APPLICATION OF PREFERENCE RANKING ORGANIZATION METHOD FOR ENRICHMENT EVALUATION METHOD IN ENERGY PLANNING - REGIONAL LEVEL

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ABSTRACT. Nowadays energy is one of the most essential needs of human being and it can be considered as the basic prerequisite of social and economic development. Hence, many of the correlations and legislations of a country are affected by it. Since Iran has huge source of gas and oil, it has turned to a fossil fuel oriented county. But as oil and gas sources are non-renewable ones and cannot be replaced, its essential for any country to focus on Renewable Energy Sources (RES). So today is the time of studying and investing on RES to be able to exploit them in the time of oil and gas crisis. In the past, the choice among alternative sources was based on cost minimization, but ranking the RES options is a complex task. The objective of this paper is determining the best renewable energy alternative for Sistan & Baluchestan province of Iran by using interval Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) method. In the application of the proposed methodology the most appropriate renewable energy alternative is determined fuel cell and biomass for the mentioned province.

Key words: renewable energy, criteria, alternative, interval PROMETHEE.

1. INTRODUCTION

Energy is a vital input for social and economic development of any nation. With increasing agricultural and industrial activities in Iran, the demand for energy is also increasing. Formulation of an energy model will help in the proper allocation of widely available renewable energy sources such as solar, wind, bioenergy and small hydropower in meeting the future energy demand in Iran [1]. In the past, the choice among alternative sources was based on cost minimization, but ranking the RES options is a complex task, considering the different aspects such as technological, environmental, social and economic ones. Multi criteria decision making (MCDM) methods can help governments to evaluate energy sector plans and policies [2]. Renewable energy sources have been important for humans since the beginning of civilization. Clean, domestic and renewable energy is commonly accepted as the key for future life. This is primarily because renewable energy resources have some advantages when compared to fossil fuels. Renewable energy sources are also often called alternative sources of energy. Renewable energy resources that use domestic resources have the potential to provide energy services with zero or almost zero emissions of both air pollutants and greenhouse gases. Main renewable energy resources are biomass energy, Fuel cells, geothermal energy, solar energy, and wind energy [3-6].

Since there are many criteria which usually are conflicting ones, conducting the survey based on e.g. cost minimization will not lead us to an acceptable output. So we need to rank the alternatives according to so many criteria which must be

summarized to the most frequently used ones. In this paper, PROMETHEE which is an outranking technique is used to rank different kinds of renewable energy sources. PROMETHEE can be easily adapted for group decision aid, for example by including different weighting schemes [7-9]. Thus, in our study PROMETHEE is preferred to other outranking approaches, because it is perceived to be more transparent and easier to understand even for decision makers (DM) not familiar with Multi Attribute Decision Making (MADM)[8,10,11].

In this paper the use of PROMETHEE method in the ranking of renewable energy sources of Sistan & Baluchestan province of Iran is shown. The method is improved by using SMART Exploiting Ranks (SMARTER) method for assigning the weights of relative importance of attributes.

The paper is organized as follows: Section 2 reviews MADM methods which have been used in energy planning and also includes some of recent studies about renewable energy ranking by use of MADM methods. Section 3 gives a brief summary about the potential of renewable energy sources of Sistan & Baluchestan province. Section 4 introduces the used methodology in this paper. Section 5 is dedicated to the explanation of interval PROMETHEE. Section 6 presents the related criteria to evaluate the alternative renewable energy resources and includes application of the proposed methodology in the energy planning problem of this paper. Finally results and conclusion are discussed in section 7 and 8.

2. Review on MADM methods on energy planning

MADM methods can help governments to evaluate energy sector plans and policies. Recently some studies about MADM have concentrated on energy planning. In this section the recently ones, after 2000, are summarized.

Kahraman et.al [2] presented the selection of criteria and options for the new and renewable energy alternative assessment. They also considered biomass, hydropower, geothermal, wind and solar energy as the most appropriate renewable energy alternative in Turkey. They used axiomatic design and Analytical Hierarchy Process (AHP) for renewable energy alternatives under fuzziness.

Kaya and Kahraman [12] aimed at determining the best renewable energy alternative for Istanbul by using an integrated VIKOR (Vlsekriterijumska Optimizacija I Kompromisno Resenje) -AHP methodology and then selecting among alternative energy sites in this city by using the same approach. Kahraman and Kaya [13] suggested a fuzzy multicriteria decision-making methodology for the selection among energy policies. The methodology is based on AHP under fuzziness. In this paper a fuzzy multi criteria decision-making procedure proposed by Zeng, An, and Smith [14] is reconstructed to select the best energy policy alternative. A modified AHP method is applied to work out the priority weights of energy policy alternatives. Yung-Chi Shen et.al [15] attempts to reveal the suitable renewable energy sources for the purpose of meeting the 3E (Energy, the Environment, and the Economy) policy goals. They used fuzzy analytical hierarchy process (FAHP) to resolve the multi-goal problem for achieving the research purposes.

Eunnyeong Heo et.al [16], according to a paper by the title of analysis of the assessment factors for renewable energy dissemination program, established the criteria and factors about effective dissemination program alongside Research and Development (R&D) on new and renewable energy technology using AHP method.

J. Terrados et als approach [17], combines advantages of PROMETHEE, Delphi and SWOT analysis. Validation and assessment of the strategies had been done by means of experts opinion. Applying Multiple Criteria Decision Analysis (MCDA), ranking of alternatives had been done and according to this stage, final strategies had been chosen and so the amounts of energy production from different renewable energy resources were suggested.

S. Ghafghazi et al [18] used PROMETHEE method to rank the energy options. The PROMETHEE II method was used to rank the alternatives against six criteria of cost, Green House Gas (GHG) emissions, particular matter (PM) emissions, maturity of technology, traffic load, and local source.

Beccali et al [19] conducted a survey to show an application of the multi criteria decision-making methodology used to assess an action plan for the diffusion of renewable energy technologies at regional scale. This methodological tool gives the decision-maker considerable help in the selection of the most suitable innovative technologies in the energy sector, according to preliminary fixed objectives. In this paper, a case study is carried out for the island of Sardinia.

Haralambopoulos and Polatidis[20] describe an applicable group decision making framework for assisting with multi-criteria analysis in renewable energy projects, utilizing PROMETHEE II outranking method. The proposed framework is tested in a case study concerning the exploitation of a geothermal resource, located in the island of Chios, Greece. . Four scenarios were chosen instead. In this paper they developed an integrated, dynamic framework for achieving group consensus in renewable energy projects based on PROMETHEE II.

Georgopoulo et al [21] presented a paper in which they used Elimination et choice translating reality (ELECTRE) III to take into account several and often conflicting points of views about a significant potential of renewable energy sources, through the examination of a particular case study in a Greek Island.

Haris Doukas et al [22], in their paper with the title of Computing with words to assess the sustainability of renewable energy options show how energy policy objectives towards Sustainable development (SD) and RES options are related and assessed using linguistic variables. The linguistic variables take values from a set of linguistic terms and their semantics is represented by the corresponding fuzzy sets. The objective of the paper is to extend the numerical multi criteria method TOPSIS for processing linguistic data in the form of 2-tuples, so as to show how energy policy objectives towards SD and RES options are related and assessed using linguistic variables.

Julia Oberschmidt et al [23] tried to elaborate a multi-criteria methodology for the performance assessment of energy supply technologies, which also takes into account the dynamics of technological change. Criteria need to be defined to measure to what degree the different energy technologies can contribute to achieving these goals. Seven criteria were applied to this case study. The approach chosen is based on the multi-criteria outranking methodology, PROMETHEE, which is linked to the concept of technologys life cycle by assigning criteria weights depending on the actual development phase of a certain technology.

Thomas Buchholz et al [24] aimed to evaluate the potential of Multi Criteria Analysis (MCA) to facilitate the design and implementation of sustainable bioenergy projects. Four MCA tools (Super Decisions, Decide IT, Decision Lab, and NAIADE) are reviewed for their suitability to assess sustainability of bioenergy

systems with a special focus on multi stakeholder inclusion. The MCA tools are applied using data from a multi- stakeholder bioenergy case study in Uganda.

J.R. San Cristbal [25] applied the VIKOR method in the selection of a Renewable Energy project corresponding to the renewable energy plan launched by the Spanish government. The method is combined with the AHP method for weighting the importance of the different criteria, which allows decision-makers to assign these values based on their preferences.

Theocharis Tsoutsos et als [26] paper exploited the multi-criteria methodology for the sustainable energy planning on the island of Crete in Greece. A set of energy planning alternatives were determined upon the implementation of installations of renewable energy sources on the island and were assessed against economic, technical, social and environmental criteria identified by the actors involved in the energy planning arena. Amongst the existing alternatives assessment methods for multi-actor policy settings, MCDA method was chosen. The energy alternatives were assessed according to PROMETHEE method.

3. Region under investigation

Sistan and Baluchestan Province is one of the 31 provinces of Iran. It is in the southeast of the country, bordering Pakistan and Afghanistan and its capital is Zahedan. The 120-day winds are a distinguishing feature of this region. Bazman, also known as Kuh-e-Bazman is a stratovolcano in a remote desert region of Sistan & Baluchestan province in southeastern Iran. A 500-m-wide crater caps the summit of the dominantly andesitic volcano. Although no historic eruptions have been reported from Bazman, it does contain fumaroles. Its satellite cones have been the source of basaltic lava flows [38].

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