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ENERGY ALTERNATIVES EVALUATION IN TURKEY BY USING MULTICRITERIA DECISION MAKING METHODOLOGIES

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As we search to achieve sustainable development and substance, energy security and efficiency should be viewed not only from the perspective of addressing short-term challenges, but also as a necessity for long-term growth of the economy. Latterly, some articles have majored on selecting the best energy policy and arbitrating the best energy alternatives. In this paper, AHP, VIKOR, PROMETHEE and TOPSIS approaches are suggested for the selection among energy policies. The methodology is based on these four methods under a comparison. In the application of the proposed methodologies, the best energy policy is determined for Turkey.

Keywords: Energy policy, AHP, VIKOR, PROMETHEE, TOPSIS

1. Introduction

Energy is an essential factor to achieve sustainable development. So, countries striving to this end are seeking to reassess their energy systems with a view towards planning energy programs and strategies in line with sustainable development goals and objectives [1].

In Turkey, the growing population, industrialization and increasing standard of living have considerably increased the dependence on imported energy. Consequently, in addition to the development of conventional energy resources, exploitation of non-conventional energy resources and energy conservation has become inevitable. Turkish energy consumption has risen dramatically over the past 20 years due to the combined demands of industrialization and urbanization [2].

In the world, particularly in the developing countries renewable energy resources appear to be one of the most efficient and effective solutions for sustainable energy development in Turkey. The most important renewable sources are hydropower, biomass, geothermal, solar and wind. Turkey's geographical location has several advantages for extensive use of most of these renewable energy sources. In recently, electricity has demand increased significantly; it is the fastest growing end-use of energy [3].

Since the early 1980s, Turkish energy policy has concentrated on market liberalization in an effort to stimulate investment in response to increasing internal energy demand. Turkey's new government has continued this policy despite lower energy demand induced by the 2001 economic crisis [1].

Energy resources which are very important for Turkey is given below:

- Hydropower
- Biomass and Bioenergy
- Geothermal energy
- Solar energy
- Wind energy
- Coal
- Petroleum
- Natural gas
- Nuclear energy

The paper is organized as follows: In Section 2, multi criteria decision making models in the literature are listed and briefly explained. The proposed methodology is detailed in Section 3. A hierarchy and evaluation criteria for the selection of the most appropriate energy policy for Turkey are presented. Conclusion and future research directions are summarized in Section 4.

2. Multi Criteria Decision Making Models for Energy Policy Making

2.1. TOPSIS Methodology for Energy Policy Making

The technique for order preference by similarity to ideal solution (TOPSIS) was first developed by Hwang and Yoon (1981) based on the concept that the chosen alternative should have the shortest distance from the Positive Ideal Solution (PIS) and the farthest from the Negative Ideal Solution (NIS) for solving a multiple criteria decision making problem (Salehi, 2009). The main aim of Cavallaro's paper (2010) is to propose and test the validity and effectiveness of the proposed fuzzy multi-criteria method (TOPSIS fuzzy) to compare different

heat transfer fluids (HTF) in order to investigate the feasibility of utilizing a molten salt. Also, Kahraman and Kaya define a modified fuzzy TOPSIS methodology that is proposed for the selection of the best energy technology alternative [4]. On the other hand, for the performance evaluation of coal enterprises energy conservation and reduction of pollutant emission, a new GRD-TOPSIS method is proposed in the article of Yan, Ling and Dequn [5].

2.2. VIKOR Methodology for Energy Policy Making

VIKOR (Visekriterijumska optimizacija i Kompromisno Resenje) focuses on ranking and selecting from a set of alternatives in the presence of conflicting criteria, and on proposing compromise solution (one or more) [6].

2.3. PROMETHEE Methodology for Energy Policy Making

Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE), a multi-criteria decision making method of outranking nature is used to rank the alternatives. This technique has all the advantages of the outranking methods, combined with ease of use and decreased complexity. It performs a pair-wise comparison of alternatives in order to rank them with respect to a number of criteria [7].

3. APPLICATION

In this study, Energy Policy of Turkey analysis by performing weight of energy types with AHP method, and tried to determine the best energy alternative and the best energy policy by using Fuzzy & AHP, TOPSIS, PROMETHEE and VIKOR methods. As shown in Table 1, the main criteria and sub criteria were identified first of all. Then, by the method of AHP, the weights were calculated (Table 2). “Criteria taken into account to select the best energy policy” is given in the Table 1.

Table 1: Criteria taken into account to select the best energy policy [4]

Main Criteria	Sub-Criteria
C1 : Technological	C11 : Feasibility C12: Risk C13: Reliability C14: The Duration Of Preparation Phase C15: The Duration Of Implementation Phase C16: Continuity And Predictability Of Performance C17: Local Technical Know How
C2 : Environmental	C21: Pollutant Emission C22: Land Requirements C23: Need Of Waste Disposal
C3 : Socio-Political	C31: Compatibility With The National Energy Policy Objectives C32: Political Acceptance C33: Social Acceptance C34: Labor Impact
C4 : Economic	C41: Implementation Cost C42: Availability Of Funds C43: Economic Value (PW, IRR, B/C)

In Table 2, b values are alternatives and a values are main criteria. Then by the method of AHP the weights were calculated as shown in Table 2.

Table 2: AHP Weighting Matrix [2]

	a1	a2	a3	a4
b1	6,85	7,71	7,87	8,48
b2	3,88	4,55	4,93	5,51
b3	6,89	7,46	7,71	8,01
b4	6,52	7,08	7,36	7,90
b5	6,06	6,57	6,77	7,14
b6	3,70	4,21	4,35	5,18
b7	3,55	4,12	4,44	5,09
b8	7,18	7,80	8,10	8,28
b9	7,68	8,30	8,59	8,78

4. CONCLUSION

Energy, along with being one of the most important factors in advanced societies, economic development is one of the most important items. Looking at historical data to obtain energy for economic development, how much they are dependent on each other can be seen. Methods laid down, "AHP, VIKOR, PROMETHEE and TOPSIS" competent persons assessment of energy resources in line with the implementation of a successful energy policy have been determined.

Table 3. Energy Resources for the results obtained from the "AHP, VIKOR, PROMETHEE and TOPSIS" methods [2]

Energy Alternatives	TOPSIS	FUZZY&AHP	VIKOR	PROMETHEE
Biomass	3	3	8	3
Coal and Lignite	7	7	9	7
Geothermal	4	4	5	4
Hydropower	5	5	2	5
Natural Gas	6	6	4	6
Nuclear	9	8	6	8
Oil	8	9	7	9
Solar	2	2	3	2
Wind	1	1	1	1

As shown in the table, the first choice of all methods can be shown that wind energy as an initial energy source. Second attractive energy source determined solar energy by the method FUZZY&AHP, TOPSIS and PROMETHEE that can be used in Turkey, despite the use VIKOR method, second attractive source of energy determined hydroelectric power. On the other hand, VIKOR method put the coal and lignite at the last alternative energy source, Nuclear energy by TOPSIS, and oil by AHP and PROMETHEE methods.

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