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Determination of Appropriate Strategies in the Field of Renewable Energies within Iranian Educational System and Prioritization of Them by Using Fuzzy Preference Programming (FPP) Technique

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تعیین راهبردهای آموزشی در زمینه انرژی‌های تجدیدپذیر در نظام آموزشی ایران و اولویت‌بندی آنها با استفاده از تکنیک برنامه‌ریزی فازی ترجیحی (FPP)

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Abstract:
The present study mainly aims to determine appropriate strategies for performing relevant educational programs to promote the level of awareness among different people of society to replace non-renewable energy resources with clean and renewable energy resources as well as to prioritize these strategies for use in the educational system of Iran. This study is conducted in two stages. In the first stage, the most important policies and strategies regarding the application of renewable energies and education in this field were extracted. Then 80 strategies proportionate according to Iran's educational needs in this field were suggested. The most comprehensive of them were determined using the comments of 50 specialists through a questionnaire. Among these strategies, 40 strategies were selected for training renewable energies at schools (10 cases), Higher Education (10 cases), informal education (10 cases), and non-formal education (10 cases). In the second stage, for prioritizing the selected strategies, another questionnaire including pairwise comparison tables of these strategies was prepared based on the results of the experts' comments and data resulting from it was used to rank the strategies using fuzzy preference programming (FPP) method in MATLAB software. All fuzzy group decision-making matrices are suitably adapted for each of the four educational groups ($\gamma i > 0.3679$). Prioritization of these 40 strategies for training renewable energies in the educational system of Iran is presented at the end of the paper in terms of formal education at schools and universities, informal and non-formal education.

Keywords: Renewable Energy Resources, Strategy, Environmental Education, Prioritization, Fuzzy Preference Programming (FPP) Technique.

چکیده:
هدف اصلی این پژوهش، تعیین و اولویت‌بندی راهبردهای آموزشی مناسب در زمینه کاربرد منابع انرژی تجدیدپذیر در نظام آموزشی ایران به تفکیک آموزش رسمی، غیررسمی و ضمنی است. بر همین اساس، این پژوهش ازنظر هدف، کاربردی و ازنظر شیوه پژوهش، توصیفی- تحلیلی است. ابزار جمع‌آوری داده‌ها، پرسشنامه و مصاحبه با خبرگان است. این تحقیق، در دو مرحله انجام گرفته است. در مرحله اول، بر اساس مرور منابع و مطالعات انجام‌شده، مهم‌ترین سیاست‌های کشورهای مختلف جهان و ایران مرتبط با کاربرد انرژی‌های تجدیدپذیر و آموزش در این زمینه استخراج گردید. سپس ۸۰ راهبرد، متناسب با نیازهای آموزشی کشور برای آموزش در زمینه بهره‌مندی از انرژی‌های تجدیدپذیر پیشنهاد شد که با استفاده ازنظر ۵۰ متخصص این حوزه، مهم‌ترین و جامع‌ترین راهبردهای مرتبط از طریق پرسشنامه تعیین شد که ۴۰ استراتژی به تفکیک برای آموزش در مدارس (۱۰ مورد)، آموزش عالی (۱۰ مورد)، آموزش غیررسمی (۱۰ مورد)، آموزش ضمنی (۱۰ مورد) انتخاب گردید. در مرحله دوم پرسشنامه دیگری شامل جداول مقایسات زوجی برای راهبردهای منتخب بر اساس نتایج نظرات متخصصان تکمیل شد و داده‌های حاصل از آن به‌منظور رتبه‌بندی راهبردها با استفاده از تکنیک برنامه‌ریزی فازی ترجیحی در نرم‌افزار MATLAB انجام گرفت. همه ماتریس‌های تصمیم‌گیری تجمیعی فازی برای هر چهار گروه آموزشی سازگاری مناسبی دارند ($\gamma i > 0.3679$). اولویت‌بندی ۴۰ استراتژی جهت آموزش در زمینه انرژی‌های تجدیدپذیر در نظام آموزشی ایران به تفکیک آموزش رسمی در مدارس، آموزش رسمی در دانشگاه‌ها، آموزش غیررسمی و آموزش ضمنی در پایان مقاله آمده است.

واژه‌های کلیدی: انرژی‌های تجدیدپذیر، راهبرد، آموزش محیط‌زیست، اولویت‌بندی، برنامه‌ریزی فازی ترجیحی.

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1. INTRODUCTION

Today, demand energy is one of the most significant problems worldwide, with enormous implications for the environment, economy, and development. The exploitation of Renewable Energy Sources (RES) in the last few years aims not only towards less dependence on oil, but also protection of the environment (Mourmouris & Potolias, 2013(. New Renewable Energy (NRE) has attracted considerable attention as a future energy source that might be a significant factor in establishing a sustainable energy supply system. This issue is becoming increasingly important due to the instability of oil prices and the issues surrounding climate change (Hong et al, 2013). By using clean and renewable energy such as water, solar, wind, geothermal, hydrogen, biomass, and wave energies as alternatives for energies resulting from fossil energies, political, economic, environmental crisis, and associated challenges would be prevented. Then, a set of renewable energies has contributed more and more to the global energy supply system so that a specific role has been assigned to renewable energy resources in UN programs toward global sustainable development. Global demand for renewable energies has increased substantially within the last years, and generally included 19.3% of world total energy consumption in 2015 (REN21,2016).

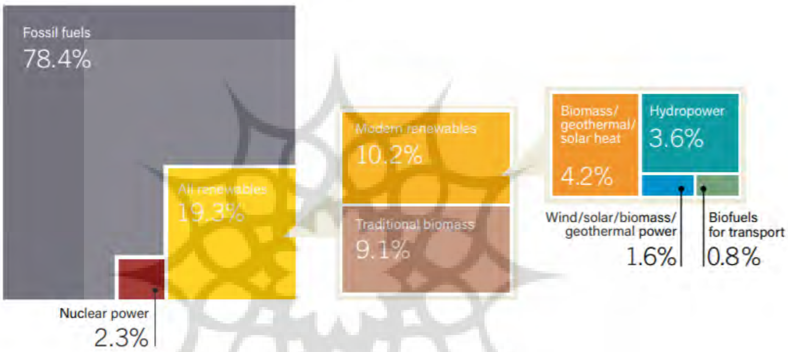

Fig. 1. Estimated of Renewable Energy Share of Global Final Energy Consumption in 2015 (REN21,2016)

According to figures released by Iranian ministry of energy, in 2015, the share of renewable energy sources in primary power production of the country is 0.9% (Ministry of Energy,2015) and its renewable energy power plants with 9859.2 MW capacity are operating. In Iran, due to the variety of climate, there is a high potential for using renewable energies. Presence of high wind energy potential (100 GW), solar energy (average radiation of 5 KWh/M2), and hydropower energy (40.9GW) as well as geothermal energy (over 200 MW) are evidence of this fact (SATBA, 2016). So non-use of these energy resources would be a strategic mistake.

Also, CO_2 mitigation from the air should become a significant part of Iran's future policy and development as an important long-term air treatment strategy for managing climate risk, especially on significant sources of CO_2 emission, power plants. There are different alternatives to mitigate CO_2 in the atmosphere, i.e., energy intensity reduction, which needs the efficient use of energy and better energy management, reduction of carbon intensity which requires switching to use non-fossil fuels such as renewable energy (Ghorbani et al, 2014).

Considering cultural and educational issues in macro scale of energy planning to educate the society about the environmental problems and necessity of using renewable energies help to move toward a sustainable future with less environmental problems (Payam & Taheri, 2017). Convenient strategy and policy-making for motivation required for the emergence of a variety of renewable energies in the economy and environment sectors of the country is inevitable. Use and application of renewable energies, and adjusting with energy resources by current system of energy consumption still face some problems that review and solving them is possible by providing proper training to increase knowledge, awareness and to institutionalize culture for energy consumption among various groups in society in order to pave the way for using clean and renewables energies and supplying energy needs of the country. Therefore, it is necessary for our educational system to develop a comprehensive educational program in the field of renewable energies. Education in this field, and developing convenient policies and strategies towards practical training for using clean energies is one of the subsets of environmental training and lack of it in a country with high potential regarding renewable energies like Iran is evident.

The general purpose of the present research is identification and prioritization of appropriate strategies to include relevant training in formal, informal and non-formal education system in order to enhance knowledge, values, attitude, commitment, and required skills for different groups in Iran to increase the portion of the renewable energies in energy basket of the country.

As a review of theoretical basics of various aspects such as global and Iranian energy policy-making, environmental education, training in the field of renewable energies, applying preference methods for fuzzy preference programs is required to conduct the present research, so in this section, an overview of the items mentioned above has been provided.

Three essential declarations issued by United Nations educational, scientific, and cultural organization (UNESCO) preface environmental training programs. These are Stockholm declaration (1972), Belgrade declaration (1975), and Tbilisi declaration (1977). Since 1970 many efforts and activities have been made towards environmental training and its resulting problems (Shobeiri & abdollahi, 2011). In 1992, the international conference on "Environment and Development" known as "The Earth Summit" was held in Rio de Janeiro, Brazil. In chapter 36 of the agenda "Promoting education, public awareness, and training towards sustainable development" has been mentioned (UNESCO-UNEP, 1975; UNESCO, 1977; UNCED, 1992; McCrea, 2006; Annette& Long, 2006). In Rio +20 conference improving capacities of education systems to prepare people to pursue sustainable development has been emphasized (United Nations, 2012).

Policy-making in the energy sector of the country consistent with global policies, including new energies, optimization of production, and consumption of energy by notifying act of energy consumption pattern modification with 75 articles has been relegated to the supreme council of energy. The tenth chapter of this act is about clean and renewable energies, and chapter 11 is on training for energy management.

Following international policies in the field of using renewable energy resources, and in order to train towards replacement of renewable energies, some activities including seminars, and training workshops in different countries have been held and the most important activity was a workshop on environmental education based on training renewable energies for children and youths held in Berlin on Sep 2005. The main subjects addressed in this workshop included how to combine renewable energies with lesson topics, reasons for presence and non-presence of lessons in this field within textbooks, how to integrate, and how to coordinate education in this field, how to combine education with decision-making on renewable energies, how to make some networks about renewable energies, and how to consider cultural, linguistic, social, and economic differences during education in this field (Institute for Futures Studies and Technology Assessment,2005).

2. MATERIALS AND METHODS:

Education is one of the most effective means for providing solutions to the problems faced by the society. Renewable energy education, in essence, is the treatment of various topics and issues related to renewable energy resources and technologies as an independent subject. The broad objectives of renewable energy education pertain to providing functional knowledge and understanding of facts, concepts, principles and techniques for harnessing of renewable sources of energy. Therefore, depending upon its level, the role of a renewable energy education program should be educative, informative, investigative and imaginative (Kandpal & Broman, 2005).

Many developed and developing countries

have changed their energy policies to find and develop new, clean, and renewable energy sources. These countries have also been aware of the importance of formal and informal energy and environmental education to make their citizens aware of the problem. Therefore they have been planning to make required changes in their educational programs to integrate some energy and environment-related concepts, units, activities, etc. into their curricula at different levels (Acikgoz, 2011).

The objective of this study is determination and prioritization of useful strategies for training in the field of clean and renewable energies in the Iranian education system. Accordingly, this research is operational regarding objective, and descriptive-analytic in terms of research method. Tools for data collection were questionnaires, and interview with elites. This research has been conducted in two stages:

2-1.First stage: selection of appropriate educational strategies regarding renewable energies

Based on library research, review of theoretical basics, review of literature, and study of available documents and the following actions were taken during this stage:

- The most critical policies associated with renewable energies and training in this field were elicited according to a review of sources and conducted studies in different countries and Iran.
- By using elicited policies and strategies in this field and educational strategies, and integrating these two, strategies were proposed according to educational needs of the country in this field. While developing strategies, opportunities and challenges present in the Iranian education system for training in the field of clean and renewable energies were also considered.
- Number of strategies proposed was initially 80, then by considering opinions of 50 experts in this field, the most essential and comprehensive strategies relevant to training in this field were specified through a Likert scale and 40 educational strategy were selected separately for training in schools (10 cases), higher education (10 cases), informal training (10 cases), and non-formal education (10 cases).
- Opinions of many professors have been used to approve the validity of questionnaire designed. Also, Cronbach's alpha coefficient has been used to obtain reliability of questionnaire which was 0.85. As the value of Cronbach's alpha has been obtained more than 0.7, it is said that questionnaire has necessary reliability in this stage.
- Strategies regarding education about renewable energies separately selected for formal education (schools, and higher education), informal and non-formal education have been illustrated as below:

2-1-1.Chosen strategies regarding education about renewable energies for formal education (schools):

1) Identification, classification, and prioritization of educational needs of students regarding types and specifications of renewable and non-renewable energy resources
2) Developing topics relevant to renewable energies within textbooks
3) Applying appropriate educational patterns to increase the efficiency of training in the field of renewable energies
4) Introducing different training methods in this field to teachers and educators
5) Utilizing proper educational technologies to transfer concepts and procedure of using renewable energy resources to students according to an educational period
6) Providing different information references in schools in the field of renewable energies
7) Allocating convenient credits, and budgets to train renewable energies topic in schools
8) Making training relevant to renewable energies more operational

9) Paving the way for activities of student associations to know about renewable energies
10) Applying new participatory techniques in schools to train in the field of renewable energies

2-1-2. Chosen strategies regarding education about renewable energies for formal education (higher education)

1) Allocating budget and credits to develop research and technologies associated with renewable energies in academic and research centers
2) Increasing faculty members to teach in the field of renewable energies
3) Creating some fields of study in academic courses separately for different resources of renewable energies
4) Establishing relations between universities and decision-making institutions in the field of renewable energies
5) Interaction with the world of sciences and technologies and user experiences of other countries in professional training in the field of renewable energies
6) Increasing access to relevant scientific references in this field
7) Adopting a research-based procedure and supporting student projects about renewable energies
8) Identifying educational needs in the field of various resources for renewable energies in universities and higher education institutions
9) Publishing specialist information sources regarding different resources for renewable energies
10) Developing specific programs to use available capabilities in universities to increase the capacity of applying renewable energies in the country.

2-1-3. Chosen strategies regarding education about renewable energies for informal education (managers and producers in the industry, agriculture, services sectors and consumers)

1) Explaining concepts of using recycled products to reduce material and energy consumptions
2) Identifying all energy resources in the country, and developing an information bank of Iranian renewable energy resources, identifying potential projects
3) Training variety of optimal investment procedures in the field of renewable energies
4) Developing educational programs to know about promotion and development of applying renewable energies
5) Introducing energy efficiency standards, and pollution standards
6) Training in the field of observance of consumption pattern, and optimization of energy consumption
7) Promoting knowledge of managers and administrators through exchanging experiences with other countries in the field of renewable energies
8) Allocating budget and credit to train managers, administrators, producers, and consumers in this field
9) Enhancing research and development in the field of renewable energies to increase competitiveness in energy markets
10) Publication of scientific-technical journals and forming technical committees in relevant ministries in the field of renewable energies

2-1-4. Chosen strategies regarding education about renewable energies for non-formal education

1) Promoting culture for consumption reduction in media by direct and indirect messaging
2) Producing TV and radio programs and introducing clean energy projects in the country, and introducing potential capabilities in this field
3) Review of current status of using these resources in the country, and notifying to increase public knowledge in the press, and other media
4) Introducing families, industries, farmers, etc. which renewable energies supply their total energy consumption.
5) Considering special facilities to advertise industrial products which use renewable energies.
6) Providing primary, and preliminary training through producing TV and radio programs to increase public knowledge

about a variety of energy resources, differences of renewable energy resources, and disadvantages of non-renewable energy resources

7) Selecting and training relevant volunteers with communicative skills to transfer knowledge on clean and renewable energies to all people
8) Publication of general and specialized books and articles in this field
9) Adequate theoretical and practical training based on national and local needs in this field
10) Paving the way for scientific discussion and participation in training renewable energies publicly

2.2. Second stage: prioritize appropriate strategies

In the second stage, a questionnaire of paired comparison introduced by Saaty (Saaty, 1980) intended to prioritize appropriate strategies to train about the application of clean and renewable energies in Iran. Research statistical population consists of 50 persons, including experts, and managers associated with energy.

2-2-1. Fuzzy Preference Programming (FPP)

One of the most well-known methods for multi-criteria decision-making (MCDM) is Analytical Hierarchy Process (AHP). Among the most important specification for this method, the following items could be mentioned:

(1) AHP is the only well-known method in multi-criteria decision-making procedures that measure compatibility of decision-makers' judgments;
(2) AHP allows decision-makers to be able to show key aspects of their problems as a hierarchical structure;
(3) Paired comparisons in AHP are preferred by decision-makers and it will enable them to obtain weights and scores of criteria and options through comparative matrices.

Despite the high reputation, AHP has been criticized because it could not deal with the uncertainty associated with registering decision-makers' perceptions (Yang et al, 2008). To cope with restrictions of traditional AHP approach, Fuzzy AHP was introduced by (Laarhoven and Pedrycz, 1983) to consider inaccurate knowledge and ambiguity in judgments and then developed by other researchers (Chang, 1996; Cheng, 1997; Csutora & Buckley, 2001).

However, one of the fundamental critics of fuzzy AHP methods is that they have not often considered the harmony of opinion. While compatibility in traditional AHP method is essential due to use of fuzzy numbers in fuzzy AHP method, incompatibility is most likely to appear (Leung & Cao, 2000). There are very few studies considered this fact in fuzzy AHP (Salo,1996; Leung & Cao, 2000; Wang & Chen, 2003; Ramík & Korviny, 2010; Rezaei, 2013).

According to Buckley, one positive reciprocal compatible matrix can be defined as below(Buckley, 1985):

Definition1: a positive two-sided fuzzy matrix $\tilde{A}$ $[\tilde{a}_{ij}]$ is compatible if and only if

$\tilde{a}_{ik}$ $\tilde{a}_{kj}$ $\tilde{a}_{ij}$,

$\tilde{A}$ matrix is a two-sided positive fuzzy matrix if and only if a_{ji} a_{ij} and a_{ii} .

Mikhailov used Fuzzy Preference programming (FPP) to obtain preference vector in fuzzy AHP (Mikhailov, 2003). His proposed procedure not only maintains an intensity of preferences but also provides an interpretable compatibility index. Although his recommended procedure removes most of the defects in previous studies in the field of Fuzzy AHP, it has not considered asymmetry and non-linearity of reverse fuzzy numbers, and as a result, Rezayi et al. offered a method to improve Mikhailov procedure that will be discussed later (Rezaei, 2013).

Here, first of all, Mikhailov procedure is discussed and then improved the method (Wang et al, 2007) is considered.

The first step constitutes hierarchy; in this step, the objective is to create a hierarchy that north of objectives includes criteria and decision-making options.

The second step is the determination of paired comparison matrices; this step includes creating paired comparison matrices to compare criteria and options.

In this matrix $\tilde{a}_{ij}$ is a Triangular fuzzy number (TFN) which shows the opinion of the Decision Maker (DM) about preferring i to j and $\tilde{a}_{ji} = 1/\tilde{a}_{ij}$

Here in this part we describe TFN and its functional rules:

$$\tilde{A} = \begin{bmatrix} \tilde{a}_{11} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & \tilde{a}_{22} & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{a}_{nn} \end{bmatrix} \quad (1)$$

Definition2. Triangular Fuzzy Number (TFN): a fuzzy number N / R is a TFN, if its membership function is defined as $\mu_N(x) : \Re \to [0,1]$

$$\mu_N(x) = \begin{cases} \frac{x-l}{m-l}, & l \le x \le m, \\ \frac{u-x}{u-m}, & m \le x \le u, \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

In which l and u are lower and upper limit values of number N, and m is the medium value. This triangular fuzzy number could be given by (l, m, u). In this research, fuzzy triangular numbers shown in figure 1 have been used for paired comparisons.

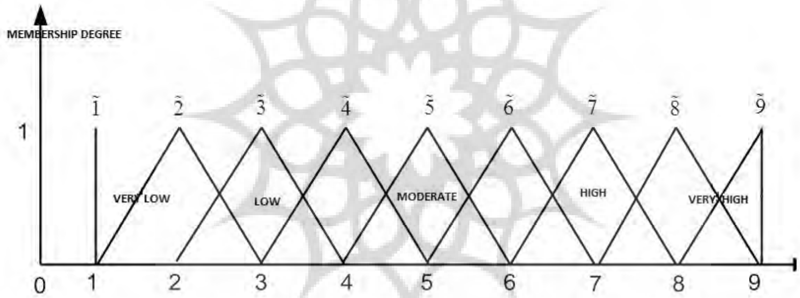

Fig. 2. Used fuzzy numbers in this research

Operational rules for fuzzy triangular numbers for two numbers (l_1, m_1, u_1) and (l_2, m_2, u_2) are as follows ($\oplus$ is a fuzzy aggregate symbol):

$$N_1 \oplus N_2 = (l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \quad (3)$$

Fuzzy multiplier operator is $\otimes$:

$$N_1 \otimes N_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = (l_1 \otimes l_2, m_1 \otimes m_2, u_1 \otimes u_2) \quad (4)$$

Of course, it is so while all numbers of l_i, m_i, u_i are positive real numbers.

The fuzzy division is ($\diagup$):

$$N_1 (\diagup) N_2 = (l_1, m_1, u_1) (\diagup) (l_2, m_2, u_2) = \left(l_1/u_2, m_1/m_2, u_1/l_2 \right) \quad (5)$$

$$N_1 \otimes N_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = (l_1 \otimes l_2, m_1 \otimes m_2, u_1 \otimes u_2)$$

$$\tilde{a}_{ij} \ i \quad ,\dots, n-1, j = 2,3,\dots,n, j > i \quad (6)$$

It is enough for decision-maker to make maximum $n(n-1)/2$ comparisons.

Third step: find absolute weights of criteria by using fuzzy prioritization programming (FPP). In this step, the objective is the determination of relative weight for criteria (

$w = (w_1, w_2, ..., w_n)^T$) that w_i / w_j ratio should be almost in range of paired judgment a_{ij} and/or equal to it:

$$l_{ij} \tilde{\le} \frac{w_i}{w_j} \tilde{\le} u_{ij} \tag{7}$$

For each of I and j criteria, there will be many w_i and w_j that will be met the above relationship. Mark $\tilde{\le}$ means less than or equal to fuzzy. However, w_i / w_j ratios provide different satisfaction levels for decision-maker that may be measured by a membership function:

$$\mu_{ij}\left(\frac{w_i}{w_j}\right) = \begin{cases} \dfrac{\frac{w_i}{w_j} - l_{ij}}{m_{ij} - l_{ij}}, & \frac{w_i}{w_j} \le m_{ij}, \\ \dfrac{u_{ij} - \frac{w_i}{w_j}}{u_{ij} - m_{ij}}, & \frac{w_i}{w_j} \ge m_{ij}, \end{cases} \tag{8}$$

Since a_{ij} judgments are inaccurate, $l_i < m_i < u_i$ and as a result, zero judgment will never be found. The above membership function takes the following values:

$$\mu_{ij}\left(\frac{w_i}{w_j}\right) \in (-\infty, 0),$$

$$if \ \frac{w_i}{w_j} < l_{ij} \ \ or \ \ \frac{w_i}{w_j} > u_{ij} \tag{9}$$

$$\mu_{ij}\left(\frac{w_i}{w_j}\right) \in (0,1), \ if \ \ l_{ij} \le \frac{w_i}{w_j} \le u_{ij}$$

When $\frac{w_i}{wj} = m_{ij}$, membership function takes the maximum value of 1.

The aim of FPP is finding optimized values for absolute weights. Considering the rule of Bellman and Zadeh, FPP becomes a non-linear programming problem as follows:

$$\begin{aligned} & \max \lambda \\ & s.t. \\ & (m_{ij} - l_{ij}).\lambda w_j - w_i + l_{ij} w_j \le 0, \\ & (u_{ij} - m_{ij}).\lambda w_j - w_i - u_{ij} w_j \le 0, \\ & \sum_{k=1}^{n} w_k = 1, w_k > 0, \\ & i = 1, 2, ..., n-1, j = 2, 3, ..., n, \\ & j > i, k = 1, ..., n. \end{aligned} \tag{10}$$

Mikhailov has claimed that optimal weights of criteria (w^*(and λ^* are found by solving the above problem. Although Rezaei et al. have demonstrated that the above programming problem does not consider asymmetry and non-linearity of reverse fuzzy numbers (Rezaei et al.2013), a slight improvement is required to be made on this model. In the description of his membership function, Mikhailov has shown that in range (l_{ij}, u_{ij}), the stated membership function matches fuzzy numbers a_{ij} $(l_{ij}\ m_{ij}, u_{ij})$. (Mikhailov, 2003)

To obtain optimal weights in the method proposed by Wang et al., the following fuzzy preference mathematical programming is used (Wang et al. 2007):

(11)

$$\text{Min } J(w_1, w_2, \ldots, w_n) = \min \sum_{i=1}^{n}\sum_{j=1}^{n}\left[m_{ij}\left(\frac{w_i}{w_j}\right)\right] = \min \sum_{i=1}^{n}\sum_{j=1}^{n}\left[\begin{array}{l} \delta\left(m_{ij} - \frac{w_i}{w_j}\right)\left(\frac{m_{ij} - \left(w_i/w_j\right)}{m_{ij} - l_{ij}}\right)^P \\ +\delta\left(\frac{w_i}{w_j} - m_{ij}\right)\left(\frac{\left(w_i/w_j\right) - m_{ij}}{u_{ij} - m_{ij}}\right)^P \end{array}\right]$$

Subject to :

$$\sum_{k=1}^{n} w_k = 1$$

, $w_k > 0$, k=1,2,…,n.

Where $i \neq j$,P ϵ N , and

$$\delta(x) = \begin{cases} 0 & , x < 0 \\ 1 & , x \ge 0 \end{cases}$$

Exponent index p is a constant value and is selected by decision-makers in a specific multi-criteria decision-making problem. It is usually suggested that p-value is considered equal to 10. Function $J(w_1, w_2 \ldots w_n)$ is a non-distinguishable function. A significant advantage for proposed preference programming is that it could solve incomplete paired comparison tables, i.e. even if some paired comparison matrix cells remain empty, proposed mathematical programming will offer valid answers based on the other cells of the matrix. To measure compatibility level of paired comparison matrix, after optimal weight vector $(w^*_1, w^*_2, \ldots, w^*_n)$ obtained, a gamma index is calculated as follows:

$$\gamma = \exp\left\{ -\max_{ij}\left\{ \mu_{ij}\left(\frac{w_i^*}{w_j^*}\right) \middle| i,\ j = 1,2,\ldots,n,\ i \neq j \right\}\right\}, \quad (12)$$

Gamma value (γ) is always between 0 and 1. If its value is more than $e^{-1}=0.3679$, it meets all paired comparison opinions of restriction number 7, and relevant paired comparison matrix has excellent compatibility. If $\gamma = 1$, it shows that paired comparisons matrix is entirely compatible. In general, the more value of γ, the more compatible opinions will be.

Therefore, a general algorithm used for optimization of the conventional convex function is not applicable for this optimization problem. For this purpose, genetic algorithms with many capabilities have been selected to solve complex optimization problems with discrete target function.

3. RESULTS:

Paired comparison questionnaire introduced by Saaty (Saaty, 1980) has been completed. 4 aggregation fuzzy opinion matrices obtained by using geometric mean of elites' opinions, in order to prioritize appropriate strategies to train in the field of renewable energies are for formal education in schools, higher education, informal training, and non- formal education are respectively as follows.

Table1. Fuzzy aggregation matrix for optimization of the appropriate strategies to train in the field of renewable energies in schools

	1			2			3			4			5			6			7			8			9			10		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
1	1.00	1.00	1.00	0.82	1.05	1.41	0.87	1.21	1.79	0.86	1.04	1.28	1.07	1.42	1.78	1.52	2.24	3.05	1.18	1.57	2.07	0.94	1.16	1.43	2.09	2.89	3.70	2.22	2.93	3.53
2	0.71	0.95	1.22	1.00	1.00	1.00	1.00	2.00	3.00	2.00	3.00	4.00	0.91	1.10	1.31	1.28	1.92	2.71	1.20	1.59	1.93	0.83	1.15	1.51	1.63	2.14	2.66	1.47	2.28	3.06
3	0.56	0.83	1.15	0.71	0.84	0.97	1.00	1.00	1.00	2.00	3.00	4.00	0.79	1.08	1.47	1.17	1.60	1.99	0.87	1.27	1.79	0.67	0.98	1.36	1.41	1.74	2.22	1.25	1.81	2.43
4	0.78	0.96	1.16	0.77	0.92	1.16	0.83	1.10	1.49	1.00	1.00	1.00	1.00	1.39	1.82	1.21	1.83	2.39	1.34	1.69	2.08	0.90	1.12	1.43	2.05	2.89	3.72	1.96	2.90	3.75
5	0.56	0.70	0.93	0.76	0.91	1.10	0.68	0.92	1.27	0.55	0.72	1.00	1.00	1.00	1.00	0.87	1.36	1.90	0.76	1.04	1.40	0.78	0.99	1.31	2.00	2.75	3.54	1.84	2.98	4.05
6	0.33	0.45	0.66	0.37	0.52	0.78	0.50	0.63	0.85	0.42	0.55	0.83	0.53	0.74	1.15	1.00	1.00	1.00	0.58	0.88	1.26	0.58	0.74	0.99	1.10	1.73	2.50	1.32	1.93	2.58
7	0.48	0.64	0.85	0.52	0.63	0.84	0.56	0.79	1.15	0.48	0.59	0.75	0.71	0.96	1.32	0.79	1.14	1.71	1.00	1.00	1.00	0.70	0.94	1.22	1.54	1.98	2.35	1.64	2.31	2.84
8	0.70	0.86	1.06	0.66	0.87	1.21	0.74	1.02	1.49	0.70	0.89	1.11	0.76	1.01	1.28	1.01	1.36	1.72	0.82	1.06	1.42	1.00	1.00	1.00	1.53	2.10	2.65	1.54	2.35	3.05
9	0.87	1.27	1.79	0.38	0.47	0.61	0.45	0.57	0.71	0.27	0.35	0.49	0.28	0.36	0.50	0.40	0.58	0.91	0.43	0.50	0.65	0.38	0.48	0.65	1.00	1.00	1.00	0.98	1.47	2.07
10	1.63	2.14	2.66	0.33	0.44	0.68	0.41	0.55	0.80	0.27	0.35	0.51	0.25	0.34	0.54	0.39	0.52	0.76	0.35	0.43	0.61	0.33	0.43	0.65	0.48	0.68	1.03	1.00	1.00	1.00

Table 2. Fuzzy aggregation matrix for optimization of the appropriate strategies to train in the field of renewable energies in higher education

	1			2			3			4			5			6			7			8			9			10		
	l	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**U**	**l**	**m**	**u**	**l**	**m**	**u**
1	1.00	1.00	1.00	0.97	1.18	1.37	0.58	0.82	1.13	0.67	1.02	1.47	0.86	1.28	1.78	1.23	1.51	1.71	0.92	1.18	1.58	0.92	1.07	1.33	0.85	1.03	1.37	1.53	2.14	2.79
2	0.73	0.85	1.03	1.00	1.00	1.00	1.00	2.00	3.00	2.00	3.00	4.00	0.67	1.07	1.66	1.00	1.41	1.82	0.90	1.11	1.39	0.65	0.90	1.31	0.75	0.97	1.37	1.64	1.96	2.26
3	0.89	1.22	1.71	1.03	1.43	1.93	1.00	1.00	1.00	2.00	3.00	4.00	1.12	1.41	1.63	1.47	2.07	2.58	1.61	2.05	2.41	0.96	1.45	2.06	1.23	1.43	1.73	1.64	2.29	2.80
4	0.68	0.98	1.49	0.84	1.22	1.71	0.71	0.81	0.96	1.00	1.00	1.00	1.12	1.37	1.61	1.32	1.58	1.78	0.94	1.31	1.80	0.90	1.09	1.38	0.99	1.27	1.69	1.46	2.09	2.88
5	0.56	0.78	1.16	0.60	0.93	1.49	0.61	0.71	0.90	0.62	0.73	0.90	1.00	1.00	1.00	0.92	1.34	1.83	0.64	0.97	1.53	0.60	0.87	1.34	0.72	0.97	1.37	1.15	1.55	2.06
6	0.58	0.66	0.81	0.55	0.71	1.00	0.39	0.48	0.68	0.56	0.63	0.76	0.55	0.75	1.08	1.00	1.00	1.00	0.68	0.81	1.00	0.49	0.71	1.12	0.54	0.76	1.20	0.99	1.49	2.11
7	0.63	0.85	1.08	0.72	0.90	1.12	0.41	0.49	0.62	0.56	0.76	1.06	0.65	1.03	1.55	1.00	1.23	1.46	1.00	1.00	1.00	0.72	0.87	1.12	0.70	0.90	1.16	1.25	1.66	2.12
8	0.75	0.93	1.09	0.76	1.12	1.53	0.49	0.69	1.04	0.72	0.92	1.12	0.75	1.15	1.66	0.90	1.41	2.03	0.90	1.15	1.39	1.00	1.00	1.00	0.72	1.00	1.39	1.48	1.88	2.26
9	1.61	2.05	2.41	0.73	1.03	1.34	0.58	0.70	0.81	0.59	0.79	1.01	0.73	1.03	1.39	0.84	1.32	1.86	0.86	1.12	1.43	0.72	1.00	1.39	1.00	1.00	1.00	1.16	1.72	2.35
10	0.75	0.97	1.37	0.44	0.51	0.61	0.36	0.44	0.61	0.35	0.48	0.69	0.49	0.65	0.87	0.47	0.67	1.01	0.47	0.60	0.80	0.44	0.53	0.67	0.43	0.58	0.86	1.00	1.00	1.00

Table 3. Fuzzy aggregation matrix for optimization of the appropriate strategies to train in the field of renewable energies in informal training

	1			2			3			4			5			6			7			8			9			10		
	l	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**l**	**m**	**u**	**L**	**m**	**u**	**l**	**m**	**u**	**l**
1	1.00	1.00	1.00	0.67	0.93	1.34	0.70	0.87	1.15	0.55	0.66	0.87	0.59	0.85	1.16	0.61	0.76	1.02	0.77	1.02	1.43	0.50	0.63	0.90	0.58	0.71	0.97	0.78	1.14	1.59
2	0.75	1.07	1.49	1.00	1.00	1.00	1.00	2.00	3.00	2.00	3.00	4.00	0.85	1.05	1.28	0.53	0.73	1.04	0.83	1.25	1.83	0.55	0.75	1.14	0.80	0.93	1.17	0.84	1.30	1.86
3	0.87	1.15	1.43	0.84	1.10	1.37	1.00	1.00	1.00	2.00	3.00	4.00	0.82	1.04	1.28	0.61	0.81	1.01	0.99	1.32	1.69	0.65	0.90	1.25	0.70	0.84	1.10	0.96	1.37	1.88
4	1.15	1.51	1.83	0.80	1.28	1.91	0.84	1.05	1.34	1.00	1.00	1.00	0.89	1.06	1.37	0.67	0.87	1.20	1.00	1.37	1.80	0.68	0.93	1.25	0.74	1.03	1.37	1.15	1.45	1.76
5	0.86	1.17	1.68	0.78	0.96	1.18	0.78	0.96	1.22	0.73	0.94	1.13	1.00	1.00	1.00	0.57	0.79	1.08	0.83	1.18	1.64	0.59	0.84	1.16	0.76	0.99	1.34	1.05	1.40	1.69
6	0.98	1.31	1.64	0.96	1.37	1.88	0.99	1.24	1.64	0.84	1.15	1.49	0.92	1.27	1.76	1.00	1.00	1.00	0.86	1.28	1.78	0.82	1.12	1.51	0.83	1.10	1.51	1.41	2.01	2.52
7	0.70	0.98	1.30	0.55	0.80	1.21	0.59	0.76	1.01	0.56	0.73	1.00	0.61	0.84	1.21	0.56	0.78	1.16	1.00	1.00	1.00	0.60	0.74	0.97	0.61	0.80	1.08	0.83	1.25	1.83
8	1.12	1.58	2.01	0.88	1.34	1.83	0.80	1.12	1.53	0.80	1.07	1.46	0.86	1.20	1.68	0.66	0.90	1.22	1.03	1.35	1.66	1.00	1.00	1.00	0.96	1.25	1.58	1.27	1.55	1.93
9	0.99	1.32	1.69	0.85	1.07	1.25	0.91	1.20	1.43	0.73	0.97	1.35	0.75	1.01	1.32	0.66	0.91	1.21	0.92	1.25	1.64	0.63	0.80	1.04	1.00	1.00	1.00	1.00	1.37	1.90
10	0.80	0.93	1.17	0.54	0.77	1.20	0.53	0.73	1.04	0.57	0.69	0.87	0.59	0.71	0.95	0.40	0.50	0.71	0.55	0.80	1.21	0.52	0.64	0.79	0.53	0.73	0.00	1.00	1.00	1.00

Table 4. Fuzzy aggregation matrix for optimization of the appropriate strategies to train in the field of renewable energies in non-formal education

	1			2			3			4			5			6			7			8			9			10		
l	M	u	l	M	u	l	m	u	l	l	m	u	l	m	u	l	m	u	l	l	m	u	l	M	u	l	m	u	l	l
1	1.00	1.00	1.00	1.20	1.58	1.88	0.90	1.28	1.69	1.87	2.83	3.65	1.22	1.73	2.48	0.87	1.18	1.60	1.30	1.68	2.17	1.55	2.31	3.13	0.94	1.31	1.69	1.52	1.86	2.22
2	0.53	0.63	0.84	1.00	1.00	1.00	1.00	2.00	3.00	2.00	3.00	4.00	0.79	1.14	1.71	0.56	0.73	1.04	0.81	1.19	1.76	1.10	1.49	1.89	0.60	0.83	1.20	0.92	1.22	1.64
3	0.59	0.78	1.12	0.70	0.96	1.37	1.00	1.00	1.00	2.00	3.00	4.00	0.84	1.15	1.57	0.50	0.68	1.00	0.81	1.05	1.38	1.15	1.66	2.07	0.63	0.73	0.93	0.83	1.25	1.83
4	0.27	0.35	0.54	0.44	0.57	0.79	0.45	0.54	0.71	1.00	1.00	1.00	0.49	0.64	0.88	0.33	0.43	0.58	0.57	0.74	0.98	0.74	1.00	1.28	0.36	0.47	0.73	0.55	0.71	1.00
5	0.40	0.58	0.82	0.58	0.88	1.26	0.64	0.87	1.20	1.14	1.55	2.05	1.00	1.00	1.00	0.49	0.61	0.79	0.99	1.23	1.62	0.90	1.47	2.24	0.61	0.75	1.02	0.66	0.95	1.33
6	0.62	0.85	1.15	0.96	1.37	1.78	1.00	1.47	2.01	1.72	2.33	3.00	1.27	1.63	2.02	1.00	1.00	1.00	1.35	1.61	1.81	0.52	2.50	3.33	0.91	1.20	1.51	1.53	1.99	2.36
7	0.46	0.59	0.77	0.57	0.84	1.24	0.72	0.95	1.23	1.02	1.34	1.75	0.62	0.81	1.01	0.55	0.62	0.74	1.00	1.00	1.00	0.92	1.31	1.83	0.53	0.67	0.88	0.69	0.96	1.37
8	0.32	0.43	0.65	0.53	0.67	0.91	0.48	0.60	0.87	0.78	1.00	1.35	0.45	0.68	1.12	0.30	0.40	1.91	0.55	0.76	1.08	1.00	1.00	1.00	0.42	0.53	0.70	0.57	0.76	1.07
9	0.81	1.05	1.38	0.84	1.21	1.66	1.07	1.37	1.60	1.37	2.11	2.76	0.98	1.34	1.64	0.66	0.84	1.10	1.14	1.49	1.89	1.43	1.89	2.39	1.00	1.00	1.00	0.96	1.34	1.76
10	0.60	0.83	1.20	0.61	0.82	1.08	0.55	0.80	1.21	1.00	1.41	1.82	0.75	1.05	1.52	0.42	0.50	0.65	0.73	1.04	1.45	0.93	1.32	1.75	0.57	0.75	1.04	1.00	1.00	1.00

Table5. Results of fuzzy preference programming in software MATLAB 2010

	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	F	γ_i*
Formal education-schools	0.122	0.110	0.100	0.119	0.096	0.112	0.104	0.093	0.060	0.081	78575.0	0.406
Formal education- in higher education	0.101	0.120	0.124	0.099	0.071	0.088	0.096	0.122	0.100	0.078	14279.1	0.48
Informal education	0.078	0.124	0.114	0.085	0.097	0.123	0.089	0.108	0.107	0.073	334.3	0.540
Non-formal education	0.139	0.109	0.106	0.051	0.092	0.143	0.083	0.063	0.127	0.087	2.6	0.660

As it is considered, for instance among matrix criteria for formal education in schools, the first criterion takes the most relative weight and as a result, it is in the priority. F represents the value of target function. Also, the less value F takes, the more indicative of opinions or judgments compatibility it is.

γ represents the harmony of paired comparisons. As it is evident from the table, all tables have convenient compatibility ($0.3679>\gamma_i$).

Prioritization of 40 strategies for training renewable energies in the educational system of Iran is presented in the following regarding formal education at schools, formal education at universities, informal education and non-formal education.

Table 6. prioritization of appropriate strategies for training renewable energies at schools

Priority	Score	appropriate strategies
1	0.122	Identification, classification, and prioritization of educational needs of students regarding types and specifications of renewable and non-renewable energy resources
2	0.119	Introducing different training methods in this field to teachers, and educators
3	0.112	Providing different information references in schools in this field

4	0.110	Developing topics relevant to renewable energies within textbooks
5	0.104	Allocating convenient credits, and budgets to train renewable energies topic in schools
6	0.100	Applying appropriate educational patterns to increase the efficiency of training in the field of renewable energies
7	0.096	Applying proper educational technologies to transfer concepts and procedure of using renewable energy resources to students according to the educational period
8	0.093	Making training relevant to renewable energies operational
9	0.081	Applying new participatory techniques in schools to train in this field
10	0.06	Paving the way for activities of student associations to know about renewable energies

Table 7. prioritization of appropriate strategies for training renewable energies In Higher Education

Priority	**Score**	**appropriate strategies**
1	0.124	Creating some fields of study in academic courses separately for different resources of renewable energies
2	0.122	Identifying educational needs in the field of different resources for renewable energies in universities and higher education institutions
3	0.120	Increasing faculty members to teach in this field
4	0.101	Allocating Budget and credits to develop researches and technologies associated with renewable energies in academic and research centers
5	0.1	Publishing specialist information sources regarding different resources for renewable energies
6	0.099	Establishing relations between universities and decision-making institutions in this field
7	0.096	Adopting a research-based procedure and supporting student projects about renewable energies
8	0.088	Increasing access to relevant scientific references in this field
9	0.078	Developing specific programs to use available capabilities in universities in order to increase the capacity of applying renewable energies in the country
10	0.071	Interaction with the world of sciences and technologies and user experiences of other countries in professional training in this field

Table 8. prioritization of appropriate strategies for training renewable energies In informal education: Managers, Industrial, Agricultural and service Manufacturers, and Consumers

Priority	**Score**	**appropriate strategies**
1	0.124	Identifying all energy resources in the country, and developing an information bank of Iranian renewable energy resources, identifying potentials, and potential projects
2	0.123	Training in the field of observance of consumption pattern, and optimization of energy consumption
3	0.114	Training variety of optimal investment procedures in this field
4	0.108	Allocating budget and credit to train managers, administrators, producers, and consumers in this field
5	0.107	Enhancing research and development in the field of renewable energies to increase competitiveness in energy markets
6	0.097	Introducing energy efficiency standards, and pollution standards
7	0.089	Promoting knowledge of managers and administrators through exchanging experiences with other countries in this field
8	0.085	Developing educational programs to know about promotion and development of applying renewable energies
9	0.078	Explaining applied concepts of using recycled products to reduce material and energy consumptions
10	0.073	Publication of scientific-technical journals and forming technical committees in relevant ministries in this field

Table 9. prioritization of appropriate strategies for training renewable energies In non- formal education

Priority	Score	appropriate strategies
1	0.143	Providing primary, and preliminary training through producing TV and radio programs to increase public knowledge about a variety of energy resources, differences of renewable energy resources, and disadvantages of non-renewable energy resources
2	0.139	Promoting culture for consumption reduction in media by direct and indirect messaging
3	0.127	Adequate theoretical and practical training based on national and local needs in this field
4	0.109	Producing TV and radio programs and introducing clean energy projects in the country, and introducing potential capabilities in this field
5	0.106	Review of current status of using these resources in the country, and notifying to increase public knowledge in the press, and other media
6	0.092	Considering special facilities to advertise industrial products which use renewable energies.
7	0.087	Paving the way for scientific discussion and participation in training renewable energies publicly
8	0.083	Selecting and training relevant volunteers with communicative skills to transfer knowledge on clean and renewable energies to all people
9	0.063	Publication of general and specialized books and articles in this field
10	0.051	Introducing families, industries, farmers, etc. which renewable energies supply their total energy consumption.

4. DISCUSSION AND CONCLUSION

The present study mainly aims to determine appropriate strategies for performing relevant educational programs to promote the level of awareness and knowledge among different people of society to replace non-renewable energy resources with renewable energy resources as well as to prioritize these strategies for use in the educational system of Iran in terms of formal, informal and non-formal education. It should be noted that the review of the research background indicates that despite numerous studies in countries to formulate appropriate policies and strategies in the field of renewable energies, there is no comprehensive study to develop and separate the strategy in the field of training renewable energies into various educational groups and prioritize these strategies in Iran and the world.

This study was conducted in two stages to suggest and prioritize appropriate strategies. In the first stage, the most important policies of different countries and Iran regarding the application of renewable energies and education in this field were extracted based on the review of resources and literature. Then 80 strategies proportionate to Iran's educational needs in the field of training renewable energies were suggested the most important and comprehensive of which were determined using the comments of 50 specialists in this field through a questionnaire based on Likert scale. Among these strategies, 40 Strategies were selected for training renewable energies at schools (10 cases), Higher Education (10 cases), informal education (10 cases), and non- formal education teaching (10 cases). The comments of several professors in this field have been used to confirm the validity of the questionnaire designed. Besides, Cronbach's alpha coefficient was used to assess the reliability of the questionnaire and its value was obtained as 0.85.

In the second stage, another questionnaire including pairwise comparison tables of strategies for training renewable energies in the educational system of Iran was prepared based on the results of the experts' comments and data resulting from it was used to rank the strategies using fuzzy preference programming (FPP) method in MATLAB software. All fuzzy group decision-making matrices are suitably adapted for each of the four educational groups ($\gamma i > 0.3679$).

In this study, essential strategies were identified and prioritized to train renewable energies in the educational system of Iran in four groups of schools, higher education, informal education and non- formal education. It is clear that strategic management process does not end with the formulation of strategies and later on strategy need to be implemented. Considering the ranking results obtained from the present study, education and energy officials of Iran can focus on higher-priority strategies and organize the required managerial actions and decisions to achieve more efficiency in time, budget, human resource planning and etc., since there may be situations where their simultaneous implementation is not possible. For example, at the initial stage, three strategies with the highest priority in each of the four mentioned training areas could be used for implementation.

It is necessary to develop practical, more accurate and more detailed techniques for implementing the strategies in functional levels through formulating an action plan and executive planning process regarding educational groups, as well as to assess and monitor various stages of the strategy implemented to determine their strengths and weaknesses.

Some of the essential steps for implementing strategies after strategy prioritizing are as follows:

- Determining Operational Objectives: Detailed measures for implementing educational strategies should be defined regarding each part of the educational system through operational planning. These planning can be described in annual and five-year periods. This type of plan is discussed in executive management level and is concerned with clear, limited and objective goals.
- Appropriate allocation of resources: it is necessary to allocate proper facilities of financial resources, physical resources such as required facilities, human resources and IT resources to different groups.
- Determining required measures to mitigate the deficiencies in policy implementation
- Restructuring and reengineering
- Creating incentive programs
- Reducing resistance to change in the policy implementation process
- Adapting managers and decision-makers with strategies
- Reinforcing a culture supporting the strategy
- Adapting strategy formulation and strategy implementation processes
- Assessing and monitoring the efficacy of strategy in the educational system and its active role in promoting and ensuring the quality of training process of renewable energies.

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