A UTILITY MODEL FOR ACID RAIN POLICY ANALYSIS

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ABSTRACT

Policies being considered for acid rain mitigation include regional emission constraints that apply to the total emissions produced in a region. A program has been developed to study the effects of these constraints on utility planning and operation. This paper describes the program and presents an example to illustrate Us uses.

INTRODUCTION

The release of sizable quantities of a wide range of pollutants is one of the unfortunate effects of electric power generation. SO_2, NO_a. CO. various hydrocarbons, suspended particulates, sludges and radioactive wastes are among the pollutants. It is now widely believed that the $SO_?$ emissions from power plants contribute in a large part to the phenomenon of acid rain, which deJeteriously affects various forms of ife.

Regional Emission Limits

Pollution regulations in the U.S. apply to individual plants rather than to collections of them. However, it is becoming increasingly apparent that collective regulations could provide a useful control strategy. The archetype of a collective regulation is a "bubble constraint" or a cap on the total emissions in a region of a particular type of producer, for nstance electric utility generating plants.

Existing Utility Planning Models

I ong range utility planning has. in the past, been formulated in terms of mixed integer or linear programming models (for a bibliography see [1).[2]). that seldom allow for regional emission constraints. In the rare cases where these constraints are included H is usually through heuristics that preclude optimum solutions over extended horizons, e.g. [3].

EPOS • A NEW PLANNING MODEL

EPOS (Estimated Planning and Operating Strategies) is a new linear programming model that estimates the optimum additions of equipment (generating plant and pollution control hardware) and their optimum operating strategies, to minimize net present worth over an extended horizon while meeting regional emission constraints.

Pollution Control Strategies

PoUution reductions can be achieved in two ways:

1. Hardware Intensive Strategies: Examples are building new, dean plants to replace or complement dirty ones; retrofitting existing plants with pollution control hardware; and increasing the efficiency of the customer's end uses of electricity and thus, reducing demand.

2. Operating Strategies: Two important subgroups of this class are:

a. Fuel Scheduling: By changing to a cleaner fuel the emissions per unit of electricity output can be reduced. Also, one can blend fuels to get the right combination.

b. Dispatching: When there is an excess of capacity, one can shift generation from the dirtier to the cleaner plants, reducing emissions. By this means, emission rates can be changed almost instantaneously.

Linear Programming Formulation

The following formulation accomodates both types of pollution control strategies over extended planning horizons (typically 20 to 30 years in length). The horizon is divided into periods and the load duration curve (LDC) for each period is divided into segments as shown in Figure 1. Then present worth is minimized over the horizon to yield:

To solve the linear programming problem we have been using a modified version of LINDO (Linear, Interactive, Discrete Optimizer) [5].

SOME SCENARIOS

In this section we describe the impact of several emission reduction scenarios on utility planning and operating costs in the state of Pennsylvania. Table 1 lists the generation capacity of different types in Pennsylvania together with future additions and retirements that are scheduled to be made. The peak load in 1980 is 24500 MW and total energy demand is 125000 GWHr. In the scenarios considered here electricity demand (power and energy) increases at an annual rate of 1.5%. A reserve margin of 10% is maintained for each of the 20 years in the planning horizon. Pollution control techniques include installation of flue gas desulfurizers (scrubbers), fuel blending and dispatching.

In scenario number 1 (base scenario), no regional emission constraints were imposed. Results for this case indicate that total SO_2 emissions are 3 million tons in 1980 and 2.19 million tons in 1990. Remaining scenarios (number 2 to 6) specify a gradual reduction of total SO_2 emissions in 1990 from the base level of 3 million tons in 1980. A brief description of all scenarios in given in table 2.

Results

EPOS was used to study the utility planning strategies for each of the six emission reduction scenarios. Results relating to the impact on Control technology costs, Operating costs and total costs are summarized in table 3. Figure 2 displays the performance tradeoffs obtained for this example. At the optimal solution, reduction in total SO_2 emissions in the state is accomplished by an increase in total utility costs. It is noted that the marginal utility costs increase as more and more reduction in emissions is required in going from scenario number 1 to scenario number 6.

At present we are applying EPOS to study several acid rain mitigation policies which apply to collections of many states, in particular to the ARMS (Acid Rain Mitigation Study) region - a collection of 31 states.

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REFERENCES

1. IEEE Power Engineering Society Engineering and Planning Economics Working Group, "Bibliography on Corporate-financial models 1964-1980", *IEEE Trans. PAS*, Vol. PAS-101, No. 9, September 1982, pp. 3084-3090.

2. Carpentier, J. and Merlin, A., "Optimization Methods in Planning and Operation of Power Systems", *Proc. of the Seventh Power Systems Computations Conference*. Lausanne, July 1981, pp. 17-29.

3. Jablonka, G. E., Erdres, V. N. and Neumeyer, D. G., "SO_2 Emission Reduction Optimization Program", Presented at *46th EEI System Planning Meeting*, Milwaukee, May 1982.

4. Bloom, J. A., "Long-Range Generation Planning Using Decomposition and Probabilistic Simulation", *IEEE Trans. PAS*, Vol. PAS-101, No. 4, April 1982, pp. 797-802.

5. Schrage, Linus, *Introduction to LINDO*, University of Chicago, Chicago, 1981.

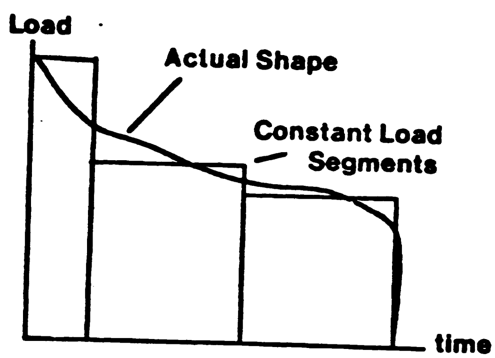

Figure 1. Division of the Load Duration Curve into constant load segments

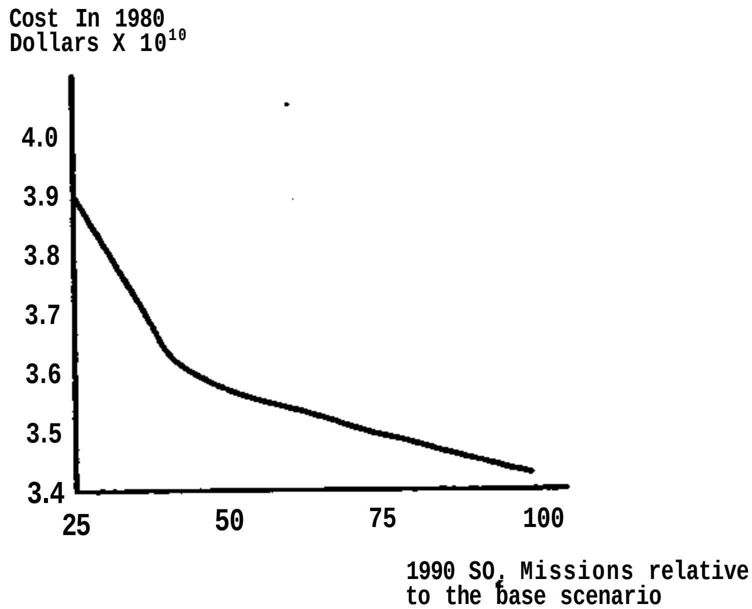

Figure 2. Iapact of diffarent acid rain Mitigation scenarios on the net present worth of total costs