Energy policy, Efficiency measurement

Multi-aspect efficiency measurement of multi-objective energy planning model dealing with uncertainties

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Abstract

This study proposes a framework that combines the concepts of a multi-objective optimization model and efficiency measurement to determine the most efficient energy mix considering the multi-dimensional aspects of energy requirements and various uncertainty scenarios. Various multi-objective functions are appended to the proposed optimization model to meet requirements related to energy need, cost, environmental impact, security, social impact, and social benefit. A slacks-based measure methodology is applied to determine the best energy mix from the alternatives produced by the appended model. The energy efficiency of each energy mix is measured from the linear combination of its defined inputs and outputs. The outputs to be maximized include total generated electricity, direct employment, and percentage of generated electricity from renewable energy, while the inputs to be minimized consist of total economic cost, carbon dioxide emission, total social cost, and power-plant-type dependence score.

Background & Results

To demonstrate the applicability of the proposed model, a case study of Thailand's power development plan is featured. Various types of power plants, both fossil fuel-fired and renewable energy-driven are considered in the empirical analysis. The model results showed the range of optimal energy mixes corresponding to the different energy policies and scenarios of uncertainty. The inability to determine in the first-stage efficiency measurement the best energy mix from the marginal differences of efficiency scores between the various energy mixes means that a second-stage group-separated efficiency measurement would be necessary. The subsequent group-separated efficiency measurement grouped by demand scenario showed that the lexicographical ordering that prioritized environment first, followed by social damage and then cost (designated as ESC), had the highest weighted-average efficiency score for all demand scenarios. The results show that the proposed method can contribute significant improvements, including a reduction in total emissions and in the power-plant-type dependence score (by 31.41% and 25.59%, respectively). It also increases total employment and the proportion of generated electricity from renewable energy plants (by 25.73% and 47.39%, respectively), with marginal tradeoffs of total costs and total social costs (which increase by 8.94% and 13.89%, respectively).

Significance of the research and Future perspective

The study established that to effectively implement the proposed model, the various choices of the multi-objective function are to be generated first, allowing the two-stage efficiency measurement method to then determine the best of the optimal energy mixes from all the possible first-stage results. Quantitative results from the model could help policy makers efficiently determine an appropriate energy policy—one that maximizes the satisfaction of multiple requirements, under a given set of constraints and scenarios of uncertainty.

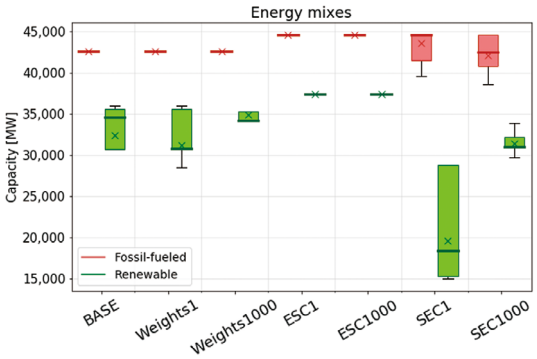

Figure 1. Optimal energy mixes of the seven energy policies under the scenarios of uncertainty.

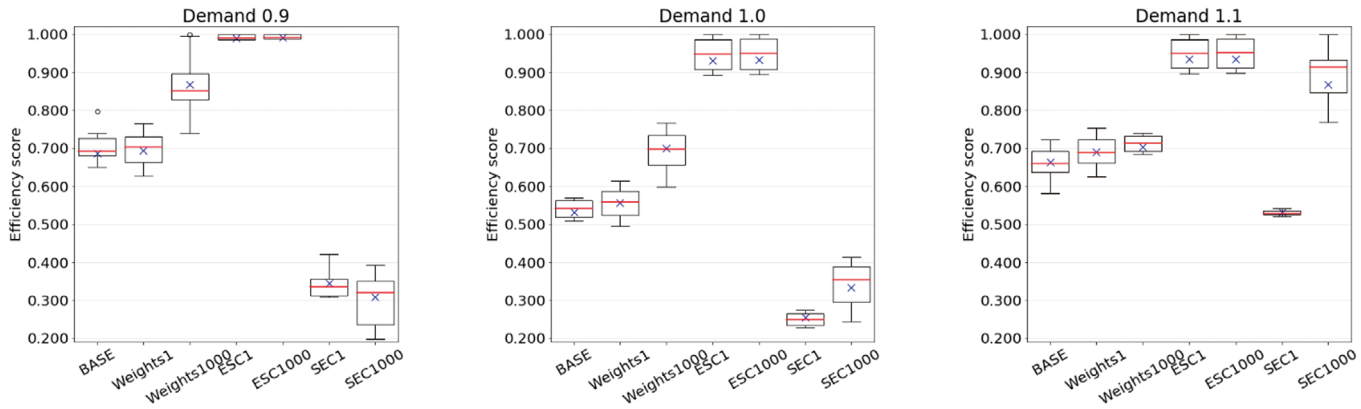

Figure 2. Efficiency score variation separated by demand scenario.

Patent
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