Expert System for Environmental Impact Assessment

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Abstract

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An effective protection of our environment is largely dependent on the quality of the available information used to make an appropriate decision. Problems arise when the quantities of available information are huge and no uniform and their quality could not be stated in advance. Another associated issue is the dynamical nature of the problem. The goal of environmentally conscious design for manufacturing is to select materials and processes that minimize environmental impact. This paper describes a general and uniform way to analyze the environmental impact of manufacturing based on the product decomposition, the materials used in the manufacturing processes, and the particular view of the environment. To accomplish this task, we developed an expert system, called Expert EIA (Expert System for Environmental Impact Assessment), that assists manufacturing engineers and environmental reviewers in assessing the environmental consequences of their manufacturing decisions. The Expert EIA combines advanced tools for environmental management like the Environmental Effects Analysis (EEA), the Life Cycle Assessment (LCA) and the Dynamic Model (DM). It uses the data regarding the characteristics of the activities, and based on the results from the EEA form, quantifies the impacts of significant activities selected and also the time residence and concentration of pollutant in the air. As a result, the expert system "Expert EIA" was chosen to provide a decision-making facility for each environmental characteristic.

1. Introduction

In recent years, in line with the technological development, it is possible to have access to the data produced somewhere in the world by converting it into numerical form and keeping it in the computer. Day by day, expert systems have gained importance for data collection, organization, transmission, and recommendation. These systems are especially helpful for authority and decision makers when data collection, interpretation and recommendation are needed [1]. Expert systems can be used in all sectors have also been used in areas related to the environment [2], [3], [4]. Expert system approaches help reduce effort and time in facilitating the Environmental Impact Assessment.

The overall objective of an expert system for a sustainable environment management take into consideration a great number of established environmental impact assessment (EIA) techniques in an attempt to combine the most appropriate elements into one comprehensive and intelligent, knowledge driven framework and easy-to-use tool. The specific objectives must to be:

To produce a computer system to increase the effectiveness of the preparation and review of EIA through systematic scoping for environmental impact assessment;

To produce software to facilitate the determination of appropriate terms and conditions to be attached to approvals of EIA reports;

To increase accessibility to existing information on environmental standards and guidelines for EIA.

To accomplish all these objectives, the system manages a database of project assessments based on the combining of three tools of environmental assessment that: The Environmental Effects Analysis (EEA), Life Cycle Assessment (LCA) and the Dynamic Models for the numerical dispersion (DM). The expert system allows the evaluation of a project in terms of its potential environmental impacts at any early stage with

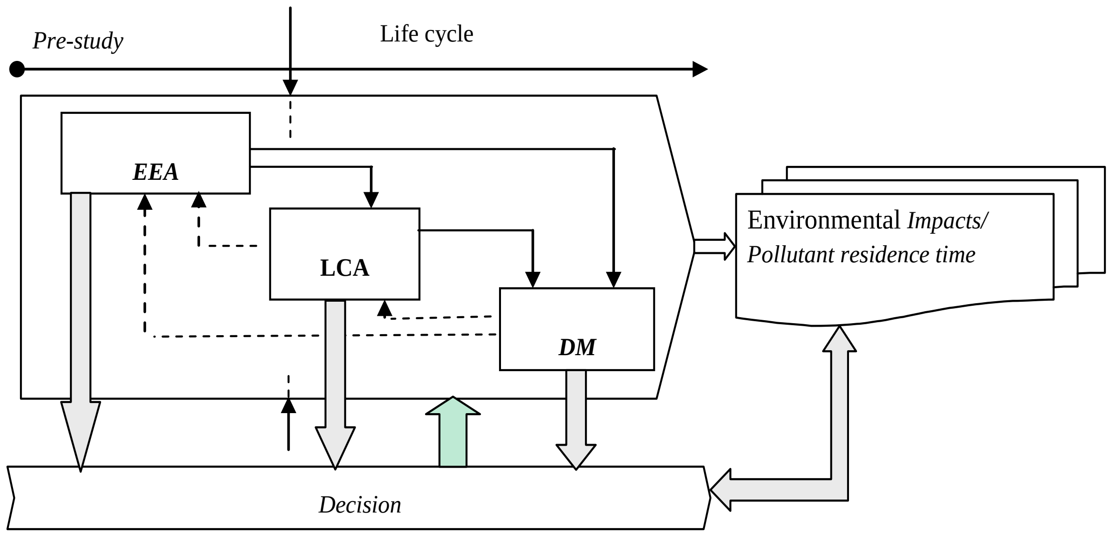

Figure 1. Combination of environmental tools for qualitative and quantitative analysis.

a minimum of project specific information. The prototype draws on extensive knowledge and databases on project characteristics based on generic profiles and a hierarchical classification scheme.

The prototype's knowledge base is limited to a few examples of checklists and rules for one problem class. Once the system is developed and validated, it is deployed to the users. If users need for an advice then, they access to the expert system and system conducts a bidirectional dialog with the user, asking her or him to provide facts about a specific incident. While accepting the user's answers, the expert system attempts to reach a conclusion.

The goal of this paper is to show how expert system have succeeded in developing adequate tools for modeling, design, simulation, prediction, planning and decision-support systems for environmental management and protection. Many environmental problems, such as damage to the biosphere, local air pollution, the spread of harmful substances in the water, and global climatic changes, cannot be studied by experimentation. Hence, mathematical models and computer simulations are being used as the appropriate means to get more insight.

The paper presents in first, the approach used for assessing the environmental impacts and which combined three tools: Environmental Effects Analysis (EEA), Life Cycle Assessment (LCA) and Dynamic Models (DM); and then in the second part, we present the expert system realized for automating this approach.

2. Combined approach for Environmental Impact Assessment

Significant attention and emphasis has been given to cleaner and greener technologies in processes and product manufacturing. This is recognized as a key element in pollution prevention and development of sustainable strategies. Sustainable development requires methods and tools to measure and compare the environmental impacts of human activities for the products. Environmental impacts include those from emissions into the environment and those due to the consumption of resources, as well as other interventions associated with the product's end-of-life. These emissions and consumptions contribute to a wide range of impacts, such as climate change, stratospheric ozone depletion and tropospheric ozone (smog) creation among others.

A clear need, therefore, exists to be proactive and to provide complementary insights, apart from current regulatory practices, to help reducing such impacts. Life Cycle Assessment (LCA) is a systematic approach that enables implementation of cleaner and greener product and process concepts in industry. It is described as a method to estimate environmental impacts associated with products, process and services. LCA approach involves quantitative analysis structured in four stages: goal definition, inventory analysis, impact analysis and improvement analysis. Common criticisms of this approach include high completion costs, labour intensive data collection, unavailability of some information for the required assessment and the failure of LCA to address other design issues such as functionality, reliability and safety requirements.

Taking these factors into consideration, a number of alternative or streamlining approaches have been suggested including a qualitative approach named as "EEA" (Environmental Effects Analysis) [5]. EEA is used in the early stages of product life cycle; it is used for the purpose of identifying and evaluating potential environmental impacts in all life cycle phases of a product. The objective of the tool is to take corrective and preventive actions to minimize the environmental burden from products during their life cycle. Moreover, to complete the analysis with LCA, process simulators providing local scale models to predict mass and energy flows around a chemical process is required. The consequences resulting from the step of "impacts evaluation" in LCA are thus studied by these models.
A Dispersion Numerical Model (DNM) is proposed for the prediction of air emissions. The DM balance quantifies the environmental impact of the pollutants emitted in a process and determines the environmental friendliness of a given process. That includes a two dimensional coupled kinetic – transport model in which mass and momentum transport equations are solved to produce estimates of the pollutant concentration evolution in atmosphere [6], [7]. If only the kinetic flux is interesting, the easiest model to use is one – step global model. The mean concentrations and concentration fluctuations are predicted by this model. This part of the work focuses on the combining of these three making decision tools (EEA-LCA-DM) and underlines their strengths and weaknesses (figure 1) [8].

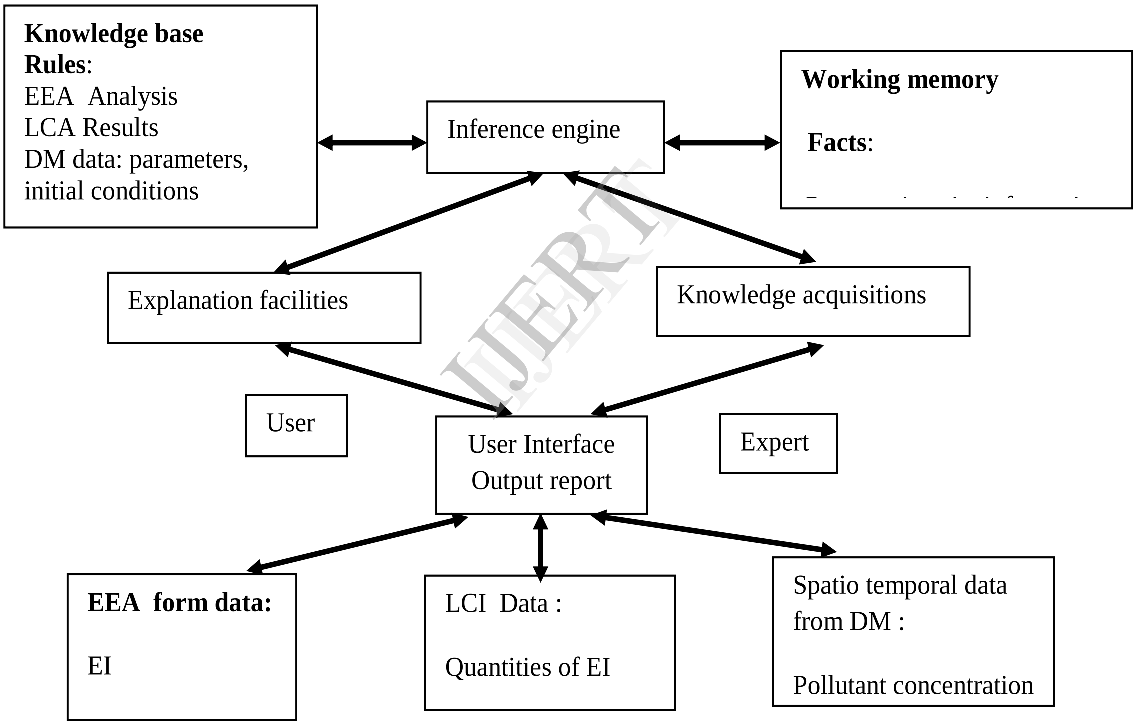

Figure 2. Combination of environmental tools for qualitative and quantitative analysis.

3. Building an expert system: The Expert EIA

Any successful decision - making is strongly dependent upon various capabilities which include the effective acquisition, storage, distribution and sophisticated use of the knowledge of human experts in the field. Systems for information retrieval are usually implemented via standard data base systems. Such systems usually work with thousands of records which have to be regularly updated and searched, so effective methods for storing and accessing large amounts of data are of great importance.
Expert systems employ human knowledge to solve problems that originally require human intelligence. They consist of two main parts: knowledge base and inference mechanism. Knowledge base contains expert knowledge for a given domain (typically in the form of rules), and inference mechanism is a domain

independent program which works with the knowledge base in order to reach final conclusions (recommendations, diagnostic) (figure 2).
During the consultation the system asks questions relevant to the investigated conclusions.

An important aspect of building and using informational systems of the sustainable development is represented by the integration of an 'expert' component in their structure. It is, in fact, about the accomplishment of a synergic interaction between components.

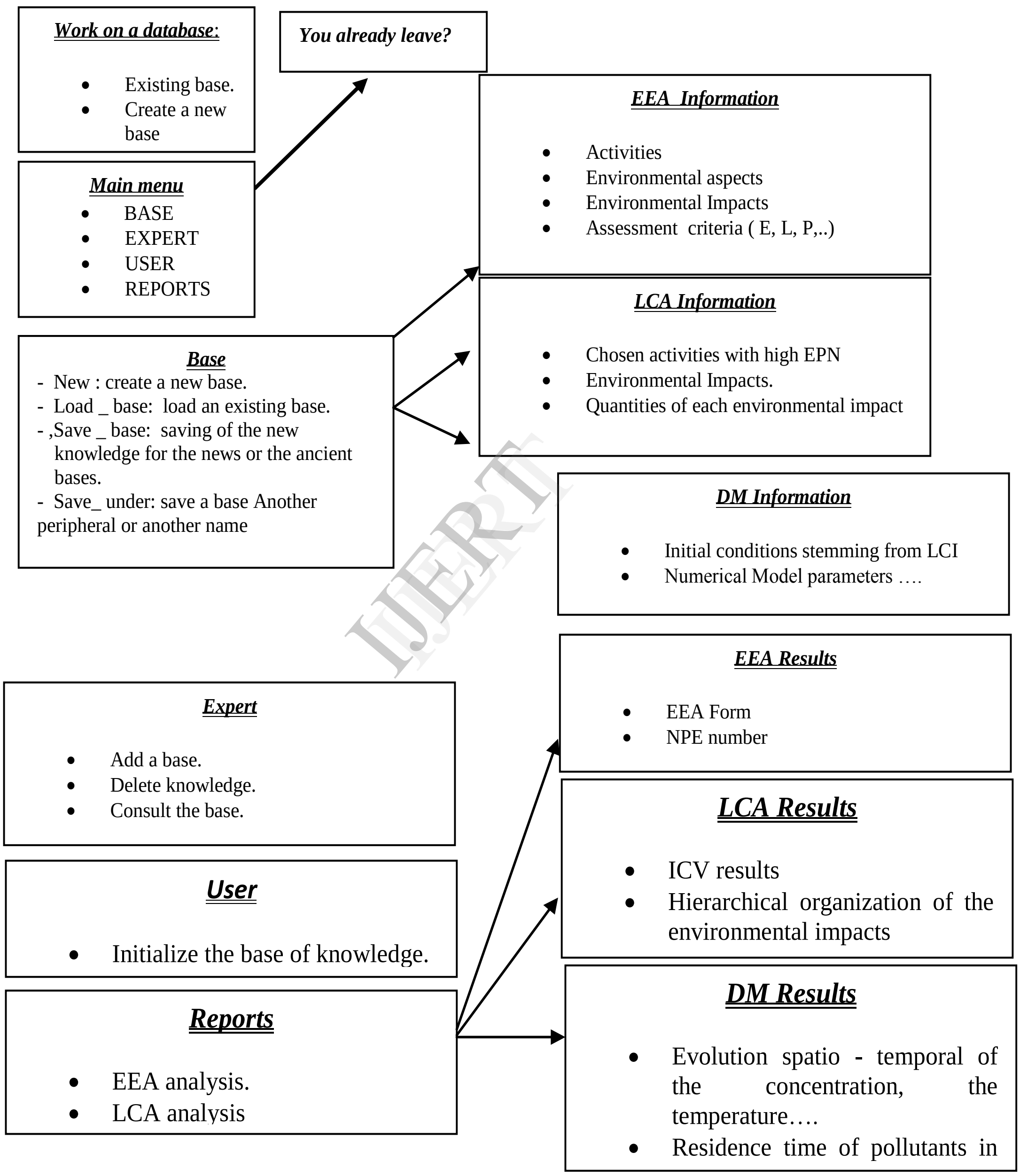

Figure 2. Functional description of expert system "Expert EIA"

This synergy is being accomplished, on the first hand, through the control transfer from one function to another in the system and, on the other hand, through the information transfer among systems (subsystems). It is essential that one model could call for the inference mechanism (the expert) which should use rules which operate with the variables used by the model or re-found in the data base. Similarly, 'the expert' should return the control to the model or to the files generator to present results. The expert component from the system's structure will imprint the character of an 'intelligent system' and will be used to be consulted as an 'expert' with the purpose of:

- Using a given volume of knowledge to obtain results of difficult to examine activities, as much as the human experts;
- Giving a diagnosis or building a solution;

Offering explanation about the way in which the given solution was obtained.

A. Functional description of "Expert EIA"

The screen of "Expert EIA" is divided to four windows, named respectively, "BASE", "EXPERT", "USER" and "REPORTS" (figure 3). In the window "BASE", it will be possible to load an existing base or to create a new base. Bases are registered with the extensions: For the base of objects " .BO", the base of facts ".BF", the base of rules ".BR" and the base specific to the reports ". MDE", ". LCA" and ". DM".

4. Knowledge representation

Our expert system is with an engine of order 0+ (logic of the propositions with global variables). It possesses three bases: the base of objects, the base of facts and the base of rules. These three bases are represented by lists of units and each unit contains:

- A timekeeper on the following unit.
- An element which can be a rule, a fact or an object.

Every object possesses the list of the facts which are associated to it and the fact contains the lists of the rules in which it can be premise or conclusion. The condition part of a rule is a list of facts premises. The action part is a list of facts conclusions. All these lists are established by timekeepers on these elements.

5. Mechanism of inference of the Expert EIA

The expert system works in forward chaining. In this mode, one starts with the data available and uses the inference rules to extract more data until a desired goal is reached. An inference engine using forward chaining searches the inference rules until it finds one in which the if clause is known to be true. It then concludes the then clause and adds this information to its data. It continues to do this until a goal is reached. Because the data available determines which inference rules are used, this method is also classified as data driven.

5. Conclusion

The overall objective of an expert system for a sustainable environment management take into consideration a great number of established environmental impact assessment (EIA) techniques in an attempt to combine the most appropriate elements into one comprehensive and intelligent, knowledge driven framework and easy-to-use tool. The specific objectives must to be:

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With expert systems, the sustainable development arrives at an operational stage obviously very promising. Two facts seem important through our realization:

- Knowledge bases are completely going to revolutionize the storage of the information. The dialogue man - machine will not ask any more for the intervention of a computer specialist. It will not be necessary any more to the user to write a program to resolve its problem but only to specify its problem in a language more formal than the natural language.

The expert system "Expert EIA" so presented, allows to mitigate the problem of heaviness and the time of analysis by the combined approach (EEA / LCA/ DM).

6. References

[1] Say, N.P., Yucel, M., and Yilmazer, M, "A Computer-based System for Environmental Impact Assessment (EIA) Applications to Energy Power Stations in Turkey: CEDINFO", *Journal of Energy Policy*, Vol. 35, (2007), pp.6395-6401.

[2] Ahlmann, A.B., Scholles, F., Schwabl, A., Simon, K.H., and Waschkowski, R. "Integrated Computer Support for Environmental Impact Assessment", In: *IFIP Transactions, vol. B-16, Proceedings of the IFIP TC5/WG5.11 Working Conference on Computer Support for Environmental Impact Assessment*, Como, Italy, (1992), pp. 289–299.

[3] Booty, W.G., Wong, I.W.S., Lam, D.C.L., Kerby, J.P., Ruddock, R., and Kay, D.F, "Application of an expert system for point source water quality modeling, *In: Proceedings of the IFIP TC5/WG5.11", Working Conference on Computer Support for Environmental Impact Assessment*, Como, Italy, (1993), pp. 245–256.

[4] Jazzar, M.M., Daud, M., Bardai, M.Z., Ramli, A.R., and Said, S, "A knowledge-based expert system for EIA using blackboard approach". *Journal of Computer Science*, Vol. 11 (2), Malaysia, (1998), pp. 15–22.

[5] Lindahl M. "E-FMEA- A new promising tool for efficient design for environment". In: *Proceedings of Eco-design 99: First International Symposium on Environmental Conscious Design and Inverse Manufacturing*, Tokyo, Japan; ISBN 0-7695-007-2 (1999).

[6] Lindahl M, "Environmental Effect Analysis (EEA)- An approach to design for environment", Licentiate thesis. Stockholm: Department of Chemical Engineering and Technology, KTH, ISBN 91-973906-2-3 (2000).

7] Tingström J, Lindahl M, "Evaluation methods for the environmental effect analysis", In: *CIRP, Seminar on Life Cycle Engineering, Life Cycle Planning*, Design and Management for Eco-Products and Systems, June 18-20, Varna, Bulgaria (2001).

[8] Vrieling, A.J and Nieuwstadt F.T.M, "Turbulent dispersion from nearby point sources- interface of the concentration statistics", *Atmospheric Environment 37*, 4493-4506 (2003).

[9] Hamzi. R, "Modélisation et impacts à court terme d'un incendie en milieu ouvert sur l'environnement", Thèse de Doctorat. Institut d'Hygiène et Sécurité Industrielle. Université de Batna (2008).

[10] Hamzi. R., M.T.Zaoui et T.Bouhoufani, "SEG-AMDE: Système Expert pour la génération des AMDE". *CIP Proceeding*. Alger (2001), 415- 419.