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ORIGINAL PAPER

A methodology for augmenting sparse pairwise comparison matrices in AHP: applications to energy systems

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Abstract Multiple-attribute decision making (MADM) techniques can be used to provide a systematic approach to selection problems in energy engineering and management. They may be used for selecting the best technologies or policies based on environmental, technical, and socio-economic criteria. Among the many available MADM techniques, the analytic hierarchy process (AHP) has become one of the most widely used due to its effective hierarchical decomposition of complex problems. However, AHP may be tedious due to the large number of pairwise comparisons needed in large problems. Furthermore, in many cases, relevant information may also be available for determining criteria weights based on past decisions that have proven satisfactory in retrospect. Thus, we propose a simple methodology for augmenting sparse pairwise comparisons in AHP through a non-linear programming model that extracts a set of consistent weights from a priori ranking of a subset of alternatives. Two case studies on the ranking of bioethanol feedstocks and of CO_2 storage sites are then shown to illustrate this technique.

Keywords Multiple-attribute decision making (MADM) · Analytic hierarchy process (AHP) · Non-linear programming (NLP) · Bioethanol feedstock · CO_2 storage

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List of symbols

Sets

I	Set of all alternatives
I'	Set of alternatives for which a priori ranks are known
J	Set of all criteria
J'	Set of criteria for which pairwise comparisons are known
J''	Set of criteria used in a priori ranks of original alternatives

Parameters

$a_{jj'}$	Pairwise comparison ratio of criteria j and j'
A	Pairwise comparison matrix
N	Total number of criteria
x_{ij}	Score of alternative i with respect to criterion j

Variables

w_j	Weight of criterion j
y_i	Overall score of alternative i based on original set of criteria
z_i	Overall score of alternative i based on all criteria

Introduction

Current global sustainability issues, such as climate change and energy security, are considered as a major area of research in systems engineering (Agrawal and Sikdar 2012). In particular, multicriterion selection problems are prevalent in energy engineering and management. Typically, such problems arise when comparing alternative technologies or courses of action with respect to various economic, technical, and social issues deemed to be relevant by the decision maker. In such cases, multiple-attribute decision making (MADM) techniques are useful for insuring that all relevant