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SUPPORT SYSTEMS FOR DECISION AND NEGOTIATION PROCESSES

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EXPERT SYSTEM FOR EVALUATION AND SELECTION OF EMISSION CONTROL MEASURES

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Abstract: A decision support system for a selected area of emission control technologies (dedusting, desulphurization, denitrification) in the frame of the TA Luft has been developed and implemented on a personal computer within an expert system shell. The analysis of the decision process and the relevant techno-economic field is documented and first results of the resulting deterministic, static decision model within an expert system are shown.

Keywords: Decision Support System, Information System, Expert System, Emission Control, Air Pollution

1. Introduction

The possibilities for the application of a decision support system in connection with environmental protection with regard to the reduction of emissions from technical installations are becoming increasingly recognised. Modern data processing and communication systems will make it possible in future to compensate for incomplete know-how and a lack of information when selecting alternatives for achieving effective and preventive environmental protection. The investigation results shown here are based on the following projects: "Information System for Environmental Technologies - Environmental Technologies Databank" /1/ and "Development of a Decision Support System for Emission Control Technologies" /2/ which are supported by the project "European Research Center for Measures to obtain Clean Air" at the "Kernforschungszentrum Karlsruhe" (Nuclear Research Centre). The result of the first project is a databank-based information system for emission control technologies (TEMITEC). Furthermore, a working party has already been established to assist the project consisting of representatives from industry, authorities, consulting engineers and ministries under the overall control of the Ministry for the Environment of Baden-Württemberg.

2. Analysis Of The Decision Problem

Here, emission control systems for dedusting, desulphurisation and denitrification of combustion installations, which are covered by the TA-Luft (Technical Guideline for Air

Quality Control (1 - 50 MW_{th})) are taken into consideration. Furthermore, deciding process of potential operators will be dealt with.

During the actual decision process for an emission control system there are several phases, which correspond to a "top-down set-up". This means that the process starts off on a general basis and then becomes increasingly detailed, whereby it is always possible to revert to the beginning of the decision process (e. g. to alter the starting point, to add configurations) /3/.

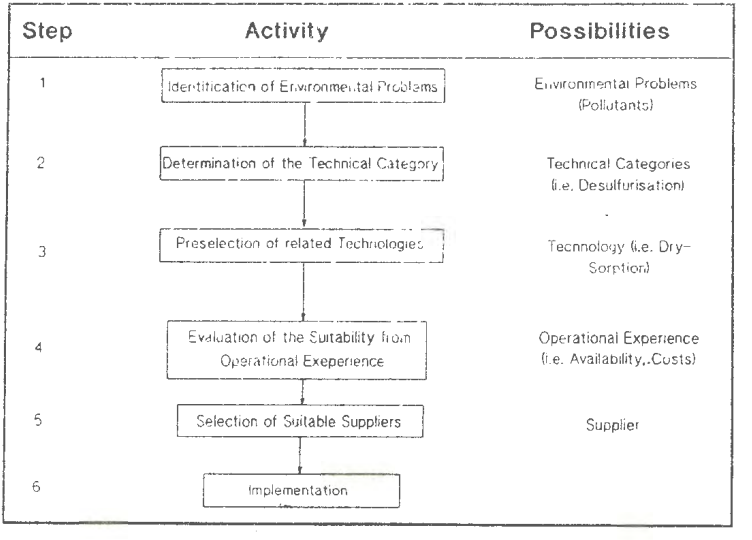

FIG 1. Decision process for the implementation of emission reduction technologies

The identification and analysis of the environmental problem is the first step, in which the environmental protection measures taken by the authorities and operators are defined. In this way the neccessary category of emission control technology, (desulphurisation, denitrification) will be determined. A combination of the categories is possible. After choosing the technology category, information about the technical characteristics, application field and technical description is required, to reduce the number of alternatives and to obtain an initial overview. As time goes on the depth of the techno-economic information required will increase because specific questions, related to the suitability of emission reduction measures for individual

combustion installations will have to be answered. Operational experience related to emission reduction arrangements of particular technologies are especially important, because the information from suppliers cannot always be relied upon. The decision for a particular emission reduction technology, is combined with the choice of a suitable supplier, which is ultimately important for the operator.

Based on this decision process a heuristic method has to developed which provides a solution for this configuration and the problem of the choice of alternatives. This heuristic method requires chemical, physical, technical and mathematic rules to calculate technical parameters, which are integrated as established knowledge. Also evaluations of the technologies, based on wide experience gained from plant erection and process-design are included. Thus both objective and subjective evaluations are included. Within this heuristic method the decision problem will be solved step by step. The suboptimal solutions of each reduction technology are also subject to global consideration with regard to optimality. The configuration and plant lay out cannot be solved completely because the available information cannot be completely modelled and is also too complex. The evaluation and preselection of alternatives reduces the total expense of the actual decision process.

The decision model should be regarded as both symbolic and mathematic, on a determining basis (in the sense of an optimisation model) /4/. Evaluations should not aim for an optimal solution, but also for a stability of results in sensitivity analyses /5/. The knowledge based on this system is dynamic and can be modified continuously. As a result the database of the resulting system has to be divided from the process, to facilitate the adaptation of environmental variables to suit the operators.

3. Modelling For The Techno-Economic Process Of Selection

In regarding the techno-economic process of selection a number of legal, ecological, technical and economic prerequisites are important. Important legal factors for emission control are the "Bundes-Immissionsschutzgesetz" and "TA Luft" (Clean Air Act and Regulations). With regard to by-products and wastewater the Refuse Law and Water Resources Law are the legal prerequisites to be taken into consideration when selecting alternatives.

The installations, which are of interest, are used for providing public heating and also for process steam. These fields of application have extremely different operating modes, which influence the process selection. The results from operator studies and experience with TEMITEC have shown, that the following aims are important:

- guarantee of an energy supply
- flexibility for more stringent emission control levels

- minimization of the environmental burden including emission reduction for ground, air and water
- minimal additional costs for the supply of energy for an operator.

Many technical restrictions can be seen here. An emission reduction measure has to fulfil the following conditions oriented to the combustion installation and energy supply:

- falling short of the limit
- flexibility and availability
- compatibility of combustion and power range of an installation and emission control measures.

The optimal aim is to minimize additional costs. For this optimisation problem there are methods of industrial management, which make a problem oriented model possible /6, 7/. To achieve minimal costs, a cost related calculation was selected, because it involves an investment decision, where the total costs per year at several alternatives can be compared. The total costs are the sum of the total costs of each single measure. The yearly total costs for a single measure are /8/:

$$Kg = Ki + Kb + Kp + Kr$$

Kg = total costs of a single measure
Ki = costs depending on investments
Kb = costs depending on consumption of means of production
Kp = staff costs
Kr = by-product disposal costs/recycling

These costs are influenced by a range of techno-economic parameters:

- amount of investment
- yearly hours of operation
- selection of additives and related costs
- ease of maintenance

There are many emission control measures for the reduction of SO_2, NO_X and dust emissions. Measures to avoid emissions should reduce or avoid pollutants by means of primary measures or the treatment of fuel. These measures are not suitable for all fuels and combustion installations. Secondary measures are used to remove or minimize existing emissions of fluegas, which reduce emissions of one or more pollutants. To obtain data for the

description of several emission control alternatives, in this model measures are considered, which are used in the power range under consideration and correspond to the state of the art.

The following shows some interesting technical parameters of emission control measures, which are relevant for decision making:

- maximal possible precipitation
- capacity limits under the clean air regulations (TA Luft)
- time availability
- flexibility in load variation
- minimal load for emission control measure
- application according to fuel
- possibility of combination with other emission reduction methods
- required additives
- environmental factor considering the utilisation of additives and degree of precipitation

The following precedure results from the aims and decision criteria:

1. Examination of individual installation to establish whether an emission control measure is necessary according to the regulations.
2. Selection of technically possible emission reduction measures
3. Calculation of yearly total costs of various alternatives4. Search for economically optimal emission control measure (possibly combination of individual measures)

This procedure makes it possible to consider legal, technical and economic influences equally in the model.

4. Prototyp Of This Decision Support System For Clean Air Technologies Within An Expert System Shell

The expert system shell "NEXPERT OBJECT" was used for the implementation of this decision support system. It is a hybrid development tool for knowledge based applications, which is both working-rule and frame oriented. The userfriendly user interface under WINDOWS makes an optimal application oriented systems developer possible. The knowledge basis can be documented in several graphics and lists. The WINDOWS environment makes it possible to use several interfaces from other programs. This allows the implementation of an attractive user-interface for a personal application. These aspects were used successfuliy for the first prototype.

Within one session the frame-conditions of the selection-process will be requested i. e. for which boiler must the emissions be reduced and under what technical conditions. When selecting alternatives fuel switches are considered, i. e. the modification to the boiler must be made, in order to use other fuels. Then the evaluation and selection process for all fuel switches will be carried out at the same time. The emission reduction measures, which are suitable, will be evaluated and graded according to the total costs and then listed, whereby a specification with individual costs is possible.

5. Outlook

This initial prototype of a decision support will be further investigated with regard to result stability using a sensativity analysis. With the help of these results, a prognoses will be analysed with regard to the potential application of emission reduction technologies and their economic effects. It should be established, whether the techno-economic depth of this model is sufficient to support the decision process in practice. Furthermore, it is intended to extend this decision support system to other environmental technologies.

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