
Bijoy Chattopadhyay, Nevada Energy, Las Vegas, USA
Angelica Rodriguez, Nevada Energy, Las Vegas, USA

ABSTRACT

This article describes how in order to prioritize the risks for a large number of assets, various criteria are used for ranking the asset risk. Since the criteria used for developing the risk rank is a mixture of quantitative and qualitative, a method was required to handle both the quantitative and qualitative criteria with varying scales that can be used for the electrical industry’s assets. This article proposes a hybrid multi-criteria decision model (MCDM) that combines both weighted sum model (WSM) and analytical hierarchy process (AHP). The hybrid model is then applied to the strategic asset management plan for the electric power industry for ranking the assets risk. In this application, a large number of criteria reflecting asset conditions with their numerical values are available for which WSM method worked quite efficiently. The AHP method was applied to the criteria where qualitative criteria were available. Both methods were then synthesized, and the proposed hybrid method was formulated which resulted in a computationally efficient outcome with robust mathematical framework. The results show that the proposed method exhibited optimal results for the electric industry’s asset where qualitative criteria are for AHP method was limited to 3 to 5. In the case of WSM, a larger number of quantitative criteria could be accommodated although for the application only six criteria were utilized.

KEYWORDS

AHP, Decision Matrix, MCDM, Pairwise Comparison, WSM

INTRODUCTION

The risk is typically defined as the likelihood or probability of failure, multiplied by the impact of the failure. The likelihood of failure is a function of several criteria involving the asset’s age, utilization of the asset, and maintenance and asset condition among other criteria. These criteria are often determined using a mixture of quantitative and qualitative assessments. In quantitative criteria, the scales and unit of criteria can vary widely. Similarly, qualitative criteria can also vary, e.g., gas analysis of insulation can be assessed as “Black,” “Green,” and “Red,” and whereas oil leak can be assessed as “Seep,” “Weep,” and “Dry.” As such, the mixture of different varying criteria makes risk assessment complicated. There are several MCDM models available that provide a mathematical framework for obtaining a robust solution of ranking. Most of the available models work quite effectively when criteria are fairly homogeneous. They are developed for specific applications.

DOI: 10.4018/IJBAN.2018070103

Copyright © 2018, IGI Global. Copying or distributing in print or electronic forms without written permission of IGI Global is prohibited.
In electric utility, there are numerous asset types and different groups involved in assessing asset conditions applying different techniques. This results in a significant amount of various types of data which are then used as criteria for assessing and ranking risks. The available MCDM techniques could not be readily applied for assessment of risks for electric utility assets. This paper proposed a hybrid technique where WSM, and the relatively recently developed AHP method, were combined to handle both quantitative and qualitative criteria. The hybrid approach exhibited improved consistency in results as well as computational efficiency.

The paper is organized to include a literature survey, followed by three key methods, the proposed method, and application of method, results, and conclusions.

LITERATURE REVIEW

Several studies have been conducted during the last decade that utilized MCDM for solving asset management and engineering decision problems. MCDM was applied in assessing decision options by many industries and ranking the decisions and scenarios (Wang, & Triantaphyllou, 2006; Shyjith, Ilangkumar, & Kumanan, 2008; Dytczak, & Ginda, 2006; Campanella & Ribeiro 2011; Prida, Viveros, Crespo, & Martin, 2014; Santiago, Romo, Marcos, Borja-de la Rosa, 2015; Thakala, Devlin, Marsch, Baltussen, Boyse, Kalo, Longrenn, Mussen., Peacock, Watkins, Ijzerman, 2016). Wang et al. (2006) provided a few criteria to establish effectiveness of multi criteria decision analysis. Others utilized AHP as a MCDM model for ranking the decisions and scenarios by applying both qualitative and quantitative criteria (Prida et al., 2014). A few other researchers applied weighting method in MCDM for financial decision in allocating research funding, and selecting R&D projects (Pirdashti et al., 2009 & Santiago et al., 2015). The MCDM methodology has been extensively used in energy and sustainability industries (Cinelli et al., 2014; Wang et al., 2009; Handfield 2002; Dytczak & Ginda, 2006; Jaderi et al., 2012; Majumder, 2015). In the construction project, AHP methodology was applied to assess the risks of the projects (Mustafa, 1991).

Triantaphyllou et al. (1998) provided a background of weighted sum method (WSM), which recommended a simple decision model for easily obtainable and quantifiable data. Another competing method, weighted product model (WPM) is considered as a modification of the WSM, and used in order to overcome some of the weaknesses of WSM (Prida et al., 2014) by eliminating units of measurement from the decision model. Thakala et al. (2016) has utilized WSM model by proposing a “swing weighting” concept. This approach takes into account of ranges of performance relevant to a set of alternatives i.e. the “swing” in performance. Hosseinzadeh et al. (2013) used voting approach in ranking the alternatives. Miljkovic et al. (2017) proposed a new weighted sum model where a normalization process was introduced. The approach allows the alternatives ranking is not reversed when a new alternative is added to the mix of several alternatives.

The recent development of AHP has become popular due to its robust mathematical construct. The AHP, developed by Saaty (2008), uses pairwise comparisons for ranking alternatives in decision making problems. He proposed a value of less than 0.1 as an allowable consistency index for any given pairwise matrix to be considered acceptable. In addition, Saaty proposed the Eigen vector method as means for developing judgement and decision matrices. Tomashevskii (2014) used geometric mean method for judgements matrices. The phenomenon of rank reversal is also explored in addition to possible solutions to this issue. The geometric mean method is simple to implement in comparison to the Eigen vector method, which has shown to yield comparable results. Brunelli (2015) described geometric mean and Eigen vector methods in detail. Triantaphyllou (1995) applied analytical hierarchy process for decision making in engineering applications. Given the computational issues connected with the AHP method, two evaluative criterion were proposed.

There are several other MCDM methods available including ELECTRE-3 and 4, PROMETHEE-2, TOPSIS, Compromise Programming, Cooperative Game theory, Composite Programming, Analytical Hierarchy Process, Multi-Attribute Utility Theory, Multi-criterion Q-Analysis etc. (Bhushan & Rai,
Discovering Business Intelligence from the Subjective Web Data
[www.igi-global.com/article/discovering-business-intelligence-subjective-web/60241?camid=4v1a](www.igi-global.com/article/discovering-business-intelligence-subjective-web/60241?camid=4v1a)

An Automatic User Interest Mining Technique for Retrieving Quality Data
[www.igi-global.com/article/an-automatic-user-interest-mining-technique-for-retrieving-quality-data/176927?camid=4v1a](www.igi-global.com/article/an-automatic-user-interest-mining-technique-for-retrieving-quality-data/176927?camid=4v1a)