A Multiobjective Generation Expansion Model

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1. Introduction

The Generation Expansion Planning (GEP) problem for an electric utility is defined as the problem of determining what generation units should be constructed, where and when they should come on line over a "long-range" planning horizon. The GEP problem is a difficult problem to solve because several conflicting objectives must be considered at the same time. These objectives can include the minimization of the system's cost, the maximization of the system's reliability, and the minimization of environmental degradation. However, in the literature, most of the GEP problems are modeled as a single objective programming problem where the objective is minimization of the total cost (least-cost). Frequently, the least-cost expansion plan found by a system planning model may not be the preferred option when considering other criteria.

This paper presents a multicriteria GEP model (MGEP1). The methodology proposed is based on some known multicriteria decision making methods and tested on an electric generation and transmission network that represents the Mexican Electric Power System. The MGEP1 considers several aspects: the incorporation of more than three criteria to generate the expansion alternatives, the importance given to renewable generation technologies, and the geographical location of the new generation units are some features of the MGEP1 which have not been considered in the literature.

2. Methodology and Computational Experimentation

The model will identify the location and type of new generation to achieve the best compromise between different objectives, such as minimizing total cost, environmental impact, fuel imports, and portfolios investments risk; and yet meet all the operating and economic restrictions that are placed on the system. The input data includes the existing network configuration and its transmission capacity limits; technology costs for new equipment; investment constraints; the generating capacity and investment / production costs of generating units; as well as the expected electric load for a period of time. The MGEP1 model is a single-time period model, considers only one (current conservation) of the two Kirchoff's laws, has continuous decision variables, and is deterministic. The importance of considering the transmission network is basically to find a generation expansion plan which can globally optimize the electricity supply chain. In addition, MGEP1 is a large-scale, linear mathematical programming problem with different conflicting objectives that must be considered simultaneously.

The proposed methodology consists of two phases. In the first phase four Multiple Criteria Programming Methods will be used to identify a set of preferred solutions. In the second phase the most appropriate solution is selected among the previously generated alternatives, using the Analytical Hierarchy Process Method. The methods used for the first phase to generate solution alternatives are: Max-Min, Min-Max, Compromise Programming, and Multiple Objective Linear Programming.

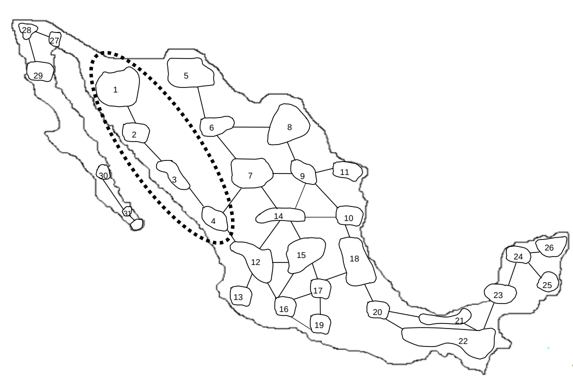

Fig. 1. Northwest Mexican Electric System

The methodology is illustrated using the Northwest Grid of the Mexican Power System (see Figure 1). In this system, there are 4 nodes, 3 arcs, 9 types of generation units, and four types of fossil-fuel. The existing capacity for such system in 2000 was 3913 MW and the expected demand for 2002 was 2572 MW.

The alternatives are obtained from the min-max, max-min, compromise programming methods, and with the ADBASE software [1] (which is a multiobjective linear programming solver). Such Pareto solutions are presented in Figure 2.

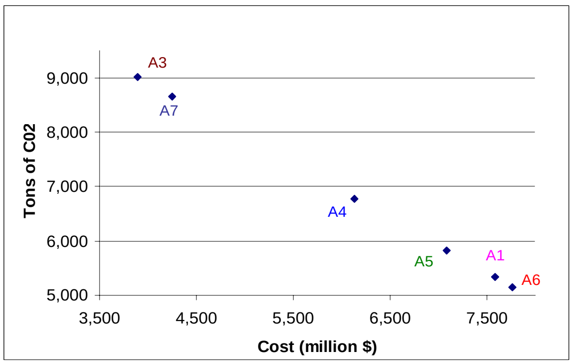

Fig. 2. Pareto Front

After obtaining these solutions from phase one, the next phase uses AHP to select the best or the most attractive Pareto solution for the Decision Maker. Following the Saaty's [2] procedure for Analytical Hierarchy Method, where cost and environmental criteria have equal importance and both criteria are slightly more important than the others two, the following ranking of alternatives is obtained:

$$A_7 > A_4 > A_5 > A_6 > A_2 > A_1 > A_3$$

Using this ranking, the best expansion alternative is selected to be A_7. This alternative takes advantage of the existing hydroelectric capacity, and adds wind capacity just in two of the nodes. If multicriteria selection methods such as compromise programming, max-min or min-max were used to determine the best expansion alternative, the best alternative would have been A_4 which is the second ranked alternative by Analytical Hierarchy Method.

3. Conclusions

The MGEP1 model considers aspects which have not been included in the literature. Using the framework described above, one can utilize MGEP1 as a base model to solve more complex models. Including more objectives, considering uncertainty into the problem, a better representation of the decision variables in MGEP1, and solving a multi-period problem are some possible extensions to the MGEP1 model.

4. Acknowledges

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Reference:

[1] Steur, R.E. Manual for the ADBASE Multiple Objective Linear Programming Package. Department of Management Science and Information Technology, University of Georgia (1992).

[2] Saaty, T. The Analytical Hierarchy Process. John Wiley, New York (1980)