

The Information Society and the Environment: a case study concerning two Internet Applications

Ildiko TULBURE

Technical University of Clausthal, Graupenstr. 3, D-38678, Clausthal-Zellerfeld, Germany
Tel: +49-5323-723123; Fax: +49-5323-722203; Email: Ildiko.Tulbure@itm.tu-clausthal.de

Abstract. In this paper the most relevant question related to the emerging information society will be touched: Does the Information Society assure per se the sustainability of our society? What are the sensible factors, which will play an important role in this context? One very important aspect related to the use of ICT is the environmental one. The danger is that so-called *rebound-effects* could occur under certain conditions, which could have a negative impact on the environment. In order to analyse possible environmental effects of different IT-applications an integrative model will be presented. Different scenarios will be developed by using the model and evaluated for the conditions of Germany in this first stage. Two IT-applications will be considered: on-line-informing and e-working. Methodological aspects in the field of integrative modelling will be also discussed.

1. Introduction

The Information Society Technologies (IST) Programme of the European Commission seeks to accelerate the emergence of an information society based on the needs of individuals and enterprises. The IST - Programme is structured around four Key Actions: Systems and Services for the Citizen, New Methods of Work and Electronic Commerce, Multimedia Content and Tools and Essential Technologies and Infrastructures.

Beside these actions, the Action Plan *eEurope* has been developed (http://europa.eu.int/comm/information_society/eeurope), which is clustered around three main objectives:

- A cheaper, faster, secure Internet
- Investing in people and skills
- Stimulate the use of the Internet

By these programmes the general use of ICT is stimulated in the European region. The effective use of these technologies is depending on the personal skills to use these. The European Commission recognised the multitude of possibilities given especially by IT-applications. In the field of e-working the Information Society Directorate-General carried out studies and delivered information in form of Status Reports about the situation in Europe for the years 2000 and 2001 [6, 8]. The goal is "to make Europe the most competitive and dynamic knowledge-based economy, capable to sustained economic growth with more and better jobs and greater social cohesion" (cited from the Foreword of P. Johnston and J. Nolan, [8], p. 3). This should happen by Realising an Information Society for All [5] in the own and specific way i.e. "The European Way" [2].

The emergence and use of ICT have impacts in all human activity fields. There are in the moment a lot of projects dealing with questions related to the use of ICT. For instance for the field of digital divide currently about 528 projects are to be found in the Digital

Dividend project clearinghouse database. The Digital Dividend Initiative (www.digitaldividend.org) is an initiative of the World Resource Institute (<http://www.wri.org/>) and covers the whole world. From the 40 European projects 12 are located in Eastern Europe and 29 in the western part, including obviously some mixture. This relation is somewhat surprising, as the needs for development are clearly bigger on the side of the Eastern European countries. Also the absolute number of projects in Eastern Europe seems small in comparison to those in other regions considering the respective populations and number of countries. A closer analysis of the 12 Eastern European projects shows the activities education application (6), youth (4), e-governance application (3) and portal (3) as most frequent (2-3 activities are assigned per project). E-commerce systems are mentioned twice, enabling technology and equipment recycling have one occurrence. Topics like e-working do not appear in the specific projects in Eastern Europe.

2. Sustainability in the Information Society

Sustainable development had arisen as a possible solution for the global complex ecological, economical and social problems. After the Conference for Environment in Stockholm in 1972 and the first report of the Club of Rome "The Limits of the Growth" [10] was understood that besides wanted effects of technological progress, undesired and negative effects can appear. It was clear that the created regional and global (environmental) problems are very serious and need to be solved.

Nowadays we confront us with a series of global problems. "World Problematique" is a concept created by the Club of Rome (www.clubofrome.org) to describe the set of the crucial problems – political, social, economic, technological, environmental, psychological and cultural - facing humanity. Some of them have been discussed a lot in the past like growth of world population, increase of energy and resource consumption and environmental pollution. Other issues regarding "world problematique" have arisen in the last years. For instance issues related to the usage of information and communication technologies (ICT) can be mentioned in this category like digital divide, new technologies, global society etc.

Discussions on political, scientific and social levels began worldwide already in the 70' years in order to find solutions for the problems shown above, which could be applicable by regional differences to the developed as well as to the developing countries. The concept of sustainable development was for the first time defined 1987 in the Brundtland Report and was very large discussed on the Conference for Environment and Development in Rio de Janeiro 1992 as well as in the closing document "Agenda 21". Many actions after this time emphasise that the evolution of technical, social and ecological systems has to be analysed in synergetic relation. The aim is to help the decision making process and to define such measures which can be applied on different levels depending on the specific problems.

The comprehensive question with which the projects in the ICT-field are dealing can be formulated like: Does the Information Society assure per se the sustainability of our society? What are the sensible factors, which will play an important role in this context? There are a lot of impact fields of ICT, but one of the most important, which has been a little bit neglected in the last time is the environmental one. Radermacher stated some years ago that an increase in the efficiency of technological applications does not implicitly lead to a decrease of energy use and of environmental stress because of changes in human lifestyles. It has been demonstrated that so called "rebound-effects" do over-compensate the effects of efficiency increase by giving more and more possibilities to spend free time in a very energy intensive way [12, 13].

The EU-project "TERRA-2000" started 2001 for a time of three years is broadly concerned with understanding changes associated with the Networked Society and particularly their medium-term sustainability implications (www.terra-2000.org). The overall objective is to seize the moment before Networked Society opportunities slip away and issues are resolved in ways that undercut European values, institutions and interests. This is related in four general questions:

- Will the Networked Society changes lead to a genuine new area around the world, or will its effects prove merely quantitative or short-lived?
- Will the technology-assisted explosion in communication lead to a more inclusive, efficient and egalitarian society, or will the Digital Divide harden into increasing inequality?
- Will the technical possibility to substitute flows of information for physical flows increase the efficiency and reduce the overall consumption of natural resources (including environmental commons), or will it increase resource use by stimulating consumption?
- What values – and consequent policies – can help the (environmental, economic, socio-political and cultural) sustainability of the Networked Society?

In order to get answers to the specific question regarding environmental impacts, different ICT-applications have to be considered and analysed by taking into account their impact on environment during the whole life cycle, as usual in the context of life cycle assessments. For this goal there is a need to build a connection among so-called "old" indicators like energy consumption, paper consumption or pollutant emissions and "new" indicators related to IT-based applications, like infrastructure for the use of IT-applications and effective use of IT-application. In this paper especially two IT-applications will be considered: on-line-informing and e-working. The conditions in which rebound-effects do appear will be discussed for these two IT-applications by developing and evaluating different scenarios. The evaluation of the developed scenarios will be carried out by using environmental indicators, like pollutant emissions in the air.

Related to sustainability the problem of evaluation is a very important one. Criteria chosen for evaluation have to refer in a way or another global issues, but on a regional or local level. In our dynamically changing society the comprehensive evaluation is very difficult. Very often aggregated entities or hardly quantifiable entities are neglected in the evaluation processes or taken into account as limitations. It is necessarily to develop new methods for evaluation especially related to technology assessment. These methods have to enable dynamic evaluations, when evaluation criteria change in time. The methods should be also transparent and robust. A promising method is the fuzzy logic based one, which enables to integrate highly aggregated entities or qualitative descriptions in mathematical models, see for instance [15].

3. Methodical Problems

Part of what engineers do is to evaluate developments in technological field. Their evaluation has up to recent time almost without exception been focused on technical aspects, like functionality and safety, and on economic aspects following legal and financial boundary conditions.

With respect to sustainability more criteria have to be considered like environmental quality, social and human values and quality of life. This kind of evaluation needs interdisciplinary co-operation in order to develop new comprehensive and integrative methods. Applying sustainable development by using technology assessment means

investigating complex dynamic systems. In this context there are many fields where research is needed; after [9] some of them are: developing sustainable development indicators, dealing with uncertain knowledge, improvement of methods and instruments, modelling and simulation of dynamic systems.

Methodological problems appear in the step of aggregation, because of using weighting coefficients, which very often are not transparently defined. In the step of modelling qualitatively different variables have to be coupled in *integrative models*. Very often qualitative information goes lost or is taken into account by coefficients or parameters which are not transparently calculated. The issue of selecting relevant indicators or evaluation criteria has to consider also regional differences. All this procedure has no weight if relevant data are not available. It is to be mentioned related to data need that not only indicators but also their gradients are relevant in order to show the trends of development. New achievements in the field of methods should assure a better integration of qualitative or hardly quantifiable entities or uncertainties in mathematical procedures. Such a possibility is given by fuzzy logic introduced by Lotfi Zadeh in the 60' years, which is a generalisation of classic logic.

4. Evaluating Possible Effects of Internet Applications on Environment

In order to evaluate the environmental effects of the use of different IT-applications several scenarios have to be developed. For helping the scenario development process, an integrative model called EFENIA has been developed [11, 16], which makes the connection among so-called "old" indicators like energy consumption, paper consumption and "new" indicators related to IT-based applications, like infrastructure for the use of IT-applications and effective use of IT-application.

Integrative modelling is a relatively new direction in the field of modelling dynamic systems. It is very relevant especially in the context of sustainable development, where qualitatively different aspects from technological, economic, environmental and social fields have to be taken into account. The concept of integrative modelling means to integrate horizontally and vertically different aspects from different scientific fields.

To give a very simple definition for such models, we can say that integrative models are such models which incorporate knowledge from more than one field of study. There are several examples of such models like the Club of Rome world model World3 [10], International Futures world model [4] or climate models [1]. To develop an integrative model a top-down and a bottom-up approach is needed, see for details [16].

The main parts of the presented model EFENIA are the following, see Figure 1:

- Infrastructure for the use of IT-applications
Ex.: Number of computers, Internet accesses
- Effective use of Internet-application: by considering two possible applications: on-line-informing (index 1) and e-working, (index 2).
- Energy and paper consumption
Ex.: Energy consumption of computers during production and during use + energy consumption for paper production, and because of travelling to the work office of the user and non-user of e-working possibilities.
- Environmental field by considering pollutant emissions and quantity of e-scrap because of old computers.

In order to use and test the developed model, several simulations have been carried out and sensitivity analyses has been done [11, 16]. The most relevant simulation runs have been stored in form of scenarios. The model has been developed and simulations have been run using the software VENSIM.

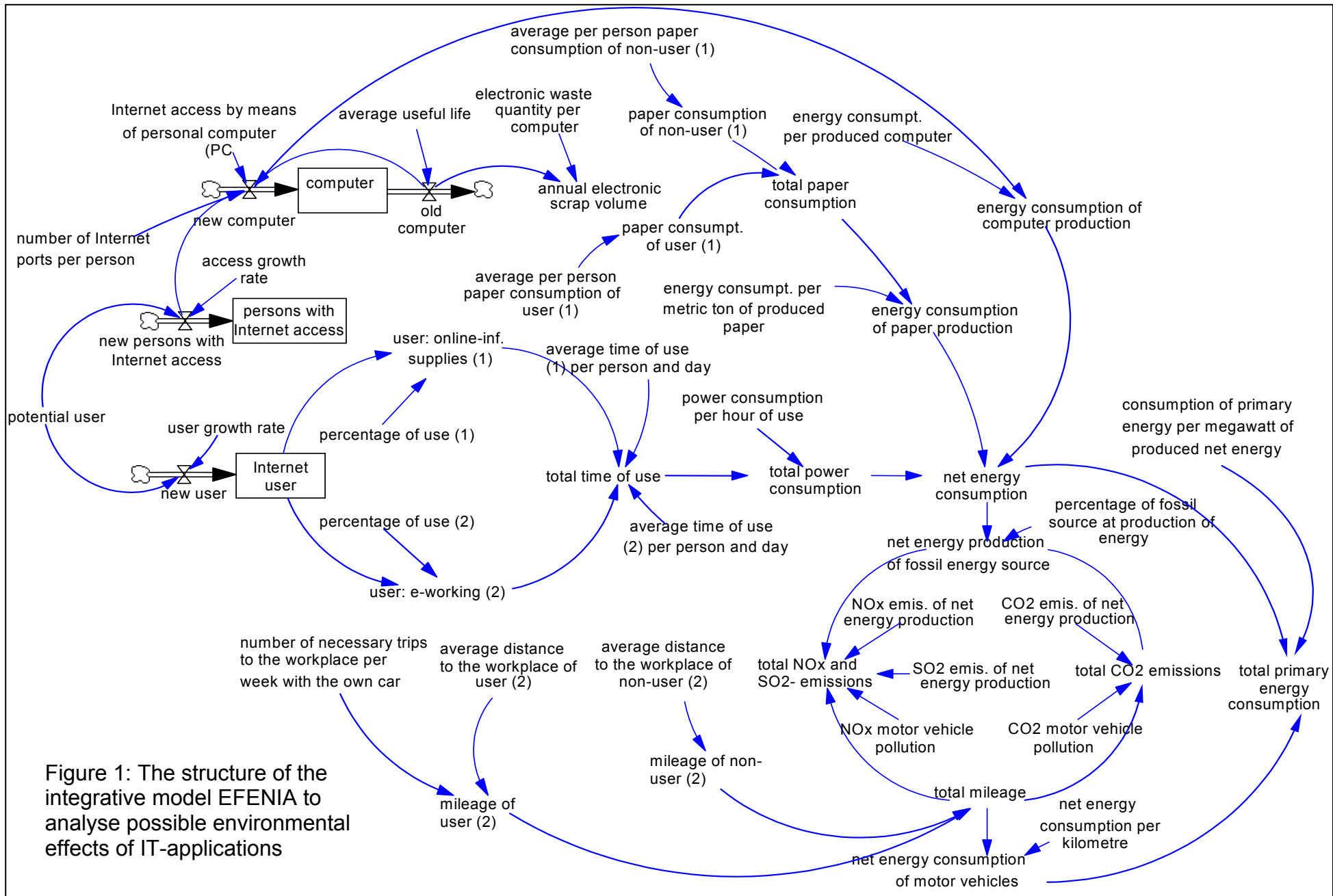


Figure 1: The structure of the integrative model EFENIA to analyse possible environmental effects of IT-applications

In the phase of data accumulation several difficulties did occur concerning some parameters of the model. There are mainly four changeable parameters, for which the data provision has been very difficult. These parameters can be found in Table 1. First applications of the model have been carried out for the conditions of Germany. Because presently it is not very exactly known how many people does use the two IT-applications, the three relevant values have been considered for the first two parameters in Table 1: 5 % (almost nobody does use the application), 50 % (the technological application is used by the half of the people) and 95 % (almost everybody does use the application). Regarding the average distance to the workplace of the e-workers (index 2) the value of 100 km has been considered, which is more than a realistic value, taking into account that e-workers will not travel so frequently to the workplace (once or twice a week). Presently the value of the average distance to the workplace is 17 km in Germany for the non-user of e-working. Regarding the average paper consumption of the users of on-line-informing possibilities (index 1) the value existing presently in Germany of 166 kg/year has been taken into account for two scenarios and a higher value of 250 kg/year for the other two scenarios.

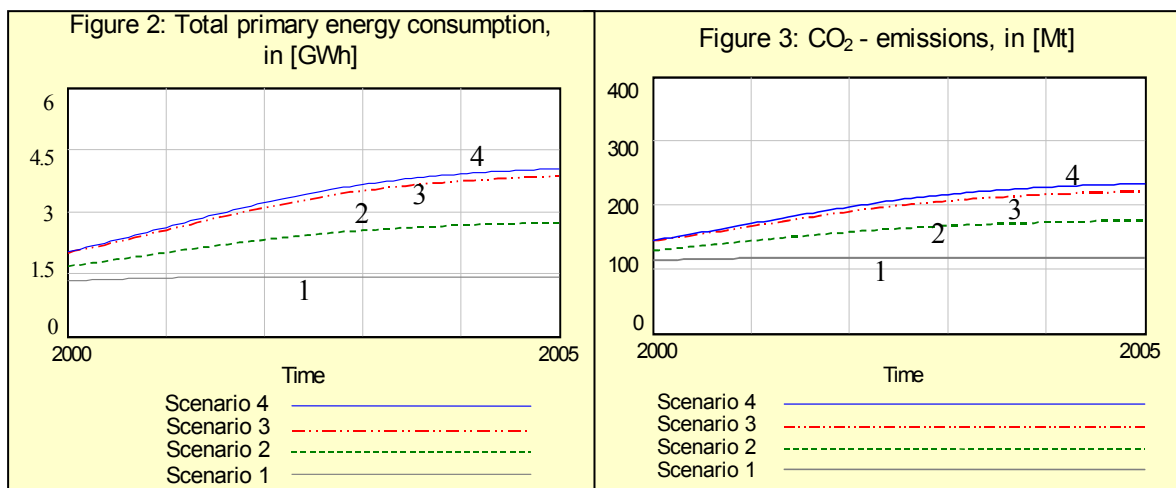
Table 1: Parameters with changeable values in the model EFENIA and their combinations for the developed scenarios.

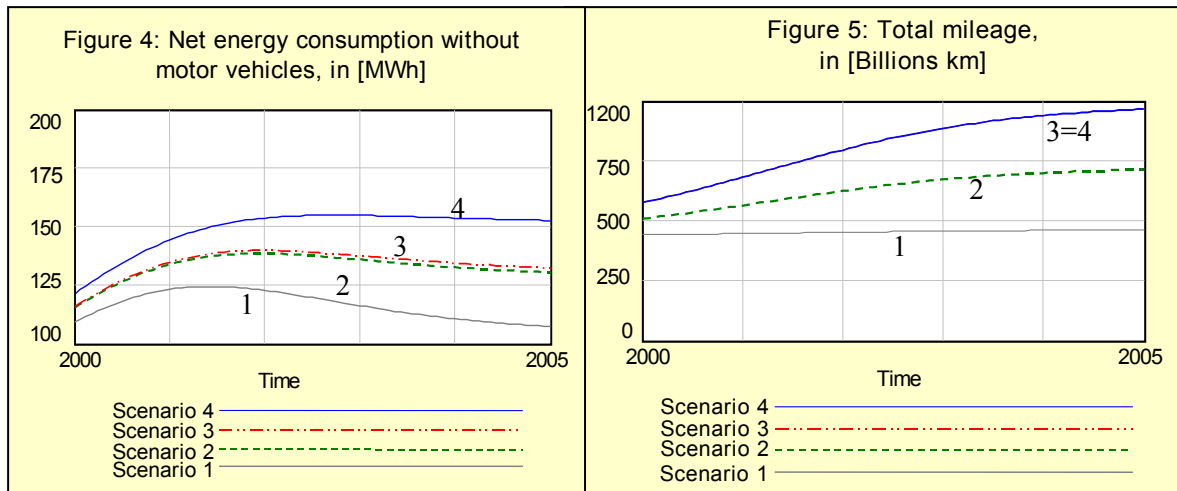
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Percentage of use (1) (on-line-informing)	5%	50%	95%	95%
Percentage of use (2) (e-working)	5%	50%	95%	95%
Average distance to the workplace of user (2)	100 km	100 km	100 km	100 km
Average per person paper consumption of user (1)	0,166 t	0,25 t	0,166 t	0,25 t

Remark: Presently in Germany the value of the average distance to the work place is 17 km for the non-user of e-working and the paper consumption is about 166 kg per capita.

5. Results

Results of the simulation runs are given in the Figures 2 - 5 for the total primary energy consumption, for the CO₂-emissions, net energy consumption without motor vehicles and total mileage. Depending on the specific problem it is possible to monitor other model variables too, the presented ones being chosen as relevant for the analysed problem.





It is to be observed that for scenario 1 the primary energy consumption because of the two considered IT-applications remains almost constantly. For the other three scenarios the primary energy consumption will increase in time. In order to analyse the role of the traffic in the energy consumption in Figure 4 the net energy consumption without motor vehicles is given. One can see that for all four scenarios the net energy consumption without motor vehicles will decrease. Making the connection with the total mileage given in Figure 5 one can conclude that using the possibility of e-working does not mean automatically a reduction of the total mileage and of the primary energy consumption. The same interpretation one can carry out also for the other IT-application of on-line-informing and for paper consumption. The NO_x and SO_2 - emissions are connected with the CO_2 -emissions, the curves having the same form as for CO_2 .

The time interval of five years chosen for the simulation runs starts with the year 2000. It is to be emphasised at this place that scenarios are not prognoses and the results from the simulation runs have to be carefully interpreted by taking into account the assumed frame conditions.

So this means that rebound effects could appear in spite of using e-working and on-line-informing depending on the behaviour of each user of the IT-applications. If an e-worker will travel once a week 200 or 300 km to the workplace, then the fact that the e-worker is travelling rarely can not compensate the total mileage increase and the possible reduction of the energy consumption will be overcompensate. And such case studies can be carried out for each specific IT-application.

6. Conclusions

Realising the Information Society for All is presently one of the main objectives of the European Commission because there is the hope that in this way the sustainability of our society will be assured.

Scientists from different fields started several projects in order to research and analyse the possible effects of the emerging information and knowledge society. One very important aspect is the environmental one. In order to analyse possible environmental effects of ICT, different scenarios have been developed and evaluated for the conditions of Germany in this first stage. In order to help the scenario development process, an integrative model has been developed, which makes the connection among so-called "old" indicators like energy consumption, paper consumption and "new" indicators related to Internet based applications, like infrastructure for the use of IT-applications and effective

use of IT-application. Two IT-applications have been considered: on-line-Informing and e-working.

Taking into account the developed scenarios by using the developed model EFENIA one can observe that the use of IT does not assure per se the environmental sustainability of our society. Under certain conditions rebound-effects could occur which have as a result the increase of energy consumption and of environmental pollution. Social factors are very important and do influence in a decisive way the scenarios. It follows that the issue of educating population for energy saving is a very important one. Although the scenarios have been developed only for Germany, it is possible to adopt the results also for other EU-countries without making too big mistakes. Further scenarios will be developed for other European countries and for Eastern European ones depending on the availability of needed data for these countries. Regional comparisons are very important in this context.

The developed model has also importance in the methodological field. It shows the potentials of integrative models compared to other usual models. For instance integrative models allow considering of "weak" factors under certain conditions. In spite of this development of methods is still needed in order to allow integrating qualitative aspects into mathematical models. In the context of Sustainable Development and its application new indicators have to be defined which evaluate systems in a comprehensive way from ecological, economic, technical and social points of view.

References

- [1] J. Alcamo, Image 2.0: integrated modeling of global climate change. The IMAGE Project. Kluwer Acad. Press, Dordrecht, Boston, 1994
- [2] Forum Information Society, A European Way for the Information Society. European Commission. Office for Official Publications of the European Communities. Luxembourg, 2000
- [3] O. Giarini, W. R. Stahel, Die Performance-Gesellschaft: Chancen und Risiken beim Übergang zur Service Economy. Metropolis-Verlag, Marburg, 2000
- [4] B. B. Hughes, International Futures - Choices in the Face of Uncertainty. 3. Edition. Westview Press, Colorado, 1999
- [5] IST, Realising an Information Society for all. Information Society Technologies. European Commission. Office for official Publications of the European Communities. Luxembourg, 2000
- [6] IST, eWork 2000: Status Report on New Ways to Work in the Knowledge Economy, European Commission, 2000
- [7] IST, SINE - Statistical Indicators for the New Economy. Information Society Technologies. European Commission and EUROSTAT. 2000, <http://europa.eu.int/en/comm/eurostat/research>
- [8] IST, eWork 2001: Status Report on New Ways to Work in the Knowledge Economy, European Commission, 2001
- [9] M. F. Jischa, Technikfolgenabschätzung in Lehre und Forschung. In: Petermann, T. und Coenen, R. (Hrsg.): Technikfolgen-Abschätzung in Deutschland; Campus, Frankfurt, S.:165-195, 1999
- [10] D. and D. Meadows, Die Grenzen des Wachstums; Rowohlt, Reinbek, 1973
- [11] T. Piechatzek: Integratives Modell zur Abschätzung umweltrelevanter Effekte der verbreiteten Nutzung verschiedener Internet-Anwendungen, Diplomarbeit. Institut für Technische Mechanik. TU Clausthal, 2001
- [12] F. J. Radermacher (Ed.), Informationsgesellschaft und Nachhaltige Entwicklung. Universitätsverlag. Ulm, 1998
- [13] T. Schauer, Lifestyles, Future Technologies and Sustainable Development. FAW. Ulm, 2000
- [14] TERRA2000: Information Society and Sustainable Development. <http://www.terra-2000.org>
- [15] I. Tulbure, An Approach to Define Sustainable Development Indicators. In: Matthies, M., Malchow, H., Kriz, J. (Eds.): Integrative Systems Approaches to Natural and Social Dynamics, Springer, Berlin, 2001, pp. 469-479.
- [16] I. Tulbure, Integrative Modellierung zur Beschreibung von Transformationsprozessen. Habilitationsschrift. TU Clausthal, 2001
- [17] UNDP, Human Development Report 2001. Making New Technologies Work for Human Development, 2001, <http://www.undp.org>