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Hydrogen economy in China: Strengths–weaknesses–opportunities–threats analysis and strategies prioritization

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ABSTRACT

The objective of this paper is to analyze the internal and external environment of hydrogen economy in China using strengths–weaknesses–opportunities–threats (SWOT) analytical method, and then to prioritize the strategies for promoting the development of hydrogen economy in China. After the key strengths, weaknesses, opportunities and threats of the hydrogen economy in China were identified and nine effective strategies were proposed, a multi-criteria decision-making method by integrating goal programming and fuzzy theory has been developed for prioritizing these strategies, which can help the stakeholders/decision-makers to implement these strategies appropriately, The proposed method is not limited to China, and it is a generic method that can also be used to study the hydrogen economy of other regions.

Contents

1. Introduction

Hydrogen is widely regarded as a promising energy carrier for decarbonizing road transport, mitigating the emission of harmful gases, and enhancing the security of energy supply, accordingly, hydrogen economy has attracted more and more attention around the world recently [1–3]. A variety of governments have published technology roadmaps of hydrogen economy, according to which,

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the scientists and engineers can closely monitor the scheduled progress of hydrogen technologies [4–7].

Hydrogen economy refers to a proposed system, in which, hydrogen is produced from carbon dioxide-free sources and is used as an alternative fuel for transport [8]. As the largest energy consumer in the world with a coal-dominated energy structure, China is also attempting to make a transition to hydrogen economy for a more sustainable future [9–15]. While an essential prerequisite for a successful transition is to accurately evaluate the current status of hydrogen economy in China and draw effective strategies for promoting its development, the objective of this study is to identify the key characteristics of hydrogen economy in China and provide strategies for promoting its development.

In the study, strengths–weaknesses–opportunities–threats (SWOT) analytical method is used to analyze the strengths, weaknesses, opportunities and threats of the hydrogen economy in China. Subsequently, the strategies for promoting its development were proposed by exerting strengths, mitigating weaknesses, exploiting opportunities and avoiding threats. While the SWOT method does not provide an analytical way to quantify the effectiveness and to prioritize these strategies according to their importance, a multi-criteria decision-making (MCDM) method has been developed to rank the prior sequence of the strategies. By combining the MCDM and SWOT methods, the stakeholders/decision-makers can make correct decisions by giving top priority to these strategies that have significant effect on the development of hydrogen economy in China.

The remainder of this paper is structured as follows: Section 2 presents the SWOT analysis method and its application in analyzing the hydrogen economy in China. In Section 3, the developed MCDM method was described and used to prioritize the strategies for promoting the development of hydrogen economy in China. Finally, the study was concluded in Section 4.

2. SWOT analysis of hydrogen economy in China

2.1. SWOT method

Strengths–weaknesses–opportunities–threats (SWOT) analytical method is widely used for strategy formulation by constituting an important basis for learning about the situation of the studied object and for designing future strategies to solve the existing problems [16–18]. SWOT analytical method can identify the strengths (elements to leverage and build on), weaknesses (areas to seek assistance and support), opportunities (areas to leverage for the advantages) and threats (elements to hinder the development of the object) of the studied objects [19]. The strengths and weaknesses are determined by the internal factors, whereas external forces dictate opportunities and threats [20]. SWOT analytical method has been successfully used in the energy fields such as the analyses of sustainable energy development [21], electricity supply chain [22], regional energy planning [23], the development of shale gas [24] and bioenergy [25].

When SWOT method was used to analyze the hydrogen economy in China, the internal and external forces which might affect the development of hydrogen economy in China are first collected and summarized according to a questionnaire survey by providing the regulations, reports, literatures, papers, documents, legislation, statistics and the data concerning the research topic to the participants, and then further determined by the experts in a way of brainstorm. Its framework consists of 5 steps (Fig. 1).

Step 1: Materials collection. The purpose of this step is to collect the related data and materials concerning the research topic, the supplementary materials such as regulations, reports, literatures, papers, documents, legislations, and national statistics are all gathered.

Step 2: Questionnaire design and survey. The main questions in the questionnaire should be developed with the help and under the supervision of the senior experts in this area. The objective of these questions is to identify the strengths, weaknesses, opportunities and threats of the studied objects. The designed questionnaire will be assigned to a number of stakeholders and experts concerning the research topic, and they are asked to fill the questionnaire based on their own experience and the provided materials.

Step 3: Brainstorm. The purpose of this step is to organize a colloquium to determine the factors regarding strengths, weaknesses, opportunities and threats, and to recommend strategies for improving the status of the studied objects. In the colloquium, many experts concerning the research topic will be invited to analyze the questionnaires responded by the stakeholders in step 2.

Step 4: SWOT analysis. According to the obtained results in the colloquium, all the factors regarding strengths, weaknesses, opportunities and threats are discussed, analyzed and specified by using the SWOT analytical method in this step.

Step 5: Strategy recommendations. According to the factors regarding the strengths, weaknesses, opportunities and threats, effective strategies to fully use the strengths and opportunities, and avoid or mitigate the weaknesses and threats are determined in the brainstorm. Afterwards, SWOT matrix [26] is used to identify four types of strategies, i.e. strengths–opportunities (*SO*) strategies, weaknesses–opportunities (*WO*) strategies, strengths–threats (*ST*) strategies and weaknesses–threats (*WT*) strategies, as showed in Fig. 2. Specifically, *SO* strategies are obtained by matching internal strengths with external opportunities and using strengths to take advantages of opportunities; *WO* strategies are obtained by matching internal weaknesses with external opportunities and overcoming the weaknesses by taking advantages of opportunities; *ST* strategies are obtained by matching internal strengths with external threats and using strengths to avoid threats; *WT* strategies are obtained by matching internal weaknesses with external threats and minimizing weaknesses to avoid threats.

2.2. Application of SWOT method in analyzing hydrogen economy in China

SWOT analysis can help stakeholders/decision-makers to better understand the current status of hydrogen economy in China, and then draft strategic plans to promote its development. According to the framework of SWOT method, the procedures for analyzing hydrogen economy in China can be specified as the followed steps.

Step 1—Material collection. In this step, the books, patents, reports, documents, legislation, statistics relating to the hydrogen economy in China, as well as the related papers in China National Knowledge Infrastructure and Science Direct were collected.

Step 2—Questionnaire design and Survey. The questionnaire for identifying the strengths, weaknesses, opportunities and threats of hydrogen economy in China was designed in Mandarin (the English version has been presented in the Appendix) [27].

The survey has been conducted by assigning the questionnaire to a total of 80 experts through emails and interviews during June to August in 2013, including 20 professors whose expertise are in the areas of hydrogen energy or other renewable energy sources from Chinese universities; 20 administrative