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Coding, evaluation and selection of thermal power plants – A MADM approach

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Abstract

This paper presents a computational methodology for a computer-based solution to the problem of evaluation and selection of an optimum power plant. This methodology is named as multiple attribute decision making (MADM) methodology and consists of elimination search and technique for order preference by similarity to ideal solution (TOPSIS) approach. Pertinent attributes have been identified. A comprehensive classification and coding scheme based on 190 pertinent attributes for a given thermal power plant is suggested that is suitable for the development of a large database of available plants, and their subsequent retrieval. This methodology allows rapid convergence from a very large number to a manageable shortlist of potentially suitable plants using 'Elimination Search'. Subsequently, the selection procedure proceeds to rank the alternatives in the shortlist by employing the TOPSIS approach. A computer software package has been developed to assist an inexperienced user to establish priorities, and to 'oversee' the selection process at various stages. This methodology has been explained with the help of an illustrative example.

Keywords: Optimal selection; Power plants; MADM

1. Introduction

All walks of society, as it stands today, heavily depend on electrical energy. From industries and factories to commercial establishments, from agricultural to municipal/civic establishments, from places and bungalows to hutment colonies, from transportation sectors to leisure pursuits, etc., electrical energy is indispensable for churning out the daily routines and for relaxation/entertainment. Amongst the several methods employed to generate the electrical power, the most commonly used are the thermal, hydro and nuclear routes. Currently, the fossil fuel fired power generating units are undergoing substantial regulatory and organizational changes. Such measures encourage rapid completion and increased efficiency in power generating operations and planning. Under these circumstances, customer satisfaction with the power supply will greatly influence a utility's competitive position. Hence, it is highly desirable that utilities find ways to reflect customer satisfaction in their operation and planning. The present state of the art in the field of power plant does, in fact, represent a stimulating challenge for Engineers because of their optimum selection with regard to various attributes like technical, economical, environmental and ecological, etc. These attributes are of different and conflicting nature and hence it becomes a complex problem.

The selection of energy sources to generate electricity can be considered as one of the most important aspects in the decision process for the national power system expansion [1,2]. Lou [3] has discussed economic feasibility of power plants taking into consideration local conditions and resources. Guidelines were given for selection of optimum location, size and type of equipments for power plants. Wang and Min [4] have developed an integrated resource-planning model for utilities with outage costs. Kordan [5]

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presented a mathematical model for reliability estimation of power plants. The literature also reveals that the effect of individual parameters like meteorological factors, economic aspects of maintenance and operation, coal quality and deterioration mechanisms [6–11], etc. have been discussed by different researchers but all such factors have not been considered all together in a unified manner. It is not possible for an individual (or a team) to take all of these considerations into account without the help of a computer software package. The complexity of the problem can be better appreciated when one realizes that there are more than 100 potential attributes that have to be considered in the selection process of a thermal power plant. So there is a need to develop a unified approach which will enable power plant development team to consider all the attributes and their relative importance concurrently in an integrated manner for optimum selection of a power plant.

The aim of this paper is to briefly analyze the state of the art in the evaluation and optimum selection of thermal power plants looking at the recent advances concerning most relevant open problems. It starts from the identification, classification and coding of the plant attributes, goes to a comparative evaluation and ranking based on certain attributes and concludes with the optimum selection of a power plant for a particular application employing a multiple attribute decision making (MADM) approach called technique for order preference by similarity to ideal solution (TOPSIS).

2. Identification, selection and coding of attributes

The modern fossil fired power plant with a typical hierarchical structure is summarized in Fig. 1. The optimum selection of a thermal power plant is mainly dependent on different attributes of the plant, e.g. efficiency, cost effectiveness and eco-friendliness, etc., which directly or indirectly affect the performance of the plant. A proper identification of the plant attributes is critically important while evaluating and comparing the various alternative power plants. In most cases, the user needs to be assisted in identifying the plant attributes wisely and according to the need for a particular application. Only on the basis of these identified attributes, the computer can evaluate, select and rank the available alternative plants on the basis of their suitability to the user. For clear identification of the plant attributes, the attributes are classified on the basis of affinity. The overall performance and selection of a particular type of a plant is proportionally dependent on the number of attributes taken into consideration. Therefore, 190 pertinent attributes necessary for the life cycle design of a thermal power plant (TPP) are identified. First, the classification of the attributes is done either quantitatively or qualitatively. Then the coding is given in ascending/descending order, as the case may be, in the case of quantitative attributes. For the qualitative attributes, the coding is done on a grade scale. Some of the attributes are coded

Table 1
Coded attributes of plant siting and layout

1	Type of load		3	Load condition	
	Load	Code		Condition	Code
	Residential	R		Peak	P
	Commercial	C		Base	B
	Individual	I		Standby	S
	Municipal	M			
	Irrigational	IR			
2	Location		4	Rate of return	
	Type	Code		% Measure	Code
	Central	C		<05	1
	Isolated	I		05–10	2
				10–15	3
				15–20	4
				⩾20	5

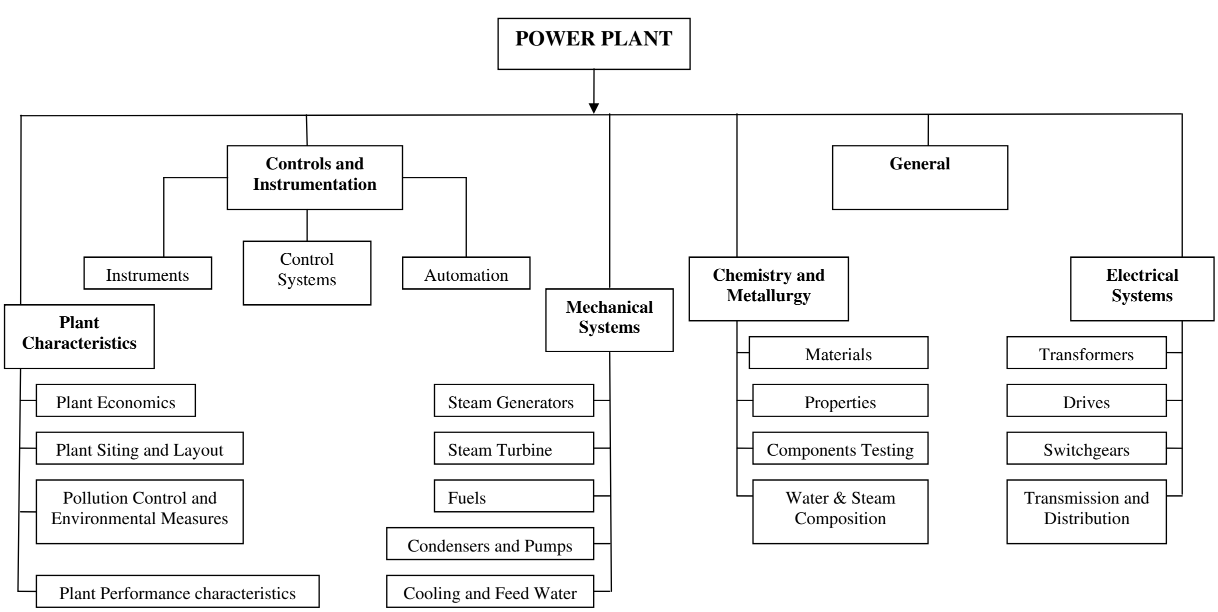

Fig. 1. Hierarchical structure of a fossil fired power plant.