Chapter 10
An Integrated Entropy–TOPSIS Methodology for Evaluating Green Energy Sources

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ABSTRACT

This research aims to select the optimum green energy sources for sustainable planning from a given set of alternatives. The study presents an integrated multi-criteria decision-making analysis—the entropy-technique for order of preference by similarity to ideal solution (TOPSIS)—to evaluate the energy sources: coal, oil, gas, carbon capture; and storage: nuclear fission/power, large hydro, small hydro, wind, solar photovoltaic, concentrating solar, geothermal, and biomass. Information related to energy parameters are always imprecise; thus, to address the impreciseness of eliciting judgments in the preferences of criteria, the entropy method is used. TOPSIS method is then utilized to select the optimum sources. Results show that solar-photovoltaic is the optimum green energy source having the highest score value, and annual generation is the most prioritized criterion. Sensitivity analysis also demonstrates the robustness of the selection methodology.

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1. INTRODUCTION

Green energy sources selection is considered as a crucial issue for any developed as well as developing countries due to its direct impact on society and environment (Çolak and Kaya 2017; Ervural et al. 2018). The process of green energy sources selection is relatively complex due to the diverse influencing criteria that must be taken into consideration (Ren and Lützen 2017; Tsagarakis et al. 2018). Due to the increased utilization of fossil fuels, energy markets today are under tremendous pressure to incorporate environmentally-benign key resources for a sustainable future (Büyüközkan and Güleryüz 2017). The extensive use of fossil fuels in industrial and non-industrial sectors causes numerous environmental problems such as SOx, NOx, CO_2 emissions, resource depletion and global warming forcing governments and environmental activists worldwide to consider the use of green resources (Midilli et al. 2006; Wurlod and Noailly 2018). Accordingly, the use of green energy sources is a hot topic of discussion in achieving a greener and more environmentally friendly future (Ren and Lützen 2017; Ng and Zheng 2018). Different green energy sources have different economic, environmental and social importance such that one green energy alternative may perform better than other energy alternatives in at least one aspect but may perform worse in other aspects (Ren and Lützen 2017; Büyüközkan and Güleryüz 2017; Wu et al. 2018). Thus, decision-makers are usually puzzled when choosing an optimum source, at the selection level, with an assessment that may cover various areas which boundaries may not be readily identifiable (Ren and Lützen 2017; Kumar et al. 2017; Kumar and Samuel 2017; Zhao and Chen 2018). The challenge is not only to recognize the role of decision-makers, energy managers or policymakers, but rather to develop a comprehensive framework combining various strategic approaches to address green energy sources selection problem (Qin et al. 2017; Yuan et al. 2018; Ren 2018; Manzella et al. 2018; Aklin et al. 2018).

It is evident from the earlier studies that a dearth of current literature is available with various energy sources selection techniques depending on data availability (Baul et al. 2018; Kardooni et al. 2018; Galvin 2018; Zhao and Chen 2018; Manzella et al. 2018; Aklin et al. 2018; Gao et al. 2018; Liu et al. 2018).

Thus, this paper aims to develop a multi-criteria decision-making support framework for the selection and ranking of optimum green energy sources. Furthermore, this work attempts to address the heterogeneous features in the selection methodology considering various conflicting criteria. This study is an initial attempt to propose and utilize an integrated methodology comprising entropy and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) for optimum green energy sources selection. Firstly, a comprehensive evaluation of the selection criteria and alternatives are selected using a literature analysis. Secondly, the entropy method is utilized to obtain criteria weights from the vague information available in the data. Thirdly, TOPSIS methodology is utilized to select the optimum alternative according to the performance of the alternatives to each criterion in the criteria set. Finally, a sensitivity analysis is performed to demonstrate the robustness of the proposed methodology. The novel aspect of this work is in the development of a ranking order for future clean energy project investment decisions considering the complexity of the selection process. The proposed methodology can systematically handle the conflicting, unstructured, multi-criteria decision-making environment of the green energy sources selection process. This work is essential to decision-makers as it attempts to help bring about crucial insights for the management of government, non-government as well as private organizations operating in the renewable energy sources sector. Findings of this work can provide useful information to governments or public sector regarding various possible investments in energy projects.