[6] They are summarised below the paragraph together with an estimation of the uncertainty of the variable (low, middle, high). The trends and developments of the ICT sectors in chapter 3 are one important source for the assessment of technological and economic uncertainties.
In task 3 additional variables are identified and analysed together with the variables extracted in this script, which reflects the mainstream scientific views. To identify the influence of policy options on the environmental indicators (task 5) some policy options are already identified in the script, others will be gathered in the scenario-building (task 3).
The relationship to external factors has been characterised in a table, giving a brief estimation of the trend, uncertainty, variables affected and a rationale. Important external factors have been derived from chapter 2.2, others are very specific, such as the number of driving license tenders.

5 background: see chapter 2

6 ↑ the higher the value of the variable the higher the diffusion/transport reduction

↓ the higher the value for the variable the smaller the diffusion/transport reduction

5.1 ICT industry

The ICT industry is characterised by it's complexity, growth and dynamic change. For this it is very difficult to give a coherent picture of the effects on the environmental indicators. There are some studies on single industries, but the picture is incomplete. Therefore attempts to reflect the whole sector have been undertaken, e.g. by Digital Europe. Despite poor knowledge about the future course of the ICT industry it can be addressed by political measures to minimise waste from daily household and commercial activities, as well as energy demand and CO2-emissions.

5.1.1 Definition and scope

The OECD classification of the ICT industry refers to the ISIC Rev. 3.1 definitions. The ICT sector is divided into manufacturing and services:

Table 5-1: OECD classification of the ICT sector related to ISIC Rev. 3.1

Manu-facturing		Services	
3000	Office, accounting and machinery equipment	5150	Wholesaling of machinery, equipment and supplies (if possible only wholesaling of ICT goods should be included)
3130	Insulated wire and cable	7123	Renting of office machinery and equipment (including computers)
3210	Electronic valves and tubes and other electronic components	6420	Telecommunications
3220	Television and radio transmitters and apparatus for line telephony and telegraphy	72	Computer and related activities
3230	Television and radio receivers, sound or video recording or reproducing apparatus and associated goods		
3312	Instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process equipment		
3313	Industrial process equipment		

5.1.2 Data for diffusion

There are no systematic and comprehensive production statistics for the ICT industry in the European Union, which are related to the physical output. But there are some statistics on the number of enterprises, value added and external trade. To give a coherent picture the complete data for 1999 is given for EU15, although there are single data for 2000 and 2001.

Table 5-2: Number of enterprises in the ICT sector (thousands)

	Total ICT sector	**ICT manufacturing**	**ICT services**	**of which telecommunication services**
EU15	442	44	397	13
B	8,9	0,2	8,7	0,3
DK	7,3	0,6	6,7	0,2
D	57,4	6,5	51,0	0,6
EL				
E	22,9	1,6	21,3	1,0
F	49,5	6,9	42,6	2,4
IRL		0,2		
I	90,4	14,3	76,1	0,6
L	0,9	0,0	0,9	0,0
NL	5,7	1,2	4,5	0,8

A	7,9	0,4	7,4	0,2
P	4,1	0,6	3,5	0,1
FIN	5,5	0,7	4,8	0,2
S	24,0	1,8	22,2	0,3
UK	143,1	9,4	133,7	5,9

Source: Deiss 32/2002

Of the 442.000 ICT enterprises in 1999 almost one third was situated in UK, 20 % in Italy and in Germany and France 13 % and 11 % respectively. The service sector accounts for almost 90 % of the total number of enterprises in the ICT sector. With 37.100 ICT manufacturing enterprises the countries Italy, UK, France and Germany account for more 84,3 % of all manufacturing enterprises. The number of ICT enterprises in all countries has risen in the two years before, in the ICT service industries more than in the manufacturing industries.

Table 5-3: Value added at factor costs in the ICT sector (billion €)

	Total ICT sector	**ICT manufacturing**	**ICT services**	**of which telecommunication services**
EU15	365,000	95,000	270,00	131,000
B	9,340	1,824	7,516	3,744
DK	6,934	1,199	5,735	2,330
D	88,794	21,941	66,853	29,099
EL				
E	14,895	2,942	11,953	7,455
F	36,019	16,700	19,319	
IRL		4,666		
I	33,535	7,345	26,191	14,441
L			892	567
NL		1,348		
A	7,840	2,728	5,112	2,555
P	4,178	768	3,410	2,514
FIN	8,949	5,066	3,883	1,886
S	11,803	5,218	6,585	
UK	88,518	19,961	68,558	26,402

Source: Deiss 32/2002

The total value added at factor costs of the ICT sector in the EU15 was 365 billion €, with services accounting for about ¾ and manufacturing for ¼. Even telecommunication services surmounted value added by manufacturing.

The value added at factor costs in the ICT sector in the EU ranges from 2,6 % in Spain and the Netherlands over the average of the 13 EU countries below 4,6 %, up to 7,4 % in Finland.

Table 5-4: Value added VA at factor cost in the ICT sector relative to GDP, 1999 (%)

Country	**E**	**NL**	**F**	**I**	**P**	**B**	**A**	**DK**	**D**	**EU15**	**IRL**	**S**	**UK**	**FIN**
VA [%]	2,6	2,6	2,7	3,0	3,9	4,0	4,0	4,2	4,5	4,6	5,1	5,2	6,5	7,4

Source: Deiss 32/2002

Table 5-5: External trade in ICT goods (billion €), 2000

	Import	Export	Apparent trade balance
EU15	190,280	125,087	-65,194
B	16,794	13,982	-2,811
DK	6,873	5,428	-1,445
D	78,812	68,941	-9,871
EL	2,750	613	-2,137
E	16,799	7,376	-9,423
F	49,009	43,293	-5,716
IRL	19,035	28,746	9,710
I	27,005	14,840	-12,165
L	1,980	1,885	-95
NL	55,612	53,906	-1,706
A	9,831	6,962	-2,869
P	4,077	2,286	-1,791
FIN	7,138	12,658	5,520
S	13,705	18,657	4,952
UK	75,867	63,283	-12,584

Source: Deiss 32/2002

The trade deficit of the EU15 in 2000 was 65 billion €, which decreased to 51 billion € in 2001. The decreasing trade gap is a trend break. How it will develop in the future is highly uncertain.

The markets for manufacturing of ICT show very different trends. As there is no breakdown by industry three illustrative examples are given qualitatively to give picture of a possible future of ICT in Europe:

- CRT glass manufacturing: The production of CRT in the EU15 is limited to 5 companies, Schott Glas, LG.Philips Displays, Samsung, Thomson and N.E.G. With regard to production costs these companies face stiff competition from production sites in South East Asia. In the short term some production is shifted to the Accession countries, especially Czech Republic and Hungary. Furthermore CRT-glass for desktop monitors will be replaced to a high degree by other technologies like LCDs, which are only produced in South East Asia. In the long-term no CRT-glass might be produced in EU15.
- Mobile phones: Sharply risen demand for mobile phones has lead to lively markets for end devices. Companies like Ericsson (Sweden), Nokia (Finland) and Siemens (Germany) erected production lines for mobile phones, which were sold below production costs in order to have a foot in the market. These companies still produce in the EU, but the hype seems to be over. It is uncertain whether customers will accept to pay for UMTS services and end devices. There are indications that many customers are satisfied with the exiting 2nd generation mobile telecommunications technology.
- Semiconductors: The development and production of chips requires a lot of R&D and related skills, as well as advanced production facilities. Strength in R&D related skills was one of the decisive factors for AMD and Infineon to produce chips in Dresden (Germany). As R&D is quite strong in EU this might be an area, in which Europe could be competitive. On the other hand many plants will shift their production, if world markets and competition requires it.

With regard to the production of new ICT it is likely that only the technologies have a chance to be produced in the European Union, in which R&D in the EU is highly competitive. A look at the IPTS technology maps unveils for example strength in 1 Mega Neurochip technology (expected 2010-2012) and industrial and home sensor/actuator networks (2004-2008). However the relation to production is very weak. A not so unrealistic scenario is that most of ICT hardware will have to be imported into the EU in 2020.

Limitations to knowledge
No systematic comprehensive statistics for the number/weight of manufactured goods and frequency of provided services by the ICT sector in the European Union are available.
Therefore generic economic data have to be used. The complexity of the sector can be handled better with aggregated indicators than with bottom up approaches. There are some data gaps for economic data of the EU15 countries. The same applies to the Accession Countries.
The total demand for ICT products will highly depend on the diffusion of ICT-applications. The share of imported goods is highly uncertain.

5.1.3 Data for environmental indicators

There are some single studies on the energy demand for ICT products:

- Every **chip** generation reduces in size by a factor of 0,7 (Schauer 2000). The production of a single chip requires 41 MJ of energy (Williams et al. 2002).
- Older studies showed a range between 9,5-37,5 GJ primary energy demand for a **PC**. Atlantic Consulting (1998) has estimated primary energy demand of a PC, including material production, manufacture and distribution, to 3,6 GJ of energy. Reichardt and Hischier (2001) are very close with 4 GJ. Energy efficiency has risen sharply but the differences may be also caused by different system boundaries and assumptions.
- It is estimated that only 2 % of the **material flows from production** are contained in ICT and 98 % are waste (IZT, EMPA 2003).

Many other examples could be added without giving a coherent picture of the future course of ICT. Knowledge about environmental impacts of the manufacturing of new technologies, such as e-paper or wearables, is even poorer.

An assessment of the environmental impact of the ICT industry is limited by the following factors:

- the heterogeneity of products and services (e.g. processors for different purposes, components, PCBs, computer, displays, embedded ICT, ...)
- the complex and rapidly changing production patterns (e.g. a chip plant with 400 sub-processes, different processes integrated into one single plant, 200 different and rapidly changing suppliers, ...)
- poor knowledge (e.g. data secrets, few specific data, allocation methodology of infrastructure, service structure ...)
- practical reasons (e.g. in depth LCA of a chip plant requires so much time that production will have changed when LCA is published).

Although there are severe difficulties in the assessment of the environmental impacts of ICT manufacturing and services some macro-economic data are available for energy demand and CO2-emissions and general strategies for environment-friendly can be outlined.

5.1.3.1 Macro-economic data

A macroeconomic assessment of energy demand and GHG-emission of the ICT industry has been calculated by Digital Europe (2003a). It is differentiated between direct and cumulated CO2-emissions and energy demand. Cumulated emissions and energy demand also consider the upstream processes. The data provided is based on input-output calculations. However there is some double counting, so that an aggregation for the whole economy doesn't make much sense, but comparisons between selected sectors are possible.

The OECD sector definitions have been related to the NACE 2-digit divisions. The following allocations have been made (Digital Europe 2003a):

- Manufacture of office machinery and computers (NACE No. 30): OECD 3000
- Manufacture of radio, television and communication equipment and apparatus (NACE No. 32): OECD 3210, 3220, 3230
- Manufacture of medical, precision and optical instruments, watches and clocks (NACE No. 33): OECD 3312, 3313
- Post and telecommunications (NACE No. 64): OECD 6420
- Computer and related activities (NACE No. 72): OECD 72

The OECD numbers 3130 (insulated wire and cable), 5150 (wholesaling of machinery, equipment and supplies) and 7123 (Renting of office machinery and equipment (including computers)) have not been used, "since NACE 2-digit division is too broad" (Digital Europe 2003a).
There is comprehensive data for primary energy and CO2-emissions (direct and accumulated for the year of 1995 and 1997) in Germany. For Italy there are only data on direct CO2-emissions for the years of 1990 and 1992. For UK there are only data on direct CO2-emissions for 1995 and 1998. For both, UK and Italy the category "Computer and related activities" is not displayed separately.

Table 5-6: Primary energy demand and intensity (direct and accumulated) of the ICT sector in Germany 1997

	GVA		Primary energy		Cumulated primary energy	
	million €	% of total GVA	PJ	MJ/€ GVA	PJ	MJ/€GVA
Manufacture of office machinery and computers	3.067	0,18	8	2,6	39	12,6
Manufacture of radio, television and communication equipment and apparatus	8.566	0,51	28	3,2	122	14,2
Manufacture of medical, precision and optical instruments, watches and clocks	14.517	0,86	22	1,5	135	9,3
Post and telecommunications	40.364	2,39	30	0,7	106	2,6
Computer and related activities	25.527	1,51	12	0,5	43	1,7
ICT	92.041	5,44	100	1,1	444	4,8
Total	1.691.090	100,00	14.601	8,6	22.118	13,1

Source: Digital Europe 2003a

The total ICT sector has a direct primary energy intensity which is far below the average of the economy. Post and telecommunications have extremely low values, but the manufacturing processes also stay far below the average values for the total economy.
If cumulated primary energy demand of the ICT sector is related to total primary energy demand, the percentage is about 2 %, whereas the share is only 0,68 % for direct energy demand. Although not directly comparable, the cumulated primary energy demand for manufacture of ICT is assumed to be in the same magnitude as for the average. This is mainly due to high energy demand for the processing of raw materials into high quality intermediate products. Examples are high grade semiconductor material, glass for CRT and pure heavy metals, such as copper and gold for Printed circuit boards. Cumulated primary energy demand of post and telecommunications as well as for computer and related activities is significantly below the average.

Table 5-7: CO2-emisssions and intensity (direct and accumulated) of the ICT sector in Germany 1997

	GVA		Direct CO2-emissions		Cumulated CO2-emissions	
	million €	% of total GVA	1000 t	kg CO2/€ GVA	1000 t	kg CO2/€ GVA
Manufacture of office machinery and computers	3.067	0,18	258	0,0841	2.165	0,7058
Manufacture of radio, television and communication equipment and apparatus	8.566	0,51	1.091	0,1274	6.716	0,7840
Manufacture of medical, precision and optical instruments, watches and clocks	14.517	0,86	850	0,0585	7.614	0,5245
Post and telecommunications	40.364	2,39	1.034	0,0256	6.137	0,1520
Computer and related activities	25.527	1,51	603	0,0236	2.443	0,0957
ICT	92.041	5,44	3.836	0,0417	25.075	0,2724
Total	1.691.090	100,00	892.743	0,5279	1.334.633	0,7892

Source: Digital Europe 2003a

For CO2-emissions the picture is similar to that of primary energy demand as most of the emissions are due to the use of energy.

In Germany "Computer and related activities" account for more than 25 % of the ICT sector's GVA. As there is no data for this category for UK and Italy, the picture in these countries is incomplete and only single aspects can be compared with Germany. Data for Italy are very old, from 1992, for UK from 1998 and for Germany from 1997.

Table 5-8: Direct CO2-emissions of the ICT sector in Italy 1992

	GVA		Direct CO2-emissions	
	million €	% of total GVA	1000 t	kg CO2/€ GVA
Manufacture of office machinery and computers	6.499	0,92	384	0,0591
Manufacture of radio, television and communication equipment and apparatus	3.389	0,48	127	0,0375
Manufacture of medical, precision and optical instruments, watches and clocks	5.542	0,79	2.093	0,3776
Post and telecommunications	14.518	2,06	1.451	0,0999
Computer and related activities	n.a.	n.a.	n.a.	n.a.
ICT[7]	24.118	3,41	1.779	0,0472
Total	705.916	100,00	462.372	0,6550

Source: Digital Europe 2003a

[7] The share of GVA is 3,41 % in the tables and the text, but calculating with the numbers, 4,24 % and a total amount of 29.948 million € would have been expected.

Table 5-9: Direct CO2-emissions of the ICT sector in UK 1998

	GVA		Direct CO2-emissions	
	million €	% of total GVA	1000 t	kg CO2/€ GVA
Manufacture of office machinery and computers	5.627	0,46	107	0,0190
Manufacture of radio, television and communication equipment and apparatus	10.011	0,81	465	0,0465
Manufacture of medical, precision and optical instruments, watches and clocks	7.326	0,60	259	0,0354
Post and telecommunications	34.969	2,85	1.664	0,0476
Computer and related activities	n.a.	n.a.	n.a.	n.a.
ICT	57.933	4,72	2.495	0,0431
Total	1.228.417	100,00	580.342	0,4724

Source: Digital Europe 2003a

The direct CO2- emissions related to GVA for "Manufacture of office machinery and computers" ranges from 0,0190 kg CO2/€ GVA in UK over 0,0591 kg CO2/€ GVA in Italy to 0,0841 kg CO2/€ GVA in Germany. More than a factor four lies between UK and Germany.
"Manufacture of radio, television and communication equipment and apparatus" accounts for 0,0465 kg CO2/€ GVA in UK, 0,0375 kg CO2/€ GVA in Italy and 0,1274 kg CO2/€ GVA in Germany. More than a factor four lies between Italy and Germany.
"Manufacture of medical, precision and optical instruments, watches and clocks" has a direct CO2-emission intensity of 0,0354 kg CO2/€ GVA in UK, 0,3776 kg CO2/€ GVA in Italy and 0,0585 kg CO2/€ GVA in Germany. The value for Italy is roughly one magnitude over the values for UK and Germany.
"Post and telecommunications" in UK, Italy and Germany account for 0,0476, 0,0999 and 0,0256 kg direct CO2 emissions/€ GVA. Almost a factor four lies between Germany and Italy.
For "Computer and related activities" there is just one figure for Germany (direct CO2-emissions): 0,0957 kg CO2/€ GVA.

It is assumed that the country specific differences rather reflect the very heterogeneous product spectrum in the categories than the efficiency of manufacturing processes. In the case of Italy the age of data might be another decisive factor.

However, if the total direct CO2-emissions of the ICT-sector are taken into account the differences are quite small:

- 0,0417 kg CO2/€ GVA for Germany
- 0,0472 kg CO2/€ GVA for Italy
- 0,0431 kg CO2/€ GVA for UK

Since heterogeneity of products, intermediate products and services of the ICT sector (within the categories listed in the statistics) is enormous, it seems to be justified to estimate average CO2-emissions and primary energy demand by intensity values and total GVA until 2020. The current actual contributions to primary energy demand and CO2-emissions are in the magnitude of 0,5-2 %. A second wave of ICT in the next years, for example due to pervasive computing, could increase the environmental impacts sharply by a factor of 2 or more.

5.1.3.2 Strategies for environmental-friendly ICT industry

A key characteristic of ICT is the coupling of software and hardware. In other electronic devices software is usually integrated and the functions of the product stay the same over the whole lifetime. The software facilitates multi-functionality and flexibility. New functions do not require necessarily new hardware.
The high innovation dynamics of the ICT industry is driven by competition and Moore's law, whereas demand has played a minor role. The fast product generation cycles lead to a rapid decline of the value of hardware and to a certain degree to software as well. Reasons are (EMPA, IZT 2003):

- relative performance drain
- incompatibility to peripheral hard- and software
- new generations of data storage systems
- fashion

The trend towards pervasive computing will push this trend:

- increasing innovation dynamics for pervasive computing hardware and applications
- incompatible interfaces, protocols and data formats
- compatibility and technological level are prerequisites for embedding of ICT
- coupling of short-living ICT with long-living products may reduce lifetime of the whole system.

From a policy perspective strategies to minimise the effects of ICT on the environmental indicators are to be addressed. The general strategies are:
1. Eco-design: miniaturisation, durability (life time), substitution of hazardous substances and design for recycling, energy efficiency
2. Optimisation of processes: increasing production yield and reduction of emissions, waste and by-products
3. Eco-usage: extension of usage time, intensification of usage, stimulation of sufficiency
4. Recycling: recycling of production waste (internal/external), recycling in the use phase, collection and logistics, component and material recycling

With regard to the environmental indicators covered in this study the following aspects are important:

Eco-design
Miniaturisation of ICT devices is encouraged by market forces, however rebound effects counteract to an unknown degree.[8] The amount of waste from daily household and commercial activities is hardly affected by the substitution of hazardous substances, fostered by the EU RoHs directive. On the other hand industry is a key player in energy efficient design of their products and design for recycling.

- Certification schemes such as Energy Star and Blauer Engel exist for a couple of ICT products, such as computers and printers. Keeping the concept of pervasive computing in mind this strategy has also it's limits, because the sheer mass of product classes containing ICT and individual solutions are practical obstacles for covering this field.
- Design for recycling might be stimulated by a future EU directive on the eco-efficient design. The existing draft is heavily disputed. It provides an assessment of environmental burdens over the life-cycle as well as provision of information for recycling, which might be provided by a smart label. Easy disassembly has to be dealt with as well.
- Keeping in mind the concept of pervasive computing design for recycling doesn't have to be applied only to ICT in a narrow sense, but for all goods with embedded ICT. Wearable might have more the character of electronic waste than of clothing waste. The scope of the WEEE-Directive might have to be enlarged in the future. The ubiquitous use of Smart labels on goods, especially on packaging, might lead to quality problems

[8] Rebound effects of miniaturisation are very complex. As shown for mobile phones and the technology shift from CRT- to LCD-monitors market developments and weight have to be analysed over long timelines. In the case of LCDs for example capital intensive production has strengthened the pressure to increase the output, not only for LCDs for computers but also for new applications like navigation systems, washing machines and so on (IZT, EMPA 2003).

in the recycling of fractions like glass and aluminium, because of copper contained in the micro-antenna (EMPA; IZT 2003).

Rapid innovation cycles in the ICT industry and the high advantages of being the first on the market limit the effects of the Eco-design strategy. This is not the case for products where there is a market incentive for low energy demand, such as mobile phones.

Optimisation of processes

Optimisation of processes is driven by market forces in many cases. The example of LCDs shows that cost reduction by increased process yield is one of the crucial criteria for competitiveness. Many ICT processes require a very clean environment (air), so that there is an incentive to minimise pollution of the neighbourhood. On the other hand pollution of waters is reported, for example from Silicon valley. The generation of clean atmospheres requires a lot of energy and some optimisation potentials can be assumed.

Eco-usage

Eco-usage is one of the soft factors which is rarely described quantitatively. Extension of usage time, intensification of usage and stimulation of sufficiency have stayed potentials, but seldom realised. As this strategy blocks the selling of new products there are only small incentives for companies to go this way. In this case political action is necessary.

Recycling

Internal Recycling of production waste is sometimes limited due to purity requirements. External downcycling, e.g. of waste from semiconductor production in photovoltaic industry are practised to a certain degree. For recycling in the use phase the main obstacles are cheap new products, incompatibility and lack of upgrading services. The WEEE-directive intends to lead to improved collection rates. However, only a small proportion of total ICT waste in the EU is covered. The recycling quota are very general and don't take enough the different recycling possibilities into account. This might be more concrete in the national implementation laws. From an ecological point of view the recycling of components or whole devices is to be favoured, but possibilities are limited due to inspection costs and small markets only. In the field of material recycling there are some positive examples, like the project of Schott Glas to recycle 80.000 t of end-of-life CRT-glass by the year 2005. Recycling of printed circuit boards in copper smelters also happens to a certain degree, but dismantling costs are high. A high percentage of ICT waste will still go into incinerators and onto landfills in the future.

Need for action lies mainly in standardisation and design for upgradeability/exchange of parts as well as customer information. Upgrading can minimise the adverse effects of rapid innovation cycles but for sure not completely. The poor knowledge on environmental effects of the ICT industry might require monitoring systems in the future. But the effort of monitoring and other measures has to be related to other measures in supposedly more important sectors from an ecological point of view.

5.1.4 Variables

Value added of ICT services [VA €]

The development of value added of ICT services is highly uncertain, as future economic markets are unknown and competition of other economic regions (e.g. India) can be hardly assessed over long periods. Currently the liberalisation of service markets is negotiated in the WTO. If it is realised international trade with ICT services will be facilitated.

uncertainty: high; effect: ↑

Value added of ICT manufacturing [VA €]

The share of imported manufactured ICT goods is already high. The development of value added of ICT manufacturing is highly uncertain, as future economic markets are unknown and competition of other economic regions (e.g. South East Asia) can be hardly assessed over long periods. The production patterns of future technologies are very insecure.

uncertainty: high; effect: ↑

Cumulated primary energy intensity [MJ/€]
Cumulated primary energy demand has to be assessed differentiating between ICT manufacturing and services. The production and service structure in the future is highly uncertain.

uncertainty: high; effect: ↑

Cumulated CO2-emissions intensity [t/€]
Cumulated CO2-emissions have to be assessed differentiating between ICT manufacturing and services as well. The production and service structure in the future is highly uncertain. The same applies to the energy mix for the ICT industry.

uncertainty: high; effect: ↑

5.1.5 External factors

Factor	Trend	Uncertainty	Variables affected	Rationale
GDP	Small growth	middle	GVA	As ICT lies across all industries GDP growth will stimulate ICT sector specific GVA
Liberalisation of international trade	increasing	middle	GVA	Further liberalisation of markets for ICT goods and services might reduce the volume of GVA for the ICT sector produced in the EU.
environmental policy/legislation	more ICT products than ICT industry in focus	middle	effects	environmental policy may lead to less energy consumption of ICT sector

5.2 ICT use

In recent years a couple of studies on electricity consumption of ICT in general and more specifically the internet and mobile telephony appeared. Countries covered are especially the USA, Germany and Switzerland. They have different methodological approaches. To assess the impact of ICT on energy consumption in the European Union it is suggested to use diffusion statistics on the European level and to assess the effects according to the methodology of the most up-to date study. The three main studies evaluated are of A. D. Little (2002), CEPE/FHG-ISI (2003) and Wuppertal-Institute (2002). Additionally a more precise look at energy consumption of telecommunication infrastructure is supplied by Novem (2002) for the Netherlands.

5.2.1 Definition and scope

In a study on the impact of ICT on energy consumption in Germany until 2010 (CEPE, FHG-ISI 2003) end devices have been clustered in the following way:

Table 5-10: ICT end devices considered in FHG-ISI/CEPE 2003

	Households	Offices
Entertainment	Audio, TV, Video, cameras, other	
Communication	Telephone (fixed and mobile)	Cameras, Telephone (fixed and mobile)
Data processing	computer, monitor, printer, other	computer, monitor, printer, other
Home network	Household devices, heating/warm water, security, other	

Table 5-11: ICT infrastructure in buildings considered in FHG-ISI/CEPE 2003

	Households	Offices
Entertainment	TV	
Communication	internet, telephone, other	networking equipment, telephone, other
Data processing		server, UPS
Home network	Networking technology	

Table 5-12: ICT infrastructure of telecommunication companies considered in FHG-ISI/CEPE 2003

Entertainment	
Communication	fixed line companies mobile phone companies
Data processing	Data centers
Home network	

Only considering the internet the Wuppertal-Institut (2002) has covered:

- PCs (home and offices)
- IRDs (TV-boxes)
- household appliances
- Internet information suppliers
- Network

A different approach for the determination of energy consumption by commercial office and telecommunications equipment in the U.S.A was chosen by A. D. Little (2002).

- Displays
- Personal computers

- Server computers
- Printers
- Copiers
- Telephone network equipment
- Computer network equipment
- Uninterruptable power supplies
- Other

On of the main differences to the CEPE/FHG-ISI (2003) study is that the backbone infrastructure is considered by A. D. Little more in detail.

5.2.2 Data for diffusion

Even for a single country like Germany the compilation of data on inventories of ICT in households and offices is a tremendous task.

Main data sources for the diffusion of ICT in the EU are the European Information Technology Observatory and the eEurope Initiative.
The eEurope initiative has set up a list of "eEurope 2005 benchmarking indicators" including citizens' access to and use of the internet, enterprises' access to and use of ICTs as well as internet costs. Broadband penetration, buying and selling online, e-business readiness and modern public services online count among the other indicators.
EITO regularly compiles data on the number of PCs per 100 population. The appendix differentiates between main lines, digital main lines, mobile subscriptions, digital mobile subscriptions , ISDN, Cable TV subscribers and wire-based internet users. The number of internet hosts according to OECD is compiled by EITO regularly.
A survey carried out in 2000 by INRA (EITO 2001) on the use ("have" and "use", "interested/plan to buy") of the internet by the European consumer covered the technologies satellite dish, cable TV, digital TV (subscription), game console, desktop computer, laptop computer, palm computer or personal organiser, CD-ROM drive, internet connection, ISDN line, fax (stand alone), mobile phone. Furthermore the use was surveyed in more detail ("applications used in the past three months", "interested in online services/ready to pay subscription", access to internet outside home").

More specific data is needed to calculate the first order effects of ICT on energy consumption.

a) households

There are quite reliable projections of the number of households until 2020, but data on ICT in households is scattered (official statistics, organisations, market and opinion research institutions and so on).
For saturation levels the logarithm curve has shown high significance in the case of Germany from 1993-2001 (CEPE, FHG-ISI 2003). Saturation levels do not have to be reached necessarily before 2010.
Saturation levels in Germany are summarised in the tables below:

Table 5-13: Saturation levels for consumer goods in Germany

Device	Saturation level [%]
Radios:	
1	100
2	90
3	68
4 or more	41
Stereo	95
TV:	
1	98
2 or more	45
DVD	50
Function "Watching video"	70
camcorder	60

Pay-TV	25
Game console	30
Satellite receiver	32
Digital camera	50

Source : CEPE/FHG-ISI 2003

Table 5-14: Saturation levels for telecommunication devices in Germany

Device	Saturation level [%]
Answering machine	50
ISDN-access	35
Telephone access	99
Cordless	52

Source : CEPE/FHG-ISI 2003

Table 5-15: Saturation levels for information technology in Germany

Device	Saturation level [%]
PC	75
Desktop computer	56 (75 % of PCs)
Notebook computer	19 (25 % of PCs)
FPD	45 (75 % of desktop PCs)
CRT	55 (25 % of desktop PCs)
PDA	20
Scanner	53

Source : CEPE/FHG-ISI 2003

Aebischer (2000) estimated diffusion patterns for smart homes in Switzerland. Aebischer refers to making networks of multimedia devices, white goods and the control of lighting by ICT. The parameters and saturation levels are summarised in the following table:

Table 5-16: Parameters for diffusion curves of home automation and networks in Switzerland

	One/Two family house			Multi family house		
	Multimedia	White goods	Lighting	Multimedia	White goods	Lighting
Diffusion in 2000 [%]	0	0	0	0	0	0
Saturation level [%]	100	100	50	80	80	20
Diffusion time [a]	20	40	40	20	40	40

Source: Aebischer 2000

b) offices

A. D. Little (2002) found it difficult to differentiate between commercial and industrial stock. CEPE, FHG-ISI (2003) choose to determine coefficients of workers per desk for different industries:

Table 5-17: Coefficients of workers per desk in different industries μ_i

Industry i	μ_i SME (10-49 employees)	μ_i SME (50-499 employees)	μ_i Big companies (> 500 employees)
manufacturing industry	0,35	0,32	0,33
construction	0,20	0,26	0,41
wholesale/commerce agencies	0,47	0,47	0,49
retail	0,35	0,29	0,16
traffic/ logistics	0,35	0,38	0,64
banks, insurance	0,97	0,98	1,00
private services	0,35	0,16	0,49
professional services	0,67	0,58	0,19
private institutions in G/E/W/K	0,39	0,26	0,16
public administration	0,76	0,74	0,60
public administration in G/E/W/K	0,35	0,31	0,60

Source : CEPE/FHG-ISI 2003

Applying these coefficients to data for the employees in the EU the number of stations (office) can be calculated.

Table 5-18: Assessment of devices required for local network infrastructure

Industry	SME (10-49 employees)	SME (50-499 employees)	Big companies (> 500 employees)
companies with networks [%] **m**	51	84	93
number of stations/server **n**	12	10	7
total number of servers[9]	**to be calculated**	**to be calculated**	**to be calculated**
number of routers/company	1 per station	3 per station	5 per station
number of routers[10]	**to be calculated**	**to be calculated**	**to be calculated**
number of hub-ports/company	1,5 hubs per station with 12 ports each	one port per station, one port per server and router, one port per network printer[11]	one port per station, one port per server and router, one port per network printer[12]
number of hub-ports	**to be calculated**	**to be calculated**	**to be calculated**

Source: CEPE/FHG-ISI 2003

Some statistical data on the diffusion of LANs is provided by EITO (2001) for 2000:

[9] Σ (MAi *µi) * (n/m)

[10] number of stations = number of employees * µi

[11] 17,7 % of all office printers

[12] 38,0 % of all office printers

Table 5-19: Percentage of LANs by vertical markets 2000 (sites with > 100 employees)

Industry	Western Europe (average) %
Manufacturing	90,7
Transport/communication/utilities	87,2
retail/wholesale	95,2
Finance	97,9
Government	95,3
Education	96,4
All industries	92,7

Source: EITO 2001

Furthermore there are regular statistics on the number of PCs per hundred white collar workers. Breakdowns by sectors are provided by e-business watch.

Table 5-20: ICT infrastructure in European enterprises in 2002 (%) for D, F, I, UK

	Internet access	use www	Intranet	Extranet	LAN	WAN	EDI	Have website
Food & beverage	87,1	79,0	38,6	10,3	59,8	28,1	34,1	56,6
publishing	97,4	93,6	57,7	24,8	74,2	37,0	22,1	76,7
chemical	97,7	94,0	61,5	22,9	82,5	48,4	39,5	81,4
metal products	91,3	84,2	40,5	9,8	62,2	17,0	22,3	64,2
machinery	93,9	88,9	60,1	15,2	75,2	29,2	24,1	79,9
electronics	98,9	92,2	79,9	25,1	91,9	51,8	38,1	89,3
transport equipment	98,8	97,5	74,3	16,2	90,3	48,9	50,6	72,2
retail	82,0	72,8	41,7	12,5	54,3	28,5	20,3	57,5
tourism	92,3	81,4	40,6	12,9	56,8	18,6	9,7	78,1
banking	94,1	93,2	73,9	29,0	95,3	69,9	33,0	93,3
insurance	98,8	93,8	78,9	39,9	86,5	63,3	24,5	92,9
real estate	92,9	84,6	34,2	11,1	52,7	17,4	14,5	60,0
business services	95,5	92,0	50,9	23,7	67,6	31,9	19,7	74,9
ICT services	98,8	97,6	85,3	54,3	95,8	72,6	32,0	92,9
Health services	82,5	72,0	33,5	15,2	52,4	21,5	13,5	48,4
Total EU4	90,9	84,4	51,0	19,5	66,5	34,1	23,4	69,9

Source: e-business W@tch (Survey 2002)

c) infrastructure

Data centers and telecom switches are constantly monitored in the Netherlands (see Novem 2002 below). Europe wide date bases are not known. BTS are built up with UMTS. But sometimes UMTS is integrated into BTS for second generation telecommunications.

Limitations to knowledge:

There are only some country-specific studies which are based on many assumptions. Data for the Accession Countries is scarce. Single ICT products and infrastructure, such as GPS and television infrastructure are not covered by the studies cited above.

5.2.3 Data for environmental indicators

5.2.3.1 Energy intensity

Both CEPE/FHG-ISI (2003) and A. D. Little (2002) had a similar methodology to assess the impact on energy consumption.

- Annual usage by mode * power by mode
- Aggregation of all modes
- Device Annual Electricity Consumption per devices via multiplication with stock
- Aggregation of all devices

Definition of modes differ significantly. CEPE, FHG-ISI (2003) distinguish between operation mode, Ready-, Stand-By and Sleep-Mode, “Off-Mode” and Zero-consumption mode. A. D. Little (2002) mentions Active, Standby, Sleep and Off mode. The latter describes turned off but plugged in, so that small power consumption is still possible.

Data sources for electricity consumption by mode are very heterogeneous. Some commonly used resources are listed below:

- MACEBUR (1996): “Management of electricity consumption in office equipment end use.” with case studies for Denmark, France and Portugal
- Data from the Swiss Federal Office of Energy
- Manufacturers’ literature
- In-house measurements

The data basis is considered to be of poor quality and comparability is very limited.

The CEPE/FHG-ISI (2003) had the following main findings for Germany in 2002:

- With 38 % ICT in offices and households contributed to 8 % of all electricity consumption in Germany.
- Household end devices consumed 50 %, office end devices 20 %, infrastructure in households 9 % and in offices 14 %.
- Until 2010 an increase by 45 % to 55,4 TWh is expected.
- The share of the infrastructure, especially in the office and telecommunication sector will rise significantly whereas the relative share of end-devices both in households and offices will decrease.
- The increase is almost entirely caused in the operation mode whereas the standby consumption will rise moderately by 8 % and consumption in the off mode will even decrease by 22%. Standby reduction is caused by energy efficiency measures already undertaken, whereas the reduction of off-mode consumption is mainly caused by the shift to standby, especially TV.
- Most important devices are TVs, stationary audio devices and servers, the latter consumed 45 % of all the end devices in 2002. These three classes will remain important. The importance of infrastructure provided by mobile phone companies and communication infrastructure in households will rise. In 2010 61 % of all the consumption will be caused by these three classes.
- Potentials for further energy reduction are as follows: Off mode consumption can be reduced from 2 TWh in 2010 to 0 by technical measures. Energy efficiency in the standby mode can be mobilised to 2,6 TWh in 2005 and 4,0 TWh in 2010. Three quarter are due to end-devices in households, the rest half and half to office end devices and household infrastructure. The situation in operation mode is far more complex:
  a) TV: Reduction of 1 TWh until 2005 and 3 TWh until 2010 by substitution of CRT by LCD or almost one TWh by penetration of best practices.
  b) Server: 50-60 GWh by switching them off during night time.
  c) Mobile phone infrastructure: Reduction of energy demand for air conditioning (climate and ventilation) in BTS and minimisation of BTS
  d) PCs: more than 600 GWh because of approximation to power consumption to notebooks.
  e) Internet- and telephone infrastructure in households: 80 GWh in 2005 and 220 GWh in 2010 by improved management of DSL-Routers

f) Monitors: Complete substitution of CRTs by LCDs in 2010 would lead to energy savings of 1 TWh. Diffusion velocity depends on price reductions

- In smart homes more demand for electricity faces reduced heat demand due to improved control of heatings. The net effect is considered to be slightly positive, but Smart homes are not considered to push energy efficiency in buildings.
- Telework will mainly lead to a shift of energy consumption from office to home, the positive net effect will be achieved by reduced transport.
- E-commerce will affect especially energy consumption of transport, but the net effects are unclear.

Main findings in the A. D. Little (2002) study can be summarised as follows:

- Commercial office and telecommunications equipment in the U.S.A. consumed 97 TWh electricity in 2000. The share of total electricity consumption is 2,7 % and of total energy consumption 1,1 %.
- Monitors and displays had a share of 22,2 %, PCs and workstations of 19,6 %, server computers of 11,6 % and copiers of 9,7 %. Telecom networks, computer networks, printers and UPSs accounted for 5,7-6,6 % each and “other” for 9,7 %.
- The study includes the first bottom-up estimate of commercial telecommunications network equipment, which accounted for 6,6 TWh in 2000. The share of cell site equipment is 36 %, followed by transmission (fiber optic) with 27 %, private branch exchanges and public phone network with 15 % each and wireless phones with 7 %.
- An upper-bound estimate shows 103 TWh electricity consumption of the “internet”, the internet backbone accounting for 29 %, residential office equipment for 27 % and other commercial equipment for 41 %. The share of total electricity consumption is 2,9 % and of total energy consumption 1,2 %.
- The active mode accounted for 77 % of office and telecommunication device electricity consumption, standby for 16 %, suspend for 6 % and off for 1 %.
- A. D. Little developed three future scenarios:
  <u>Ubiquitous computing</u>: Continuous connectivity as away of life, high bandwith and reliability
  <u>PC reigns</u>: computing remains anchored to desktop PCs of high performance, widespread high bandwidth connectivity
  <u>Greening of ICT</u>: EU and Japan sign Kyoto protocol, energy consumption of ICT as a major concern, power aware design
- Electricity consumption in the scenario Ubiquitous computing would rise to 110 TWh in 2010 and in the scenario PC reigns to 135 TWh. Greening of ICT would lead to a reduction to 62 TWh in 2010. The range of the share of electricity consumption by 2010 is 1,6 % to 3,5 %, of total energy consumption 0,7 % to 1,5 %
- Monitor electricity consumption is mostly affected by LCD penetration (LCDs require one quarter of energy compared to CRTs), size of future CRTs and “energy star”-enabled rates.
- Key drivers for future electricity consumption of PCs are the stock of mobile computing devices, future microprocessor power draw and “energy star”-enabled rates.
- Severs’ total electricity consumption is mainly a function of the growth rate of data access, migration of the stock between different server classes and low end power draw.
- The share of telephone networks will rise in all three scenarios substantially due to 3G mobile telephony expansion and continued deployment of fiber-optic equipment (more sites, higher bandwidth).
- UPS electricity consumption will also grow in all three scenarios because the uptake of e-commerce and higher connectivity rates require a higher backbone reliability.
- The energy to manufacture equipment is in the same order as direct energy consumption but has not been included. The same applies to equipment disposal.

There is just one European study carried out by the Wuppertal-Institut (2001), in which Germany’s electricity demand by internet is estimated at 4000 GW, equalling about 0,8 %. Web servers and other hardware of information suppliers account for 26 %, routers and knots for 33 % and PC end devices with 40 %. For 2010 the internet electricity demand would reach 6 %

(35 TWh/a) if no efficiency gains would be realised. Taking the latter into account only 13 TWh would be required.

The Wuppertal-Institute recently updated it's study on GHG emission trend of the internet in Germany (2002). Only the energy use of PCs, monitors and IRDs for internet use was considered, but all energy use of mobile phones, telecom and computer networks. Energy use of home automation devices was included as well. The energy for production of ICT was excluded as well, although it is considered to account for 15-80 % of energy consumption, depending on study and use.

- In 2000 five Scenarios were built, covering PCs, IRDs and household appliances. power consumption of household appliances was varied between 3 and 1 W/device and IRDs (TV boxes) between 20 W and 5 W. For PCs it was generally assumed that 50 % are always on. The differences between the scenarios were due to monitor on/off at night and weekend, power consumption of PC between 110 W and 77 W (power management), energy star standby at night and on weekends between 15 W and 5 W (optimised) and 5 W consumption (scenario 5) always when not in use.
- In all scenarios PCs accounted for the biggest share of electricity consumption, which varied from almost 35 TWh/year to about 13 TWh/year.
- The scenarios have been updated taking into account a high share of LCD monitors in 2010 and laptops significant in offices. mobile internet and m-commerce are not covered in the study, however it is assumed that PC will dominate internet access even in 2010.
- The following table shows the results of the electricity consumption -total and internet only- in Germany for 2001:

Table 5-21: Electricity consumption -total and internet only- in Germany for 2001 [TWh/a]

	All	Internet
Home PCs	3,26	1,15
Home Telecom	1,68	
Audio	3,92	
Video	11,77	
Office ICT	5,7	1,20
Network & E-Commerce	8,7	3,58
UPS	0,87	0,87
Total	35,90	6,79

Source : Wuppertal-Institut 2001

- For 2010 it is assumed that 95 % will have internet access, 80 % with PC (50 % laptops), 15 % with TV reception platforms and that 50 % of all household appliances are online. Internet access units in offices are assumed to double (50 % laptops). All PCs will have an LCD monitor. 50 % of all users turn off PC when not in use, whereas 50 % stay online all the time (sensitivity analysis for 25 % and 75 %).
- Three scenarios have been calculated: No power management, 15 W standby, 5 W standby after 15 min. Substantial reductions in the case of 50 % always online from about 25 TWh (Scenario 1) to half of it (scenario 3) are expected. Of course the result is very sensitive with regard to the share being online: from 20 TWh (25 %) over more than 25 TWh (50 %) and more than 30 TWh (75 %) when no power management is used. On the contrary the result shows hardly any sensitivity when 5 W standby are achieved after 15 minutes. Electricity consumption will remain in the magnitude of 12 TWh.
- Additionally two home automation scenarios "business as usual BAU" and "efficiency" have been calculated, based on the scenarios of Aebischer for Germany until 2020. BAU requires 35 TWh/year, the share of multimedia being almost 25 TWh. In the efficiency scenario electricity consumption is reduced to about 15 TWh, the multimedia share dropping to slightly more than 15 TWh/year.
- It is concluded that the Internet can cause up to 5 %, or only 2 % of Germany's electricity consumption in 2010. home automation could add 7 %, or only 3 % by 2020.

- Main policy recommendations include to limit sleep/standby or off-mode to < 5 W for PCs/digital TV platforms and < 1 W for intranet appliances as well as the reduction of on-mode electricity consumption.

Novem (2002) have analysed the factors and variables that determine energy consumption of data centers for the internet and main switches for mobile telecommunications. Both are monitored because of their rapid development.

- A data center at full load requires a total energy of 160 MWel., the computer floor covering alone 7.000 m2. Total electricity consumption is 64 GWh per year. This amount equals the electricity consumption of approximately 38.000 households and the energy consumption of 12.000 households.
- Data centers work around the clock. About 30 % of power demand is needed for cooling. Computer cabinets and climate control units account for 6 MWe constant over the year, whereas chillers vary between 2 and 0 MW depending on ambient conditions.
- The infrastructure for mobile telecommunication accounts for about 80 %. Infrastructure energy consumption is independent from utilisation.
- The development of data centers and telecom switches in the Netherlands shows an almost exponential growth of gross floor space from 1996 to 2003. 600.000 m2 were assumed for 2002 and more almost 1.100.000 m2 for 2003. 166 sites, existing and planned have been considered. Unknown initiatives would have to be added.
- The financial crisis (bankruptcy, delay roll out of carrier networks, delay roll out of UMTS) lead to a breakdown of planned capacities. Few new data centers and growth mainly due to new telecom switches already planned are expected.
- the actual occupation rate of data centers varied between 5 and 100 %, the average being 15-25 %. In the growth scenario it is expected that 4-8 years will be between erection and 90 % occupation of data centers.
- The additional growth of national electricity consumption due to data centers and telecom switches have been estimated to 0,8 % in 2000, 1,6 % in 2002 and 2,4 % in 2005.
- In a scenario up to 2010 it is assumed that stock markets will recover, energy efficient CPU/higher performance will be developed and UMTS infrastructure will be used. Energy efficient site design with utilisation of waste heat and optimisation of free cooling count among the assumptions.
- Starting points are (1) After 2003 no new data centers built. (2) Occupation sites up to 90 % in 2010, (3) 2005-2010 power density up to design conditions (40 % growth of power demand of hard ware), (4) optimisation free cooling (35 % to 50 %). These starting points result in a power consumption of 300 MWel. in 2005 and 600 MWel. power demand and 4.4 TWh/year electricity consumption in 2010 (additional growth 3,9 %).
- Computers consume 65 %, UPS 5 % and cooling 30 % (20-25 % for chillers and 5-10 % for fans, pumps, etc.) of total electricity consumption. The maximum potential for free cooling is an energy reduction of 15-20 %. More efficient CPU and higher performance will equal or even lead to a higher electricity consumption. Waste heat utilisation has been assessed possible if distance waste-heat and heat demand is small and building heating system is designed to 40 °C up to.
- As a basic rule pay back for energy saving measures is below 5 years.

Other studies are summarised in brief:

- Server farms can consume as much electricity as a small airport or four large hospitals. In London for example a 24 MW gas fired power station is built for such a server farm (FFF 2002).
- The total electricity demand of the internet is discussed controversially. Beginning with an estimate by Mills (1999) of 8 % discussion among scientists was launched. Romm (2000) maintained that a figure of 1-2 % is more realistic which is supported by an estimation of N4E saying that office and network devices consume 2 % of the US electricity consumption. If telephone infrastructure and production of semiconductors and computers are added the share rises to 3 %.

- The German telephone net (fixed line and mobile) required 3,1 TWh/a in 1996 (0,7 %). This figure might have risen through the expansion of mobile networks, which is estimated at 0,4 TWh. 90 % are due to BTS, end devices account for only 10 % (Schaefer, Weber 2000). As long as the capacity stays constant increased use has only a slight impact on total energy demand.
- Reichling and Otto (2001) calculated primary energy demand for the infrastructure of Deutsche Telekom at 405 GJ for production and 15 years of use.
- Standby losses in Germany have been published by the Umweltbundesamt (1997). ICT accounts for 8 TWh and consumer electronics for 16,1 TWh per year. If the same end devices of 1995 would have been used standby losses in Germany would rise by 11 % from 1995 until 2010. Digital TV may increase standby losses, but increased energy efficiency has to be taken into account as well.

New developments, not considered in the studies above, include distributed and pervasive computing.
The **calculation capacity** of a typical PC-application is used to roughly only 20 %. Decentralised parallel calculation of packages enables better capacity use. Examples include: (EMPA, IZT 2003)

- seti@home 2002: 2 mln. PCs looking for extraterrestrial radiosignatures
- Folding@home: 200.000 users supplied capacity to unveil protein structure. On average 70.000 processors are bundled to one "supercomputer"
- Intel plans a project for cancer research assisted by distributed computing in the magnitude of 50 Teraflops
- The distributed network of the company "Distributed Science" has the power of three ASCI White "Supercomputers".

One ASCI White **"**Supercomputer" has a performance of 12,3 Teraflops per second and requires 1,2 MW (Bantle 2001). The most powerful computer in the world "Earth Simulator" has a performance of 35 Teraflops per second and requires 13 MW power. Big cooling aggregates are necessary to getting away waste heat (Pöppe 2002).

The music exchange platform "Napster" is one example for **decentralised filesharing**. Data exchange of music files has become quite popular, whereas decentralised memory is still a niche application. In the near future files may be saved somewhere in the internet. The Internet spanning operation system ISOS for all the different applications may make calculation and filesharing a standard internet technique.

The trend towards **pervasive computing** would increase calculation and memory capacity by magnitudes, possible also without internet access but among different chips in a local area ad-hoc network. The vision of eGrains supplies functionality independent from localisation.

Resource efficiency could be improved by a factor 5, but energy will be still required to keep the ad-hoc network going (EMPA, IZT 2003). Rebound effects due to growing data are likely to occur. The biggest obstacle against distributed computing may be declining prices for semiconductors.

5.2.3.2 Waste from daily household and commercial activities

The effects of ICT use on waste of daily household and other commercial activities are manifold. In principle the following effects can be distinguished:

- Growing amounts of ICT waste
- Other waste streams get the character of ICT waste
- Contamination with ICT blocks recycling of other waste streams

Total WEEE waste in the EU is 6. Mio. tons/year (1998), equalling about 4 % of "municipal waste". Annual growth is predicted at 3-5 %, resulting in a doubled waste stream in 2012. Waste from EEE grows three times faster than conventional municipal waste.

ICT waste is just a part of it. In Germany waste amounts for the fractions consumer electronics, office equipment, information technology and communication technology is 753.000 t/a of a total 2.000.000 t WEEE/a. The same share applied to EU results in a total share of 1,5 % of ICT waste of total municipal waste. Due to immense innovation dynamics it can be expected that the ICT fraction will grow faster than the average WEEE.

By dividing stocks of ICT with their average usage time waste streams can be estimated for saturated markets. When stock is still built up sales data have to be used. An important source for sales data is EITO.
To convert numbers into mass steams weight per ICT items have to be known. The immense heterogeneity of ICT products makes estimations of specific weights of ICT products a sysiphus work. Typical weights for some ICT products are compiled in IZT, DIW (1998).

Technical life-time and typical usage time of selected ICT products, ending up to some degree in household waste, are estimated in the following table:

Table 5-22: Technical lifetimes and typical usage times of selected ICT goods

product group	Techn. life time [a]	Usage time [a]	short term Trend	long term trend ?
TV	10-20	8-10	↘	3 years?
PC	10	1,5-3 (business) 3-4 (consumer)	↘	1 year?
Laser printer	10	3-5	→	
Telephone (fixed)	12	5-5	→	
Telephone (mobile)	?	1,5	↘	one-way mobile phones dominate?
Photo-cameras	10-20	8-10	↘	one-way cameras dominate

Source: IZT 1999, own estimations

The lifetime for a business PC is three years and mobile phones are replaced every 18 months (FFF 2000). On the other hand one way cameras and one way mobile phones are already on the market, but the amounts are considered to remain small compared to the secondary effects. This might change in the future.
The baseline scenario from "Scenarios for household waste generation in 2020" has a total percentage of electronics from the infotainment fraction is 1 %. The whole infotainment category is dominated by paper consumption (ESTO 2003).
With the embedding of ICT in other product categories the character of waste streams might be changed. As the integration of ICT in electric and electronic devices and cars has been a fact for long, in the future other product categories like clothes and furniture might have different characteristics when they become waste. An overview on typical lifetimes for medium and long-living products and the impact of increased ICT usage is given in the table below:

Table 5-23: Technical lifetimes and typical usage times of selected medium and long-living products in households

product group	Techn. life time [a]	Usage time [a]	short term Trend	long term trend ?
washing machine	10-15	7-10	↘	3 years?
furniture	3-300	3-300	→	integrated ICT might reduce usage time significantly
clothes	5	3-5	→	wearables with 1-2 years lifetime?

Source: IZT 1999, own estimations

If innovation dynamics of ICT reach other product groups, life-time and usage time might be reduced dramatically. In the case of furniture very long-living goods might become medium-living goods by embedded ICT. Refurbishment of this in part craft industry would face massive changes.
In a scenario for wearables in Switzerland it could be shown that wearables can contribute significantly to WEEE (EMPA, IZT 2003). If they are not treated as WEEE they, together with “smart pencils”, “e-paper” and so on, might lead to a high concentration of pollutants in mixed waste. Separate collection would not make much sense in the case of fully developed pervasive computing.

However ICT has also a potential to prolong the lifetime of ICT and other products. ICT products could be updated with software, if interfaces and software-codes (e.g. open-source, free software) are favourable. Information on adequate use, help for repair and so on can be downloaded from the internet.

Smart labels can be applied to a vast amount of products. Already used for logistics especially the application on packaging in combination with information on feed and the smart fridge might lead to important effects on waste from daily household and commercial activities. If we talk about packaging we talk about billions of items in Switzerland alone. Although smart label will be light-weight they have a potential for creating problems in recycling processes. First thoughts about this problem indicate that copper contained in the antenna might have adverse effects on glass and aluminium recycling processes (EMPA, IZT 2003). The strategies to encounter this problem include design of copper free smart label and separation before processing.

5.2.3.3 Other indicators

The emission of Greenhouse gases can be calculated easily once energy consumption is known. As mainly electricity consumption is affected emissions will generate from power stations. Urban Air Quality will not be affected very much due to emission standards of power stations.

Passenger and freight transport intensity are not directly covered by the use of ICT, but indirect effects are treated in separate fact sheets.

5.2.4 Variables

5.2.4.1 Diffusion

a) households

Households [total number of households]
The total number of households will determine the stock of ICT. There are predictions for the number of households in the EU until 2020 by OECD. The trend towards smaller households is quite stable.

uncertainty: low; effect: ↑

Penetration rates of ICT end devices [% of product per household]
The penetration rate of ICT in households has to be given for each end device separately. There are many data sources. Data quality differs significantly by source and ICT product. Many estimations have to be made, supposedly to a high degree in the accession countries.

uncertainty: middle; effect: ↑

Saturation levels of ICT end devices [% of product per household]
Saturation levels are often derived by more or less plausible assumptions, sometimes the reflect an extrapolation of the S-curve. The inherent assumptions for building the S-curve are highly uncertain.

uncertainty: high; effect: ↑

White goods connected to the internet [% of all white goods in stock]
Teleoperation and –maintenance and other functions can be provided for white goods when connected to the internet. Today it is highly uncertain whether the benefits justify a internet connection. The ipv6 standard however enabled the connection of billions of devices.

uncertainty: high; effect: ↑

Smart homes [% of all households]
Smart homes are considered to increase electricity consumption significantly. However acceptance is small. This might change until 2020, including home and service robots.

uncertainty: high; effect: ↑

b) offices

Desk workers [total number of desk workers]
Offices are found in the tertiary sector, in industry and home offices. The total number can be derived from known coefficients which indicate the proportion of desk workers of total number of workers per industry. However these coefficients might vary by time and region. A distinction by company size is necessary.

uncertainty: high; effect: ↑

Companies with networks [% of all companies]
There is quite reliable data on companies' networks. A distinction by company size is necessary.

uncertainty: low; effect: ↑

Stations [number of stations per server]
Rough estimations are made, considering the companies' size.

uncertainty: high; effect: ↑

Routers [number of routers per company]
Rough estimations are made, considering the companies' size.

uncertainty: high; effect: ↑

Hub ports [number of hub ports per company]
Rough estimations are made, considering the companies' size.

uncertainty: high; effect: ↑

c) infrastructure

Fibre optic equipment [total length km]
The total length of fiber optic equipment is supposed to grow in order to enable high data transfers. However an overall estimation seems to be impossible, because many single projects are undertaken, some of them are scheduled.

uncertainty: high; effect: ↑

Data centers [total number]
The total number of data centers highly depends on the prosperity of the whole economy. Whether new data centers are built depends on the occupation rate of existing data centers. In some countries the numbers are monitored.

uncertainty: middle; effect: ↑

Telecom switches [total number]
The total number of telecom switches highly depends on the prosperity of the whole economy. Whether new telecom switches are built depends on the occupation rate of telecom switches. In some countries the numbers are monitored.

uncertainty: middle; effect: ↑

BTS [total number]
Electricity consumption of mobile telecommunications is dominated by infrastructure, especially Basis transmission stations. 3rd generation mobile telephony is built up in Europe, but faces competition from improved 2nd generation mobile telephony, WLAN and bluetooth.

uncertainty: middle; effect: ↑

d) Distributed computing

Total capacity used by distributed computing [Teraflops]
Distributed computing can take place between every computer connected to the internet in the world. Some single projects have been carried out, but diffusion is still slowed down by small incentives to offer one's calculation or storage capacity. Business models, e.g. with micro-payments might make this an important field in the future. It is unclear to which degree supercomputers can be replaced. Quantum and molecular computers might be disincentives for distributed computing in the next decade.

uncertainty: high; effect: ↑

5.2.4.2 Effects on environmental indicators

a) and b) households and offices

Average growth rate of ICT waste [%/year]
The growth rate of ICT waste can only be assessed roughly. As there are no valuable bottom-up scenarios for ICT waste generation in the EU this pragmatic approach is recommended. Differing from the ESTO (2003) scenario it is estimated that ICT waste grows much faster than feed (+ 10 %) and the remaining fraction (+ 55 %) until 2020, resulting in a total growth of household waste of 43 %. The triple velocity of WEEE growth will probably slow down with increased saturation rates. A doubling of ICT waste until 2020 seems to be a realistic magnitude. However this assessment is highly uncertain.

uncertainty: high; effect: ↑

New waste fractions with character of ICT [% of waste fraction]
Embedding of ICT into clothing and furniture might reduce their usage time and waste characteristics, so that the waste amounts grow and recyclebility is made worse. However the extent to which wearables and electronic furniture are bought cannot be determined in a serious way.

uncertainty: high; effect: ↑

Power consumption by mode [W]
the power consumption by mode has to be gathered for each product separately. Data sources are very heterogeneous and some of poor quality. It can be assumed that in the ACs on average less efficient and older equipment is used. The total development until 2020 is not known, because technological developments are highly uncertain. Access to telecommunications can be realised over PCs, but also ubiquitous with high impacts on energy consumption. On the other hand substitution of CRT-monitors by LCD-monitors and power consumption of microprocessors in the same magnitude as today seem to be quite certain. The power consumption of an all in one screen for TV and computing is very insecure, but they might enter the market in the near future. Power consumption of white goods by internet connection might be between 1 and 5 W for example, depending on the technology chosen. High reduction potentials can be exploited by using technical measures, but they have to be addressed as goals.

uncertainty: high; effect: ↑

Usage by mode [h/a]
The annual usage of an ICT product by mode depends on the behaviour of the user and power management systems. Many games can be played offline, the same applies to other uses like e.g. household expenditure monitoring.

uncertainty: high; effect: ↑

Broadband Access [% of households]
Usage of telecommunications will be made more convenient by broadband access. The eEurope Initiative has chosen broadband access as one of the indicators for Europe's way towards an information society. The user behaviour shows high sensitivity to broadband access and tariff structures. Broadband access already has high penetration rates in offices, but not in households. Broadband access makes ICT more convenient and flat rates give no incentive to use ICT only when needed. Widespread Real time voice and television over IP might increase internet use dramatically, substituting conventional TV and telephone.

uncertainty: low; effect: ↑

Shift by telework [% of households with one or more teleworkers]
A considerable increase of usage of ICT at home can be induced by home-based telework. On the other hand ICT is less used in offices.

uncertainty: middle; effect: ↑

E-commerce [% **of households using e-commerce]**
If household activities like shopping are done via internet usage of ICT will be higher. Potentials seem to be overestimated.

uncertainty: high; effect: ↑

Smart homes [total electricity consumption kWh/a]
Smart homes are considered to increase electricity consumption significantly. Aebischer (2000) estimates that this application will be the fastest growing electricity consumer in households.

uncertainty: high; effect: ↑

Local network power consumption [total electricity consumption kWh/a]
Power consumption by networks in offices is an important aspect. However the layout and extension is very individual.

uncertainty: high; effect: ↑

c) infrastructure

Energy demand of fiber optic lines [kWh/y*m]
Fiber optic lines have to be supplies with power. There are very heterogeneous power demands, so that only a rough estimation on average energy demand can be carried out.

uncertainty: high; effect: ↑

Power consumption of data centers, telecom switches and BTS [MW]
Power consumption of data centers and telecom switches is very high. For this there is a monitoring system in the Netherlands to estimate future power demand. As they run around the clock, no annual usage has to be determined. Power consumption of BTS varies considerably so that it is difficult to give an overall number.

uncertainty: high; effect: ↑

Share of cooling systems for data centers, telecom switches and BTS [% of all power consumption]
Cooling systems are estimated to consume about 30 % of total power consumption in data centers and telecom switches. As reduction potentials for computers seem to be small measures to optimise cooling systems can mobilise substantial energy savings.

uncertainty: high; effect: ↑

d) all

Power consumption of computers for distributed computing and file sharing [W]
If distributed computing would spread there are many possibilities to influence power consumption, for example addressing the most energy efficient computers with priority. However it might be impossible to calculate a EU share.

uncertainty: high; effect: ↑

Computers being "on" due to distributed computing and file sharing [total kWh]
It might be almost impossible to assess the usage patterns in a world of distributed computing.

uncertainty: high; effect: ↑

Servers and supercomputers idle due to distributed computing and file sharing [total kWh]
Distributed computing and peer-to-peer exchange have a potential for reducing server activity or the use of supercomputers. However the extent is hardly to determine.

uncertainty: high; effect: ↑

5.2.5 External factors

Factor	Trend	Uncertainty	Variables affected	Rationale
GDP	small growth	middle	ICT penetration	the higher GDP growth the higher ICT penetration in offices and households (expenditure)
Structure of the economy	towards tertiary	middle	ICT penetration	the higher tertiary GVA the more ICT in tertiary sector
Population size	small growth	low	ICT penetration	The higher population size, the more ICT in use
Lifestyles	towards mobile and individual	middle	ICT penetration	The more mobile and individualised people live, the more ICT they use for communication
environmental policy/legislation	More ambitious EU policy	middle	Power consumption	environmental policy may lead to improved power management
Electricity costs	declining	middle	usage patterns of ICT	the higher electricity costs the more incentives for energy saving measures.

5.3 E-business

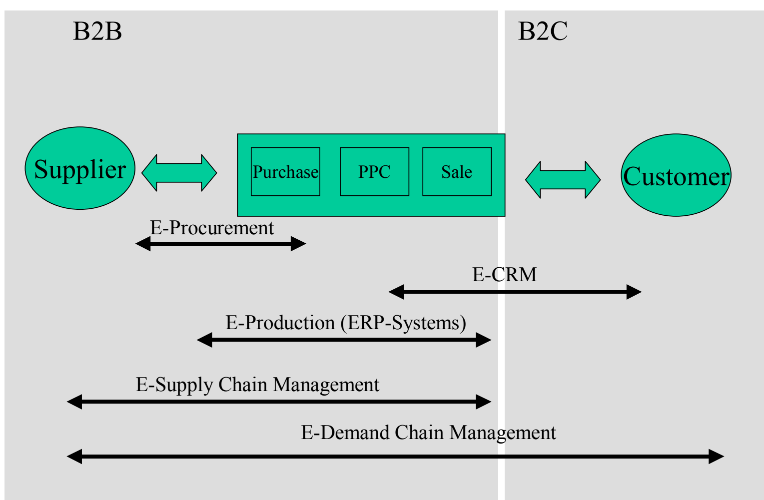
ICT increase efficiency by promoting flexibility, speed and geographic independence of transactions. Efficiency increases result in price reduction and economic growth. ICT industry and services restructure economies. In contrast to other technologies a nearly cost-less reproduction of digital goods is possible. The transaction costs for remote activities are tiny compared to physical transport. The low market entry barriers led to growing economic importance of “Start-ups”, many of which have already “touched down”. Others like yahoo! or Amazon have become companies of global importance, their stock exchange value surpassing the value of traditional enterprises like DaimlerChrysler or DuPont. Optimists claim that an ICT-based economy is a frictionless and weightless economy, and that friction means the loss of energy. Pessimists express that the “New economy” accelerates all businesses, including those with heavy environmental impact. Furthermore the system boundaries are very difficult to determine.[13] There is no proof for one of these hypothesis.

An increased uptake of e-business is highly certain, because competing companies can achieve considerable efficiency gains which result is cost reduction. The uptake of B2C e-business is much smaller than B2B e-business. A net reduction of energy consumption per product sold is achieved by reduced overproduction and inventories. On the other hand the net effects on freight transport are very uncertain, because efficiency gains go hand in hand with longer supply and distribution patterns.

5.3.1 Definition and scope

E-business comprises e-commerce plus e-based and/or e-supported activities within a company or between different companies. The term e-commerce is applied for commercial market transactions by using interactive media (e.g. Internet, Digital TV, Mobile) for supply, order and/or use. In this chapter the main focus is on B2B and B2C e-business. E-business can be divided into buy-side e-commerce, sell-side e-commerce and electronic markets.

Figure 5-1: Typology for e-business



E-CRM: E-customer relationship management, PPC: production process control

Source: IZT, Borderstep 2002

[13] The opportunities to communicate all over the globe has fostered flexible virtual companies with wide-range information flows. Globally acting companies have organised workflow across time zones, e.g. documents can be handed over when work is finished to somebody else whose office hours just started. A more general approach is labelled “distributed computing”, in which the capacity usage of ICT is organised around the globe to a potential comparable to super-computers. This globalisation process brings together different cultures and changes also the contents generated.

On the supply side e-procurement is done by both the industrial and tertiary sector. More integrated ICT-based approaches for the supply side are enterprise resource planning and supply chain management, for the demand side e-demand chain management and e-customer relation management. Electronic markets can be organised in the form of catalogues, pin boards, exchange or matching systems and auctions. B2C e-commerce is mainly catalogue shopping and auction (used goods, power shopping).

5.3.2 Data for diffusion

B2B e-commerce is estimated to have 5-10 times the size of B2C e-commerce in the USA (Romm et al. 1999).

5.3.2.1 Business

E-business watch carried out a survey on e-business applications and services in 2002.

Table 5-24: e-business applications and services in 2002 (%) for D, F, I, UK

	SCM	CRM	ASP	ERP
Food & beverage	4,1	13,6	7,3	18,8
publishing	5,7	15,3	12,7	17,6
chemical	12,5	23,3	14,6	50,1
metal products	4,9	5,9	5,2	24,9
machinery	8,4	17,6	8,8	36,6
electronics	18,9	32,5	22,3	60,5
transport equipment	16,8	18,3	19,3	53,4
retail	9,1	15,8	8,9	13,8
tourism	4,1	12,9	10,9	6,5
banking	2,3	39,2	18,5	11,7
insurance	5,6	30,1	39,3	11,5
real estate	2,6	5,7	6,4	5,2
business services	3,5	16,9	15,2	13,1
ICT services	8,8	42,0	33,6	41,1
Health services	1,6	4,1	9,0	5,1
Total EU4	6,5	17,2	13,3	20,2

Source: e-business W@tch (Survey 2002)

Current data on markets can be derived from http://cyberatlas.com.
Eurostat, together with the European Commission's Directorate General for Enterprise, conducted a pilot survey on e-commerce in which 13 Member states participated (Deiss 2002). The following table summarises key findings:

Table 5-25: Share of enterprises using ICT, end of 2000 [%]

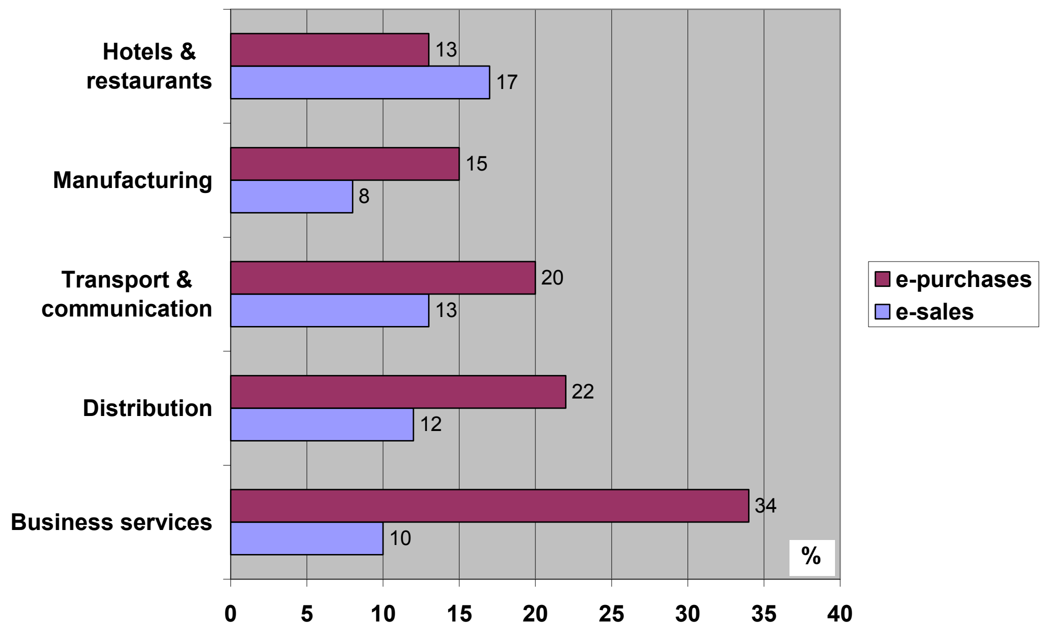
	size	**All**	**DK**	**D**	**EL**	**E**	**I**	**L**	**NL**	**A**	**P**	**FIN**	**S**	**UK**
Computer	**Total**	**92**	95	96	85	91	86	91	88	92	89	98	97	92
	SME	**92**	95	96	84	91	86	90	87	92	89	98	96	92
	Large	**97**	100	96	98	100	99	99		100	99	100	100	100
Web-access	**Total**	**68**	87	67	51	67	66	55	65	76	72	91	90	63
	SME	**67**	86	67	50	66	66	54	62	76	72	91	90	62
	Large	**81**	99	77	84	97	94	70		91	94	97	99	90
Own web-	**Total**	**46**	63	67	29	7	9	41	35	54	30	60	68	50

site														
	SME	**44**	62	65	28	6	9	39	31	53	30	58	67	49
	Large	**80**	89	86	54	35	22	67		86	59	93	91	80

Source: Deiss 2002 (http://www.europa.eu.int/comm/enterprise/ict/statistics/e-commerce.htm)

92 % of the companies surveyed worked with computers, 68 % had a web-access and 46 their own web-site. Large companies are equipped significantly better than SME. The use of computers has become a standard throughout the countries studied, but there are significant differences between countries regarding web-access (from 51 % in Ireland to 91 % in Finland) and own web-sites (from 7 % in Spain to 68 % in Sweden).
The following figure shows the shares of enterprises using e-commerce for sales and purchases:

Figure 5-2: Share of enterprises using e-commerce for sales and purchases (by NACE sections), 2001 [%]; country coverage: DK, EL, I, L, NL, A, P, FIN, S, UK



Source: Deiss 2002 (http://www.europa.eu.int/comm/enterprise/ict/statistics/e-commerce.htm)

The important economies of Germany and Spain are not covered in the figure above. 26 % of the enterprises implemented e-purchasing and 19 % made e-sales.

Table 5-26: Share of enterprises using e-commerce for purchases, 2001 [%]

	size	**All**	**DK**	**D**	**EL**	**E**	**I**	**L**	**NL**	**A**	**P**	**FIN**	**S**	**UK**
used	**Total**	**26**	37	37	5	9	10	19	25	15	12	35	31	33
	SME	**25**	36	35	5	9	10	18	23	14	12	34	31	32
	Large	**47**	66	51	8	20	21	28		30	22	45	37	50
> 2 years	**Total**	**3**		5	1	3	2	5		4	3			
	SME	**3**		5	1	3	2	5		4	2			
	Large	**2**		2	1	3	3	8		7	5			
planned for 2001	**Total**	**8**	3	9	5	18	1	7	12	14	7	11		9
	SME	**8**	3	9	5	18	1	6	12	14	7	11		9
	Large	**10**	5	9	11	23	5	15		18	8	22		14

Source: Deiss 2002 (http://www.europa.eu.int/comm/enterprise/ict/statistics/e-commerce.htm)

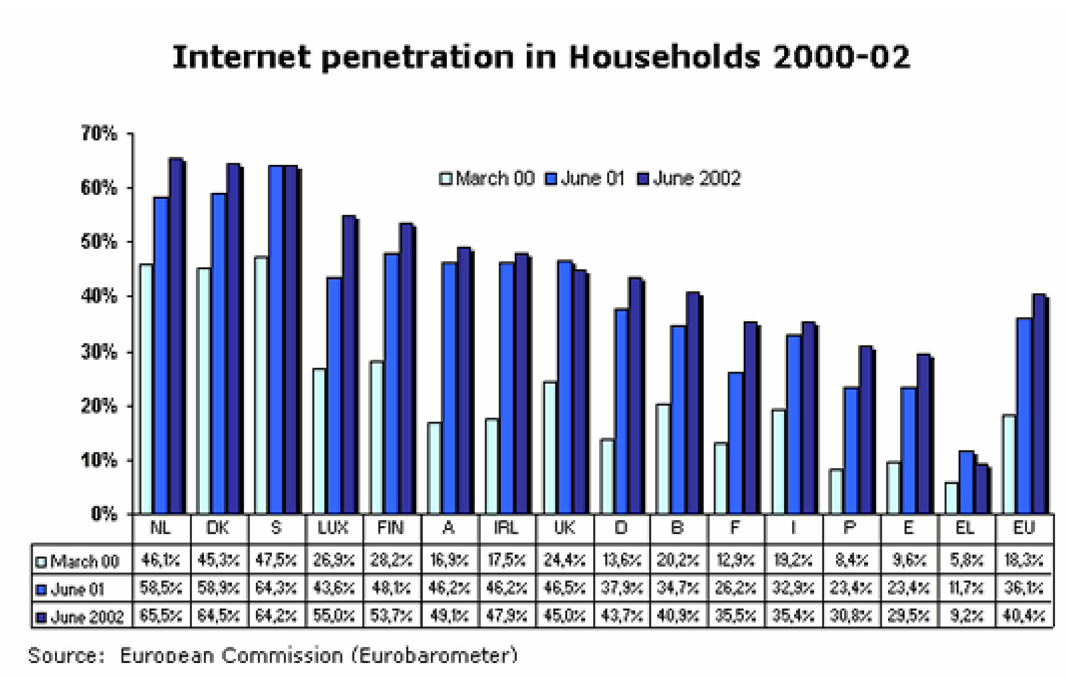
26 % of the companies surveyed used e-purchasing, only 3 % for more than two years and 8 % plan do it in 2001. Large companies are represented to a higher extent in the use (47 %) and planned use for 2001 of e-purchasing (10 %). Real e-commerce is far from having pervaded the economies in Europe, but there are significant differences between countries regarding planned use (from 1 % in Italy to 18 % in Spain). In Germany and Denmark there is already a high level of e-purchasing.
About 14 % of enterprises used e-business for at least 1 % of their purchases and 6 % for at least 1 % of their sales. Sales can be B2B and B2C e-commerce.

Main barriers to e-purchasing were uncertainties about contracts, deliveries and guarantees, unavailability of products and uncertainty in making payments. The top three barriers to e-sales are unsuitability of product for e-sale, maintenance and development costs and, as well, uncertainty in payments. Speed gains are seen as more beneficial than cost gains.

5.3.2.2 Consumer

Only few data relevant for B2C e-commerce exist on the level of the EU up to now. Among them are the internet penetration in households, and in future the benchmarking indicators of the eEurope initiative on e-business and e-government.

Table 5-27: Internet penetration in households in the EU (2000-2002)



	NL	DK	S	LUX	FIN	A	IRL	UK	D	B	F	I	P	E	EL	EU
March 00	46,1%	45,3%	47,5%	26,9%	28,2%	16,9%	17,5%	24,4%	13,6%	20,2%	12,9%	19,2%	8,4%	9,6%	5,8%	18,3%
June 01	58,5%	58,9%	64,3%	43,6%	48,1%	46,2%	46,2%	46,5%	37,9%	34,7%	26,2%	32,9%	23,4%	23,4%	11,7%	36,1%
June 2002	65,5%	64,5%	64,2%	55,0%	53,7%	49,1%	47,9%	45,0%	43,7%	40,9%	35,5%	35,4%	30,8%	29,5%	9,2%	40,4%

Source: http://europa.eu.int/information_society/eeurope/benchmarking/list/2002/

There are significant differences from country to country, northern and central European countries on top and southern European countries at the bottom.

The eEurope Action Plan Benchmarking Report shows that less than 5 % of the internet users, 1,7 % of the population, make online purchases.

The extent of customers' use of the internet has been investigated in different studies in more detail. The development of internet use and online shopping in Germany is described in the following table:

Table 5-28: Development of internet use and online shopping in Germany

	1998	1999	2000	2001	2002
Use of Internet	11,8 %	16,9 %	28,6 %	40,0 %	45,7 %
Online shopping	1,3 %	3,7 %	9,7 %	25,3 %	29,6 %
More often bought via internet	n.a.	2,0 %	1,7 %	3,8 %	5,9 %

Source: Institut für Demoskopie in Allenbach 1998-2002, compiled by TAB2002

A breakdown by products is given below:

Table 5-29: Share of products and services in all internet shopping transactions and share of turnover, 4th season 2002 in Germany

Products and services	Share of shopping transactions	Share of turnover
Books, maps, magazines	28,2	9,1
Clothing, shoes	11,4	11,5
CD and other music storage	10,2	3,1
Other	9,9	6,3
Goods for daily needs/feed	8,2	3,8
Toy articles	7,5	4,1
Computer and accessories	6,0	11,8
Tickets (travel, plane, hotel)	4,2	15,7
Video/DVD	3,7	1,6
CD-ROM	3,2	2,2
Events (incl. Tickets)	3,1	3,6
Sport and leisure articles	3,0	3,0
accessories	2,7	1,8
Electric appliances	2,6	3,4
Household goods	2,3	0,9
Consumer electronics	2,2	6,7
Gifts	2,2	1,0
Textiles for households	2,1	1,3
Commercial downloads, shareware, services	2,1	0,9
Telecommunication devices	1,5	1,2
Foto-/videocamera and accessories	1,4	2,8
Garden and handyman	1,2	1,1
Car and accessories	0,9	1,0
Furniture, kitchen, matrasses	0,9	2,0
Plants, flowers	0,4	0,2
Sum	17.760.000	1.320 million €

Source: GFK 2002, compiled by TAB 2002

These impressive figure have to be seen in combination with total retail turnover:

Table 5-30: Share of B2C turnover of total retail turnover in Germany

	1999	2000	2001	2002
Internet turnover [billion €]	1,25	2,5	5	8,5
Share of total retail turnover [%]	0,25	0,5	1,0	1,6

Source: HDE 2001, prognosis for 2002,; compiled by TAB 2002

The internet accounts for about 5 % of retail sales across all categories in the U.S.A.. Others estimate that the figure is a mere 0,5 % of all retail sales (Romm et al. 1999, S. 29-30). According to Forrester this figure will reach remarkable 7 % in 2004. According to composed estimates of the extent of teleshopping in the U.S.A. sales over the internet will account for 6-6,5 % of retail sales between 1999-2002 (Romm et al. 1999).

Single data for Germany by product include a current share of 0,15 % in feed retail, 8,8 % in mail order business, below 0,5 % in clothes retail, less than 1 % in consumer electronics and about 3 % in book retail. On the other hand much higher figures for other countries are reported. IDC states that there were 6.6 Mln. households banking online in the U.S.A. 1998. This number is estimated to grow to 32 Mln. by 2003. 30% of the PCs bought by U.S. households were bought online (Romm et al. 1999). The extent of online-shopping of food for UK has been estimated to reach 2,5-10 % in 2005 and 15 % in 2010.

An OECD report from 1999 assumed that e-commerce will reduce total wholesale and retail trade activity for consumer expenditures by 25 %. Today more critical voices ask whether B2C e-commerce will remain a 1 % issue. It is expected that increase rates will be flatter in the next years. B2C e-commerce is supposed to be fostered by safe e-cash systems, which are expected for 2004-2006. Additional impetus might come from m-commerce.

Amore detailed picture is given for feed traded over the internet, which is still quite small. In an empirical survey for Germany the following shopping behaviour has been extracted:

Table 5-31: Percentage of online expenses for food

Percentage of online expenses for food	response
< 5 %	38,4 %
5-10 %	16,6 %
10-15 %	10,3 %
15-25 %	9,8 %
> 50 %	9,4 %
100 %	1,2 %

Source: Symposium Publishing 2000, compiled by TAB 2002

For the Netherlands there is a optimistic prognosis, that 10 % of food products will be sold through e-shops in 2005.

With the “Smart fridge” another type of B2C e-commerce is enabled. With full interactive services they only exist as prototypes. However the “Smart fridge” is are already promoted on exhibitions. The full use can be only achieved when smart labels are printed on packages. Intensive activities are undertaken to reduce the prices of these smart labels. The acceptance of customers is highly uncertain.

Limitations to knowledge

Not all EU15 countries are covered in the studies cited above. There is a high uncertainty about the diffusion of ICT and e-commerce in the acceding countries. The structure of the economies may have a correlation with the uptake of e-business.

5.3.3 Data for environmental indicators

A clear distinction of general trends and the effects of e-business is very difficult. As only a few data on the effects of e-business on the environmental indicators exist the illustration of examples remains anecdotal. The impacts of e-business on mass and energy flows show a heterogeneous pattern of positive, neutral and negative effects. They depend highly on framework conditions and assumptions. Up to now only single aspects have been highlighted, an integrating perspective is still missing. Especially the socio-economic environment has not been considered enough. For the effects on transport intensity substitution[14] and induction[15] are discussed controversially.

5.3.3.1 Business

ICT allows the constant monitoring of purchases, the estimation of stock requirements and the projection of future consumption.

Goldmann Sachs (1999, in ABARE 2001) estimated the productivity gains in different industries from B2B e-commerce in the USA:

Table 5-32: Maximum possible productivity gains in different industries from B2B e-commerce in the USA

Industry	Potential cost saving [%]
Electronic components	29-39
Machinings (metals)	22
Forest products	15-25
Freight transport	15-20
Life science	12-19
Computing	11-20
Media and advertising	10-15
Aerospace machinings	11
Steel	11
chemicals	10
communications	5-15
Oil and gas	5-15
Paper	10
Health care	5
Food ingredients	3-5
Coal	2

Source: Goldmann Sachs 1999, compiled by ABARE 2001

In the table above it is assumed that all transactions are undertaken by e-commerce. It reflects a very optimistic picture of e-business during the internet hype. The real figures however are highly uncertain. The potentials can be weighted by e-commerce penetration rates by industry to give a maximum potential productivity impact. For other countries than the USA there is a time lag which has been estimated by ABARE (2001) based on data from OECD and Economist Intelligence Unit.

ICT makes it possible to match supply and demand more closely so that over-production and waste can be avoided. The information asymmetries are substantially reduced and the barriers to market entry lowered. E-business will cause less predictable flows, smaller orders placed more frequently and some parts of the distribution chain will disappear. The main effects are

- Supply chain and demand chain management: transport optimisation, less overproduction, less warehouses and retail stores
- Electronic markets: recycling of used goods, better utilisation

Romm et al. (1999) estimated the energy savings due to reduced area requirements by ICT for the USA:

[14] virtual goods, telematic support of production, organised deliveries instead of private traffic, telework and virtual meetings

[15] world wide supply and demand patterns

Table 5-33: Potential impact of internet on buildings' energy consumption and GHG emissions in the USA (1997-2007+)

building type	bln Sq. Ft. saved	Electricity saved [TWh]	Natural gas saved [MBTU]	GHG saved [million t]
Retail	1,5	18	67	14
Office	>2	35		21
Warehouse	up to 1			
Total	> 3	53	67	35

Source: Romm et al. 1999, p. 37

A bulk of **online trade and auction portals** with used goods and spare parts has evolved. In the case of business investment goods platforms (machines and plants) like www.Goindustry.com are to mention. Secondary raw material like scrap and old paper, manufacturing capacity as well as free space on cargo trucks, vacant airline seats and hotel beds count among the goods traded. The internet helps to a more efficient use of manufacturing capacity which could slow the need for construction of new plants. The amount of incremental construction required per GDP unit may fall. As construction using materials like steel and aluminium is energy intensive energy intensity might fall. Via online selling of cars the amount of produced but not sold cars could be reduced by 320.000 to 400.000 in Ford company. Therefore space requirements at retailers could be reduced.

Resource productivity of e-business has been investigated in case studies by IZT, Borderstep (2002). The case studies focussed on big companies of the car industry (DaimlerChrysler, Ford) and electronic industry (IBM, Siemens, Hewlett Packard and I2[16]) in Germany. The scope included effects of e-business on supply amounts, errors (production, orders), inventories, over-production and logistics.

Better prognosis of production and selling leads to reduced **inventories** in the supply chain, not in the companies who are already used to just-in-time deliveries. Warehouses are less energy intensive than retail stores because more books can be kept in a given area, having lower heating and lighting costs. Romm et al. (1999) estimated that an online book store 7 % of the energy per US-$ of sales related to a traditional book store. Construction needs and energy required can therefore be reduced. Online retailers may build their own warehouses or rely on warehouses of existing distributors or manufacturers. The potential can attain up to **25 %** (Siemens), which is supported by other studies (IZT, Borderstep 2002).[17]
According to (Romm et al. 1999, S. 37) B2B and B2C e-commerce might render 1.5 bln. square feet of retail building in the USA unnecessary which may result in a reduction of 18 bln. kWh of electricity and 67 million MBTU natural gas. Total energy to produce one square feet is about 1 mln. BTU. One bln. square feet in warehousing and storage in the commercial and manufacturing sectors could be saved. Annual energy savings might be small. Nevertheless some unneeded buildings will be destroyed and rebuilt.
The customers' attitude towards mass customisation and subsequent built-to-order or print-on-demand processes differs between the USA and Europe. In Europe for example mass customisation of cars is much more established than in the USA. Therefore the potential reductions in inventory space are significantly lower.

E-customer relation management includes one-to-one marketing and data mining, which shall bind the clients over a long time. Consumers can be informed more individually also on environmental characteristics of products offered. Mass customisation on the one hand enables customer specific production and on the other hand these modified products remain mass

[16] Supplier of supply chain management software

[17] Ernst&Young (2000) estimate that inventories in the US car industry can be reduced by 20-25 % through e-commerce. Durable goods manufacturers estimated to have reduced inventories as a share of sales by more than 25 % over the 1990s, partly due to ICT (OECD 2000, ABARE).

products. Build to order and print on demand ensure that a mass product is only produced if there is a demand. Over-production can therefore be reduced. Toyota is able to produce a car within five days of receiving a custom order from North America. The company uses a computer-based “virtual production line” which is created two weeks before production. In-house inventories were cut down by 28 % and storage requirements in the plant by 37 % (Romm et al. 1999, S. 32). A computer company reduced the planning error for market demand from 40 % to 12 % via introducing E-supply chain management. Inventories of ICT become old very fast, thus **overproduction** was reduced. The total effect is estimated to **5 %** reduction of material required to sell a product. In the long term the potential could be even higher (IZT, Borderstep 2002).

If we take a closer look at geographic patterns we notice that the differences between center and periphery have not been eliminated by ICT. Sassen (1996) has emphasised the growing importance of Global cities in the information age, the same cities which were powerful before (e.g. London, Tokio, New York). This hypothesis is supported by Wildson (2001, in FFF 2002), who found for the UK that dot.companies were concentrated in the zones of traditional economic power. 80 % were located in the South East of England and 60 % in London.

The main effects of e-business on regional relations discussed are (IZT, SFZ, Borderstep 2001):

- cities: centralisation versus decentralisation
- enterprises: decentralisation and changing location factors
- information business: clustering
- commerce: substitution of area for commerce, new space for inventory and distribution

As the effects on geographic structures are ambivalent the total effects are not known.

Just-in-time leads to a **transport volume** increase. World-wide supply and distribution patterns are enabled by ICT. Complex centralisation and decentralisation processes in the logistics markets can be noticed. On the other hand via better planning traffic can be shifted form air and express deliveries to rail and sea and capacity usage can be increased by fleet and logistic planning (**modal split**). The distribution of products to big customers can be organised more efficiently as well. Siemens reports for single distribution cases a reduction of 20 % by point to point logistics. Ford claims that internet based routing and capacity optimisation have reduced empty truck travels by 40 %. “If online auctions were to increase the overall load of cargo trucks on the road by even 10 percentage over the next 10 years, the impact on transportation energy intensity would be enormous” (Romm et al. 1999, S. 64). However as the case studies by ICT showed the effects on transport intensity are highly uncertain. The overall effect is unknown**,** but adverse effects on modal split for freight transport are highly certain. For this it makes no sense to discuss the effects on Greenhouse Gas emissions and Urban Air Quality. Quantitative data for the effects on cardboard packaging is not available. Freight transport effects of B2B e-business will modelled in the chapter on transport management systems.

It is improbable that there will be a quantum leap of productivity by e-Supply chain management, but **incremental** ones. The uptake of SCM in the electronics industry has gone fast, whereas the uptake in the car industry has been much slower due to the product complexity and mass customisation. Tracking and tracing with Smart Labels and improved data and management systems will improve efficiency further in the future. Potentials for e-procurement of the administration have not been assessed yet. Ecological criteria may be included e.g. by “total Cost acquisition and ownership”. The efficiency strategy may induce new mass- and energy flows because products can be produced and offered more cheaply (IZT, Borderstep 2002).

5.3.3.2 Consumer

There have been several case studies on the effects of B2C e-commerce on energy, transport and waste. The results have in common that the overall effects highly depend on framework conditions.

With regard to **energy and transport** the main effect is that organised deliveries replace own shopping tours to a certain degree. Main results from different studies are:

- It is estimated that home shopping will reduce car-based shopping travel by 5 % by 2005 and 10 % by 2010. On the other hand there are increased delivery traffic and supply lines. A study for the Netherlands predicts that if E-commerce makes up 11,5 % of retail sales, road traffic will increase by 17 % (NERA 2000).
- The conventional and e-commerce distribution of Harry Potter books have been compared by Matthews (2001). Total energy demand per book for conventional delivery was 115 MJ and by using e-commerce 98 MJ.
- Online shopping of a book has been compared with traditional shopping by Deutsche Telekom (Reichling, Otto 2001). The running of the PC accounts for 59 % of primary energy demand for online shopping of a book, the remaining 41 % are due to transport. The overall result highly depends on the consumers behaviour (using car or bicycle).
- The clothing retailer Patagonia reported a share of 6 % of the total energy demand for traditional transportation. Using overnight mail this figure rose to 28 % (Romm et al. 1999).
- A study by Caudill (o.J.) assessed the effects of e-commerce for desktop PCs of Dell. If e-commerce is used only for the purchase of PCs, energy consumption rises by 9 % related to the whole life cycle. This can be explained by increased express deliveries via air plane. If internet is used in SCM energy consumption in the case of air transport is 3 % lower and in the case of road freight transport 11 %.
- Lund University (Department of Design Sciences, Packaging Logistics) investigated the environmental effects of conventional shopping and organised delivery vans. Bundled deliveries show advantages if the route is below 185 km. High population density, high capacity usage of the vehicle and efficient routing contribute to a net energy saving effect.
- Home shopping may increase the demand for goods and freight movements with smaller vehicles. The atomisation of deliveries tends to increase freight transport (Aden 1999).
- Mobility researchers notice a relatively constant time budget of 60-65 minutes per day. With the growing distances covered total passenger transport volume rises. Shopping has also an event character and is often combined with travel to/from work or leisure activities. Time saved by home shopping may increase leisure mobility (Burgdorf 2000).
- A minute spent travelling uses 8-12 times as much energy as a minute spent in service buildings or at home (Romm et al. 1999, S. 58).

The overall effects highly depend on the way how the deliveries are organised. They can be organised in the following ways (TAB 2002):

- Direct delivery to homes by a small transport vehicle
- Convenience store in town to be reached by foot (video shop, petrol station, ...)
- Convenience store in rural areas to be reached by car (pick up after work)
- Big boxes in towns (delivery by agencies nearby)
- Small and medium boxes (delivery at workplace)

Concentration in retail leads to increased distances between customer and retail store. Almost all ways are more environment friendly than shopping with the own car, big box systems offering the biggest advantages. However it is considered to be unrealistic. More realistic are convenience stores and direct deliveries by high capacity usage of a bigger vehicle. The location of the inventory to the point of delivery is the main variable to be considered. The effects of deliveries could be substantially reduced by making it a post service. If people order via internet they might lose their feeling for distances and will choose long distance delivery channels. Current barriers to home deliveries are the costs for the supplier, small user friendliness and poor user technology equipment. For optimising the deliveries the structure of clients, goods and traffic have to be known. It may be assisted by a digital map and demographic data.

The exchanges and auction of used goods has become very popular. The car-recycling auction Renet and e-bay are just two examples for e-commerce that might substitute the purchase of new products to a significant degree.
However these goods traded are rarely products which will end up as **waste from daily household and commercial activities**. The effects of B2C e-commerce on this indicator have not been investigated in detail up to now.

The most important fractions vulnerable to be changed by B2C e-commerce are feed[18] and packaging. Paper is important as well but will be treated in a separate chapter, because of the overall dematerialisation potential and non-commercial use.

- ICT enabled **lifestyles** contribute to easy and fast to prepare convenience food as well as eating outside of the household, which has indirect consequences for the food losses and packaging. Convenience is assumed to require more packaging than fresh food. On the other hand restaurants need big amounts with relatively low packaging. This advantage might be outweighed if fast food with a lot of packaging is chosen.
- Internet shopping of food might lead to **another choice of food**. It can be estimated that especially convenience food and other intensively packaged food is ordered. Fresh fruits are often sold without or with small packaging, but the reason is that people want to see and touch fresh food before buying them. Shopping robots could assist in finding not only cheap but also ecological products. Optimists hope that consumers build virtual communities to promote ecological products and services which are captured by companies and realised in the next product or service generation. A closer look at the food market in the internet (Kobilius, Nachtmann 2000, in TAB 2002) unveiled that the market for organic food is hardly developed.
- What is called "**Smart Fridge**" could lead to less food being thrown away because expiry dates have been passed. Smart labels on packages could inform the customer which food has to be eaten in the next two days. The ease of convenient ordering of food could lead to smaller amounts being bought. On the one hand this could lead to more packaging, on the other hand the amount of food (including packaging) thrown away could decrease.
- In the case of home deliveries of products which have been ordered via the internet it has to be assumed that the **atomisation of packages** leads to more packaging. A book bought in the store can be transported at home in a reusable bag, delivered it will be wrapped in cardboard and/or plastics. Food is especially vulnerable to damage due to road transport. For this it has to be packed carefully.

Summing up, these effects can only be described in a qualitative manner, but they seem to have an important impact on the total amount of waste from daily household and related activities.

5.3.4 Variables

A combined indicator for e-business readiness comprising adoption and use of the internet is currently developed under the domain of eEurope. A first pilot study is carried out in 2003 but results will probably not be available in time for this project.

5.3.4.1 Business

Total commerce-volume [GVA of commerce]

The uptake of e-commerce depends on the total volume of commerce. Regarding the environmental effects mainly the GVA of commerce as part of tertiary should be taken into account. The future development until 2020 is highly uncertain.

uncertainty: high; effect: ↑

Enterprises having access to the internet [% of all enterprises]

There is a growing number of enterprises which have access to the internet. Already a must for large companies there is an important potential for SME (e-Europe benchmarking indicator B.2).

uncertainty: low; effect: ↑

Turnover from e-commerce [% of total turnover]

The turnover from e-commerce is often limited to a few percent. In many industries the products are of limited suitability for e-commerce. It is unclear how big the real potential might be. The definition of the indicator only considers companies with a share of more than 1 % (e-Europe benchmarking indicator G.1.)

[18] Feed comprises food and drinking

uncertainty: middle; effect: ↑

Orders received online [% of enterprises]
Uncertainties in payment and costs to set up an e-sales system are barriers, so that a widespread adoption is uncertain (e-Europe benchmarking indicator G.3.)

uncertainty: middle; effect: ↑

Purchases online [% of enterprises]
Purchases online are limited due to uncertainties about contracts, deliveries and guarantees, unavailability of products and uncertainty in making payments (e-Europe benchmarking indicator G.5).

uncertainty: middle; effect: ↑

Mass customisation [% of turnover with suitable products]
There is a potential for mass customisation which has not been exploited yet. In combination with built-to-order inventories can be reduced and unnecessary extras, e.g. in cars, need not to be produced. Suitable products are vehicles, computers and machinery.

uncertainty: middle; effect: ↑

The net effects on transport intensity are seen as very uncertain due to rebound effects and enlarged supply and distribution chains. They are treated in the transport chapter. Main effects that determine the effects of e-business on energy intensity are:

Commerce with long-lived products [% of all weight]
The reduction of overproduction will take place only in the segments which are suitable for e-commerce. The real amount is highly uncertain. A rough estimation for the potential is 5 %.

uncertainty: middle; effect: ↓

Inventory reduction [total square meters]
The reduction of inventories is often estimated too optimistically as subsequent uses are neglected. Retail stores might be used for other purposes.

uncertainty: middle; effect: ↓

Third order effects [% of saved energy]
The increase in efficiency may lead to a price reduction and stimulate demand to a certain degree. Complete overcompensation is not probable.

uncertainty: middle; effect: ↑

Intelligent transportation systems [% of all freight transport]
The logistics market has already taken up substantial ICT based solutions. Nevertheless efficiency could be further stimulated if the system boundaries would be enlarged to more companies. Europe has set up ambitious goals for intelligent travel systems, to provide better traffic fluidity. Optimised traffic systems are supposed to be pushed by the set-up of Galileo, starting in 2008.

uncertainty: low; effect: ↓

Third order effects [% of reduced travel km]

There are hints that optimisation of logistics leads to global supply and distribution. However empirical data on the net effects are not available.

uncertainty: high; effect: ↑

5.3.4.2 Consumer

The uptake of B2C e-commerce will be highly influenced by the demand side.

Internet access [% of households]
Internet access is a prerequisite for B2C e-commerce. In future m-commerce might be also important. Internet access of households is likely to grow with smaller rates and will be monitored intensively throughout the EU.

uncertainty: low; effect: ↑

Broadband Access [% of households]
Simple internet access is suitable enough to order a simple ticket for a train. However faster internet access enables a higher comfort for browsing catalogues, animations and so on. This is the case for example when choosing a car. Virtual test drives and the composition of accessories with attractive surfaces will require a lot of capacity. It is one of the eEurope indicators.

uncertainty: low; effect: ↑

Online shoppers [% of all households]
Not all people with online or broadband access will use the internet for shopping. Main barriers are the fear of insecure payment systems and inconveniences, which can be mitigated to some degree by broadband access.

uncertainty: middle; effect: ↑

Uptake of B2C E-commerce [% of total retail turnover]
The uptake of B2C e-commerce will be different in different product and service categories. Some are suitable for online orders (e.g. tickets and software), others are less (e.g. fresh food, shoes).

uncertainty: middle; effect: ↑

"Smart fridge" [% of all households]
The uptake of the Smart Fridge is highly uncertain, because there are mainly prototypes. To become a mass application it has to be affordable, of high value and in fashion. To get full benefits of a "Smart fridge", Smart label have to be on packaging. Prices are still too high, but severe efforts are undertaken to reduce costs, so that they are applicable on almost every package.

uncertainty: high; effect: ↑

To assess the effect of B2C e-commerce on transport and waste from daily household and commercial activities the following variables have to be determined:

Increase in home deliveries [total number]
An appropriate access to home deliveries might be the total number by year. It is highly uncertain if and how people will accept deliveries until 2020.

uncertainty: high; effect: ↑

Method of product delivery [% of all types of deliveries]
There are different types of deliveries which determine the effect on transport. As this infrastructure is hardly built future split of the types of deliveries is highly uncertain.

uncertainty: high; effect: ↑

Transport effect by method of product delivery [tkm/delivery]
Each of the methods for delivery has different environmental effects, the distances of transport being the crucial point.

uncertainty: high; effect: ↑

Modal split of delivery [% of all deliveries]

Atomisation and just in time deliveries favour very flexible and fast means of transport. Especially road and air transport are favoured. However there are just single case studies on these effects.

uncertainty: high; effect: ↑

Reduced travel by motorised individual transport [pkm]
The extent to which individual traffic is substituted is highly uncertain, as people seem to have an almost constant mobility time budget. Online-shopping seems to be more additional than substitutive.

uncertainty: high; effect: ↓

"Choice of food"- packaging effect [% more packaging/item of feed]
There is hardly any information how online shopping in the internet influences the choice of food. However it is probable that this food has more packaging, as a direct physical impression plays hardly any role. The extent of substitution however is unknown.

uncertainty: high; effect: ↑

"Smart fridge"-packaging effect [% less food & packaging thrown away]
Although the Smart Fridge is not used by the mass by now it makes it possible to display expiry dates of feed deep in the back of the fridge, to give recipes for meals with goods which are close to expiring. Ease of buying might either lead to small amounts ordered, consuming them all, or to consciousness ordering of food not needed.

uncertainty: high; effect: ↓

Atomisation effect [kg packaging per home delivery]
The atomisation effect is very difficult to determine. The product categories delivered have to be considered.

uncertainty: high; effect: ↑

5.3.5 External Factors

Factor	**Trend**	**Uncertainty**	**Variables affected**	**Rationale**
GDP	small growth	middle	GVA of commerce	the higher GDP growth the higher GVA of commerce
Structure of the economy	towards tertiary	middle	GVA of commerce	the higher tertiary GVA the more e-business encouraged
Individualised and mobile Lifestyles	growing	high	Food and packaging waste	The more people mobile and living in small households the more convenience food in small packages but the more eating outside
Secure payment systems	priority EU activity	low	Turnover from e-commerce	The more secure payment systems the more e-business
environmental policy/legislation	More ambitious EU policy	middle	ITS	environmental policy may lead to increased road traffic control
Transportation costs	almost constant	middle	Turnover from e-commerce	the lower costs the less the companies willingness for SCM

5.4 Telework and virtual meetings

A significant diffusion of telework and virtual meetings in EU until 2020 is considered to be highly certain. A net reduction effect on passenger transport intensity is also highly certain, but it may be smaller than expected due to the complexity of variables/factors and third order effects.

5.4.1 Definition and scope

One of the key characteristics of ICT is that affordable hard- and software and marginal transaction costs offers the possibility to everyone to be a producer of digital goods like media, music and design. New interactions and communities are enabled. These communities have differing intentions also including work and co-operation. This could result in a radical change in our conceptions of work, production and consumption (Oekonux 2002).

Telework and virtual meetings are conceptualised in narrow sense in this chapter to reduce complexity, in order to see something.

Telework and virtual meetings are two types of **virtual mobility** which have a potential to reduce commuting and business travel. They are bound to work (mostly in the tertiary sector) whereas the virtual mobility of citizens is discussed in chapter 4.4.
Telework is defined by the European Commission as
“ a method of organising and/or performing work in which a considerable proportion of an employee’s working time is: away from the firm’s premises or where the output is delivered; and when work is done using information technology and technology for data transmission, in particular the internet.”
ECaTT (2000b) describes home-based teleworking as:

- work from home at least one full day per week
- use of a PC for this work
- use of the phone, fax or email to communicate with colleagues from home
- that teleworkers are either salaried or self-employed.

In other definitions (e.g. empirica 2000) self-employed work from home is not included.
According to Digital Europe (2003) “it is the change of location which is important rather than the use of ICT”. Telework involves the potential work shifts from the office to home, on-site, telework centers or during transport.
Virtual meetings are used to communicate and collaborate in business via audioconferencing, videoconferencing and web-meetings (Arnfalk 2002). New technologies emerge. The term teleconferencing is often used as a synonym.

5.4.2 Data for diffusion

5.4.2.1 Status quo and developments in telework

In 1999 about 5 million residents of the EU did telework. Home-based telework and all kinds of telework have been assessed for 10 EU countries by Electronic Commerce and Telework Trends ECaTT (2000) and calculated for EU 15 by empirica (2000).

Table 5-34: Spread of telework in Europe 1999

	home-based teleworkers		**all teleworkers**	
	absolute	% of labour force	absolute	% of labour force
EU 10	2.687.000	2,0	8.205.000	6,1
EU 15	2.946.000	2,0	9.009.000	6,0

Sources: ECaTT 2000 and empirica 2000

The patterns of adoption are usually assumed to follow a “S-curve” with the parameters current penetration of telework, saturation level, other constants and time as the variable. According to ECaTT saturation levels in five EU countries –taking the employee interest into account –are as follows:

Table 5-35: Estimated saturation levels of telework penetration in Europe

	teleworkability	**employee interest**		**saturation level**	
	any kind = home-based	home-based	any kind	home-based	any kind
France	62,8	58,9	64,8	37,0	40,7
Germany	69,1	56,6	64,7	39,1	44,7
Italy	74,2	62,4	69,5	46,3	51,6
Spain	64,8	50,7	60,6	32,9	39,3
UK	67,9	58,7	64,8	39,9	44,0

Source: empirica 2000

All teleworkable jobs can be carried out in principal from home. Taking into account the employees' interest, which is different for home-based and any kind of telework the saturation levels are calculated by multiplication with total teleworkability.

With data for 1994 and 1999 the diffusion of telework has been calculated by empirica (2000). For Germany and Italy strong growth is predicted. They will reach their saturation levels in 2020.
In a second extrapolation model the willingness by companies to offer telework to their employees has been taken into account for 10 EU countries. According to empirica (2000) the share of home-based telework of total labour force will rise from 2,0 % in 1999 to 4,2 % in 2005. The figures for all forms of telework are 6,1 % and 10,8 % respectively. In absolute numbers by 2005 there may be 16 million teleworkers with 6,3 million who will regularly telework at home.
Other country specific differences have been identified in the e-living project (2003). High extents of telework are reported for Israel due to insecurity and in Norway for geographic considerations. The strong growth in Italy and Germany is explained by attempts to catch up the forerunners UK and some Scandinavian countries. In Bulgaria insufficient infrastructure limits the extent of telework. Similar conditions can be assumed for some of the acceding countries.

Limitations to knowledge
Current data for the extent of telework and saturation levels in some European countries are incomplete. There is no specific data for on-site work, telework centers or during transport. Especially for the acceding countries there is no reliable data basis.
Forecasts for diffusion patterns of telework are often incorrect as they omit decisive factors. A potential "mainstreaming of telework" -pushed by rapid progress in mobile data communications- may lead to inability to measure teleworking.

5.4.2.2 Status quo and developments in virtual meetings

Limitations to knowledge
There is no aggregated statistical material on virtual meetings. Single current figures can be collected from the providers (e.g. Deutsche Telecom and British Telecom) as well as some big companies (e.g. IBM, Siemens). As a consequence the spread of virtual meetings can only be estimated roughly.
For Telia it is reported that the had 34.000 teleconferences in 1998 (+ 300 % in the past three years), whereas business trips fell to 149.000 per year, down by 12 % from 1997 levels (Romm et al. 1999, S. 64).
IDC estimates that videoconferencing shipments in the USA will rise from 400.000 in 1999 to 4,2 mln. in 2003.

5.4.3 Data for environmental indicators

5.4.3.1 Effects on passenger transport intensity

The amount of passenger transport only has a weak correlation with GDP. As a consequence passenger transport is discussed without referring to the development of GDP in this chapter.

There is no consistent data basis for travel by purpose on a European level. Especially for the acceding countries there is no reliable data basis. Many third order effects of telework and virtual meetings on passenger transport are not fully understood by science and far from being quantified. The modal split for commuting is known for some countries. **Telework** will affect especially MIV, Rail and public transport travel. The shares are unknown.

According to Aebischer (2000) the average commuting distance is 27 km/workday, taking into account the number of working days it is 17,9 km/day. In an empirical study the travel behaviour of 80 teleworkers was investigated (Vog 2000, in Aebischer 2000). A total reduction of **9 km/d** (-24 %) on average was found for passenger transport. Those commuting by car reduced the daily travel distance by 7,2 km/d (-25 %) on average.

According to Romm (2002) home based business workers spend 1,23 h/d travelling in cars for all purposes, home-based commuters 1,39 h/d and conventional workers 1,61 h/d.

Digital Europe (2003) has roughly assessed the potential of telework to reduce passenger transport. From all passenger transport activities about 20 % (pkm) fall to commuting. About 30 % of the total labour force have teleworkable working places resulting in a potential of 6 %. If you assume that there will be 2 days of telework out of 5 a week the total reduction potential of passenger transport is **2,4 %**.

The modal split for business travel is known for some countries. How telework changes the modal split is unknown. Mostly MIV and air travel will be affected.

People perceive a net reduction effect by virtual meetings and telework, which can be shown at the organisational level as well (Arnfalk 2002).

Some limited surveys and case studies have been carried out:

- An empirical survey of Swiss companies gives an estimated range of “low” to 25 % of business travel reduction (Rangosch 2002).
- According to Cook and Harver (1994) 25 % of business travel by plane could be replaced until 2010.
- Arthur D. Little (1995) estimates the reduction potential of videoconferencing for air travel to 15 %, while the figure for business travel reaches 40 %.
- Roy and Filiatrault (1998) estimated the current impact of videoconferencing at 1,8 % and a reduction potential of 3,6-8,6 % of business air trips in 2000.
- Reduction of travel costs in different big companies is reported (e.g. Tetra Pak: –10 %, Siemens – 4 %).

In Sweden roughly 10 % of all passenger transport is business travel. Taking into account the maximum share of business travel for Switzerland estimated by Rangosch (2002) that could be saved by **virtual meetings** passenger transport volume could be reduced by a maximum of **2,5 %**. According to Romm et al. (1999, S. 64) video-conferencing has 1 % of energy consumption of air travel.

5.4.3.2 Effects on other indicators

Directly affected sector/indicator-combinations are:

- **energy intensity of the industry**: teleworkers may need an additional PC and further equipment at home and/or a notebook. This is treated in chapter 3.4.
- **energy intensity of the domestic sector**: will rise (heating, space, operation of PCs)
- **energy intensity of the tertiary sector**: can be reduced (heating, space, operation of PCs) or transferred to satellite offices

According to Atlantic Consulting (1998) the production of a PC requires 3,6 GJ of energy.

Rough bottom-up estimations for energy demand are compiled by Aebischer (2000):

a) one person out of two makes telework in a household

Electricity consumption at home rose from 3.036 kWh/a (1992-1996) to 3.944 kWh/a (1997) which equals an increase by 30 %. The share of ICT and lighting of workplace was

491 kWh/a (54 %). The rest is due to increased warm water, food and beverage consumption and lighting.

b) empirical survey of 80 teleworkers

According to the data by Vog (2000) fuel consumption per teleworker is reduced by 1,2 MWh.

c) desk sharing and home office

Four teleworkers are supposed to rationalise three work places in a bank. The additional area for a home office is 11 m^2. Consumption of fossil energies rose by 1,7 MWh per telework place whereas electricity consumption increased by 0,1 MWh/a for one day of telework per week and decreased by 0,3 MWh for four days a week.

Based on these data the minimum and maximum energy effects for Switzerland were calculated. 25 % of passenger transport are due to commuting. The average distance is 17,9 km per day. Modal split is 69 % by car and 23 % by public road and rail transport. It is assumed that passenger transportation reduction is between 0 % (full compensation) and 100 % of the average value, which leads to these ranges (MWh/a and teleworking place):

Electricity consumption:	[-1,0;+0,2]
Fuel consumption for heating:	[-0,7;+1,1]
Petrol:	[-3,2;+/-0]

AT&T has reduced square footage per person from 230 to 120. The potential for shared-office workers is estimated to 2/3 using 1/3 of office space compared to traditional offices. A typical office building in the USA uses about 20 kWh per square foot and 35.000 BTUs per square foot of natural gas. The increase of home based electricity is assumed to be significantly lower with 500 kWh for a shared office worker and 1000 kWh for a virtual worker. Each shared office worker saves 175 square feet per worker times 20 kWh per square foot or 3.5000 kWh a year, a virtual office worker 270 square feet per worker or 5.400 kWh a year. This results in a net reduction of 3.000-4.000 kWh a year (Romm et al. 1999, p. 34-35).

Home-based work is enabled by small market entry costs. Incremental home based electricity consumption is estimated at 1.500 kWh yielding in a net saving of 4.500 kWh compared to a traditional small office building generating the same type of revenue (Romm et al. 1999, p. 36.).

Supposed that from 1997 to 2007 the internet leads to an additional 1 million home offices a year, half of the workers being telecommuters (-150 square feet), the other half internet entrepreneurs (-300 square feet) that would avoid 2 bln. square feet of office space by 2007. If the net saving of a telecommuter is 3.000 kWh and of a internet entrepreneur 4.000 kWh 35 bln. kWh could be saved.

The effects of telework and virtual meetings on **CO_2-emissions** (Arnfalk 2002) have been calculated in more detail using a model integrating transportation, office space, equipment and communication. Passenger transport and energy intensity are not expressed explicitly. For virtual meetings the reduced use of hotels and for telework the increased use of home space were added. For telework CO_2-emissions mainly depend on the effects of commuting, the need for extra ICT equipment and changes in area required at home and in the office. The overall result is very sensitive to assumptions that reflect the use and system boundaries and can be positive or negative. On the other side even a slight reduction of transport by virtual meetings leads to an overall reduction in CO_2-emissions. Equipment and premises for virtual meetings have a relatively small impact.

Assuming one million additional home-based business per year from 1997-2010 avoiding 0,38 h travel/d 250 days per year this would avoid 15 mln. tons of CO2 in 2010 in the USA (Romm et al. 1999, p. 55-56).

Hischier/Hilty investigated the environmental effects of a three day long conference in Zürich. The total environmental burdens measured by **Eco-Indicator-Points (EIP)** were dominated by air travel (4207 EIP out of 4650 EIP in total). A scenario of three virtually connected conference locations (Zürich/ Dallas/Tokio) reduced EIP by almost 50 %. A totally virtual meeting would have led to only 10 EIP.

The effects on **GHG emissions** and emissions of **Urban air pollutants** can be calculated easily by using emission factors related to passenger transport and energy sources. The emission patterns of urban air pollutants will change. People living close to streets will profit from virtual traffic whereas emissions from heating in office areas will be transferred to living quarters in the case of home-based telework. It is not known how the **modal split** will be affected, but probably MIV and air travel will be reduced mostly by telework and virtual meetings. **Energy intensity of transport** is closely interrelated with the modal split. **Municipal waste** is probably affected to a very low degree.

5.4.4 Variables

5.4.4.1 Telework

Telework is mainly motivated by private benefits and by companies' efficiency considerations.

Total labour force [number of persons]

The absolute extent of telework until 2020 will depend on the total labour workforce, which itself depends indirectly on factors like productivity growth, demand expectations, competitiveness and public employment measures. It is unclear in which sectors the EU will have high competitiveness. Growth projections are moderate, other economic blocks like South East Asia may catch up Europe.

uncertainty: high; effect: ↑

Teleworkable jobs [% of jobs]

The proportion of teleworkable jobs is subject to change due to the restructuring of the economies. Especially office jobs can be carried out easily outside a certain building. The share of home-based teleworkable jobs could be separated but the effects of the other forms on passenger transport are unknown.

uncertainty: high; effect: ↑

Companies' willingness [% of companies]

A company doesn't have a direct incentive for the reduction of commuting costs. Indirectly it may profit from better employee motivation and less office capacity through desk sharing. On the other hand telework entails deep changes in a companies culture. The lack of policies and agreements, management acceptance and poor equipment are barriers to the introduction of telework. Secure VPNs can contribute to the spread of telework.

uncertainty: middle; effect: ↑

Employees' interest [% of employees]

For individuals the main interest in telework is to have a better work/life-balance. The reduction of travel time is seen to have only a relatively small contribution (e-living D7.5 2003). Cost considerations supposedly play a minor role because commuters mostly have monthly tickets for public transport and the use of car is barely influenced by cost considerations. Family characteristics and flexibility requirements point at growing importance of work-life balance. The trend towards declining home care for children, elderly or sick/disabled persons may reduce employees' interest.

uncertainty: high; effect: ↑

Broadband Access [% of households]

Telework will be made more convenient by broadband access. The eEurope Initiative has chosen broadband access as one of the indicators for Europe's way towards an information society. Broadband access, new ergonomic interfaces and easy to handle software may foster telework.

uncertainty: low; effect: ↑

"Smart home"-Technology [% of households]

A "Smart home" provides sophisticated possibilities for a better work-life balance to make household, leisure and working activities more efficient. Experiments with families showed reluctance to many functions. Single applications though were appreciated. This may change in the future. In the IPTS Technology map for ubiquitous computing almost any home tasks will be undertaken by robots (2009-2015).

uncertainty: high; effect: ?

Frequency of telework [full days per week]

If telework is carried out only during half of the day and people spend the other half of the day in the office there is no travel reduction effect. For this the full days per week spent at home instead of commuting should be a taken into account. Less than half of all telework leads to travel savings because work is allocated to parts of the day, evenings and weekends.

uncertainty: high; effect: ↑

Intelligent transportation systems [% of road network]

One motive for telework is to avoid traffic congestion. eEurope has set up ambitious goals for intelligent travel systems, to provide better traffic fluidity and more efficient parking. Car navigation systems have already become a standard in high and middle class cars. Optimised traffic systems are supposed to be pushed by the set-up of Galileo, starting in 2008.

uncertainty: low; effect: ↓

Regulation for road traffic control [% of road network]

Car bans from inner cities or ICT based road pricing may encourage the use of public transport or a shift towards telework. In single big cities cars might be banned from the city centers. Roadpricing systems are more probable but they may be limited to motorways and towns with much pollution and/or interest in additional income.

uncertainty: middle; effect: ↑

Efficiency of public transport network [average travel time by commuters]

The more people are annoyed by public transportation and train services the more incentives are given for commuting by car or home-based telework. On the other hand public transport offers the possibility for telework e.g. in suburban trains. Considerable efforts are undertaken to make public transport more efficient by using ICT Intermodal transportation is encouraged by the EU.

uncertainty: low; effect: ↓

***

Main variables that determine the effects of telework on passenger transport are the frequency of telework (see above), the distance to work and third order effects.

Average distance of commuters to work [reduced travel km]

The longer the way to work the more time for commuting can be saved. People who live close to their office only have small incentives for telework.

uncertainty: low; effect: ↑

Third order effects [% of reduced travel km]

Free parking space and less congestion may encourage others to commute by car instead of public transport. The time saved may lead to increased leisure travel and the worker's car might be used by other household members.

uncertainty: high; effect: ↓

5.4.4.2 Virtual meetings

Virtual meetings are mainly motivated by companies' cost reduction considerations and employees' time savings.

Total labour force [number of persons]

see telework

uncertainty: high; effect: ↑

meetings replaced [% of meetings]

Work meetings, work orders, discussion and reporting count among the most important forms of communication which contribute to this potential when personal communication plays a minor role. The total number of meetings and potential meetings is hardly to determine.

uncertainty: high; effect: ↑

Companies willingness [% of companies]

Companies can reduce travel expenses significantly by virtual meetings. There is only a short payback time for equipment. The time saved by employees will be used to a high extent for additional work. Barriers to companies willingness are the companies culture, insufficient availability of equipment as well as reliability and support.

uncertainty: low; effect: ↑

Employees interest [% of employees]

The employee has no direct benefit from the cost reduction because travel expenses are usually covered by his company. The main motive might be that he is less time away from family and friends. On the other hand barriers include the miss of small talk and non verbal gestures in audio-conferences, the attractiveness of travel (prestige, combination with holiday), lack of interest and skills.

uncertainty: middle; effect: ↑

New technologies for tele-cooperation [% of companies]

Apart from improving existing teleconferencing technology new technologies may push virtual meetings. Mobile video-conferencing probably will remain a niche application. New technologies (IPTS 1999) in the short-term include "groupware decision support tools" (2003-2005), in the mid-term "global distributed networks on distributed database with personal ID" (2007-2011) and in the long-term "true artificial intelligence" (starting from 2015).

uncertainty: high; effect: ↑

Intelligent transportation systems [% of road network]

Intelligent transport systems for roads may discourage virtual meetings (see telework), but more long distance travel is affected (motorways).

uncertainty: low; effect: ↓

Regulation for road traffic control [% of road network]

Car bans from inner cities or ICT based road pricing may encourage the use of public transport or virtual meetings (see telework).

uncertainty: middle; effect: ↑

Efficiency of air travel [average time for air business travel]

The EU white paper on transportation has stressed the need to control growth in air travel, i.e. "allowing traffic to grow while guaranteeing safety". ICT plays an important role in making the whole air travel system more efficient by reducing waiting times (e.g. via self-check) and travel time (e.g. optimised use of airports).

uncertainty: low; effect: ↓

***

The effects of virtual meetings on passenger transport mainly depend on the number of meetings substituted (see above), the distances to business partners and third order effects.

Average distance to business partners [reduced travel km per trip]

There is a wide range of distances of business travel ranging from inner cities bicycle rides to long distance flights. Especially the expensive long distance travel by air, train and car is supposed to be reduced by virtual meetings. The longer the distance to business partners the more travel time is saved.

uncertainty: middle; effect: ↑

Third order effects [% of reduced travel km]

There are hints that virtual mobility stimulates travel as more contacts in a given time over larger distances are facilitated which generates the need or willingness to meet face-to-face (Arnfalk 2002).

uncertainty: high; effect: ↓

5.4.5 External Factors

Factor	Trend	Uncertainty	Variables affected	Rationale
population size	small decline in the EU	low	total labour force	the more people the more work
population structure	age pyramid	low	employees' interest	elderly people become less mobile
population distribution	(sub)urbanisation	middle	travel distance for commuters	the more (sub-)urbanisation the more commuters
GDP	small growth	middle	total labour force	the higher GDP growth the higher total labour force
Structure of the economy	towards tertiary	middle	teleworkable jobs, meetings replaced	the more jobs in tertiary sector the more teleworkable jobs and meetings replaced
environmental policy/legislation	More ambitious EU policy	middle	road traffic control	environmental policy may lead to increased road traffic control
Technology development and acceptance	continued	high	Smart home and technologies for co-operation	Better technologies lead to higher diffusion of smart homes and co-operation technologies
ICT skills	fast growth	low	employees' interest	the higher the ICT skills the higher employees' interest
Security	world becomes more insecure	high	employees' interest	the more secure the world the more employees interest
Mobility costs for commuters	almost constant	low	employees' interest (telework)	the higher mobility costs the higher the employees interest
Mobility costs for companies	slightly reduced	low	companies' willingness (virtual meetings)	the higher mobility costs the higher the companies willingness

5.5 Virtual goods

ICT has a dematerialisation potential for information goods. The main areas are physical goods for displaying and storing text, software, audio and video. However easy copying and rematerialisation have lead to significant increases in paper consumption, CDs, DVDs and other electronic storage means. With regard to waste from daily domestic and commercial activities electronic means of storage are of minor importance compared to paper.

5.5.1 Definition and scope

In this section the following items are investigated:

a) Digital office

For decades the vision of the paperless office has been proclaimed:

- documents generated electronically
- documents published and distributed electronically (e.g. download)
- documents read electronically

However, as the paperless office has stayed a vision it is more appropriate to talk of a digital office.

b) Electronic media

Electronic media which compete with newspapers for long are TV and radio. New electronic media, intensively used include above all:

- Online news in the internet
- News via mobile telecommunications

The newspaper crisis in some European countries with declining numbers of copies sold is partly caused by competition by new electronic media.
Other electronic media include directories, insert mail, encyclopedias and so on.

c) E-mail

In the past print documents have been distributed mainly by post. Present documents are distributed mostly electronically via e-mail. Electronic mail comprises the following services:

- e-mail (internet)
- SMS (short text messages)
- MMS (multimedia messaging)

The sending of letters in some countries has declined in the past years, partly by substitution of e-mail, and to a lower degree SMS and MMS.

5.5.2 Data on diffusion

Total paper consumption has grown in western Europe over the last decade (The paper federation of Great Britain, Nov. 2000). Per capita paper consumption of paper and board in Western Europe has grown from about 160 kg in 1989 to about 190 kg in 1999, partly due to an increase in cut size paper demand. As the figures for Germany stayed almost constant at 210 kg, per capita consumption of paper and board in the UK rose from about 160 kg in 1989 to more than 210 kg in 1999 and in France from 150 kg per capita to about 180 kg per capita.

According to an EMGE World Graphic Paper (Oct. 2002) forecast graphic paper demand in Western Europe will grow from 2002-2006 by almost 8.000 kilo tons, representing a rate of 2,2 % per year. Main drivers are GDP growth and office technology.

Data on diffusion of ICT technology and the relationship to paper consumption is scarce.

a) Digital office
Almost all offices have been digitised to differing degrees. As only case studies are known the variables for digitised offices remain highly uncertain. It can be noticed that paperless offices

are seen as a vision mainly in big companies of the tertiary sector. To realise significant paper reductions intra- or extranets have to be installed (chapter ICT use), thus requiring installation costs. Peripheral equipment like scanners is also required, but are already a standard in most offices.
The total potential for digital offices is assumed to be limited to big companies with intra- and/or extranets. SME and households are less probable, as their benefit often doesn't justify the effort. Romm et al. (1999) even think that by immaterial goods banks may be replaced completely.

b) Electronic media
Time use statistics for electronic media and traditional media are available for many countries. A clear trend towards online media and away from newspapers can be observed. As TV and radio are nothing new the main focus should be on the relationships of newspaper reading and reading of online news. It remains unclear whether customers are willing to pay per use in the future.

c) E-mail
The frequency of e-mail use has been surveyed in the e-living project (D 7.2). The average number of e-mails sent per day divided by country in the UK, D, I and Norway is as follows:

- 6-10 % internet users send more than 5 e-mails a day
- 20-28 % send 1-5 e-mails a day
- 38-43 % send less than one e-mail per day

The remaining shares are "negligible frequency" of e-mails sent.
It has been shown that e-mail usage is related to age, but not to income or education. Young people tend to write more often e-mails than older people.

5.5.3 Data on environmental indicators

Virtual products can be distributed online reducing packaging and transport costs. Buildings can be saved as well. Romm et al. (1999) estimate that digitisation of paper will cut down 0,25 % of total industrial energy use. By 2008 this effect will be more than double.

On the other hand Digital Europe (2003) doesn't expect savings on the macro level. E-commerce is just another sales channel parallel to other channels. The number of products suitable for digitisation is very limited. Consumer habits and rebound effects probably have a counterbalancing influence.

5.5.3.1 Digital office

According to Romm et al. (1999) demand for **cut-size** paper will grow from 3.8 million tons in 1996 to 5.4 million tons in 2003 due to increased use of paper in offices. 300.000 more tons have to be added for print-on-demand in homes.

Although there is an overall trend towards increased office paper consumption, there are some case studies which show that a paperless office is possible:

- The total procurement process at IBM, from the identification of needs, over ordering and payment is supported electronically and automated. This is only possible because almost all of IBMs suppliers have electronic order and bill processes. World wide orders are collected in one data base. Procurement processes have become much faster. Paper consumption has been reduced almost completely with the exception of faxes from suppliers and internal paper sketches. In the general procurement office in Böblingen 100.000-150.000 paper bills have been replaced electronically (IZT, Borderstep 2002).
- The U.S. Commerce Department estimates that online-banking will cut down paper-based processing dramatically, which will lead to cost saving from 19-46 bln $/a (Romm et al. 1999, S. 27).
- An office company cut the amount of paper required from 13 ml. sheets to 1 ml. sheets by introducing an electronic invoicing system (Financial Times 2001, cited in IZT, Borderstep 2002).

In each office there are many possibilities to reduce paper consumption. Rematerialisation effects though compensate theses potentials to a high extent. The increase of paper use is partly due to the ease and low costs of processing, storing and printing texts with the support of PCs and software programmes. Usually there are hardly any incentives for the individual to reduce paper consumption as it is not an important cost factor. Individual number and/or cost accounting of printed copies could raise awareness and alter behaviours. Interactive and more ergonomic screens could give a push towards paper reduction.

5.5.3.2 Electronic media

Reichardt and Hischier (2001) compared the use of **electronic media and print media**: Looking at and reading a typical news in the daily press, on TV and in the internet. Electronic media proved to have ecological advantages if used in a very selective and addressed way, if digital information is not printed and if electricity from renewable resources is used. Decisive factors are the frequency and length of use of the electronic media. The ecological break even point for reading/watching a typical news is 20 min for the online news and 1 hour for television. For extensive information and entertainment conventional media have ecological advantages.

A study by (Plätzer 1998) compared a **reference article in the newspaper with a printed version from the internet**. from an ecological point of view a conventional newspaper is favourable, but it is not taken into account that a whole newspaper has to be bought and the www offers a higher usability. Primary energy consumption for a printed newspaper has been calculated by Plätzer (1998) to 14,7 kJ, whereas an online article required 141 kJ. If the article is printed the value rises to 257 kJ. The extent of paper recycling has a high impact on the overall result.

Boston Consulting (1999, cited in Romm et al. 1999) carried out a study on Paper and the Electronic Media. The following six drivers were included: internet penetration, match of demographics, enhanced functionality, superior economics, reading habits and emotional attachment. The shift of advertising from traditional media to the internet was included as well.
By 2003 internet will have reduced paper demand by 2,7 mln. tons in the U.S.A.. Without internet it would have been some 30 mln. tons. The energy savings by avoiding one ton of paper is 30 mln. BTUs. This results in 80 tln. BTU, which is nearly 0,25 % of all energy consumption of the industry. The net reduction in paper consumption in 2008 could double the 2003 reduction, resulting in 0,16 quads (Romm et al. 1999, S. 39).
The biggest single user of paper – **newspapers-** is the biggest loser. The online business doesn’t have the efforts of newsprint, physical distribution and the costs to manufacture and print the paper. These costs represent 30-40 % of total costs. Demand for newsprint paper is supposed to fall from 9,8 mln. tons in 1996 to 7,4 mln. tons in 2003.
Forrester research assumes that over the next 5 years 27 Bln US-$ will be drawn away from traditional media to the internet which equals 10 % of total US spending on media.

In the internet we already see many books and reports which can be downloaded by chapter. Rematerialisation can be reduced by new technologies like e-paper, which might be combined with a “digital kiosk” in the future. Via such a digital kiosk, separate articles from different content providers could be downloaded instead of buying a whole newspaper which is only read in part. However information demand could also increase, reading news about the same subject from different sources. As these are future technologies, no empirical data is known.

It is unclear whether the use of online-media really substitutes newspapers or is only additional. In the case of mobile news, which are very short, a substitution is less probable. However they might contribute to changed information behaviour, i.e. people are satisfied with short news which they get often. Compared to other leisure activities like physical mobility the use of online media is assumed to have relatively small environmental effects.

5.5.3.3 E-mail

According to Romm at al. (1999) B2B first calls mail in the U.S. dropped by one third in the 1990s due to **e-mail**. The revenues may be reduced by more than 25 % in the next five years, which depends on infrastructure, security and public acceptance. Some of the post offices will have to be closed, also due to competition from UPS and other delivery systems. Direct mail will lose up to 18 % of its revenue by 2004 (Romm et al. 1999, S. 28).

A comparison of the sending of a letter and an e-mail with 1000 letters over 100 km showed the impact of the ICT hardware in a dramatic way. A physical letter involved 5,3 g CO2, an e-mail between two PCs 15,1 g CO2 and between two energy saving laptops 2,7 g CO2.

In a survey covering UK, D, I, N and ISR e-mail users claimed to write less letters because replaced with e-mails:

Table 5-36: Percentage of e-mail users who claim to write less letters because replaced with e-mails

Frequency	Negligible	Less than 1/day	1-5/day	More than 5/day
Percentage	34	54	63	67

Source: e-living D7.2

The use of e-mail seems to grow with familiarity with the internet, expressed in years using the internet. The percentage of those who mentioned writing fewer letters is between 50-70 % in the classes of 5 and 6 years. Country specific differences are considerable. Italy accounts for the smallest numbers, UK and D for the highest.

However e-mails are rematerialised as well. The total extent is unknown.

5.5.4 Variables

5.5.4.1 Digital office

Total number of desktop workers [number]
The total number of desktop workers will change with the structural change towards the tertiary sector. However rationalisation might reduce the absolute number.

uncertainty: middle; effect: ↑

Cut size paper demand per desktop worker [t/a]
Cut size paper demand per desktop worker in offices can be determined by dividing total paper demand in offices by the number of desktop workers. It is assumed that most of the desktop workers already have access to the internet and printers. Information density at work is already very high, so that growth of this variable is assumed to be incremental.

uncertainty: middle; effect: ↑

Companies with Intra-/extranet [% of all companies]
Big companies of the tertiary sector have the main potential to reduce paper demand by using intra-/extranets. However the share which aims at reducing paper is difficult to determine.

uncertainty: middle; effect: ↑

Accounting [% of companies with intranets]
Incentives for reducing the printing of paper can be given by individual accounting. However other information measures are possible and might be effective as well.

uncertainty: high; effect: ↑

New display technologies [% of all displays in stock]
A high proportion of documents are printed because reading at the display is an effort. New display technologies which are more user friendly might reduce print outs. Technologies for digitally augmented paper for example is an active area of research. It includes new forms of

paper and ink ("e-paper"), new printing technologies and new reader devices (maybe reading and writing, swipe wand, pointing device). E-paper aims at physical characteristics which are similar to those of paper made out of pulp. Significant market penetration is expected for 2010-2012.

uncertainty: high; effect: ↑

Paper reduction [t/desktop worker]
The paper reduction effect per desktop worker is unknown. But a rough estimation, e.g. 1/3 due to accounting and new display technologies by can be given.

uncertainty: high; effect: ↓

5.5.4.2 Electronic media

Population online [total number]
The total population online is monitored regularly and can be determined with low uncertainty.

uncertainty: low; effect: ↑

Online readers [percentage of population online]
The percentage of online news readers is investigated in single studies. Data gaps for some countries (e.g. Acs) and time discontinuities (e.g. during war) are difficulties.

uncertainty: low; effect: ↑

Newspaper substituted per online reader [kg/a]
Empirical studies are unknown, but rough estimations can be made. For example 1-2 newspapers/week and online reader.

uncertainty: high; effect: ↑

Online information materialised [kg/a]
The print out of online news is not known. But a figure like 2 or 10 pages per online reader and day might be realistic.

uncertainty: high; effect: ↓

5.5.4.3 E-mail

E-mails [total number per person]
The total number of e-mails sent is known for some countries. Estimations for other countries are difficult as cultural behaviour is involved. Furthermore then figures are related to e-mails sent and not to e-mails received. An e-mail can be sent to many of persons, thus replacing many post cards or letters.

uncertainty: high; effect: ↑

Letters substituted per e-mail [number]
An estimation of letters substituted by e-mail is possible, but very uncertain. It is assumed that it is outweighed by far by rematerialisation.

uncertainty: high; effect: ↑

Rematerialisation effect [% of e-mails printed/received]
Rematerialisation of e-mails is probable for long e-mails and important e-mails which should not be overseen. It is highly uncertain which amount is printed.

uncertainty: high; effect: ↓

5.5.5 External factors

Factor	Trend	Uncertainty	Variables affected	Rationale
Structure of the economy	Trend towards tertiary	middle	uptakes	the higher GVA of tertiary the more desktop workers
environmental policy/legislation	Few activities on paper saving	low	Uptakes and effects	environmental policy may lead to less paper consumption
Paper costs	constant	middle	Uptakes and effects	the higher paper costs the more incentives for paper saving measures

5.6 Waste management

The future impact of ICT on the amounts of selected fractions of waste from daily household and commercial activities has been discussed for three fractions, which are especially vulnerable to ICT influence. ICT waste streams are part of the electronics fraction in household waste, virtual goods affect consumption of office paper and newspapers, demand for food and packaging is influenced indirectly by e-commerce. In addition there are scenarios on household waste generation until 2020, which offer an insight into the factors that influence total amounts of waste. With regard to waste management ICT have a potential to increase efficiency of collection and sorting systems.

5.6.1 Definition and scope

a) Amounts of waste

The development of the amounts of household waste between 1995 and 2020 in EU 15 have been assessed in a study carried out by TMO-STB and VDI-TZ (ETSO 2003). The baseline scenario for 2020 was based on private consumption expenditure projections delivered by OECD. For the fractions the following assumptions were made:

- food leftovers/kitchen waste and food related packaging: + 10 %
- all other categories: + 55 %

The overall estimated growth is 42,5 %, just below the OECD MSV projection in OECD countries (OECD 2001).

However ageing population and the trend towards smaller household sizes are not considered in the baseline scenario but to some degree in the scenarios.

Trends with the highest impact and uncertainty are:

- Place of fulfilling the functions (inside or outside home): As waste from daily and commercial activities are analysed in this study the shifts in the location of the function are not that important.
- Extent of materialisation/dematerialisation: Life time and weight of the artefacts determines the amounts of waste to a certain degree. ICT might have an important impact on lifetime of clothes and maybe furniture. Infotainment for example can take place via electronic devices or traditional paper media.
- Behaviour of individuals: Waste management before it is collected via regular waste channels might have an important impact on total waste amounts.

Four scenarios have been built. Media@home (M@H), On the road (OTR), Comfort community (CC) and Home sweet home (HSH). The scenario calculations have led to the following results:

Table 5-37: Scenario calculations for household waste generation in EU; total waste in 1995 = 100 (GDP 2020 = 155)

Per function	**1995**	**2020**	**M@H**	**OTR**	**CC**	**HSH**
Feeding	33	39	72	21	21	41
Recreation	20	30	47	19	13	23
Infotainment	14	22	88	33	9	31
Housing	14	21	55	9	13	32
Care	6	9	16	8	6	12
Clothing	4	6	9	11	3	3
Not allocated	10	15	35	12	8	17
Per Waste fraction	**1995**	**2020**	**M@H**	**OTR**	**CC**	**HSH**
Compostable waste	29	40	57	24	18	35
Packaging	16	19	33	12	12	19
Paper	12	18	80	24	6	27
White and brown goods	2	3	8	8	2	3
Other	41	63	144	46	35	75
Total	100	143	322	113	73	160

Total excluding indoor/outdoor shift	100	143	253	175	84	110

Source: ETSO 2003

M@H shows an enormous increase due to the indoor and materialisation life style. Driving factors are:
- working at home
- no systematic paper reduction for reading
- fast ICT penetration in household and home working applications
- increased packaging for convenience (esp. Food)
- no increase in home composting or similar

OTR shows a growth lower than GDP due to counteracting combination of these effects:
- waste intensive activities like feeding and information gathering often done outside
- inefficient use of resources due to smaller households (food, paper for reading and advertisement)
- Short-life products, due to fashion consciousness and “show off and live to the max”.
- Fast ICT penetration in households and home working applications
- increased packaging for convenience (esp. Food)

CC leads to a significantly reduced household waste generation. Main factors are:
- More time spent and activities done outside. Indirectly gardens become smaller and less cats are held at home
- Replacement of paper by electronic media
- Service orientation leads to longer economic lifetime for many products

HSH leads to growth in waste amounts in the magnitude of GDP. The following drivers are important:
- shift from outside activities to home
- large households lead to efficient use of resources
- life-style promotes a long use of products
- efficient waste management at home (e.g. home composting and using food for pets)

Main drivers which are highly influenced by ICT include (derived from other chapters):
- feeding and packaging waste might be altered by internet shopping and smart fridge
- paper consumption can be reduced by electronic media
- ICT waste (e.g. one way cameras and one way mobile phones, batteries)

On the other hand, as waste from daily household and commercial activities are regarded in this study the following drivers play only a small role:
- working at home and shifts between household activities to outside
- product life-time can be influenced by ICT, but most of the products in the waste fraction are already very short lived.

Working at home will lead to a shift from paper consumption from offices and food/packaging waste from commercial waste to household waste. The changes in amounts are probably small, empirical data is unknown. The same applies vice versa to household activities carried out outside of the house.

Most of the products in waste from daily household and commercial activities have a very short life-time (e.g. food packaging). ICT is supposed to affect the life-times of the following product categories:
- Clothing: reduced lifetime of wearables
- Furniture: reduced life time by integration of ICT
- EE: already a common standard, but a potential impact on life-time

Total WEEE has been discussed in the chapter “use of ICT”. Furniture has a share of 6,7 % and clothes of 3,0 % in household waste. However wearables, embedded ICT in furniture and one-way applications are very rare today. Future acceptance is very uncertain. More certain is a rise in batteries due to many intelligent devices, but small effects on the total amount of waste.

b) Collection and recycling

There are many different collection schemes in the EU, ICT based collection and weighing being only one of them.

Sorting of waste fractions can be run more efficiently by using ICT. Separation rates by optic sorting, bar code recognition or smart labels can be increased.

5.6.2 Data for diffusion

5.6.2.1 Materialisation and dematerialisation by ICT

The diffusion of ICT-applications affecting office paper consumption can be derived from the chapter "virtual goods".
The diffusion of ICT-applications affecting feed and packaging waste can be derived from the "e-business" chapter.
The diffusion of ICT hardware can be derived from the "ICT use" chapter.

5.6.2.2 ICT based waste management

ICT based collection schemes with pay-per weight are reported from some municipalities in Denmark, representing 4 % of the population. Other pilot projects are known from Germany and France. However it is estimated that only a very small percentage of the EU population is connected to weight-based fee schemes for the collection of household waste.

The collection systems vary from country to country. Austria, Denmark, Finland, Germany, the Netherlands and Sweden have had well functioning systems for glass and paper for long. Most comprehensive collection is done in Austria and Germany, also including plastics.
Collection modalities in the EU countries, total packaging consumption, recycling and energy recovery data can be derived from European Commission DGXI.E.3 2001. As there are many other measures to increase separate collection is it doubtful whether weight-based collection schemes application will spread significantly in the future.

The sorting of municipal waste began by hand. Today a pre-sorting by hand and automated sorting are combined. It is quite certain that fully automated sorting facilities will conquer markets in the near future, because fully automated sorting of waste replaces expensive labour force.

5.6.3 Data for environmental indicators

5.6.3.1 Materialisation and dematerialisation by ICT

The effects of ICT on office paper consumption can be derived from the chapter "virtual goods".
The effects of ICT on feed and packaging waste can be derived from the "e-business" chapter.
The effects of ICT on waste from daily household and commercial activities can be derived from the "ICT use" chapter.

5.6.3.2 ICT based waste management

Differentiated tariffs for waste collection have been investigated in a case study carried out in Denmark.
The system is based on weighing the dustbin when it is emptied. The trucks weigh them automatically and an electronic plate on the dustbin identifies the dustbin electronically. Weighing data is tabbed from the truck to the payment system, which generates the individual account for the household. The fees only apply to mixed household weight, therefore recycling of glass and paper as well as home composting are stimulated. There is a certain number of "free kilos". If it is exceeded additional fees have to be paid (EEA 2/2002).

In a study consumer behaviour of people in an area with weight-based collection fees has been compared with a reference group of a similar social structure. Effects on the amounts of waste could not be observed, but on the level of recycling. There is significantly higher separate collection of paper and cardboard in municipalities with weight based collection fees. The collection of glass however stayed at the same level.

Indications of large scale illegal handling have not been found. A small amount of waste in areas with weight based collection schemes might be brought to civic waste facilities/bring banks/recycling centres, burnt in a wood burning stove at home or left at lay-bys or service areas.

Table 5-38: Waste generation in "pay-per-kg" municipalities and reference municipalities (kg/a)

Fraction	Average households in "pay-per-kg" municipalities	Average household in reference municipalities
Mixed household waste	325	729
Paper and cardboard	105	67
Glass	38	36
Biodegradable waste	124	44
Total	592	876

Source: EEA 2/2002

The difference in the total waste amounts are explained with overestimated amounts of mixed household waste from reference municipalities. This might be due to garden waste, bulky waste, commercial waste and similar items, which will end up in the dustbin if there is enough space. In households with "pay-per-kg" these fractions will be avoided in the dustbin (EEA 2/2002).
Acceptance of the weight-based collection scheme has proved to be high, being an advantage for them and the fairest way of calculating refuse collection fees.

ICT-based sorting technology has become a big business as expensive sorting by hand can be minimised or even totally abolished. Sorting technology is either applied for separately collected glass and plastics, or for multi-material input. Some examples are given by Bourely (2002):

- Pre-sorting appliances by raisin and colour for further recycling
- The MistrAll technology for example measures the material on an area of 1 cm2 by 25.000 measurements per second. It separates plastics, beverage cartons, paper, metal and so on.
- Another appliance TVB is based on the colour sorting principle. Clear and light blue bottles are separated with a correctness exceeding 95 %.
- The PET recycling machines operate in many European countries.
- The AMCOR PVC sorting system has four stages. The PVC input (France conditions) with 1-5 % to 0-20 ppm is substantially reduced. The average removal efficiency per step is therefore about 95 %. The total material losses on the 4 stages are below 1 % of the input.

It has to be emphasised that sense and performance of automated sorting systems highly depend on separate collection systems, e.g. for plastics, metals, paper and cardboard, glass and WEEE.

5.6.4 Variables

Waste per fraction [kg/person]
The total amount of waste from daily household and commercial activities has grown constantly over the years in close relation to GDP growth. However the different fractions change substantial with separate collection policies.

uncertainty: middle; effect: ↑

Differentiated tariffs for waste collection [% of population]
It is doubtful whether ICT based "pay-per-kilo" collection schemes will be widespread as there are many national and municipal policies to reduce the fraction of mixed waste. On the other hand it is an effective tool to reduce mixed waste and to increase separately collected fractions.

Acceptance in Denmark was high, considering it fair and assuming private benefits. On the other hand from municipalities in France resistance of citizens' is reported, because they feel controlled.

uncertainty: high; effect: ↑

Fully automated sorting technology [% of collected waste treated]
This technology will probably conquer markets because of cost reductions. Efficiency is constantly improving, so that old and new technologies are difficult to distinguish. It has to be differentiated between sorting technology for single fractions like glass or mixed fractions.

uncertainty: low; effect: ↑

Increased collection rate by "pay-per-kilo" collection schemes [% per fraction]
The Danish case study found out increased collection of paper and cardboard, but almost constant rates for glass. As there is no separate collection system for plastics, metals and WEEE the effects on these collection rates are unknown.

uncertainty: high; effect: ↑

Sorting efficiency [% of waste collected]
There are material losses in the sorting process as well as incorrect allocations of material fractions. The higher the degree of separating the better the options for recycling, especially for plastics. Sorting efficiency is different, depending on waste input, sorting stages, required output characteristics and many more factors.

uncertainty: high; effect: ↑

5.6.5 External factors

Factor	Trend	Uncertainty	Variables affected	Rationale
Lifestyle	individual and small households	middle	Amount of waste	the amounts of waste highly depend on our lifestyles, small units involving more waste than bigger ones
Household expenditure	Small growth	middle	Amount of waste	the higher GVA and household expenditure the more waste
environmental policy/legislation	Recycling instead of landfills	low	Uptakes and effects	environmental policy may lead to less waste landfilled and more waste recycled
Costs for disposal	Almost constant	middle	Uptakes and effects	the higher disposal costs the more incentives for waste prevention

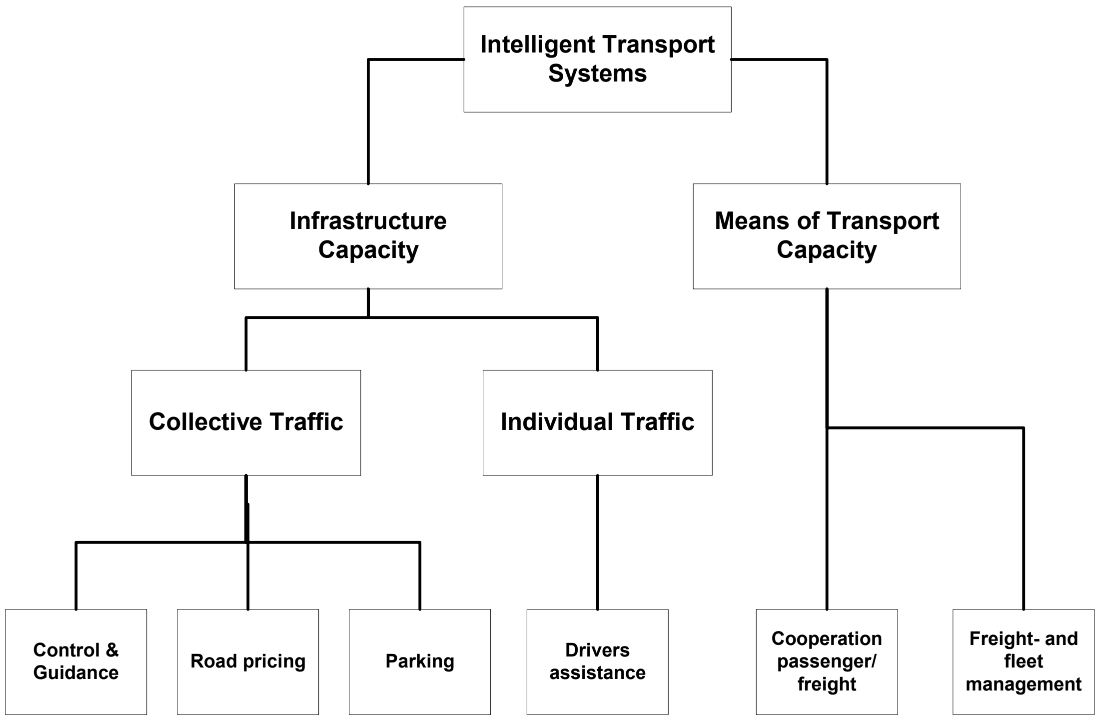
5.7 Intelligent transport systems

As Intelligent Transport Systems are an integral part of the eEurope initiative the consequences on passenger and freight transport intensity are crucial points with regard to environmental sustainability. Additionally other travel information systems fostered by market forces gain importance, such as travel online and navigation systems.

5.7.1 Definition and scope

There is no agreed definition of Intelligent Transport Systems or telematics.
A principal typology is given in the figure below:

Figure 5-3: Typology for intelligent transport systems



Source: Gassner et al. 1994

The eEurope initiative mainly aims at improving the infrastructure capacity on the collective level. Control & guidance systems are applied to all modes of transport, such as road, rail, water and air. Road pricing and parking management systems are road-specific. Control & guidance systems shall reduce traffic congestion and reduce accidents.

Drivers assistance systems are fostered by industry. Being a standard in planes and ships for long, navigation systems in individual vehicles have been introduced by the car industry recently. In the rail sector there is still a considerable potential for improved assistance systems.

To increase the capacity of the means of transport freight and fleet management have become more efficient by using ICT. Co-operation in freight and passenger transport increases the capacity usage by pooling and sharing of means of transport.[19] Furthermore inter-modal transport is covered by this section.

Not directly covered by this typology is online-travel information, which is often combined with e-selling/auction of free space and e-payment systems.

[19] Sharing includes informal common use of a car (e.g. in households), organised car-sharing, car rental and taxis.

Pooling comprises informal resource pooling (e.g. hitchhiking, commuting communities), as well as organised forms by agencies.

5.7.2 Data for diffusion

Past average traffic growth on European motorways between 1990 and 1999 for light vehicles was 4,15 % per annum for light vehicles and 3,85 % for HGVs. Average growth in motorway traffic in the EU is expected to be around 20-30 % from 2000 to 2010 (CEMT/CM(2001)4). Heavy congestion is forecasted for Finland, UK and the Netherlands. The enlargement of the EU will significantly increase traffic flows on the existing east-west corridors.

There is no coherent data base for the extent to which ITS are used in the European Union. Some single data for road pricing, in-vehicle navigation systems and car sharing exist. Most of the data is qualitative, focussing on projects and aims.

5.7.2.1 Telematic systems

Telematic systems deliver additional information on traffic, individual information, rapid information availability independent from location, automation, context sensitive traffic guidance and new interfaces. Dynamic routing via GPS/Galileo will increase the effectiveness of telematics.

The development of Galileo is classified as a research priority which contributes to all the projects mentioned above. Galileo services will be available from 2008. Main applications will be road services and location based services.
The strategic objectives for ITS deployment are justified with costs for road accidents (45 bln €/year), non-efficiency in road capacity use (e.g. 1 bln € in Belgium and Netherlands, 1,5 bln € each in Germany and 13 France, bln € in UK) and environment (pollution on highway costs in Belgium of 0,12 bln €/year). The objectives of the Kyoto protocol are mentioned as well.

The TEN-T Expert Group on ITS for Road Traffic Management identified the following priority applications for the European road network:

- Traffic management and control
- Traveller information services
- Freight and fleet management
- Incident and emergency handling
- Electronic fee collection
- Monitoring infrastructure
- Traffic centers

Projects under way in the European Union are listed Annex IV of the White paper “European Transport Policy for 2010: Time to decide”. Areas which are linked closely to ICT include:

- Large scale deployment of intelligent road transport systems:
  * telematic infrastructure/systems, traffic control, road information centers
  * traffic management plans, pre- and on-journey information services, freight management services, electronic road-charging systems and other automatic fee collection systems
  * Demand management measures to rationalise conventional private car use in town centers.
- The European Rail Traffic Management System:
  * Improvement of capacity of means of transport and traffic management systems for rail. Automated system to monitor and ensure a minimum distance between trains
  * Full interoperability between rail infrastructures, vehicles, cabs and crews
- Air traffic
  * More precise positioning information and better communications
  * Greater integration and management of information at airports to increase airports’ capacities
- Maritime traffic safety
  * automatic vessel identification and monitoring systems
  * standardised telematic exchange (ship and cargo information)
- Inter-modal transport
  * Integrating urban transport services to promote clean urban transport

* Inter modal freight transport (Marco Polo-programme)

Road pricing has been introduced on motorways and in urban areas. Electronic tolls in urban areas are reported from the Netherlands and UK but are limited to single towns. Tolls on motorways are far more widespread. Tolls can be limited to certain categories of transport (heavy goods vehicles in Germany, Austria and Switzerland) or settled as a function of time to reduce peak demands.
Eurostat gives the following figures for toll roads in Europe:

Table 5-39: Road networks and tolls in the European Union [km]

	Motorways 2000	Toll roads 2000
B	1.702	1
DK	922	8
D	11.712	-
EL	707	871
E	9.049	2.320
F	9.766	7.603
IRL	103	-
I	6.478	5.593
L	115	-
NL	2.289	-
A	1.633	227
P	1.482	1.116
FIN	549	-
S	1.506	8
UK	3.546	-
EU15	51.559	17.748

Source: Eurostat (http://europa.eu.int/comm/energy_transport/etif/transport_infrastru.../road_motorways.htm)

Most of the toll roads in the EU are motorways, but not all of them. The relation of the lengths of toll roads to motorways in EU15 is 34,4 %. Especially the plans in Germany with a long motorway network to introduce an electronic toll system for freight traffic might increase the share of toll roads dramatically.
The collection of tolls causes congestion, delays, incidents and accidents. There is a proposal for a Directive of the European Parliament and of the Council on the widespread introduction and interoperability of electronic road toll systems in the Community (COM(2003) 132 final). Electronic toll systems will speed up toll collection, thereby increasing the capacity of the motorway.
There are national systems in Italy, Portugal, France, Switzerland, Slovenia and Norway, using different technologies. The directive shall ensure interoperability. According to the draft directive the use of satellite positioning and mobile communications technologies is advocated for the deployment of the European electronic toll service. The roadmap includes to following goals (COM(2003) 132 final):

- from 2005 services for electronic toll payments by HGVs, buses and coaches
- from 2010 services for cars
- by 2010 full interoperability between national electronic toll systems

Galileo services, starting after 2008, are expected to support road pricing. With satellite supported toll collection systems an extension to any kind of road or zone is possible.

There is no coherent picture of the diffusion of traffic information and management systems in the EU. In Germany by the end of 2001 3.200 km of motorways were equipped with traffic management systems (BMVBW 2003). In other countries, especially the acceding countries the share of the total motorway system equipped will be significantly lower than around 27 % in Germany.
In the eEurope 2002 Action Plan Initiative quantitative goals for ITS are set:

- **Traffic and travel information systems** in 50 % of Europe's major towns and cities
- **Systems to manage traffic** and to detect accidents and congestion on 50 % of Europe's major motorways

In-vehicle navigation systems have already become a standard in many upper and middle class cars as well as taxis and cars for rent. The following table shows a prognosis for sales and inventories of navigation systems by ADAC assuming a positive economic development (Nowicki 2002):

Table 5-40: Navigation systems in Europe, e = prognosis

	2001	2002e	2003e	2004e	2005e
Sales [1000]	1.050	1.230	1.500	1.850	2.300
Share AM [%]	30	28	25	22	20
Share OEM [%]	70	72	75	78	80
Inventory [1000]	2.765	3.995	5.495	7.345	9.645

Source: Nowicki 2002

By the end of 2002 almost 4 million vehicles were equipped with navigation systems, 2,3 million alone in Germany. Annual growth rates for sales in Germany are estimated to decline, whereas in the total EU annual growth might increase from 17 % in 2002 to about 24 % in 2005. The German share will decrease from 56 % in 2001 to less than 50 % in 2005. The optimistic prognosis is justified with significant drivers' interest, e.g. the ADAC website on consulting and tests of navigation systems is visited 30.000 times a month.

Table 5-41: Share of navigation systems of vehicle sales and stocks 2001

	D	EU	J	USA
Sales [%]	10	5	50	2
Inventory [%]	4	2	30	1

Source: Nowicki 2002

A comparison of navigation systems sales and inventories in the EU especially with Japan shows that there is a substantial potential for further growth. The usefulness of navigation systems is higher in densely populated and urban areas than on the countryside or motorways.

Personal navigation in public transport is subject to change in the future. For passenger transport in general the Prisma project has created a vision for 2010 comprising the following items:
- Widespread adoption of Smart Cards, seamless multi-modal-systems and intelligent information services
- Smart cards will streamline ticketing and payment systems for public transport
- Internet access points and mobile technologies
- Linkage with GNSS

In the German Delphi (BMBF 1998) mobility experts estimated that Personal Travel Assistants PTA will be on the market by 2005 (median; N=16) while the whole set of experts expected it for 2008 (median; N=85).

The use of ICT for **freight and fleet management** is state-of-the art in the logistics industry. Main functions are capacity and route optimisation.
Future developments for freight transport have been compiled by the Prisma project:
- door-to-door system, based on multi-modal transport routing,
- online information systems for cargo terminals,
- intra-company resource management systems,
- integration of route planning with mobile communications, provide real-time, intelligent end-to-end freight and vehicle tracking and tracing

Smart Label and data scanner for seamless labelling and identification of freight will reduce total time and costs for logistics. Sensors may continuously control the status of the freight. The main task is to optimise the total system which involves intelligent software.
There are no macroeconomic data on the extent of use of freight and fleet management systems, but further potentials are assumed for inter-company fleet sharing and inter-modal traffic management.

5.7.2.2 Car on demand

Car on demand is practised by car sharing companies, car rentals and taxi companies. ICT can give substantial impulses for car on demand. Taxis or cars for rent may be called, located and booked from elsewhere with the help of mobile telecommunication systems. Car rentals and taxis are already widespread in use in the European Union, which is not true for car sharing. The benefits of car sharing will be highest if there is a high density of pick-up and drop points for the shared cars. Main focus should therefore be addressed to the distribution of car-sharing.
The European Car Sharing Organisation has set up a database for car sharing stations in Switzerland and Germany, which includes only their members (www.carsharing.org). In Germany there are more than 200 and in Switzerland more than 250 entries. The other countries mentioned Italy, Norway and Denmark together have 12 car-sharing entries. According to an empirical survey by IZT (2000) in Germany there were 22.800 and in Switzerland 25.000 car sharing user a year in 1999. Numbers are still small but rising. Other companies with significant numbers of car-sharing offices are the Netherlands and Austria. Different estimations for the Market potential of Car-sharing are summarised in the table below:

Table 5-42: Market potentials for Car-Sharing

criteria	**Percentage of driving licence tenders**	**source (compiled in IZT 2000)**
Attitude to cars	20,7 %	Baum, Pesch 1994
cost benefits	5,2 %	Baum, Pesch 1994
usefulness for transport, shopping, leisure and holiday travel	7,0 %	Baum, Pesch 1994
potential according to frequency of use	6,3 %	Baum, Pesch 1994
potential according to interest in “km-leasing”	18,8 %	Frick 1999
potential for mobility packages in agglomeration areas (18,8 mln., diffusion 40 %)	19,0 %	Prognos 1998
potential according to interest in mobility packages (interest quote 25 %, diffusion 40 %)	4,8 %	Prognos 1998
potential according to demand willingness for mobility packages in agglomeration areas (diffusion 40 %)	0,9 %	Prognos 1998

Source: compilation from different sources by IZT (2000)

5.7.2.3 Travel information

Travel information for passenger transport has changed dramatically with the rise of the internet. People now have access to a bulk of timetables of public transport, trains and planes. In many European countries almost every community has it’s own website with travel information. In a study carried out by IZT (2001) it was found out that online tourist information is still very poor in some regions. The total number of online offers can hardly be determined and is subject to change.

The total number of people using online travel information is also unknown. In an empirical survey in Germany 56,4 % of travel active interviewees uttered that they use the internet for travel planning and travel information on destinations as well as online booking. The users tend slightly to be between 30 and 50 years old, have a full time job and have an income of more than 2000 € per month. Other demographic profiles showed no significance. 17,4 % of travel active interviewees have made online-bookings, hotel and flight and train ticket bookings being the most frequent purposes (Zoche et al. 2002).

More than half of the online-travel users said that they only use the service when needed, slightly less do it sometimes just for fun, to spend time or being curious. Advantages are the independence from opening hours and opportunity to look on one's own, disadvantages are the costs for being online and security matters in payments. Assuming ideal services 70,3 % of all internet users said that they would use online travel services, a potential which is already exploited to 75 % (Zoche et al. 2002). Fast and safe online-access and cheap tariffs can stimulate the usage intensity.

Future trends in eTourism services are far from being predictable. A tentative picture is given by Prisma:

- widespread use of internet-based tourism services
- new intermediaries transforming/eliminating traditional travel agents
- Direct online bookings will have a significant market share in 2010
- higher personalisation
- growing share of people over 50 will stimulate demand for e-services related to foreign travel, culture purposes and eco-tourism
- time poor - money rich will stimulate demand for short time holidays
- Smart cards, ticket automation, virtual test drives in destination
- datamining and active marketing
- mobile e-city-guides

The future spread of these technologies is highly uncertain.

5.7.3 Data for environmental indicators

Traffic telematics aim at improving the capacity usage of means of transport, capacity usage of infrastructure and the linking of different transport modes. Both passenger and freight transport are affected.

The heterogeneous picture of effects has to be coupled with the environmental indicators investigates in this study. The following table indicates the coverage of the survey:

Table 5-43: Directly investigated effects of telematic applications

	Typology	Passenger transport	Freight transport	Modal Split	Energy intensity
Information systems for passenger transport	Travel planning systems, car sharing, public transport	x		x	
Information systems for freight transport	Fleet management, communication interfaces		x	x	
Control and guidance systems	road, rail, air, water	x	x		x
Payment systems	urban, motorways, time/distance/area	x	x	x	

Information systems for passenger transport have an influence on the distances travelled and the choice of means of transport. Indirectly energy intensity is affected.

Information systems for freight transport lead to route optimisation and contribute to more complex linkages of means of transport.

Control and guidance systems increase the capacity of infrastructure. Increased fluidity and avoidance of congestion give incentives to drive more often and to choose longer deviations. Energy consumption in fluid traffic is reduced directly.

Payment systems also contribute to better capacity usage of road infrastructure. On the one hand traffic might be avoided on the other hand other longer routes might be chosen.

5.7.3.1 Telematic systems

The main effect of collective traffic management systems is the improved capacity usage of existing transport infrastructure. For the case of road transport there is the argument that better capacity usage of roads slows down the building of new roads, which would have to be used to avoid traffic congestion and delays. Enhanced traffic fluidity may also avoid deviations. In this case passenger and freight transport intensity remain unaffected but energy intensity, greenhouse gas emissions and urban air quality are reduced. Safer travelling by ITS will lead to less congestion due to incidents, not only saving peoples lives but also a considerable amount of cars which don’t have to be repaired or replaced by new ones.

A comprehensive study on the impact potentials of traffic telematics in Germany with a time horizon of 2010 has been carried out by Prognos (2001). The reference was the usage of telematics in 2000. Telematic applications which are already widely used have only be treated if important further developments were expected. The main focus is on applications which can be used but are still not widespread.

The following tables summarise the effects of the investigated telematic applications:

Table 5-44: Effects of selected telematic applications on freight transport:

	capacity of means of transport			**capacity of infrastructure**			**Linkage**		
	Road	**Rail**	**Air**	**Road**	**Rail**	**Air**	**Road**	**Rail**	**Air**
Group 2: Control & guidance systems for road traffic									
2.1 Road traffic information				x					
2.2 Dynamic destination guidance				x					
2.3 Traffic adaptive light signal control				x					
2.4 Adaptive public transport priority by light signal control				x	x				
2.6 Lane management on motorways				x					
2.7 Net management on motorways				x					
2.8 Hold-up management on motorways				x					
Group 3: Payment systems									
3.1 Electronic fees for HGV on motorways	x			x			x	x	
Group 4: Information and management systems for PT									
4.5 Guidance and securing technologies for railways					x				
Group 6: Information systems for freight transport									
6.1 Fleet management	x								
6.2 Communication interface station		x					x	x	
6.3 Communication interface inland harbour							x	x	x
6.4 Nautic information systems			x						

Source: Prognos 2001

Table 5-45: Effects of selected telematic applications on passenger transport:

	capacity of means of transport		capacity of infrastructure			Linkage		
	MIT	**PT**	**Road**	**Rail**	**Air**	**Road**	**Rail**	**Air**
Group 1: Information systems for passenger transport			x			x	x	x
1.1 Travel planning systems		x				x	x	x
1.2 Car on demand		x						
Group 2: Control & guidance systems for road traffic								
2.1 Road traffic information			x					
2.2 Dynamic destination guidance			x					
2.3 Traffic adaptive light signal control			x					
2.4 Adaptive public transport priority by light signal control		x	x	x				
2.5 Dynamic parking information and guidance systems			x			x	x	
2.6 Lane management on motorways			x					
2.7 Net management on motorways			x					
2.8 Hold-up management on motorways								
Group 3: Payment systems								
3.2 Electronic fees in PT		x						
Group 4: Information and management systems for PT								
4.1 Dynamic passenger information at stations		x						
4.2 Connection management		x				x	x	
4.3 Hold-up management		x						
4.4 need-related PT		x				x	x	
4.5 Guidance and securing technologies for railways				x				
Group 5: Guidance systems for air								
5.1 Runway guidance					x			
5.2 Departure and arrival control					x			
5.3 Flexible air corridors					x			

Source: Prognos 2001

Two scenarios have been developed:

- Scenario A: Trend extrapolation
- Scenario B: Active co-ordination of the use of telematics (standardisation, interface management, readiness for co-operation among actors from politics and economy)

Main results for the scenarios are (Prognos 2001):

a) capacity usage of means of transport

- Quality and attractiveness of **public passenger transport** are improved. Local capacity usage in scenario A will be improved by 3-4 %. In scenario B the number of passengers in public transport will increase by up to 10 % due to the shift from motorised individual traffic. The impacts highly depend on local conditions. In long distance passenger transport up to 7 % of the people might shift from MIT to railways in scenario B, provided the necessary offers by railway companies. In car and air passenger travel no improvements of capacity usage are expected.

- Average capacity usage in road **freight transport** for long distance travel will increase until 2005 by 2-3 % and until 2010 by another 2 %, due to more and better usage of fleet management systems. the development is assumed to be fostered by road tolls for heavy goods vehicles depending on distances travelled. The overall effect, including short distance transport, is estimated at up to 4 % in Scenario B. Better linkage of rail freight transport with inland water and road transport will lead to an increased capacity usage of 3-4 %. For inland water transport improvements are also assumed but available data are not sufficient for a quantitative estimation.

b) capacity usage of transport infrastructure

- **Dynamic guidance systems and traffic information** for road traffic will lead to a shift from traffic in **agglomerated areas** to less used roads. Travel times are reduced by 3 % on average despite longer routes by choosing deviations. Avoiding inefficient search for parking places and destinations will lead to a reduction of car traffic in cities of 1-2 %. For this capacity limits of the road network will be touched less often.
- Traffic sensitive control of **traffic lights** will improve the **capacity of crossings** taking advantage of improved algorithms. Travel time will be reduced in the magnitude of 6 % during peak times.
- On **motorways** without **lane management systems** capacity will increase by about 10 %, improved algorithms for existing devices and optimised traffic diagnosis will lead to improvements of up to 5 %. Capacity for cars will rise by another up to 4 % indirectly caused by less lorry traffic due to better capacity usage of lorries and shift of freight transport to other roads.
- **Optimised detection and management systems** will reduce the time spent in **congested areas** by 3 % in the respective areas.
- For **railways** in highly used main rails capacity can be increased by 2-4 % until 2005 and up to 20 % until 2010. For the local transport of passengers no capacity effects are expected.
- Capacity of German and international **air corridors** can be increased by up to 30 % by making them more flexible.
- No capacity effects for **inland water ways** are expected.

c) Linking means of transport

- Telematics can improve linkage of public and motorised individual traffic significantly. Public transport on demand can be added to scheduled public transport.
- In freight transport road transport can be shifted to combined road/rail transport. In the most optimistic case rail transport can increase by 18 % until 2010, for inland water ways up to 13 %.

However it is conceded that the resulting effects in reality highly depend on local conditions (Prognos 2001).

Additionally some single studies have estimated selective effects of collective traffic management systems. Their main findings are summarised below:

- The electronic toll system in London claims to reduce traffic in the city center by 15 % Oppenheimer 2003), which seems to be achievable.
- Other studies estimate the traffic reduction potential of road pricing in inner cites during peak times at 5-10 % (OECD observer 1 March, 2002) and 20 %, 9 % of total traffic in inner cities (Ecoplan 1997).
- The effects of traffic congestion on fuel consumption have been calculated by using the Tremod-Model. Stop and go traffic increases fuel consumption of passenger vehicles by around 1 %. The average time lost per day and inhabitant is one to two minutes (Schallaböck 2003).

- An elastic response to road pricing is expected by Leach (2001). Elasticity of the amount of income and car traffic is between 1,1 an 1,8, thus growing GDP outs pressure on transport. Short-term elasticity of traffic with respect to price is estimated at –0,15 and long-term –0,3.
- The overall potential energy savings of telematic applications for transport have been assessed in a small Delphi-like study (IZT, ETSU 1999) . Energy experts expect a reduction of around 11 %, whereas ICT experts assume 16 % to be more realistic.
- Intelligent Traffic Guidance Systems has proved to reduce travelling time in rush hours by 50 % compared to conventional static navigational systems (Schauer 2000).
- The Dutch government has set the ambitious goal to reduce vehicle miles by 25 % from 1998-2003, in part by ITGS.
- Telematics in the road logistic business have high potentials for optimisation and substitution. One study however showed that induction effects overweigh (Rangosch 2000). Efficiency leads to time and cost reductions, so road logistic companies become more competitive.
- The effects of in-car navigation systems on transport volume are very complex, but no empirical data is available on changed travel behaviour. On the one hand advertisement promises time and fuel savings by using the quickest and fastest routes – thus avoiding traffic jams and road works. On the other hand the quickest route need not be the shortest. The use of time saved is unsure as well. Rebound effects due to increased leisure travel are probable.
- Personal travel assistants have a potential to avoid of congestion and delays and change travel plans mid-trip.
- Telematics for road transport make road transport more even more flexible while rail transport has the inherent disadvantage of inflexibility of the infrastructure. The disadvantages are encountered by the European Train Control System which enables a more flexible use of the railway net, including fully automated vehicles.

In the Annex IV of the White paper "European Transport Policy for 2010: Time to decide" the potential impact of intelligent transport systems has been estimated:

- journey time reduction of up to 20 %
- increase in network capacity of 5-10 %
- safety improvements of around 10-15 % for certain types of accidents (rear-end collisions)
- 6 % of road accidents seem to be unavoidable and beyond the reach of technology.

As car on demand and online travel information are not covered in detail the effects of these two applications are described additionally from other sources.

5.7.3.2 Car on demand

The environmental effects of car-sharing discussed in literature have been assessed by IZT (2000). The tariff structure usually gives incentives to change to public transport, foot and bicycle. The car is used only selectively. The cars are chosen according to the purpose, e.g. for short distances small cars, for holidays big cars.

- According to the European Car Sharing Association each Car Sharing car replaces 5 to 6 private cars.
- The capacity utilisation of car sharing is 1,98 persons/vehicle compared to the average of 1,62 persons/vehicle in Germany (Baum, Pesch 1994). For the production 80 MJ/middle class car are needed.
- The traffic effects depend on how many people will give up their own car. The inventory reduction has been estimated by IZT to 44 %.
- The average distance travelled by car in Germany is 12.700 km/year, whereas travel volume of somebody before joining a car sharing system is about 7.350 km/year. After the travel volume is reduced by 2.950 km/year, a reduction of 42,1 % (Baum, Pesch 1994). On the other hand other means of transport are used more intensively: increases of 39,4 % are mentioned by the same authors.

- For Germany an absolute reduction from 16.000 pkm to 13.300 pkm is reported for those who get rid of their old car. additional traffic is induced for second users. Mulheim (1998) estimates an increase of 1.666 km/year for MIV, but a reduction of 509 km/year for public transport.

The overall potential differs highly with the overall diffusion potentials.

5.7.3.3 Travel information

Zoche et al. (2002) have shown that there is a positive correlation between frequency of online-travel information use and the number of private journeys in the last 12 months. The durance of the journeys showed no differences.
A look at the travel destinations unveils that multi-users of online travel offers make there longest trip to a destination outside of Europe whereas the few-users have no striking differences. Analogue the use of planes in the multi-user group increases compared to cars. 15 % conceded that they have been inspired to use another means of transport than intended before by using online travel information, 32,5 % of the multi-users and 8,5 % of the few users. 40 % of all interviewees said that they have already used last-minute flights (cheap and far away destinations). ICT enables also auction of free places in planes and super-last minute offers to increase the capacity of planes.
Only 7 % of all users said that they made an unintended journey after using online-travel information. The total relevance of changed physical mobility behaviour is estimated at 25 % of all online-users (Zoche et al. 2002).

5.7.4 Variables

5.7.4.1 Information systems for passenger transport

a) online travel information

Tourist regions online [% of all touristic regions]
The choice of the destination depends to a certain degree on the publicity of tourist destinations, the internet being a more and more important means of information. A study carried out by IZT (2001) showed significant differences in the online presentation of the most important touristic destination s in Europe.

uncertainty: middle; effect: ↑

Public transport of communities online [% of all communities]
In many big cities of EU 15 information services (schedules, prices, ...) on public transport are available online. This is often not the case in smaller communities and also in bigger cities in some countries, where the internet is not that widespread (some of the acceding countries, but also Italy for example.

uncertainty: middle; effect: ↑

Willingness to use online travel information [% of all online users]
The willingness of people to use and appreciate online travel information depends on the availability of personalised travel information, the opportunity of online booking, including secure payment systems and in future maybe virtual test drives in tourist destinations. How willingness will develop in the future is highly uncertain.

uncertainty: high; effect: ↑

Online travel information users [% of all online users]
The online travel information users are part of the group above. The heterogeneous offers make an exact determination difficult.

uncertainty: high; effect: ↑

Broadband access [% of all accesses]

Broadband access improves the quality and speed of visual travel information in the internet and is a technical prerequisite for applications like virtual test drives. It is a goal of the eEurope initiative.

uncertainty: low; effect: ↑

Distance effect [average distance of destination]
Distance and number of journeys in the multi internet user group have shown significant changes with the rise of internet offers. This group tends to have more short term vacations and chooses travel destinations which are more often outside Europe. However knowledge on causes and effects is poor.

uncertainty: high; effect: ↑

Shift effect [km shifted to air transport]
Short holidays incite the use of very cheap air companies with offers in the internet, e.g. to spend an extended weekend in Paris. The choice of long distance destinations is fostered by cheap last minute offers and e-auction of free space in aircrafts. Uncertainty is high (see above).

uncertainty: high; effect: ↑

b) car on demand

Car sharing density [stations/100*100 km2]
Car sharing is most attractive in regions with a high density of pick-up and dropping stations. Switzerland is most progressive in this field. The number of car sharing stations can be determined, but future development is quite uncertain as the success depends on many factors like policies, tariff structure, etc.

uncertainty: middle; effect: ↑

Cars offered on demand [number]
The number of cars on demand is very difficult to assess, as no convincing business concept for the mass market is in operation yet. Only the development in car rentals and taxis is quite certain, but a completely new business concept is enabled by ICT.

uncertainty: high; effect: ↑

Accessability [% of cars offered]
Smart cards for payment and mobile and delocalised access are incentives to use a car on demand everywhere and anytime. The technological prerequisites will be guaranteed soon.

uncertainty: middle; effect: ↑

Interest in car on demand offers [% of all driving license tenders]
About 4-7 % of the driving license tenders is supposed to have and interest in car on demand offers. The figures result from expected cost benefits, frequency of use patterns, usefulness for purpose and interest in mobility packages in agglomerated areas. A lot of research has been carried out, but results on the overall potential diverge significantly.

uncertainty: middle; effect: ↑

Distance effect [reduced km per year by car]
People who use car sharing offers tend to contribute less to passenger traffic volume than the average. The extent of the distance effect is discussed controversially.

uncertainty: high; effect: ↓

Shift effect [km shifted to rail and public transport per year]
People who use car sharing shift a certain amount of their transport budget from car to rails and public transport. This is not the case for people who have an own car and use a taxi or rent a car in holidays. A lot of research underlines the shift effect and it is fairly easy to quantify it. However research is limited to single case studies. The shift effect might depend to a high degree on local conditions and cultural settings.

uncertainty: middle; effect: ↑

c) public transport

Traffic and travel information systems [% of Europe's major towns]
The eEurope initiative has set the goal that 50 % of Europe's major towns and cities shall be equipped with travel and traffic information systems to increase traffic fluidity and to find one's way.

uncertainty: low; effect: ↑

Attractiveness of public transport [% of major cities]
The attractiveness of public transport can be fostered by widespread adoption of Smart Cards, seamless multi-modal-systems and intelligent information services. Smart cards might streamline ticketing and payment systems for public transport. Internet access points, mobile technologies and linkage with GNSS might increase attractiveness of public transport for a certain degree. Telematics can improve linkage of public and motorised individual traffic significantly. Public transport on demand can be added to scheduled public transport. Technical projects are under way but to which extent they really enhance public transport is uncertain.

uncertainty: middle; effect: ↑

Personal Travel Agents [total number in use]
Personal travel assistants are believed to enable mobility without sticking to a certain means of transport. Personal navigation In the German Delphi (BMBF 1998) mobility experts estimated that Personal Travel Assistants PTA will be on the market by 2005 (median; N=16) while the whole set of experts expected it for 2008 (median; N=85). However it is highly uncertain whether the additional use can be transformed in a convincing business model.

uncertainty: high; effect: ↑

Shift effect [km shifted to public transport per year]
Increased attractiveness of public transport, travel and traffic information systems as well as PTAs give incentives to use more public transport. This might reduce some travel by car, bicycle and by foot. The total extent is uncertain.

uncertainty: middle; effect: ↑

5.7.4.2 Information systems for freight transport

Freight transport organised by fleet management systems [% of all freight transport]
There is no empirical data on how much freight transport is organised by fleet management. It can be reasonably assumed that almost all the transport volume of logistic companies is organised by fleet management systems. This doesn't apply to freight transport organised by individual companies. Either, especially big companies, extend their own freight transport to offering services to others or outsourcing to logistics companies is possible.

uncertainty: middle; effect: ↑

Road freight transport effect [Δtkm]
Fleet management systems increase the capacity usage of all means of transport, but main potentials exist for road freight transport. Furthermore routes can be optimised and empty driving can be avoided. The bigger the system boundaries the higher the optimisation potential. Quantification though is highly uncertain.

uncertainty: high; effect: ↑

Third order effects [Δtkm]
Better organisation of freight transport reduces costs, thus supplier from far away and delivery to remote areas are fostered. The overall effect is unknown.

uncertainty: high; effect: ↓

Communication interfaces at cargo railway stations [% of all railway cargo terminals]

Communication interfaces at railway cargo station facilitate interoperability with road and waterway transport. To increase the number of cargo railway terminals with communication interfaces is an aim of the European Union's activities on inter-modal transport.

uncertainty: low; effect: ↑

Shift to railways [Δtkm]
Optimistic potentials to increase rail traffic by 18 % until 2010 are estimated. The effect will highly depend on the acceptance which is determined by prices, friction losses, flexibility and speed.

uncertainty: high; effect: ↑

Communication interfaces at cargo port [% of all port cargo terminals]
Communication interfaces at port cargo station facilitate interoperability with road and railway transport. To increase the number of cargo port terminals with communication interfaces is an aim of the European Union's activities on inter-modal transport.

uncertainty: low; effect: ↑

Shift to inland water ways [Δtkm]
Optimistic potentials to increase inland water way traffic by 13 % until 2010 are estimated. The effect will highly depend on the acceptance which is determined by prices, friction losses flexibility and waiting time. A shift to water ways is more probable for bulky goods because of cost considerations.

uncertainty: high; effect: ↑

5.7.4.3 Control and guidance systems

Motorways with traffic management systems [% of all motor ways]
The eEurope initiative has set the goal that 50 % of Europe's major motorways shall be equipped with Systems to manage traffic and to detect accidents and congestion.

uncertainty: low; effect: ↑

Traffic and travel information systems [% of Europe's major towns]
The eEurope initiative has set the goal that 50 % of Europe's major towns and cities shall be equipped with travel and traffic information systems to increase traffic fluidity and to find one's way.

uncertainty: low; effect: ↑

In-vehicle navigation systems [% of vehicles]
In-vehicle navigation systems are introduced rapidly driven by market forces. Middle and upper class cars, cars for rent and taxis count among the most important segments. As freight transport often is a matter of time, navigation systems in HGVs might also spread rapidly. With Galileo starting from 2008 more accurate positioning will be possible. Dynamic routing services will enhance the usefulness of navigation systems further.

uncertainty: low; effect: ↑

Reduction of car traffic in inner cities and induction in other areas [Δkm]
Better finding of destinations will lead to reduction of car traffic in inner cities. On the other hand traffic in agglomerated areas will be shifted towards other longer routes.

uncertainty: high; effect: ↑

Travel time reduction in peak times [commuting hours]
Traffic sensitive traffic lights have a potential to reduce travel time in peak hours. The time saved might be used to a certain degree for longer connected shopping trips.

uncertainty: middle; effect: ↑

Control & guidance systems on long distance railways [% of all long distance rails]

The White book on transport policy 2010 includes the European Rail Traffic Management System to Improvement of capacity of means of transport and traffic management systems for rail, e.g. by an automated system to monitor and ensure a minimum distance between trains.

uncertainty: low; effect: ↑

Rain traffic effects [Δpkm, Δtkm]

On long distance railways there is a potential to increase capacity and thus making railways more attractive by higher frequencies of transport in heavily used areas. Faster deliveries of goods and better interconnection of trains and other means of transport are enabled.

uncertainty: high; effect: ↑

Flexible air corridors [% of all air corridors]

Congestion in the sky gives high incentives to improve the air capacity by introducing flexible air corridors.

uncertainty: low; effect: ↑

Air traffic effects [Δkm]

Capacity increase due to flexible air corridors makes flying more attractive. On the other hand waiting in the sky for landing or using remote airports, with a following long car or train drive, can be avoided.

uncertainty: high; effect: ↑

5.7.4.4 Payment systems

Motorways with road tolls [% of all motorways]

The length of the motorway network with road tolls will influence both, the choice of roads for long distance travel and the usage of motorways. Statistical data can be derived from Eurostat. The revenues might be used either for maintenance and building of new motorways or for making other long distance freight transport systems more attractive.

uncertainty: low; effect: ↓

Elasticity of motorway tolls for HGVs [Δkm/€]

From 2005 services for electronic toll payments by HGVs, buses and coaches should be in operation in the EU. The effect of motorway tolls highly depends on the amount which has to be paid. The elasticity of freight transport is considered to be comparatively small due to the small share of transport costs of total costs for industrial goods. Delivery in time is far more important. The revenues might be used either for maintenance and building of new motorways or for making other long distance freight transport systems (e.g. inter-modal) more attractive.

uncertainty: middle; effect: ↑

Elasticity of motorway tolls for cars [Δkm/€]

From 2010 services for electronic toll payments for cars shall be applicable. People have other cost calculations than companies. If time is the limiting factor they might be willing to pay, if they have time (e.g. on a holiday) people might prefer national routes. The revenues might be used either for maintenance and building of new motorways or for making other long distance passenger transport systems (e.g. railways) more attractive.

uncertainty: middle; effect: ↑

Major cities with road pricing [% of all major cities]

Significant inner city traffic reductions are reported from cities which introduced road tolls. The development of ICT now enables charging without having to pass stations in the cities.

uncertainty: middle; effect: ↓

Elasticity of urban tolls for cars [Δkm/€]

People might pay the tolls or shift to other means of transport The revenues might be used either for maintenance and building of the road network and parking space or for making public transport systems (e.g. subways) more attractive.

uncertainty: middle; effect: ↑

Countries with distance based road tolls for all freight transport [% of all freight transport]
The shift to other routes could be avoided if road tolls would be applied on all routes. A far more optimised capacity usage would be the probable effect. By 2010 full interoperability between national electronic toll systems shall be guaranteed.

uncertainty: middle; effect: ↓

Elasticity of motorway tolls for distance based road tolls for all HGVs [Δkm/€]
See above. The value for elasticity will be lower than for motorways only but the network covered is much bigger.

uncertainty: high; effect: ↑

Elasticity of motorway tolls for cars [Δkm/€]
See above. The value for elasticity will be lower than for motorways only but the network covered is much bigger.

uncertainty: high; effect: ↑

Countries with distance based road tolls for all passenger transport [% of all passenger transport]
It is highly uncertain whether people would accept distance based road tolls. If they are introduced fuel taxes could be lowered. On the other hand people could become annoyed and refuse to buy or use a car.

uncertainty: middle; effect: ↑

Third order effects for freight transport [Δtkm]
Increased traffic fluidity will foster the attractiveness of just-in-time deliveries of smaller packages. On the other hand elasticity is quite small so that third order effects are considered to be negligible.

uncertainty: middle; effect: ↓

Third order effects for passenger transport [Δpkm]
If people have to pay for road use they might spend their time driving on uncharged roads. The fluidity effect gives some incentives for driving even more.

uncertainty: middle; effect: ↓

5.7.5 External factors

Factor	Trend	Uncertainty	Variables affected	Rationale
GDP	small growth	middle	passenger and freight transport volume (indicators)	The higher GDP the more income to spend on mobility and the more freight transport due to increased economic activity
Regional structure of the economy	? (agglomeration versus decentralisation)	high	heavy goods to be transported, commuting and shopping travel	Supply and demand patterns of food, minerals and (semi-) finished products determine distances travelled. The same applies to settlement and working patterns.
Passenger transport volume without ITS	correlation with GDP small to medium	low	almost all	The higher transport volume, the higher the effect of ITS
Freight transport volume without ITS	high correlation with GDP	low	almost all	The higher transport volume, the higher the effect of ITS
Transportation costs	almost constant	middle	passenger and freight transport volume	The higher transportation costs the lower transport activity
Length of transport network	expanding	low	road pricing, control & guiding systems	The higher the length of transport network, the higher transport volume
Number of driving license tenders	almost constant	low	car sharing	The higher the number of driving license tenders, the higher car traffic
Environmental policy/legislation	More ambitious EU policy	middle	ITS	environmental policy may lead to increased road traffic control

5.8 Energy supply

In April 2000 the European Commission presented its Action Plan on Energy efficiency, aiming at a 1 % improvement of energy intensity per year compared to a business as usual scenario. Many measures are enabled or fostered by ICT-applications, but the specific contribution of ICT is sometimes difficult to determine.

5.8.1 Definition and scope

Energy supply of buildings and industry is changing, on the one hand due to European Union initiatives to foster renewables and CHG, on the other hand by liberalised electricity markets. With regard to the environmental indicators “greenhouse gas emissions” and “share of renewables” the most important changes are:

- E-commerce in electricity and gas markets
- Virtual decentralised energy generation
- ICT-based greenhouse gas emission trading

Followed by the opening of electricity and gas markets ICT supported exchange of electricity has risen significantly. Forms of commerce are wholesale, retail and international trade with electricity and gas.

Virtual decentralised power stations can reduce disadvantages of small-scale decentralised power generation units (e.g. solar and CHP) which have to compete with well established large scale technologies (e.g. gas power stations).

The envisaged greenhouse gas emission trading scheme of the European Union will be based on ICT, which allows tracking and trading of the allowances. However external goals are set.

5.8.2 Data for diffusion

5.8.2.1 Electricity and gas markets

Electricity and gas markets have been opened to a different degree. Percentages are related to the domestic consumption in the year 2000:

Table 5-46: EU electricity and gas market opening in 2000 (%)

	Electricity	Gas
Directive – min.	30	20
A	32	49
B	35	59
DL	90	30
FIN	100	90
F	30	20
D	100	100
GR	30	0
IRL	30	75
I	35	96
LUX	40	51
NL	33	45
P	30	0
E	54	72
S	100	47
UK	100	100
EU average	66	79

Source: COM(2001) 125 final

Most of the member countries intend to liberalise all electricity customers by 2007 and gas customers by 2008. However one of the most important tasks for politics is to ensure fair and non-discriminatory access to the network, so that companies which don’t have own power generation installations or an own transport grid can take part in the commerce with electricity and gas. Fill international trade between EU countries is still not ensured by political measures.

Wholesale e-commerce with electricity can have the form of a single-dealer system, market place (one or two-sided) or stock exchanges. While the trade in exchanges is organised electronically, non-stock exchange transactions are still realised to a high extent by personal communication (face-to face, telephone). The shares of e-commerce for the year 2000 are estimated to be between 20 and 30 % (TAB 2002).

NordPool ASA in Oslo was the pioneer in electricity exchanges. In 1999 the Amsterdam power exchange started business. Beginning with the year 2002 the two German spot markets Leipziger Power Exchange and European Energy Exchange Frankfurt merged to EEX in Leipzig. On the German spot markets for electricity about 90.000 MWh were traded in 2001, representing a share of 6,8 % of all electricity sold. The long-term goad is a share of 20 % (TAB 2002). Data for other countries can be collected as well. The spread in the Accession Countries is assumed to be comparatively low.

Retail e-commerce with electricity can either be B2B or B2C. For the B2B sector there are no surveys or estimations on the share of e-commerce, the number of business customers in Germany who claim to have changed their supplier varies between 12-50 % (TAB 2002).
Since 1998, when the electricity market was opened in Germany, only 3,7 % of households changed their supplier. Another 28 % changed their contract, but stayed at the same supplier (TAB 2002). Internet is mainly used as a media for information, online-contracts are not offered. On the one hand electricity can be bought directly from the supplier (e.g. Yellow) and on the other hand intermediaries can be involved (e.g. institutions which offer electricity produced by renewables or CHP). The share of e-commerce is estimated to be below of 5 %.

Many changes in the electricity market can be either attributed to deregulation or to e-commerce. A distinction is very difficult. The clearest ICT impact is seen in the electricity exchange markets.

5.8.2.2 Virtual decentralised energy generation

The potentials of environmental-friendly energy generation installations for the supply of buildings has been assessed in the explanatory memorandum of the Proposal for a Directive of the European Parliament and the Council on the energy performance of buildings (COM(2001) 226 final). On the one hand there is often the possibility of decentralised on-site generation, on the other hand a connection to exiting supply nets is possible. Three areas are covered, renewable energy sources, combined heat and power generation and heat pumps. Renewable energy sources and combined heat and power generation have there full benefits when operating connected to other power and heating/cooling grids, whereas heat pumps are mainly designed for own supply only.

a) Renewable energy sources (RES)
Connection to electricity networks in combination with ICT based controlling and accounting systems enable the selling of excessive electricity generated by photovoltaics. The total installed capacity of photovoltaics has been estimated in the White paper to 3000 MWp by 2010, compared to today’s level of around 200 MWp. Most of this capacity is expected to come from grid connected installations on roofs and facades of buildings.
Also the connection to existing heating and cooling systems is possible. The total installed capacity of solar collectors has been estimated in the White paper to 100 million m2 by 2010, compared to around 9 million m2 in 1998. In a follow-up report on the white paper it was estimated that a large proportion of solar collectors could be for domestic hot water production (50 %), space heating (11 %) and large collective solar heating systems (19 %).

b) Combined heat and power (CHP) and district heating/cooling
The share of CHP shall double to 18 % in 2010 according to EU targets. It is applicable mostly in larger buildings like apartment blocks, hospitals, hotels, leisure centers, airports, shopping

centers and large office buildings. “In the medium to long-term, micro cogeneration units for installation in the residential sector may also offer an additional potential” (COM(2001)226 final). Connection to existing heating/cooling systems with ICT based accounting and controlling can make the most efficient use of the installed CHP capacity.

Furthermore the EU Commission has presented a proposal for a Directive on the promotion of renewable energy sources in the internal energy market and the proposal for a revised large Combustion Plants directive, that promotes the use of co-generation. The same applies to the recent Action Plan on energy efficiency, which also list many measure to promote CHP.

The integration of CHP and renewables into the electricity system requires sophisticated ICT solutions. Considering that decentralised power generation (wind, photovoltaic, fuel cell, biomass and CHP) will rise significantly in the next years, some companies developed systems to combine them under the concept of a “Virtual power station”. Energy demand and available resources have to be monitored and prognosticated in order to plan the usage of single decentralised power stations in a cost efficient way. The beginning is the weather forecast, to assess the availability of regenerative energies like wind and sun. But also consumer behaviour is linked to weather conditions, e.g. for heating and cooling. The single power stations can be controlled online. However this technology is still in the pilot phase. A main supplier of IT solutions for virtual power stations is Siemens.

5.8.2.3 Greenhouse gas emission trading

Greenhouse gas emission trading in the EU is envisaged to assist in meeting the obligations of the Kyoto protocol to reduce GHG emissions by 8 % in 2008-2012, related to the reduction of 1990. The instrument emission trading is supposed to meet the intended goals exactly and efficiently. But it is not the instrument that realises the emission savings itself, but many other measures for energy saving and increased efficiency.

In a proposal for a Directive of the European Parliament and of the Council on establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (COM(2001) 581 final the concept for the trading system is explained in the explanatory memorandum:

- In the preliminary phase from 2005-2007 there are no binding targets
- From 2008 allowances can be exchanged between installations of two different member states. Holding and tracking of allowances will be done through an electronic register. Market intermediates will facilitate price discovery.
- From the start only CO2-emissions will be included. Later on all Kyoto gases might be traded, but problems in monitoring, reporting, verification and possible local impacts have to be resolved.

Carbon dioxide accounts for about 80 % of the EU GHG emissions. Approximately 46 % of the estimated CO2-emissions in the EU in 2010 are covered by the activities listed in the annex 1, which is oriented at the annex of the IPPC-directive. The activities include:

- Energy activities (combustion installations > 20 MW (input), mineral oil refineries, coke ovens)
- Production and processing of ferrous metals (Metal ore roasting and sintering, installations for production of pig iron and steel (incl. continuous casting) > 2,5 t/h)
- Mineral industry (installations for cement clinker and lime, manufacture of glass and fibre, ceramics – all exceeding certain thresholds)
- Other activities (industrial plants for the production of pulp from timber or fibrous materials, paper and board > 20 t/d)

Some 4.000 to 5.000 installations are comprised. Compared to the IPPC-directive power and heat generation between 20 and 50 MW is also included, because the number is likely to increase in the future. The chemical sector is not included, because direct emissions are not so important and the number is very high with 34.000 plants. The waste sector is considered neither, because of the difficulties in the assessment of the carbon content of waste.

Although the final version of the GHG trading system might differ from this draft, the main elements will probably stay the same.

But not only state activities, but also emission trading schemes in single companies are reported. For example BP Amoco has set the goal to reduce its GHG emissions by 10 % from a 1990 baseline over the period to 2010 by internal emission trading. 127 individual business units are involved, operating in 100 countries.

5.8.3 Data for environmental indicators

5.8.3.1 Electricity and gas markets

There is a time lag between opening up markets and the effects of ICT based electricity and gas trading.

The environmental consequences of energy market opening have been assessed in the Communication from the Commission to the Council and the European Parliament document on Completing the Internal Energy Market (COM(2001) 125 final). Main effects are:

- improvements in generating plants
- increased operational efficiency
- switch to cleaner fuels in power production

The UK was the first country to open up gas and electricity markets. The share of natural gas increased from 0,5 % in 1990 to 38,5 % in 1998. The average conversion efficiency increased by 9,5 % in the same period. CO2-emission from power generation decreased by 27 % in UK, compared to an average of 3 % in the EU.

In the EU between 1990 and 1998 the use of natural gas for power production increased by 128 %, while solid fuels decreased by 18 %. The average conversion efficiency of thermal power stations increased by 6 % and Carbon intensity (CO2/GWh) decreased by 15 %.

The trend towards cleaner power generation is expected to accelerate as market opening progresses.

Electricity prices have fallen dramatically after the liberalisation of electricity markets in some countries (COM (2001) 125 final):

- Prices for industrial users in UK have fallen by 35 % in real terms since 1990
- Finland and Sweden opened their markets in 1995 and 1996. Electricity prices for industry dropped by 20 % and 15 %, although electricity prices were already very low before.
- Electricity prices for industry in Germany fell by 25 % on average between March 1998 and August 2000.
- In countries where consumers are free to change suppliers price reduction effects for households are in the same magnitude. Since 1998 average prices for electricity for domestic consumers have fallen by 13 % in Finland and by 16 % in Sweden.

It cannot be concluded that prices will decrease in the future as they are determined to a high degree by fuel prices.

The picture for gas is less clear. Prices for natural gas are coupled with crude oil prices. Real gas-to-gas competition has not developed by now. Significant price reduction have been reported for the UK between 1990 an 1999: 45 % for industry and 20 % for domestic. However it was an isolated market. Prices doubled during 2000 when continental gas, linked to oil prices, was connected to the UK.

With market opening electricity prices may decline resulting in an increased demand, partly due to less efforts in energy savings and efficiency.

The Green Paper on Security of Energy Supply estimates that demand may increase by 20 % due to lower energy prices. It is guessed that electricity from new and less developed energy sources (e.g. renewables and CHP) may become less attractive.

5.8.3.2 Virtual decentralised power stations

The increase of the electricity share of renewables and CHP are political goals of the European Union. On the other hand liberalisation of electricity markets favours well developed technologies. ICT based coupling of decentralised power stations will improve the cost effectiveness and competitiveness of renewables and CHP. The extent is unknown.

5.8.3.3 Greenhouse gas emission trading

With the implementation of the electronic emission trading system it is expected that efficiency gains in the EU will be made, where it is cheapest to make them. The efficiency gains have been demonstrated in different studies. However the environmental goals of the single countries are fixed. The reduced amount or discounting of allowances is directly controlled by governmental authorities. Efficiency refers to cost efficiency, while the CO2-emission level stays constant. The setting of goals by the member states itself is not a process which requires ICT necessarily.

A GHG emission trading system within a company, such as BP Amoco, can lead to reduced GHG emissions as well. However, where the effects are realised in such a global company operating in 100 countries can't be predicted.

5.8.4 Variables

5.8.4.1 Electricity e-commerce

Electricity sold at exchanges [% of all wholesale electricity]
The percentage of electricity sold at exchanges is monitored. However future prognosis are uncertain. Other long-term contracts will be still an alternative channel.

uncertainty: middle; effect: ↑

Efficiency effect [Δ % of conversion efficiency]
Competition among energy supply companies has already lead to significant energy gains in the production of electricity. Future potentials and their exploitation are highly uncertain.

uncertainty: high; effect: ↑

Shift effect [Δ % for each power generation technology]
The liberalisation and competition among energy suppliers in ICT-based electricity exchanges in the UK have led to big increases in the share of nuclear power and gas power electricity generation. Coal and oil fire power stations were among the losers. Gas power stations have relatively small pay-back times. Nuclear power station capacity didn't chance in UK, but the output increased, because excessive electricity could be sold easily. In Germany nuclear power generation is restricted at a total level, which might be totally exploited until 2020.

uncertainty: high; effect: ↑

Rebound effect by reduced energy prices [% increased energy demand]
High price reductions due to increased efficiency have been reported. Future development of the rebound effect depends on fuel prices and elasticity of electricity demand to prices.

uncertainty: high; effect: ↓

5.8.4.2 Virtual power stations

Renewables connected to virtual power stations [MW capacity]
The renewables can be connected to the electricity grid, so that total power station capacity can be optimised. Although there are ambitious plans of the EU to increase renewables' share future development is difficult to determine as many factors interfere, such as subsidies for renewables' installation or payment rates for electricity of renewables.

uncertainty: high; effect: ↑

CHP connected to virtual power stations [MW capacity]
CHP can be connected to the electricity grid, so that total power station capacity can be optimised. Power and heat generation can be varied depending on current supply and demand needs. CHP diffusion will be fast in energy supplies for large buildings, the application for smaller and distributed houses will spread much smaller.

uncertainty: high; effect: ↑

Share of renewables [% increased by virtual power stations]
The share of renewables is an environmental indicator addressed by the EU. Many measures are possible. Virtual power stations will contribute to the spread, but it will be very difficult to determine the effect.

uncertainty: high; effect: ↑

Share of CHP [% increased by virtual power stations]
The share of CHP is addressed by many political measures as well. Virtual power stations will contribute to the spread, but it will be very difficult to determine the effect.

uncertainty: high; effect: ↑

5.8.4.3 ICT based GHG trading

GHG emissions covered by emission trading [% of all GHG emissions]
The GHG emission covered by GHG emission trading can be determined quite easily as there are reporting mechanisms. Future predictions are highly uncertain and based on many assumptions.

uncertainty: high; effect: ↑

GHG reduction dynamic without goals [% per year]
The GHG emissions might be reduced even without making the GHG allowances more scarce from year to year. This effect can be monitored in the phase from 2005-2007, but today's knowledge is poor. The goals set have to be treated as external factors, as they are not related to ICT.

uncertainty: high; effect: ↑

5.8.5 External factors

Factor	Trend	Uncertainty	Variables affected	Rationale
GDP	Small growth	middle	energy demand	the higher GDP the more energy demand
environmental policy/legislation	Meeting Kyoto targets	low	Uptakes and effects	environmental policy may lead to less energy consumption (esp. GHG trading goals)
Fuel prices	Almost constant	middle	Uptakes and effects	the lower fuel prices the more energy demand

5.9 Facility management

Construction activity shows a high correlation with GDP, as people spend their money in part for housing and offices are built. By the shift to the tertiary sector it can be assumed that total office capacity will rise, the same applies to the number of dwellings due to smaller family sizes.

5.9.1 Definition and scope

The building sector accounted for 40,7 % of total final energy demand in EU 15 in 1997. A breakdown by end-use is given in the following table:

Table 5-47: Percentage of energy consumption in the residential and tertiary sector

	Residential buildings	Tertiary sector
Space heating	57	52
Water heating	25	9
Cooling		4
Lighting		14
Cooking	7	5
Electric appliances	11	
Other		16

Source: COM(2000)769

More than half of energy consumption of buildings is due to heating. This section doesn't cover non-installed equipment, such as cooking and electric appliances. In the tertiary sector lighting is included as mostly lighting is installed. Non-installed equipment in the residential and tertiary sector account for 18 respectively 21 % of final energy consumption.

Eurostat carried out a survey on "Energy consumption in Households 1999" which also covered some Accession Countries.[20] In most of the countries studied the percentage of space heating exceeds 70 % of total household energy consumption.

There are many measures and policies to reduce energy consumption of buildings, ICT being one of them. The different applications are covered under the terms telematic applications, facility management and building management systems. On the other hand energy efficient or even self-containing houses can be realised cheap and easy without complex building management systems.

An overview of telematic applications for buildings is given by IZT, ETSU (1999). The items with relevance to energy consumption are summarised below: The two main topics relevant for energy consumption are

1. Telematic applications to analyse, plan and refurbish existing buildings and new buildings

Building analysis

- Redevelopment (Thermography, Remote sensing)
- Energy concepts (standardisation, data collection, data base)
- Integrated planning strategies

2. Telematic applications to support energy management (control, monitoring and optimisation) for the use of buildings

- Automation and co-ordination of building maintenance
- Individual calculation
- Tele-services
- Counselling

[20] Countries covered: Albania, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania, Slovak republic, Slovenia and Poland.

Integrated facility management bundles the control of heating, lighting and air conditioning for single rooms and for the whole building. Electronic devices might be integrated as well. Intelligent energy management systems as part of the facility management facilitate for example need adapted temperature profiles and air-conditioning in rooms via automated opening and closing of windows. Remote control of the heating via telephone or internet are state-of-the-art technologies, whereas planning of heat demand according to weather forecasts has not pervaded the markets. Furthermore the integration of renewables into the energy supply system is an important field of action.

5.9.2 Data for diffusion

Sciotech (1998, cited in COM(2000)769 final) made an inventory of buildings in the EU. For 1995 the following data are given:

- 150 million residential dwelling
- stock built prior to 1945: 32 %; between 1945 and 1973-75: 40 %; since the 28 %
- 56 % of residential buildings occupied by owners (from 40 % in Germany to 80 % in Spain)
- 66 % of dwellings in EU 15 are in single family houses (more than 80 % in Germany, Ireland, Luxembourg and UK)

Eurostat carried out a survey on “Energy consumption in Households 1999” which also covered some Accession Countries.[21] The share of owner-occupied dwellings is on average higher than in EU 15. Often it achieves 80-90 %, only in Poland, Czech Republic and Latvia the share is lower than 55 %.

In a proposal for a Directive of the European Parliament and of the Council on energy performance of buildings (COM(1001)226 final) for main elements are covered:

a) Establishment of a common framework of a common methodology for calculating the integrated energy performance of buildings.
b) Application of minimum standards on the energy performance to new buildings and to certain existing buildings when they are renovated.
c) Certification schemes for new and existing buildings on the basis of the above standards and public display of energy performance certificates and recommended indoor temperatures and other relevant climatic factors in public buildings and buildings frequented by the public.
d) Specific inspection and assessment of boilers and heating/cooling installations.

An integrated approach for the energy performance of buildings has already been applied in D, F, UK, I and NL but to varying degrees. The proposal lays down the requirements for a methodology for the integrated calculation of the energy performance which will require the use of software programmes.

The difference in standards indicates are large potential for energy savings. New residential buildings and buildings in the tertiary sector should meet minimum standards. The same applies to larger existing buildings (e.g. > 1000 m2), when the buildings undergo renovations.

Clear and reliable information by a certificate shall alleviate market imperfections due to the different interest of owner and renter of a building, dwelling or office. Because the renter normally pays the energy bill, owners interest in energy saving measures are small. Certification for new buildings is mandatory in DK, D and UK, for existing buildings only in DK. For public buildings and other buildings often frequented by the public information on indoor temperature and humidity shall create awareness on optimal conditions.

Inspection of boilers is compulsory in 10 member states, whilst the others apply voluntary measures. The same is necessary for cooling systems. In the annex requirements for the inspection of boilers and central air conditioning systems are set.

[21] Countries covered: Albania, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania, Slovak republic, Slovenia and Poland.

The explanatory memorandum states that the largest potential for improving energy performance in short and medium term is in the existing stock of buildings. In 2020 most of the buildings used today will still exist. The main focus should be therefore on stock management.

Building management systems are widely marketed throughout Europe. Usage is unlikely to develop beyond the largest organisations until the price falls significantly and adaptability of the systems is increased. They are mostly used in large buildings such as office blocks, hospitals, cultural centers, universities, airports and exhibition centers. Components of BMS are sometimes not compatible with appliances and systems customers have already installed. Sales in 1995 were worth 1.600 million ECU. By 2010 an amount of 17.000 million ECU could be achieved.

Major barriers for diffusion are (ATLAS 1997):

- "A lack of knowledge in potential user organisations.
- The high cost of installation and maintenance of BMS
- The systems lack of flexibility to adapt to a wider range of potential usage which varies with the age, size and ownership of buildings.
- The risk of incompatibility between parts of the system affecting technological performance."

It is estimated that remote control systems will grow considerably due to the increasing standardisation of automated buildings systems and the long-term trend towards the extension of applications from primarily office buildings, hotels, schools to include automation of private households. More and more households are connected to the internet.

5.9.3 Data for environmental indicators

The overall potential energy savings of telematic applications for commercial and domestic buildings have been assessed in a small Delphi-like study (IZT, ETSU 1999) . Energy experts and ICT experts both estimate the potential reduction at around 16 %.

In COM(2000)247 the savings potential for energy in buildings used for heating, air-conditioning and lighting has been assessed to 22 % of present consumption which can be realised by 2010. The savings potential has been calculated by considering investments in energy-efficient technology with a payback time of less than 8 years. In the Green Paper "Towards a European Strategy for Energy Supply" (COM(2000)769) energy intensity shall be reduced by 1 % per year. Meeting this target in the building sector would realise two thirds of the available savings potential. The energy requirements per square foot of office space in the USA fell from 115.000 BTU (1979) to 90.500 BTU (1995) (EIA 2000, cited in ABARE 2001)

Eurostat carried out a survey on "Energy consumption in Households 1999" which also covered some Accession Countries.[22] In most of the countries studied central heating systems are predominant. A high potential for energy reduction is assumed for large-panel construction, built from the late 60's up to the 90's. Energy demand per square meter is 2 to 3 times higher than that of the EU, mostly due to poor insulation standards.

A general problem is that ICT is a prerequisite for almost all the measures, but the specific contribution cannot be separated. Saving potentials measures mentioned by COM(2001)226 and the contribution of ICT are as follows:

a) building envelope

Average loss heat for new buildings is 55 W/m2 compared to 100 W/m2 for pre-1945 housing stock.[23] Total energy used in new dwellings is 60 % of that used in old dwellings. The effect is mainly due to better insulation. The building envelope of new buildings is usually planed with

[22] Countries covered: Albania, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania, Slovak republic, Slovenia and Poland.

[23] Multi-family houses built between 1919 an 1948 consume 260 kWh/m2 whereas modern houses only need between 120 and 75 kWh/m2. Low energy and passive energy houses reach 20-70 kWh/m2 (IZT, GdW 2002).

ICT tools which take into account energy demand. Dimensioning of insulation when renovated is also calculated by ICT tools.

b) boilers
5 % of the energy used for heating in the residential sector can be saved by the replacement of old boilers.[24] More than 20 million boilers in the EU are more than 20 years old. ICT enables correct matching of the boiler to the heating installation, use of control devices and correct sizing of the boiler for the building and climate. Furthermore ICT might be used for life-cycle costing of the new boiler and alternative costs of retaining the old boiler.

c) lighting and cooling
In the tertiary sector 30-50 % of the lighting energy could be saved with the use of most efficient components, of control systems and the integration of daylighting technologies. Especially control systems and the integration of daylighting require ICT. The EU GreenLight Programme has demonstrated the cost effectiveness of most of the energy saving measures.
Air conditioning accounts for 0,7 % of final energy consumption in the two sectors and will double until 2020 if current trends persist. The cost-effective savings potential is estimated at 25 %, which can be exploited to a high degree until 2010.

d) bioclimatic design and orientation
Taking into account local bioclimatic conditions (sun, wind direction, shading from trees, heating and cooling potentials of surrounding environment) when designing, locating and positioning buildings can reduce energy consumption of buildings significantly. Cases have been reported for already well insulated buildings that energy demand can be reduced by 60 % in using passive solar design, optimised solar systems for heating, improved daylighting and natural cooling and solar/glare control. New buildings can be constructed this way with ¼ of current space heating demand. For existing buildings this measure is more limited.

In a study on telematic applications for sustainable energy management the potentials of telematic applications have been estimated, mostly in a qualitative manner due to the lack of data of disaggregated statistics. The following applications were included (IZT, ETSU 1999):

a) Building analysis
Refurbishment, modernisation and changes in the use of buildings require analysis of a building's performance. The energy performance determination intended by the EU enables a relativistic assessment in the form of benchmarking. Individual data is being collected in data banks, for example by BINE, in which 120 field- and 450 building case studies are compiled for external users. The thermograph can discover weaknesses in buildings' insulation. This instrument is not used systematically nor is the resulting information connected with existing data banks. The buildings analysis is a prerequisite for ICT based planning of renovation measures.

b) Automation and Co-ordination of building management
This application is also called building management system. Intelligent programs are regulating and controlling heating, ventilation and air conditioning systems and lighting. Automatic decisions can be taken, thus avoiding for example heat losses through mis-operation by hand or disattention. Sensors can for example identify if somebody is in a room and actors will trigger the switch-off of light or lowering the room temperature. BMS can integrate energy cost accounting and be combined with less energy intensive building management tasks such as safety systems, access control and other security systems or lift control. On the other hand CEPE/FHG-ISI (2003) state that the energy saved by home automation is approximately compensated by increased electricity consumption for BMS. This might be true for some cases with low energy saving potentials, but cost calculations show a high correlation with energy

[24] Standard old boilers are reported to consume about 270 kWh/m2*a, modern condensing and ICT controlled boilers achieve 100 kWh/m2*a and below (Schulte 2000).

consumption. Energy management control systems have e.g. led to energy savings of 25 % in Texas A&M buildings (Romm et al. 1999).

c) Individual calculation

In many buildings energy costs are not calculated individually but distributed by average energy use. Thus there are hardly any incentives for the user to save energy. Computer assistant heating systems can continually monitor the energy consumption of each tenant and bill him accordingly. Energy service companies are thus able to customise bills for electricity, water and heating. Single case studies in Germany have shown that consumption for individually rented units differ up to one third per annum. The use of radio technology for data transmission reduces installation costs significantly.

d) Tele-services

Tele-services include telecommunications support for the start up, installation, trouble shooting, maintenance and repair of systems and update of software. The increased efficiency of tele-maintenance will decrease the time of inefficient heating conditions. Telemaintenance and – management allow outsourcing of building management. Remote controlled home energy management systems were suggested to facilitate a reduction of energy costs of about 10 %.

e) Counselling

Telematic consumer advice is provided by consumer and environmental organisations as well as municipal services and energy suppliers. In addition to the download of brochures there are data tools to test one's behaviour with regard energy consumption. Energy related computer games are available as well. Online diagnosis of behaviour can be combined with subsequent e-mail advice. The case study of Vattenfall in Sweden showed that liberalisation of energy markets played an important roll to offer such services in order to get into contact with customers. The overall effects on energy consumption are hardly to determine.

The degree to which ICT contributes to the energy saving effect is very different. For this some rough estimations are made:

- Standards are directly linked to environmental goals and cannot be guessed in advance.
- Inspection of boilers and cooling systems will give incentives to acquire new devices, but the influence of ICT based inspection is considered to be small.
- Building analysis is a support tool for optimised insulation. Heat losses due to optimised detection and insulation measures might be reduced by an additional 5-10 % by using ICT.
- Home automation and tele-services will lead to optimised operation of heating, lighting and ventilation in the magnitude of 5-10 %.
- Individual calculation is relevant for multi-family and office buildings. As the minimum to maximum difference in case studies is about one third, it is assumed that the potential for heat and warm water reduction is about 10-15 %.
- Certification schemes will create transparency about energy costs when renting or buying a house, dwelling or office. The choice of a dwelling usually depends on other factors, but especially in the office sector energy certificates might incite energy efficient new building and renovation of old offices. Most energy efficient office space might be spread by an additional 20-25 %.
- Public display of temperature and humidity will lead to an increased awareness of energy costs. 1 K less indoor temperature will lead to about 6 % heating energy reduction.

5.9.4 Variables

5.9.4.1 Diffusion

Buildings in stock [total number]

The total number of buildings in stock, differentiated by age, will determine the renovation and refurbishment cycles of houses until 2020. Projections are quite stable.

uncertainty: low; effect: ↑

Bioclimatic design [% of buildings to be built]
Bioclimatic design has its use when there is much space, aesthetic considerations are not crucial and local climatic conditions offer possibilities. It will be limited to certain groups of houses. The extent is considered to be very uncertain.

uncertainty: high; effect: ↑

Intelligent heating systems [% of all residential and office buildings]
The uptake of intelligent heating systems is determined by renovation cycles, investment and fuel costs. These parameters are considered to be uncertain, but there is a political will behind modernisation of heating systems in the EU.

uncertainty: middle; effect: ↑

Home automation [% of all new residential and office buildings]
Smart home technology is usually only applied when building a new house, because installation costs are considerable. New sensor-actor networks might increase the benefits so that the uptake is more probable. Mostly big buildings will be the target group.

uncertainty: high; effect: ↑

Individual calculation [% of all multi-party used buildings]
Individual calculation is already the case in single-family houses and in some dwellings. The extent and saturation levels are difficult to determine. In office houses individual calculation might be much more widespread as cost accuracy is required in business.

uncertainty: middle; effect: ↑

ICT based modernisation of buildings [% of all modernised buildings]
Thermography and ICT based optimisation of insulation in the modernisation process will only be the case for a certain share of buildings. To which degree ICT will be applied is very uncertain, as thermography is still not widespread in use.

uncertainty: high; effect: ↑

Certificates [number of rents and buys of certified dwellings and offices/a]
Certificates for new buildings and for some big old buildings may be compulsory in the near future, but it is not sure whether the EU proposal will be accepted or not. However in single countries this way has been chosen and the probably positive effects will be communicated.

uncertainty: middle; effect: ↑

Public display [% of buildings with public displays]
A ubiquitous information about temperature and humidity in public buildings and big buildings often frequented by the public is intended by the EU proposal for a directive.

uncertainty: middle; effect: ↑

Lighting in offices [% of all office capacity]
The EU-Initiative GreenLight promotes intelligent lighting systems which are especially useful for big offices.

uncertainty: low; effect: ↑

5.9.4.2 Environmental indicators

Intelligent heating systems [% of heat energy saved]
The environmental effects of intelligent heating systems are considered to be positive, although the potentials are not always fully exploited. The heat energy saved can vary considerably with technology and usage behaviour (e.g. chosen indoor temperature).

uncertainty: middle; effect: ↑

Home automation and tele-services [% heat, warm water, ventilation and lighting energy saved]
Home automation and tele-services will lead to less wasting of heating, ventilation and lighting. The overall effect is difficult to assess. A potential for heating and lighting energy reduction of 5-10 % is assumed, but there is no reliable proof that home automation and tele-services are not used to increase comfort instead of saving energy.

uncertainty: high; effect: ?

Bioclimatic design [heating energy and lighting energy saved]
New buildings can be constructed this way with ¼ of current space heating demand. The effect however depends on local climatic conditions.

uncertainty: high; effect: ↑

Individual calculation [% of heating and warm water energy saved]
Individual calculation gives incentives to improve one's energy consumption behaviour. However the realised effects are not well known.

uncertainty: high; effect: ↑

Building analysis [% heat energy saved]
Optimised detection of heat losses and design of insulation might lead to an additional energy saving effect of 5 % of office and residential stock.

uncertainty: high; effect: ↑

Certificates as a rationale of choice [% of heat energy saved]
Costs for facilities are an important factor for office rent. Combined with databases for benchmarking there will be incentives for energy saving measures, when customers take life cycle costs into account. In the office sector it is quite certain that these considerations will be taken into account. Most energy efficient offices might be spread by another 20-25 %.

uncertainty: high; effect: ↑

Awareness effect [ΔK average indoor temperature]
Heating energy is reduced by 6 % per K less indoor temperature. The awareness effect might be different in residential and office buildings. The awareness effect will be difficult to estimate, but the total amounts of heating energy saved might be substantial.

uncertainty: high; effect: ↑

Lighting [% lighting energy saved]
In the tertiary sector 30-50 % of the lighting energy could be saved with the use of most efficient components, of control systems and the integration of daylighting technologies.

uncertainty: middle; effect: ↑

5.9.5 External factors

Factor	**Trend**	**Uncertainty**	**Variables affected**	**Rationale**
GDP	small growth	middle	buildings in stock	the higher GDP growth the higher construction and modernisation activities (expenditure)
Structure of the economy	towards tertiary	middle	buildings in stock	the higher tertiary GVA the more buildings in tertiary sector
environmental policy/legislation	More ambitious EU policy	middle	energy demand	environmental policy may lead to improved energy standards and management
Energy costs	declining	middle	all	the higher energy costs the more incentives for energy saving measures.

5.10 Production process control

ICT for production process control is used to increase production yield and to minimise energy demand. The restructuring of the EU 15 economies will lead to different shares of single industries of energy consumption. Taking the development until 2020 into account it is possible that major European industries will have to close down because they face stiff competition in global markets. This applies especially to labour intensive industries.

5.10.1 Definition and scope

The industrial sector accounted for 28,2 % of total final energy demand in EU 15 in 1997. It consumed 35 % of EU primary energy demand in 1995. The energy consumption per unit industrial output has fallen in the EU since 1973. Energy efficiency measures and a shift to lighter industries have contributed to the reduction. However in a business as usual scenario cited by ATLAS (1997) industrial energy demand is expected to grow between 0,5-0,9 % per year from 1990-2020, equivalent to a total increase of 16-31 % over this period.

Key technologies which reduce energy consumption of the industry are either cross-sector or sector-specific technologies. Potential long-term savings in cross-sector technologies have been compiled in the ATLAS project. High influence of ICT is the case in **production process control & energy management and adjustable speed drives**.

Less information exists on sector-specific technologies. As ICT based production process control tools are being introduced and optimised mainly in big companies the focus is on basic energy intensive industries. A breakdown for primary energy demand is given below:

Table 5-48: Industrial primary energy demand in EU 12

Product/Process	% of total primary energy demand in EU
Steel	5,7
Non ferrous metals	1,1
Bulk chemicals	2,0
Oil products	3,1
Petrochemicals/Plastics	5,3
Cement	1,4
Building bricks	0,3
Glass	0,4
Paper	1,7
Textile/Leather	1,1
Dairy	0,4
Sugar	0,4

Source: Worrell et al. 1994, cited in ATLAS 1997

These sectors cover 22,9 % of primary energy consumption. Many other industries, such as the automobile industry and SME, are not included in this table.

Due to extraordinary complexity of the industrial sector a selection has to be made. According to the share of energy consumption the **steel industry** and **petrochemical industry/plastics** industry are most important.
In the ICARUS data base there are sector studies for The Iron and Steel Industry as well as for the Chemical Industry. ICARUS is a database of technological options for energy efficiency measures for the Netherlands. It contains achievable energy savings, costs and current penetration data. Furthermore the data base can serve as a tool for assessing potential energy and GHG emission savings in the period up to 2020.

5.10.2 Data for diffusion

a) Process control and energy management:
Savings by process control and energy management can be made by good housekeeping and sophisticated sensor & control systems. Many of the measures are simple, e.g. switching off equipment when not in use, preventive maintenance, repairing leaks and rescheduling loads. Access to real-time information can be fostered by cheap and reliable sensors.
According to DETR, ETSU (1995, cited in IZT, ETSU 1999) about 20 % of companies use no energy management system. Technology is relatively mature but needs further dissemination and improved sensors to facilitate automation. which yet have to be developed. Capital investment varies from 0,5-40 ECU/GJ saved energy. Payback time ranges from less than one to 4 years.
High growth rates are predicted for process control equipment for monitoring temperature, flow, moisture content, chemical composition and machine conditioning.

c) Adjustable speed drives:
Adjustable speed drives offer the largest single opportunity for increasing a drive systems' energy efficiency. Fans and pumps for example are often operated at part or variable load. For variable load operation ASD are the most suitable control technique. They are becoming increasingly popular. Current market deployment of ASDs is estimated at 15 % of potential applications in the EU market. Main barriers for the diffusion are the capital costs, especially for small motors (< 10kWel.).
Further dissemination to stimulate uptake of existing units and demonstration to promote new markets and reduce costs count among the most important actions. Therefore information about appropriate use, short pay back time, ease of control, reduced system maintenance and low operating costs have to be communicated. Meanwhile there is an EU initiative to promote ASDs, including a Data base for motors provided by DG TREN.

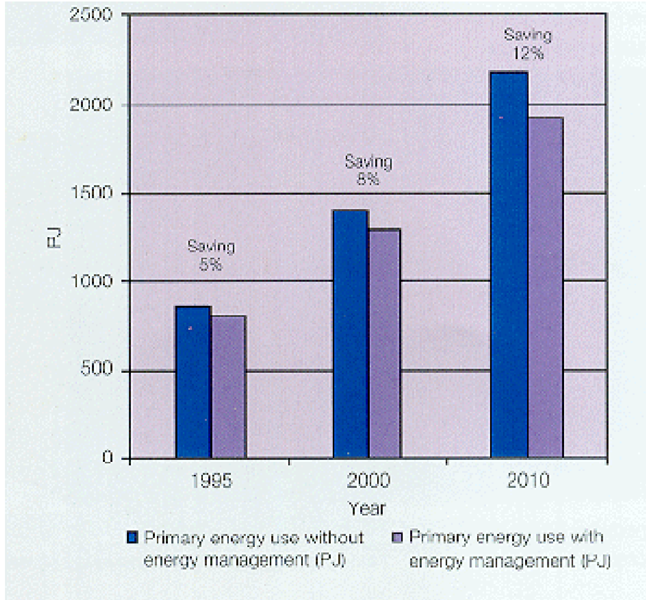
Forbes states that only 1/3 of U.S. companies seriously scrutinise energy usage (Romm et al. 1999). General barriers for the measures cited above are low energy prices, lack of awareness of decision makers (energy and environment), risk perception (changing processes) and lack of information.

5.10.3 Data for environmental indicators

The overall potential energy savings of telematic applications for energy management have been assessed in a small Delphi-like study (IZT, ETSU 1999). Experts expect a potential reduction of 16-18 %. In the energy supply industry a range of 11-14 % is given, whereas in the manufacturing industry 14-18 % are estimated.

Potential energy saving by implementing **process control and energy management** described in ATLAS (1997) are inconsistent. On the one hand an overall potential of 5-10 % is indicated, on the other hand energy management is supposed to have a potential of reducing up to 15 % of primary energy demand by 2010. A more differentiated picture is given in the following figure, also from the same source:

Figure 5-4: Predicted total energy savings from energy management systems in EU countries and Norway, relative to industrial energy consumption in 1990



Source: ATLAS 1997

The potential energy reductions by process simulation and planning has been estimated by AEA (1999, cited in IZT, ETSU 1999) to 2-6 % on average. It is unclear of this potential is included in the potentials shown above.

For adjustable speed drives a energy savings potential of 10-20 % is estimated by ALTAS (1997):

Table 5-49: Summary of projected energy savings potentials by adjustable speed drives

	1995	2000	2010
Electricity use [PJ]	200	260	360
Primary energy use [PJ][25]	500	650	910
Savings [%][26]	10	13	18

Source: ATLAS 1997

The technical long-term potential savings of primary energy demand are estimated by around 40 % of industry's primary energy consumption. CO2-reduction potential is 100.000 kt/a. But these potentials don't refer to ICT only.

Some single saving potential by industry can be derived from the ICARUS data base:

a) Iron an steel industry

The following table shows realised and projected energy savings in the iron and steel industry:

Table 5-50: Realised and projected energy savings in the iron and steel industry in the Netherlands

	Energy efficiency index projected	Energy efficiency index realised
1989	100	100
1990	99	98
1991	99	100
1992	95	94
1993	93	90

[25] electricity generation efficiency assumed to be 40 %

[26] relative to EU and Norway electricity consumption for motors

1994	90	89
1995	88	89
1996	87	89
1997	85	85
1998	84	84
1999	82	
2000	80	

Source: ICARUS 2001

Among the measures which belong to Process control and management and which are not fully implemented are:

Table 5-51: Selected energy efficiency measures in the iron&steel industry

	data	comments
Good house keeping[27] in coke production		
Saving fuel/heat	0,5 GJ/t	
current penetration	14 %	
maximum penetration	43 % 100 %	2010 2020
Additional investments	0,01 €/tcs 0,03 €/GJ	Uncertainty: medium Reliability: medium
Additional O&M costs	0,02 €/tcs 0,03 €/GJ	Uncertainty: medium Reliability: medium
Retrofit of hot stoves[28]		
Saving fuel/heat	0,57 GJ/tcs	Uncertainty: medium Reliability: medium
current penetration	50 % (1995)	Uncertainty: medium Reliability: medium
maximum penetration	100 %	in ?
Additional investments	0,3 €/tcs 0,5 €/GJ	Uncertainty: medium Reliability: medium
Additional O&M costs	0 €/tcs 0 €/GJ	Uncertainty: medium Reliability: medium

Source: ICARUS 2001

For refineries the fuel savings potential of advanced process control has been estimated to 2,5 % by ICARUS. Cost estimates are not available, but investments may be relatively high, because of the requirement to install several sensors and the need to customise the software to each specific plant. Improved reliability and yields will lead to benefits. Investment costs are estimated at 25 GJ/€. Implementation of this measure can start from 2010 onwards. The maximum installation rate is 100 %. There are no additional O&M costs. Uncertainty and reliability have not been assessed.

[27] category of different smaller measures including energy management and insulation. “The contribution [...] to the energy efficiency is estimated to increase 0,072 % over total energy consumption each year.

[28] combination of computer controlled air delivery, preheating, adaptation of burners and rapid O_2-measurement.

Table 5-52: Selected energy efficiency measures in the petrochemicals/plastics industry

	data	comments
Good house keeping[29] and process control in organic basic chemicals industry		
Saving fuel/heat	2 %/2 %	
current penetration	n.a. (0 % in 1995)	
maximum penetration	100 %	
Additional investments	3 €/GJ*a	Uncertainty: 30 % Reliability: medium
Additional O&M costs	0 €GJ/a 0,03 €/GJ	Uncertainty: Reliability:
Energy management in other basic chemicals industry[30]		
Saving electricity	5 %	Uncertainty: 25 % Reliability: medium
Saving fuel/heat	5 %/5 %	Uncertainty: 25 % Reliability: medium
current penetration	40 % (1995)	Uncertainty: Reliability: medium
maximum penetration	100 %	in ?
Additional investments	5 €/GJ*a	Uncertainty: 30 % Reliability: low
Additional O&M costs	0,5 €/GJ	Uncertainty: 30 % Reliability: low

Source: ICARUS 2001

It should be noticed that the cross-sector and sector-specific measures interfere and cannot just be added. As energy management systems are important measures in the iron&steel as well as in the petrochemicals/plastics industry ASDs are not mentioned explicitly in these two energy consumptive industries.

5.10.4 Variables

5.10.4.1 Cross-sector

Take-up of EMS [% of all energy intensive companies]

Uptake of EMS depends on energy prices. The lower energy prices the longer pay-back rates for investment in EMS. Cheap and reliable sensors for real-time information are mature enough, but sensors have to be improved to facilitate automation. High growth rates are predicted for process control equipment for monitoring temperature, flow, moisture content, chemical composition and machine conditioning.

uncertainty: middle; effect: ↑

Reduced energy use by EMS [% of total primary energy demand of industry]

The heterogeneity of industry makes it almost impossible to assess an average percentage of energy saved by EMS. Only rough expert estimations for the whole sector exist, but they lack empirical proof. Continued development of improved software will contribute to increased efficiency, but the degree is unknown. Sophisticated sensor & control systems can maximise the

[29] category of different smaller measures including energy management and insulation. “The contribution [...] to the energy efficiency is estimated to increase 0,072 % over total energy consumption each year.

[30] including manufacture of plastics in primary forms and synthetic rubbers in primary forms

energy savings in the future. Augmented reality can contribute to a better understanding of material- and energy flows.

uncertainty: high; effect: ↑

Rebound effect [% of saved energy]
Cost reductions due to saved energy might lead to increased demand for products from energy intensive industries. However the effect is considered to be small, as total potentials for EMS are at about 5-10 %.

uncertainty: high; effect: ↓

Take up of ASDs [% of all motors]
Uptake of ASDs depends on energy prices as well. For variable load operation ASD are the most suitable control technique. They are becoming increasingly popular. Current market deployment of ASDs is estimated at 15 % of potential applications in the EU market. Main barriers for the diffusion are the capital costs, especially for small motors (< 10kWel.). There is an EU initiative to promote ASDs, including a Data base for motors provided by DG TREN.

uncertainty: middle; effect: ↑

Reduced electricity use by ASDs [% of total electricity demand for motors in industry]
There are databases on power consumption of motors with or without ASDs. However the usage patterns throughout industry are very uncertain. For this there are only generic estimations for the potential in industry. Advanced software might further reduce power consumption of ASDs in the future.

uncertainty: high; effect: ↑

Rebound effect [% of saved energy]
Cost reductions due to saved energy might lead to increased demand for products from industries. The total potential however is spread over all industries, so that significant cost reductions for single companies are likely to be small. However the effect is considered to be small, as total potentials for EMS are at about 5-10 %.

uncertainty: high; effect: ↓

5.10.4.2 Sector specific

a) Iron and steel industry

Uptake of good house keeping in coke production [% of all coke plants]
The variable in general has been described above. However investment, O&M costs and energy costs saved can be determined specifically. Energy is a very important cost factor in coke production, for this a significantly increased uptake is highly certain.

uncertainty: low; effect: ↑

Saved fuel in coke production [GJ/t]
As good house keeping comprises many small measures, the potentials will differ from plant to plant. The levels achieved will probably be in the same magnitude, because of best available technique documents and benchmarking. Sophisticated sensor & control systems can maximise the energy savings in the future.

uncertainty: middle; effect: ↑

Retrofit of hot stoves [% of all stoves]
The percentage depends on the number of hot stoves which are suitable for retrofitting. Current and expected future market conditions determine this figure.

uncertainty: middle; effect: ↑

Saved fuel in hot stoves [GJ/t]
The energy saving potentials can be given very specifically, but also a bulk of measures is included. The levels achieved will probably be in the same magnitude, because of best available

technique documents and benchmarking. Sophisticated sensor & control systems can maximise the energy savings in the future.

uncertainty: middle; effect: ↑

b) Petrochemicals/Plastics

Uptake of good house keeping in organic basic chemicals industry [% of all companies in organic basic chemicals industry]
The variable in general has been described above. However investment, O&M costs and energy costs saved can be determined specifically. Energy is a very important cost factor in coke production, for this a significantly increased uptake is highly certain.

uncertainty: low; effect: ↑

Saved fuel & heat [% of total fuel & heat demand]
The energy saving potentials can be given very specifically, but also a bulk of measures is included. Sophisticated sensor & control systems can maximise the energy savings in the future.

uncertainty: high; effect: ↑

Uptake of EMS in other basic chemicals industry [% of all companies in plastics/rubber industry]
The variable in general has been described above. However investment, O&M costs and energy costs saved can be determined specifically.

uncertainty: middle; effect: ↑

Saved fuel & heat/electricity [% of total fuel & heat/electricity] demand
The energy saving potentials can be given very specifically, but also a bulk of measures is included. Sophisticated sensor & control systems can maximise the energy savings in the future.

uncertainty: high; effect: ↑

5.10.5 External factors

Factor	Trend	Uncertainty	Variables affected	Rationale
GDP	small growth	middle	uptakes	the higher GDP growth the higher demand for physical products
Structure of the economy	Heavy industries of declining importance	middle	uptakes	the lower GVA of heavy industries the less uptake of energy saving measures
environmental policy/legislation	More ambitious EU policy	middle	Uptakes and effects	environmental policy may lead to improved energy standards and management
Energy costs	declining	middle	Uptakes and effects	the higher energy costs the more incentives for energy saving measures

6 NEXT STEPS

The application of the script for the scenario building, modelling and derivation of policy recommendations will be discussed intensively in a meeting of the project partners on 10th June 2003 in Lund (Sweden).

Before, on the 9th of June 2003 scenario description documents will be circulated.

Task three, the building of scenarios has begun in the end of April 2003. The Scenario validation workshop will take place on 23rd June 2003 in London (UK).

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GLOSSARY

AC 10	10 acceding countries to EU (1st May 2004): Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia
AC 13	AC 10 + 3 applicant countries: Bulgaria, Romania, Turkey
ASD	Automated speed drives
ASP	Active server pages
BMS	Building management systems
BAN	Body Area Network
BTS	Basis transmission stations
B2B	Business to business
B2C	Business to Consumer
CFC	Chloro-fluoro-carbons
CHP	Combined heat and power generation
CRM	Customer relationship management
CRT	Cathodic ray tube
EDI	Electronic Data Interchange
EMS	Energy management systems
ERP	Electronic resource planning
EU 15	Current 15 EU member states: Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, Netherlands, Portugal, United Kingdom, Austria, Finland, Sweden
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GVA	Gross Value Added
GWP	Greenhouse Warming Potential
HGV	Heavy goods vehicles
ICT	Information and communication technologies
IRD	Integrated Receiver Decoder
ITS	Intelligent transport systems
LAN	Local Area Network
LBS	Location Based Services
LCA	Life cycle assessment
LCD	Liquid crystal displays
MAN	Metropolitan Area Network
Mbit	Megabit per second
MIV	Motorised Individual Traffic
MUD	Multi-user Dungeons
O&M	Operation and maintenance
PCB	Poly-chlorinated biphenyl
PPC	Production process control
PTA	Personal travel assistant
SCM	Supply chain management
SME	Small and medium size companies
UPS	Uninterruptable power supply
VA	Vale added
WAN	Wide Area Network

e-business	E-commerce plus e-based and/or e-supported activities within a company (e.g. telework, teleconferencing, ...)
e-commerce	Commercial market transactions by using interactive media (e.g. Internet, Digital TV) for supply, order and/or use
First order effects	The impacts and opportunities created by the physical existence of ICT and the processes involved.
Second order effects	The impacts and opportunities created by the ongoing use and application of ICT.

Third order effects	The impacts and opportunities created by the aggregated effects of large numbers of people using ICT over the medium to long term.
Factors	Factors are over-arching and define the scenarios (e.g. demographic change)
Variables	Variables are smaller scale and can be quantified or qualified (e.g. households broadband access). They are the same within each scenario, but change in different ways according to factors.