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Preface

Potentially dangerous environmental changes are happening in the atmosphere, oceans, animal habitats and places where hazardous materials are used, or have been discarded without adequate environmental protections. These increasing problems that also affect human health demand for interdisciplinary approaches where engineers, natural scientists, economists and computer scientists work together. Information technology has become significant to all scientific groups and fields involved in environmental engineering: Model based systems which enable the study of environmental changes have been developed and are being extended to manage those environments. New paradigms for designing objects to enable easy disassembly and recovery of components contribute to reuse. Web-based information systems enhance public awareness to environmental changes and allow participation in decision making. Developments in exploiting alternative energy sources are reducing dependence on non-renewable resources. Numerical economy-environment models contribute to cost-benefit analysis of environmental policy, and environmental monitoring and accounting systems facilitate market-based environmental regulation. Further advance is only possible if scientific teams have adequate experience, methods and tools for investigation of the changes in the environment. Success requires a high level of organization related to technical as well as scientific and human aspects of information handling. This book publishes the results of the ITEE 2007 conference where information about the topics above has been presented and discussed among environmental engineers, computer scientists and economists.

March 2007

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Keynotes

Air Pollution

Corporate Sustainability Reporting

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Environmental Risk Assessment

Life Cycle Assessment

Spatial Applications

Water Pollution

Workshop: Corporate Environmental Management Information Systems

Our Energy Supply Future - 10 BULLENSEE ASSUMPTIONS

Werner Brinker

CEO, EWE AG, Oldenburg, Germany

Keynote

The global energy sector is currently undergoing a period of fundamental change. Increasing demand is threatening to outstrip the world's limited energy resources, resulting in high and very volatile commodity prices. At the same time, industrialized nations are becoming increasingly dependent on energy imports from just a handful of countries, and the world is waking up to the negative and irreversible consequences of climate change. These developments have a major bearing on the future energy supply situation and require new and sustainable solutions. The challenges are great: government and business must work together to meet them if end consumers are to have a reliable, affordable supply of energy into the future.

EWE is committed to contributing to this process, and has sought to push the debate forward at the political and scientific levels with its ten "BULLENSEE ASSUMPTIONS". These assumptions about our energy future, and the recommendations derived from them, were developed jointly by EWE and some of the leading experts from Germany's research and scientific communities. The name "Bullensee" is taken from the place where the authors met to formulate the assumptions and recommendations Lake Bullensee, a small lake near Bremen in North Germany.

The Bullensee strategy is based on three core principles: the world must achieve greater energy savings, it must significantly improve its energy efficiency, and it must make greater use of renewable. The measures developed by government and business to address these principles must be economically efficient, they must be environmentally sustainable, and they must not jeopardize security of supply.

Since its inception, the BULLENSEE think-tank has grown, allowing more in-depth discussion. The most recent sessions have been dedicated to BULLENSEE ASSUMPTION No.8: the role of distributed micro-CHP, that is, micro-cogeneration plants with an electric output of less than 5 kilowatts. Micro-CHP plants will have an important part to play in the energy supply mix of the future because they are very efficient, simultaneously producing useable heat and power close to the locations where the energy is used.

Using the insights gained from both the BULLENSEE and the Micro-CHP discussions as the starting point, EWE will continue to forge ahead with forward-looking projects, develop innovative products and thus play a long-term role in shaping our energy supply future.

Sustainability Impact Assessment – The Role of Numerical E3-Models

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Keynote

Sustainability Impact Assessment (*SIA*) of economic, environmental, and societal effects triggered by governmental policies has become a central requirement for policy design. The three dimensions of *SIA* are inherently intertwined and subject to trade-offs. Accomplishing one objective frequently means back-pedalling on another. Therefore, research activities on *SIA* increasingly aim at developing quantitative tools for trade-off-analysis along the *SD* dimensions. Since economics is the study of trade-offs, there is plenty for economists to contribute in order to make the concept of *SD* operational.

The quantification of trade-offs calls for the use of numerical model techniques in order to assess systematically and rigorously the interference of the many forces that interact in the economy thereby affecting potential *SD* indicators. Compared to stylized analytical models, the numerical computer-based approach facilitates the analysis of complex non-linear system interactions and the impact assessment of structural policy changes. In the end, the decisions how to resolve potential trade-offs must be taken on the basis of societal values and political decisions. However, model-based analysis puts decision making on an informed basis concerning sustainable development rather than on fuzzy or contradictory hunches.

A major challenge in building quantitative *SIA* tools is the policy makers' demand for comprehensive coverage of potentially important policy impacts. *SIA* tools must identify "the chain of significant cause-effect links from the … [policy] measures … through to any sustainability impact" and produce "comparable indicators of the magnitude and dimensions of each sustainability impact" as an input into policy formulation and implementation. There is a wide range of quantitative models for assessing the causal chains between a proposed policy change and its potential economic, environmental, and social impacts. In general, there is no specific model, which fits all requirements for comprehensive *SIA*, but rather a package of models or methods depending on the policy measure or issue to be assessed and the availability of data.

Regarding the appropriateness of quantitative *SIA* we investigate the use of so-.called energy-economy-environment (E3) models that are concerned with linkages between economic activities, energy transformation, and associated environmental impacts. We find that operational versions of E3-models have a good coverage of central economic indicators.

Environmental indicators such as energy-related emissions with simple direct links to economic activities are widely covered, whereas indicators with complex natural science background such as water stress or biodiversity loss are hardly represented. Societal indicators stand out for very weak coverage, not at last because they are vaguely defined or incommensurable. Our analysis identifies prospects for future modeling in the field of integrated assessment that link standard E3-models to theme-specific complementary models with environmental and societal focus.

The Material Side of Virtualization

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Keynote

The Environmental Informatics community could recently celebrate its 20th anniversary [Tochtermann et al. 2006; Hilty et al. 2006a]. The application of Information and Communication Technology (ICT) to problems of environmental research and management has made considerable progress and contributes to sustainable development [Hilty et al. 2004a]. Moreover, ICT has the potential to virtualize processes that would otherwise consume considerable amounts of material and energy; virtual meetings, for instance, could avoid 97-98% of the CO_2 emissions of physical meetings [Hischier and Hilty 2002].

The time, space, material and energy needed to provide a unit of ICT service have roughly decreased by a factor of 1,000 since the first PC was sold. It seems therefore natural that researchers and industries using ICT in the environmental field ignore the environmental impacts caused by ICT hardware – they are just negligible compared to the environmental benefits that can be realized with the applications.

Paradoxically, it is the progress in ICT hardware efficiency that has made ICT a part of the problem, too. The global mass and energy flows caused throughout the hardware life cycle are increasing due to the widespread use of ICT products and their decreasing useful lives. The environmental problems caused by the production, use and disposal of ICT hardware are solvable in principle; they are not as hard as the discrepancy between – e.g. – growing mobility and CO_2 reduction goals. But problems can only be solved if they are not neglected.

The Technology and Society Lab at Empa has explored some environmental and social aspects of ICT production, use and disposal at a global scale under the umbrella of the "Sustainability in the Information Society" research program funded by the ETH Board. This research was based on Life Cycle Assessment (LCA) studies, prospective Technology Assessment (TA) studies and technology cooperation projects with partners in emerging economies (China, India and South Africa). These projects have identified the following issues:

- *Production*: The scarcity of some chemical elements (e.g. Indium used for LCDs) may constrain some development paths in the near future.
- *Use*: The overall energy demand of ICT infrastructure tends to increase, but it is possible to go against this trend.
- *Disposal*: There is a huge informal electronics recycling sector in Asia with relevant health and environmental impacts [Hilty 2005]. Recycling systems as they have been implemented in Switzerland and now in the EU (WEEE directive), are indispensable because electronic waste contains toxic as well as valuable substances. However, miniaturization of devices and the trend towards pervasive computing [Hilty et al. 2004b] create new challenges for electronic waste recycling. In the long run, ICT industry will have to find ways to avoid toxic and scarce materials.

The vision of a sustainable information society, i.e. a society which virtualizes those processes that are no longer acceptable for ecological reasons and keeps the material side-effects of ICT small at the same time – such a vision is not completely unrealistic. However, using more ICT does not automatically “create” a sustainable information society, as our observations and models clearly show [Hilty et al. 2006b]. Political strategies are needed if ICT is to serve sustainability.

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Electric Power Management and a Clean Environment – a Discrepancy and an Algorithmic Challenge

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Keynote

For maintaining an efficient and reliable supply of energy throughout the next decades under a growing shortage in fossil fuel, renewable energies will be further utilized and integrated into the current electric infrastructures. Such sources are based on solar or wind power, on renewable fuel like linseed oil, or on hydrogen technology. They are used for electric power generation in typically highly distributed small or mid-size facilities. The sources are inexhaustible, and through coupling electric and heat energy (e.g. in block heat and power plants) the technical efficiency is well over 90%. Furthermore these energy sources are ecologically clean.

Establishing clean or renewable energy sources involves the key problem of adequate management for the networked power sources:

- Typically, producers are at the same time consumers, and vice versa;
- Production plant or facilities are of small or medium size. They are widely distributed.
- They are operated on quite different supply and voltage levels which, in the current architectures, are opposed to trading, or purchasing, energy within the power grids.
- For the same reason they are excluded from serving as local (or regional) nodes of reserve capacities (in case of power failures), or as providing balancing energy in case of excess production or unexpected excess consumption that will not be requested for consumption. Even worse, due to the unpredictability from a global perspective, there will be traditional facilities (e.g. coal-based power plants) established that run continually (and mostly quite predictably) side by side with renewable sources just to make up for failures or unpredictable power declines. In case of excess production the renewable sources are disconnected from the grid in order to keep the balance, in terms of voltage

level and cycle frequency. At any rate this causes an enormous waste of energy.

The major drawback for the traditional approach is a conceptually centralized management approach for producing and trading electric energy as well as for safety and security. While such approaches are even quite error-prone as recent experience shows more and more frequently they rely at the same time on forecast mechanisms, within prediction periods ranging from 15 minutes to 1 year. Only under these circumstances the variation of capabilities as normal for sources based sun or wind power appears to be non-manageable.

In this lecture we describe several first phases of the joint R&D funded project DEZENT between the School of Computer Science and the College of Electrical Engineering at the University of Dortmund, devoted to decentralize and adaptive electric power management through a distributed real-time multi-agent architecture. Unpredictable consumer requests or producer problems, under distributed control or local autonomy, will be handled through distributed (P2P) real-time negotiation algorithms involving agents on different levels of negotiation, on behalf of producers and consumers of electric energy. *The key idea is that these negotiations take place (locally and regionally) on such a short-term basis that negotiation can be considered to be constant during these time intervals (ca. 40 msec) while the electric distribution processes can be finalized within the same time frame*. Despite the lack of global overview we are able to prove that in our model no coalition of malicious users could take advantage of extreme situations like arising from an abundance as much as from any (artificial) shortage of electric power that are typical problems in "free" or deregulated markets. Our multi-agent system exhibits a very high robustness against power failures compared to centrally controlled architectures. In extensive experiments we have demonstrated how, in realistic settings of the German power system structure, the novel algorithms can cope with unforeseen needs and production specifics in a very flexible and adaptive way, taking care of most of the potentially hard deadlines already on the local group level (corresponding to a small subdivision). We further demonstrate that under our decentralized approach customers pay less than under any conventional (global) management policy or structure.

We will report on our current progress which includes preparations for extensive real field studies in Southern Germany.

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A Spatial Assessment of Air Pollution Impact of a Highway Project Using GIS

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Abstract: In the recent years Government of India as well as different provincial governments have taken up several ambitious high-way developmental activities to accelerate the economic growth of India. The increased vehicular traffic caused due to highway development is a major source of air pollution. Carrying out environ-mental impact assessment (EIA) is an essential part of major road development projects in India. Also, the assessment of impacts on air pollution is an important aspect of EIA. In the present paper, a methodology has been presented for incorporating spatial data in GIS environment for assessing air pollution impact of a highway project.
Keywords: environmental impact assessment (EIA), highway development project, Geographic Information System (GIS).

1 Introduction

Infrastructure is the basic need for accelerating the economic growth and development of a country. Highway development is one of the important infrastructure development activities. In the recent years, the need for developing adequate road transportation infrastructure has been realized by Government of India and various state Governments. Major road development projects have been formulated at national level under National Highway Development Project (NHDP), which will strengthen and widen 14,000 kilometers of National Highways by 2007 [Maitra et al. 2002]. Various State Governments have also started projects for upgrading some of the state highways. All these efforts are intended to provide improved road transportation facilities for passenger and goods traffic.

Vehicular emission contributes significantly towards the total air pollution load. Development of roads encourages the growth of traffic, which eventually increases the air pollution level of the surroundings. Vehicular emissions are of particular concern since these are ground level sources and therefore, have the maximum impact on the population of the surroundings. For sustainable road development, it is necessary to understand the impact of the road development on the air quality. A suitable methodology is also required for assessment of impact on air quality due to the development of high-ways.

In the process of assessing impacts on air quality, it is necessary to consider the concentration levels of different pollutants and their spatial distributions. Both of these aspects are important as the detrimental effect of a pollutant depends on its concentration and the concentration level varies with the distance from the source of emission. For a realistic assessment of impact, it is necessary to relate the concentration levels with the area affected. Altogether it is necessary (i) to model the level of pollutants (ii) understand their spatial distribution, (iii) define suitable impact categories for each pollutant and (iv) express the impacts in relation to both impact categories and the area affected under each category.

The line source model (IITLS) developed by Indian Institute of Technology (IIT) Delhi, is based on Gaussian dispersion approach with suitable modifications in dispersion parameters [Goyal and Ramakrishna 1999]. The modifications in dispersion parameters included in the IITLS model makes it more suitable for Indian conditions as compared to other models normally used for the same purpose. In the process of air pollution mode-ling and mapping vast data is used, which is spatial in nature. Therefore, a suitable tool for spatial database management, analysis and display of results is of immense use for air pollution impact assessment due to vehicular traffic. The other aspect, which demands the spatial analysis of air pollution impacts, is to determine the extent of dispersion of pollutants and their concentration at different places surrounding to the highway. Since early 90's, attempts have been made by researchers to use GIS in transportation related air quality modeling and management [Moragues and Alcaide 1996; Andersons et al.1996; Briggs et al.1997; Li et al. 1999; Sharma et al. 2002].The above discussions supports the utility of GIS for analyzing spatial data in connection with air pollution modeling and impact assessment.

For presenting the spatial distribution of impacts, it is necessary to express the pollutant's concentration in different ranges instead of discrete values. Therefore, for assessment of air pollution impacts, a quantification technique considering the area affected under a particular impact category, is useful. The main objective of the present work is to improve the rationality of air pollution impact assessment process by integrating IITLS model with a GIS database by considering the spatial distribution of the impacts with reference to a case study of highway project in India. Carbon Monoxide (CO) is considered here for demonstrating the methodology adopted in this study. The impact is assessed for the base year (1999) as well as for horizon years (2010 and 2020).

2 Study Area

In order to demonstrate the methodology for modeling and mapping air pollution in a GIS framework, a stretch of National Highway in India and its surroundings is considered. The study stretch considered in the present work is a part of National Highway (NH-60) between Jaleshwar to Kharagpur in India. This stretch of highway is in the process of being upgraded from two lanes to six lanes. To generate air pollution impact map, about 15 km on either side of the highway is considered so that the maximum possible impacts can be captured.

3 Methodology

The major steps followed for the integration of GIS database with IIT line source model (IITLS) include (i) estimation of air pollution emission rate (q) due to highway traffic; (ii) modeling and mapping of dispersion of pollutants in atmosphere; and (iii) quantification of impacts. The detail process adopted for each step is discussed below.

4 Estimation of Air Pollution Emission Rate (q) due to Highway Traffic

To estimate the emission rate of different pollutants caused by highway traffic, it is required to estimate the classified traffic volume and use suitable emission factor for each vehicle category.

– Traffic volume data- The traffic volume data for the base year (1999) is taken form secondary source [NHAI 2000] and for predicting the traffic volume for horizon years (2010 and 2020), the growth factor is taken equal to 8 percent per annum as per NHAI [2000]. Traffic volumes are categorized in three classes namely heavy vehicle (heavy commercial vehicles and buses), medium vehicles (light commercial vehicles, diesel driven cars, jeeps and pick up vans), and light vehicles (petrol driven cars and all two wheelers). The classified traffic volume data used for the work are presented in Table 1.

Table 1. Maximum hourly traffic volume (source: [NHAI 2000]*)

Category of Vehicles	Base Year* (1999)	Horizon Year-I (2010)	Horizon Year-II (2020)
Light vehicles	145	338	729
Medium vehicles	31	973	157
Heavy vehicles	236	550	1187

– Emission factors- It is a very tedious and complex task to obtain suitable emission factors for different vehicle types as the emission factor depends on type of fuel, condition of engine, driving cycle, age of the vehicle, speed of vehicle, driving mode etc. Goyal and Ramakrishna [1998] have worked out emission factors for different categories of vehicle for Indian conditions and the same are adopted for the present study. The emission factors for different category of vehicles, as used in the present work, are mentioned in Table 2.

Table 2. Emission factors for different category of vehicles

Pollutant Emitted	Emission Factor (gm/vehicle/km)		
	Heavy vehicles	Medium vehicles	Light vehicles
Carbon Monoxide	11.2	12.4	4.5

Emission rate of a pollutant caused by each category of vehicle is calculated by multiplying the emission factor (gm/vehicle/km) of the vehicle category with the number of vehicles under the same category passing the road stretch in one hour. The emission rate thus obtained in gm/km/hr is converted to gm/m/sec for use as input to IITLS model for the prediction of pollutant concentration.

4.1 Modeling and Mapping of Dispersion of Pollutants in Atmosphere

In order to predict the dispersion of pollutants in atmosphere due to highway traffic, the IIT line source (IITLS) model [Goyal and Ramakrishna 1999], as given in Equation (1), is adopted. The value of H is taken as 0 for ground level concentration of pollutants and therefore, the model in Equation (1) reduces to Equation (2).