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Assessing the renewable energy producers' environment in EU accession member states

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Abstract

One of the most important elements of renewable energy sources development in the accession member states of the European Union (EU) is the enhancement of the related producers. However, the success of the stated energy companies is based on the formulation of an up to date operational environment in each member state. Indeed, the dynamic environment of renewable energy producers in the EU accession member states is less mature than the environment of the 15 EU member states and is still developing due to the lower social acceptance and public awareness, the fact that the Kyoto Protocol is not a top priority yet as well as the absence of appropriate financial resources. The main aim of this paper is to present an integrated approach of qualitative judgments for assessing the renewable energy producers' operational environment of the fourteen (14) different member states of the EU accession. The current approach, which is based on a multi-criteria decision making methodology of quantifying multiple qualitative judgments, takes into account the many opportunities and threats that the energy market's "new parameters" involve, namely the continuously growing tendency to deregulate the energy market and the climate change.

Keywords: Renewable energy producers; Accession member states; Decision making

1. Introduction

Nowadays, the European Commission (EC) aims to facilitate the exchange of knowledge and experience between the 15 European Union (EU) member states and the accession countries in enhancing renewable energy sources (RES) development. The accession member states group of countries comprises the 10 member states (Cyprus-CY, Czech Republic-CZ, Estonia-EE, Hungary-HU, Lithuania-LT, Latvia-LV, Malta-MT, Poland-PL, Slovenia-SL, Slovakia-SK) that joined the European Union (EU) in 2004, Bulgaria-BG and Romania-RO that are going to join the European Union in 2007 as well as Turkey-TR and Croatia-HR that have recently started negotiations with the EC.

Indeed, there is a significant potential for RES development in the above-mentioned states [1]. Therefore, the expectations for a major increase in RES contribution to the primary energy supply are high. The ultimate goal is to reach 26% in the year 2030 [2], from 10% in the year 2003 [1] in the overall EU.

One of the most important elements of RES development is the enhancement of the related producers that are either companies, which may derive from utilities that produce energy from conventional sources and have decided to activate in the field of RES, independent power producers (IPPs), or companies already engaged in the construction and trade of renewable energy technical equipment, which have decided to enter the market as IPPs.

These companies should play an important part in the world energy evolution and, apart from traditional solutions, they should foster a series of innovations in the market. Furthermore, liberalization of the energy markets,

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technological progress and the always increasing need of meeting energy demand in combination with the non-stop crude oil price increases have had a decisive influence on the development of the above-mentioned companies. Moreover, apart from economical profit, these companies have the opportunity, in combination with deterioration of the climate, to exculpate electricity production in the eyes of the public.

The success of the stated energy companies is based on the formulation of an up to date environment in each member state of the EU. However, the environment of the EU accession member states is less mature than the environment of the 15 EU member states, and it is still under formation due to several reasons such as the lower social acceptance and public awareness, the fact that the Kyoto Protocol is not a top priority yet as well as the absence of appropriate national financial sources.

According to the survey of international literature [3,4], the purpose of multi-criteria decision making (MCDM) methods is to correlate efficiently the various characteristics of any given problem and, as a result, to demonstrate the best possible solution to this problem. In this context, each member state needs to formulate an up to date market environment, which must be enhanced in order to give opportunity to more companies in the accession member states to activate properly. However, the environment of renewable energy producers is complicated and influenced by several parameters that are not always related to each other. With respect to the above, the use of MCDM approaches can help energy actors to evaluate the companies' environment. These methods can be very useful for each state, which is the "decision maker" of defining importance, shaping the environment of the energy companies' operation.

With regard to the EU accession member states, Bechberger in 2003 [5] and Patlitzianas et al. in 2004 [6] presented general renewable energy overviews of the candidate countries. In 2005, Streimikiene [7] described RES development in the Baltic States and Reiche [8] presented an investigation of the driving forces for a further proliferation of renewable energies in the accession states in 2006. The aforementioned papers tackle some crucial issues related to the companies' environment in a sporadic and not in a systematic way. In addition, these papers do not take into consideration the recent developments regarding the EC's accession negotiations with Turkey and Croatia. Based on the international literature, there are no papers investigating the operational environment of RES producers.

In the above framework, the main aim of this paper is to present an integrated approach of qualitative judgments for assessing the environment of renewable energy producers in the fourteen (14) different member states of the EU accession.

The paper is structured in three sections. Apart from Section 1, Section 2 provides a description of the adopted approach for assessing the renewable energy producers' operational environment in the EU accession member states and describes the choice of criteria, the choice of available MCDM method and the application of the approach. Section 3 presents the conclusions, which summarizes the main points that have been produced in this paper and outlines the perspectives for the development of the energy companies' environment in the region.

2. The approach

2.1. The choice of criteria

Taking into consideration the literature that is related to the operational environment of the companies and its correlated strategy [9–11], it can be described through four dimensions. In particular, the dimensions (D_i) of the environment were selected as political/legal, financial, social/cultural and technological ($i = 1, 2, 3$ and 4).

For each dimension, six qualitative criteria were chosen that can assess the dynamics of the environment in which these companies activate. These criteria refer both to the suitability of the existing activation environment for each dimension and to the influence of the current energy market parameters in the activation field of these companies.

Initially, the choice of the appropriate criteria for the energy companies' operational environment took into consideration the developments, the needs and the given experience of the 15 EU countries. In particular, based on an analytical literature review, the characteristics of the renewable energy producers' environment for each one of the aforementioned four dimensions in the 15 EU countries are briefly described in the following paragraphs:

D_1 – *political/legal environment*: The EC and literally all member states have set up ambitious capacity installation targets and have developed various policy instruments [12–15]. As a result, the EC has formulated the Community's aim to cover 21% of electricity consumption in 2010 by RES [16]. This overall goal has subsequently been split into indicative targets for the EU member states [17]. More precisely, a number of legal and regulatory measures were taken in the last years to remove existing administrative barriers and to provide a better framework for companies to activate in Finland [18] and Denmark [19]. The fully competitive German market [20] obliges suppliers to purchase all electricity produced by RES at a fixed tariff [21]. The competition forces newly entering companies to offer both high quality services and low end user prices in the United Kingdom [22]. France's electricity market has recently entered a phase of intensive reform. Consequently, the promotion of competition resulted in the entry of more than 50 companies [21]. The Italian government has started reforming the internal energy market. Efforts now focus on clarifying the legal framework, adopting more environmental policies and giving assurances to producers [23]. The consistent "green" policy of the Dutch government (introduction of a "green certificate") along with the liberalization of the energy market has created an environment that appears to be rather attractive for a producer to activate [24]. On the other hand, a possible activation of a producer has some uncertainties concerning mostly the quantity of electricity produced by RES that will be purchased in Spain [21]. Furthermore, the main obstacle for companies in Spain is the high level of concentration in the internal market, which approaches 82% for the 3 biggest companies [20,21].

D_2 – *financial environment*: The development of these companies is based, in some cases, on the existence of financial resources. In particular, Germany has the maximum installed wind capacity in the whole EU [25] due to its wind potential and appropriate financial support. Sweden's support in electricity production mainly focuses upon large hydropower plants with RES contribution only to a small percent in the total electricity production [26]. The high RES potential has induced the government to support all forms of RES electricity production in Spain [21]. The French government has tried to support independent production from RES by offering a secure market to producers for the next 15 years [16]. The support for wind energy is slightly left behind because of the absence of relevant natural resources in Finland [27] and Austria [21].

D_3 – *social/cultural environment*: The proliferation of RES producers is directly related to the social acceptance of such sources. Therefore, public awareness is of crucial importance for fostering development of the social environment of these companies in the EU. The EC gives extra focus on supportive actions for enhancement of employees' knowledge regarding RES. As a result, it is a main priority of the member states [28]. For instance, the already developed market of RES producers in Denmark, after its liberalization in 2000, evolved through a number of reformatory stages. In particular, the government promotes education of the producers' employees in an effort not only to enhance the current status but also to establish the future infrastructures for a safe passage to cleaner technologies [21]. In the Austrian energy market, a number of public investments were used for education purposes as well as for the support of the personnel capabilities of these companies and the enhancement of public awareness [21]. Similarly, RES are more and more popular in the United Kingdom due to the educational supporting programmes [22].

D_4 – *technological environment*: The research and development (R&D) effort has made considerable funds available, to be allocated for renewable energy technologies in the EU. Complementary national programmes exist with emphasis on different RES topics according to national resources and preferences [29]. The technological know how of industry offers the potential to these companies to utilize in the best possible way the electricity produced by RES, especially hydropower and biomass combustion in Finland [18]. In Denmark, the local research and manufacturer wind industry also gives a significant advantage to potential producers, whereas solar energy and hydropower's limited natural resources do not presently favour producers' active involvement [21]. Moreover, a prototype industry of electricity production from biomass combustion has been developed, which contributes significantly to the energy balance of the UK [22].

With respect to the above, four criteria were selected for each dimension of the companies' operational environment so as to incorporate the necessary factors that should be taken into account. In addition to this, the choice of criteria should take into consideration the various opportunities and threats that the energy market's "new parameters" involve, namely the continuously growing tendency toward deregulation of the energy market [30] and climate change [31] and their influence on the decision making process. In this framework, the last two criteria of each dimension were selected with a view to incorporating all the emerging needs and opportunities of the companies' operational environment related to the "new parameters", which determine the final decision.

As a result, the criteria selected, based on the appropriate literature survey, are presented in Table 1.

2.2. Choice of the appropriate MCDM method

Both in the scientific literature and in reality, there are many controversies about the "right" MCDM method [32,33]. Multi-criteria analysis has been used in order to select from multi-attribute discrete options, which is the case for our problem. According to the review by Pohekar et al. [34], the most common MCDM methods used for energy planning are the multi-attribute utility (MAUT), the ELECTRE, the PROMETHEE, the analytical hierarchy process (AHP) and the ordered weighted average (OWA).

In particular, the MAUT takes into consideration the decision maker's preferences in the form of the utility function, which is defined over a set of attributes. There exist some applications of the MAUT in energy planning [35–37]. However, it is not very extensively used due to the requirements of an interactive decision environment for formulating utility functions and the complexity of computing scaling constants using the algorithm [38].

The outranking methods belonging to the ELECTRE family yield a whole system of binary outranking relations between the alternatives. In addition to this, the ELECTRE methods are sometimes unable to identify the preferred alternative, and in this case, they produce a core of leading alternatives. Such methods have been used in energy planning, such as for renewable energy plant selection [39,40]. ELECTRE methods are particularly convenient when encountering a few criteria with a large

Table 1
The chosen criteria

D_1	Political–legal	D_2	Financial	D_3	Social–cultural	D_4	Technological
$C_{1.1}$	Supportive legislation for RES production	$C_{2.1}$	Economical support of RES projects	$C_{3.1}$	RES contribution to the employment	$C_{4.1}$	Supportive actions for R&D on the energy sector
$C_{1.2}$	Standardization of RES contracts	$C_{2.2}$	Economical support of RES electricity projects	$C_{3.2}$	Social acceptance of RES	$C_{4.2}$	Supportive actions for R&D on new innovative electricity technologies for RES
$C_{1.3}$	Political support of RES	$C_{2.3}$	Economical support of RES thermal projects	$C_{3.3}$	Educational supportive actions for RES	$C_{4.3}$	Supportive actions for R&D on new innovative thermal technologies for RES
$C_{1.4}$	Promotion of international energy cooperation	$C_{2.4}$	Promotion/support of new financing sources	$C_{3.4}$	New RES energy companies in regions	$C_{4.4}$	Supportive actions for the commercial exploitation of the research results
$C_{1.5}$	Level of energy market liberalization	$C_{2.5}$	Participation in the international energy spot markets	$C_{3.5}$	Social activities to increase the energy market competitiveness	$C_{4.5}$	R&D expenditures for increasing the energy sector's competitiveness
$C_{1.6}$	State's proximity to Kyoto Protocol targets	$C_{2.6}$	Participation in the international carbon spot markets	$C_{3.6}$	Social activities to increase the energy environmental awareness	$C_{4.6}$	R&D expenditures for mitigating the climate change's impact

number of alternatives in a decision making problem [41], which is not the case for this specific decision making problem.

The outranking methods belonging to the PROMETHEE category use the outranking principle to rank the alternatives. These methods have been used in energy project planning and applications, such as for geothermal site selection [42,43], impact analysis of energy alternatives [44,45] and building product designs [46]. However, in these methods a pair wise comparison of all alternatives has to be performed by the decision maker in order to rank them, which is really difficult for the current problem that incorporates four dimensions, with six criteria in each one of them.

The AHP originated in the work of Thomas L. Saaty about 1972–1973 at the National Centre for Energy Management and Power at the University of Pennsylvania [47]. The AHP has been used in renewable energy planning [48–52]. However, a scale of 1–9 has to be used in order to assess the intensity of preference between two elements, which is restrictive for the current decision making problem.

Many researchers use the OWA, since its development is much easier than the other ones, and it is a convenient modelling form for ordinal scales, such as in the current problem, where a scale of 1–5 will be used [53,54]. Another advantage of this method is that, in case it is used, the order of the alternatives is unambiguous. As a result, taking into consideration the flexibility and transparency of this method, it was selected for solving the current decision making problem.

2.3. The application

2.3.1. Background

An aggregation operator is a function $F: I^n \to J$ where I and J are real intervals. I denotes the set of values to be aggregated and J denotes the corresponding result of the aggregation. The set of aggregation operators is denoted as $A_n\,(I,J)$ [55–57].

An OWA operator is an aggregation operator from A_n (I,J) with an associated vector of weights $w \in [0,1]^n$ such that:

$$Fw(x) = \sum_{i-1}^{n} w_i * b_i, \quad \text{where } \sum_{i-1}^{n} w_i = 1 \tag{1}$$

and b_i denotes the performance of the alternative in criteria $x_1, \ldots, x_n$.

2.3.2. Inputs

The procedure incorporated two basic elements: each state's performance in a four dimensions' framework, which is based upon the information that has been gathered in each specific dimension and the determination of the weights for each criterion.

Especially, the member states' performance on each one of the criteria is assigned based on a 1–5 ordered qualitative scale, with "1" illustrating an insignificant progress of the country regarding the particular criterion, "2" a low, "3" a moderate, "4" a high and "5" a very high progress of the member state regarding the particular criterion.

The weights of the first four criteria of each dimension were defined to be "0.200", while the last two criteria of each dimension, which express the impact of the "new parameters" (liberalization of energy market and climate change) in the final result, were defined to be "0.100". The weights express the view of the "decision maker", so the results range between subjectivity and objectivity.

With respect to this, the performances' assignment was preliminary based on the results of a project funded by the ALTENER programme of the EC [58]. In addition to this, the collected information was enhanced and updated, through the implemented events and the initial outputs of the on going FP6 project funded by the EC [59]. Last,

Table 2
The performances

Criteria	EU – accession member states													
	BG	CY	CZ	EE	HR	HU	LT	LV	MT	PL	RO	SK	SL	TR
D_1 – political/legal														
$C_{1.1}$	2	3	3	3	2	3	3	3	2	2	2	2	3	3
$C_{1.2}$	2	2	2	3	1	3	2	3	2	3	2	2	2	2
$C_{1.3}$	1	2	3	3	2	2	2	3	1	3	1	2	2	2
$C_{1.4}$	3	2	2	2	1	2	3	3	1	3	2	2	3	3
$C_{1.5}$	2	1	3	3	2	2	3	3	1	3	2	2	2	2
$C_{1.6}$	1	1	2	2	1	2	2	2	1	3	1	1	2	1
D_2 – financial														
$C_{2.1}$	2	2	3	3	2	3	2	3	2	4	2	2	3	2
$C_{2.2}$	2	3	2	2	1	3	3	3	1	3	2	1	2	3
$C_{2.3}$	2	2	2	2	2	3	3	3	2	3	2	2	3	2
$C_{2.4}$	2	2	2	2	2	2	2	3	2	3	2	2	2	2
$C_{2.5}$	1	2	1	2	1	2	2	2	1	2	1	1	2	2
$C_{2.6}$	1	1	1	2	1	2	2	2	1	1	1	1	1	1
D_3 – social/cultural														
$C_{3.1}$	2	2	2	2	1	3	2	2	1	2	2	1	2	2
$C_{3.2}$	2	3	2	3	2	3	3	4	1	3	2	2	3	2
$C_{3.3}$	2	3	2	3	2	2	2	3	2	3	2	2	2	2
$C_{3.4}$	1	1	2	2	1	2	2	2	1	3	1	1	2	2
$C_{3.5}$	2	2	2	2	1	2	3	3	1	2	2	2	3	2
$C_{3.6}$	2	2	2	3	2	2	2	3	2	3	1	1	2	2
D_4 – technological														
$C_{4.1}$	2	2	3	3	2	2	3	3	2	3	2	2	2	2
$C_{4.2}$	2	1	2	3	2	3	2	3	1	3	2	2	2	2
$C_{4.3}$	2	2	2	2	1	3	2	2	1	3	2	1	2	2
$C_{4.4}$	1	1	2	2	1	2	2	2	1	2	1	1	2	1
$C_{4.5}$	2	2	1	3	1	3	3	3	1	3	2	1	2	2
$C_{4.6}$	2	2	2	3	2	2	2	3	2	2	2	2	2	2

the related implemented events in the region [60,61] as well as the reports written by the EREC (European Renewable Energy Council) [16] were taken into consideration.

The performances of the procedure are demonstrated in Table 2.

2.3.3. Outputs

The following outcomes have resulted for the 14 accession member states in Table 3.

The progress of states in comparison to others is depicted in all four different dimensions of the environment. According to their geographical location, a number of sub-groups of countries are perceived that appear to have a consistency based upon the rankings of Table 3. These two basic groups are the countries of the Baltic Sea (Lithuania, Latvia and Estonia) and the Central European (Poland, Hungary and Czech Republic), which rank high. In general, it must be stressed that the differences between the first five or six countries for each dimension are not significant. This is also the case for the countries that score from the middle to the lowest places.

In order to check for possible variations in the obtained rankings, which may mislead the decision process, an analysis of the results' flexibility was also performed as regards the impact of the new parameters' weights. In particular:

Case I: Zero (0) weights were assigned to the last two criteria of each dimension so that the countries' ranking is to be formulated without taking into consideration the "new parameters". Correspondingly, to each one of the remaining four criteria of the four dimensions, the weight was assigned to be "0.250".

Table 3
The results

Operational environment's dimensions			
D_1	D_2	D_3	D_4
Latvia	Poland	Latvia	Poland
Poland	Latvia	Poland	Latvia
Estonia	Hungary	Estonia	Estonia
Czech Republic	Lithuania	Hungary	Hungary
Lithuania	Slovenia	Lithuania	Lithuania
Slovenia	Estonia	Slovenia	Czech Republic
Hungary	Turkey	Cyprus	Slovenia
Turkey	Cyprus	Czech Republic	Turkey
Cyprus	Czech Republic	Turkey	Romania
Bulgaria	Bulgaria	Bulgaria	Bulgaria
Romania	Romania	Romania	Cyprus
Slovakia	Malta	Slovakia	Slovakia
Croatia	Slovakia	Croatia	Croatia
Malta	Croatia	Malta	Malta

Table 4
Comparative results

Operational environment's dimensions							
D_1		D_2		D_3		D_4	
Case I	*Case II*	*Case I*	*Case II*	*Case I*	*Case II*	*Case I*	*Case II*
Latvia	Poland	Latvia	Estonia	Latvia	Latvia	Latvia	Estonia
Estonia	Estonia	Hungary	Latvia	Poland	Estonia	Hungary	Latvia
Poland	Latvia	Slovenia	Lithuania	Hungary	Lithuania	Estonia	Lithuania
Lithuania	Lithuania	Poland	Hungary	Estonia	Poland	Poland	Hungary
Hungary	Czech Republic	Lithuania	Cyprus	Cyprus	Slovenia	Lithuania	Poland
Slovenia	Hungary	Turkey	Poland	Lithuania	Bulgaria	Czech Republic	Bulgaria
Czech Republic	Slovenia	Estonia	Slovenia	Slovenia	Cyprus	Slovenia	Cyprus
Turkey	Bulgaria	Czech Republic	Turkey	Czech Republic	Hungary	Turkey	Slovenia
Cyprus	Romania	Cyprus	Bulgaria	Turkey	Czech Republic	Romania	Turkey
Bulgaria	Slovenia	Bulgaria	Malta	Bulgaria	Turkey	Bulgaria	Malta
Romania	Turkey	Romania	Romania	Romania	Malta	Cyprus	Romania
Slovakia	Croatia	Malta	Slovakia	Slovakia	Romania	Croatia	Slovakia
Croatia	Cyprus	Slovakia	Czech Republic	Croatia	Slovakia	Slovakia	Czech Republic
Malta	Malta	Croatia	Croatia	Malta	Croatia	Malta	Croatia

Case II: The weights of the last two criteria of each dimension were increased to "0.500", so as to raise to the maximum the impact of the "new parameters" in the final result. For the remaining dimensions' criteria, the weight was defined to be zero.

In this context, the results of the approach with these weights are illustrated in Table 4.

From the above preceded analysis, it becomes evident that the countries that hold a high position in the rankings of Table 3 remain also in high places, with small variations of their positions in Table 4. Another significant result is that countries that appear to perform moderately, in some cases, score comparatively high or low, which illustrates the dynamics that the energy market exhibits as it is formulated nowadays, with the inclusion of the two "new parameters".

3. Conclusions

After taken into consideration the outcomes of the approach, the following observations can be made:

- The political/legal operational environment of the EU accession member states has not developed yet compared to the corresponding environment of the 15 member states. However, in some cases (such as Slovenia, Lithuania, Latvia, Estonia, Hungary, Poland and the Czech Republic), significant progress has been observed. This progress is a result of the intensive reform that is attempted by the governments of the aforementioned countries to surpass the past and harmonise their energy policies with the policy of the EU in an efficient manner.
- These states have had a century long tradition in the utilization of renewable energy, primarily in biomass and hydropower. As a result, the financial environment of the accession member states should be enhanced in order to exploit efficiently their potential. Particularly, apart from Latvia and Poland that have a lead, Turkey is in a relatively satisfactory position, taking into consideration the fact that Turkey is not a member state yet. Therefore, a high dynamic can be foreseen for the future in its energy sector. In addition to this, Cyprus has a satisfactory performance in this category if one takes into consideration its small size.
- The social/cultural dimension brings a different outcome to one's attention, especially in the middle places. Cyprus ranks relatively high compared to the other dimensions, showing its high social RES awareness in that way. Nevertheless, what can be concluded is that countries (Latvia, Estonia, Poland, Lithuania and Hungary), which are active and evolving, carry the crowds along with them.
- In the technological environment, Poland and Latvia surpass the rest by their traditional technological know how, as a result of having already a "heavy" industry, followed at a close distance by Estonia, Hungary, Lithuania and the Czech Republic.

It has to be stressed that countries like Bulgaria, Croatia, Malta, Romania and Slovakia are not in the higher places in most categories. The above-mentioned states have just entered or are still entering into a phase of reform and development in order to increase their strengths and decrease their weaknesses according to their special characteristics. Therefore, the efforts can focus on fields that are left behind based on the current study results.

Based on the comparative results, it is concluded that in *Case I* in all four dimensions, the variations of the places of each country are rather small and insignificant. This is an expected result because this particular study is focused on countries that have not yet incorporated totally the "new parameters" in their internal energy market. This is also the reason, for the noted variation in *Case II*, where the influencing factors are only the "new parameters". In particular, the countries that perform the most significant variations are Poland, which loses strength in most cases, Cyprus, which has not yet implemented a competitive market but has the financial resources for several investments, and the Czech Republic, which has an energy market environment characterized on the one hand by a substantial effort to comply with EU's directives and on the other hand by imbalances that apply barriers to energy reform.

Taking into consideration the results of the adopted approach in the current study, the perspectives of those companies' environment can be summarized as follows:

- The region is a developing market that has special characteristics and figures that, in a way, diversify it from the one of Western Europe. Private enterprises and initiatives or market competition are newly entering concepts in this framework, and this fact is currently offering a virgin field for evaluations and speculations about the future of each member state's internal market.
- The EC as well as governments of the above member states are facing a challenge on the one hand to assess the current situation that interests their policy and on the other hand to coordinate their actions, mainly in the form of economical subsidies and policy regulations.

Finally, the fact that the presented approach does not intend to replace the decision maker must be underlined. With appropriate use, it could establish a useful decision support framework for the assessment of the environment's characteristics and for the final evaluation of the energy environment in each country. Especially, this approach makes an integrated and systematic view of each country's environment possible, giving to decision makers, in this way, a clear view of the distinctive emphasis that is needed for each specific country. Finally, the approach's concept can provide a sufficient framework for supporting other decision making problems.

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