INTERNATIONAL STRATEGIC MANAGEMENT REVIEW 3 (2015) 66–80

HOSTED BY

ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: http://www.elsevier.com/locate/ism

INTERNATIONAL STRATEGIC MANAGEMENT REVIEW

USEK | HOLY SPIRIT UNIVERSITY OF KASLIK

A SWOT framework for analyzing the electricity supply chain using an integrated AHP methodology combined with fuzzy-TOPSIS

CrossMark

Kazem Zare[a]*, *Javad Mehri-Tekmeh*[a] and *Sepideh Karimi*[a]

[a]*University of Tabriz, Tabriz, East Azarbaijan, Iran*

ARTICLE INFO

Article history:
Received 14 February 15
Received in revised form 05 July 15
Accepted 16 July 15

Keywords:
electric power supply chain
SWOT framework
AHP
fuzzy TOPSIS

ABSTRACT

Supply chain refers to the integrated chain of organizations, loops, persons who are involving in stuff generati and costumer servicing. One of these services is the electricity which can be consumed as domestic, industr agriculture and etc. It can be considered that the electric power supply chain network has four stages which electricity generation, transmission, distribution and consumption. In this paper, a framework of Strengt Weaknesses-Opportunities-Threats (SWOT) is presented to analysis the electricity supply chain in north-west Iran. In this regard, some interviews are done with several experts of electricity industry. In addition, integrated AHP method which is combined with fuzzy-TOPSIS is proposed to prioritize the SWOT factors for proposed electricity supply chain. The results show that the proposed method can be used effectively in order determine a strategy plan with high prioritizing for planning and decision-making in electricity supply chain.

1. Introduction

Supply chain refers to an integrated network between various producers which has different transmission stages until stuff approached to the final user [1]. A supply chain network consists of various elements such as suppliers, producers, stocks, distribution centers and customers, which means stuff supplying, using raw material produces outputs, and then transmits production to the stores and distribution centers to satisfy customers' demands [2]. Planning and coordination in optimized direction and effectiveness of supply chain activities is called supply chain management, which means competitive market needs on-time delivery with low inventory for the lowest price of servicing by the chain [3]. Supply chain management is actually a method in which the materials and services reach to the customers in the proper amount and place with the least monetary and with proper combination of suppliers, producers, stores and shops. Supply chain management affects every part of the chain and also have some influences on each part related to the final customer [4].

It is argued by Forrester [5], that how the management encounter the changes related to information process, material, stock and equipment would affect organization success. Chopra and Meindl [6] believe that supply chain is the all of elements of an organization which are included supplying of customers' demands, directly or indirectly.

Most of the research in supply chain network majority is for profitability improving and service increasing within a supply chain. For validating service and activity of supply chains, various methods are presented in the literature. These methods consist of analytic hierarchy, Balanced Score Card (BSC), Analytic

* *Corresponding author.* Tel.: +989126194396; fax: + 984133300829.
E-mail address: kazem.zare@tabrizu.ac.ir; zare.kazem@yahoo.com

Peer review under responsibility of Holy Spirit University of Kaslik.

http://dx.doi.org/10.1016/j.ism.2015.07.001

Hierarchy Process (AHP) and Data Envelopment Analysis (DEA) to name but a few. Cho et al. [7] proposed a framework for measuring service level in supply chain according to level operation of tactical and plan strategy in the supply chain. The methodology presented in [7] is on the base of fuzzy-AHP. In other research for operational measuring, balanced scoring was used [8]. Zhang et al. [9] checked the uncertainly effects in demands, material price and other parameters in supply chain operation by the use of sensitivity analysis. They used diffused combination from Evolutionary Algorithm (EA) and fuzzy random programming. Chen [10] discussed one structural methodology for supplier selection in supply chain network in Taiwan textile industry with SWOT analysis and a Multi Attribute Decision Making (MADM) method for prioritizing potential suppliers. A closed-loop model is configured in [11] for validating and selecting the best suppliers of one supply chain network. In this model, the uncertainty in demands was also mentioned. The results show that the proposed model can be useful in closed-loop supply chain networks management. Awasthi et al. [12] used one fuzzy multi criteria model for evaluating the suppliers in supply chain environment.

The SWOT analysis is a powerful strategic tool for evaluating an organization according to internal and external key factors [13]. Strengths and Weaknesses are often internal to the organization, while Opportunities and Threats generally relate to external factors. After identifying SWOT factors, every organization should use its strategies in protecting or improving strengths and eliminating weaknesses and usage of opportunities and collation with threats [14]. Quantitative SWOT methodology first was presented by Kurttila et al. [15] that named A-WOT and was used in AHP method. Other authors have used the A-WOT in their surveys [16-18]. Yuksel and Dagdeviren [19] used Analytic Network Process (ANP) in a SWOT analysis. Gao and Peng [20] used Multiple Criteria Group Decision Making (MCGDM) for prioritizing SWOT factors. This methodology is evaluated by an example in their survey. Lee et al. [21] proposed one quantitative SWOT-fuzzy method for competitive environment evaluating in distribution centers of international transmission in Pacific Ocean. According to the literature review, other quantified SWOT methods have been proposed with or without uncertainty considerations [20, 21]. However, the application of quantified SWOT methodology in energy programming has been relatively scarce [22, 23]. In this paper, a Strengths- Weaknesses- Opportunities- Threats (SWOT) framework is proposed for electricity supply chain in Iran and SWOT factors are prioritized in order to determine a strategy plan. The innovation of this research is in considering of both internal and external factors as an integrated way for strategic analysis. For this reason, by the help of experts in each stage of generation, transmission, electric distribution and consumption, strength and weakness factors related to internal conditions of chain and opportunities and threats related to external conditions are identified. Figure 1 shows SWOT evaluating framework fits into a strategic evaluation.

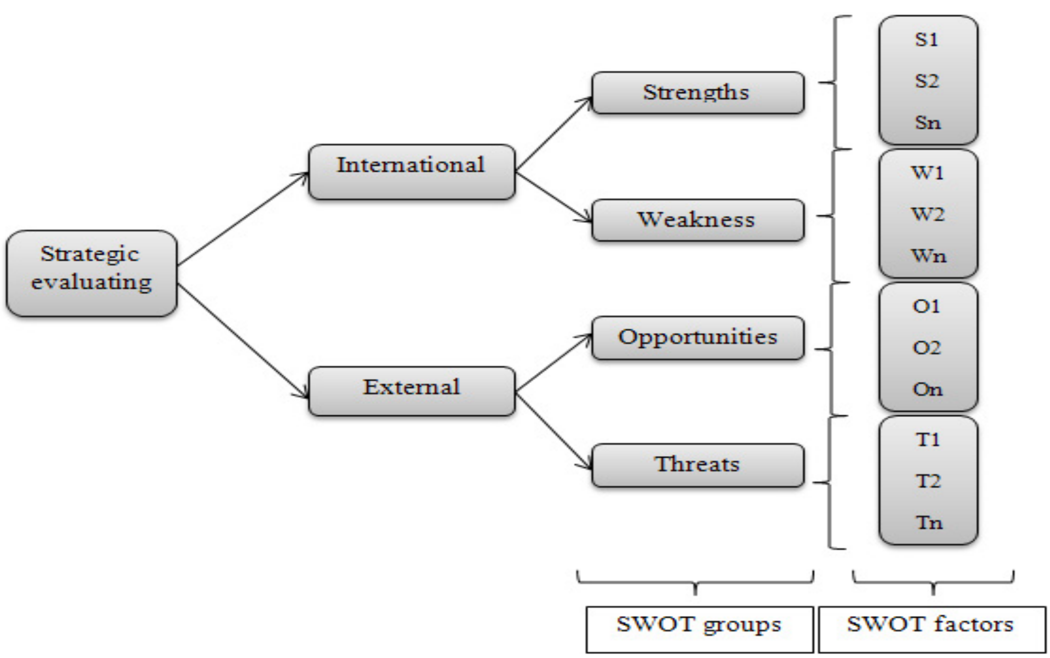

Fig. 1. SWOT evaluating framework

The remainder of this paper is summarized as follows. In section 2, the electric power supply chain network, in section 3, information gathering method, in section 4, research methodology, in section 5, case study is discussed. Finally, conclusion is presented in section 6.

2. Electric power supply chain network

Electricity supply chain consists of four stages which includes generation, transmission, distribution and consumption, as shown in Fig. 2. In Ref. [23], one static model with defined demand is expanded for the electric power supply chain network. After that, for power flow pattern, a balanced model for the transmission network with static demand is presented and then, the static supply chain model with balanced ultra-network is formulated. Finally, the dynamic supply chain model with defined demand is proposed.

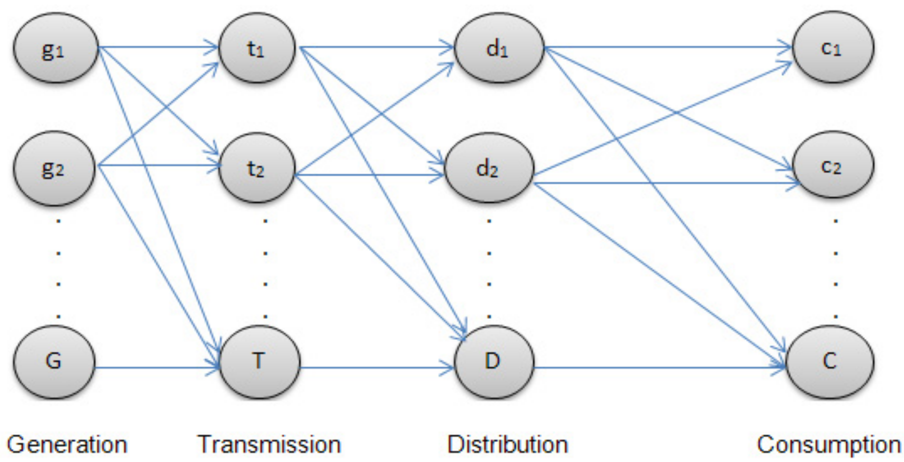

Fig.2 - Electric power supply chain (adapted from [22, 24]).

A sample of supply chain management of electricity in the form of simultaneous management with the traditional and modern way is proposed in [25]. Zhang et al. [26] used bargaining solution according to game theory to reach lower price in electric distribution network and a new programming approach mixed of nonlinear integer programming and linear integer programming is used in five participated groups. The electricity supply chain network in Turkey is studied in [22] and an integrated framework is proposed to analyze the electricity supply chain. The methodology proposed in [22] is SWOT-fuzzy TOPSIS combined with AHP method. Lin and Yeh [27] used genetic algorithm according to finding the shortest path of proper transmission with high reliability in electricity supply chain.

The aim of this paper is analysing the electrical energy supply chain. The output of electric energy supply chain network plays an important role in economical extension process of countries. Also, it provides necessary bed for dynamism and country improving in various majors such as economical, industrial, cultural and social [28].

In this paper the electricity supply chain in generation, transmission, electricity distribution stages until it reaches to the consumer is evaluated. This evaluation is consisted of both internal and external. In internal evaluation of a supply chain or organization, the internal conditions are discussed. However external evaluation emphasize on factors that are not related to the internal management or organization.

3. Information gathering method

The way of validating of SWOT factors in comparison to each other is very important. In this survey, the information gathering is in the form of expert questionnaire and interviewing with experts in each stage of generation, transmission and electric distribution. We designed the questionnaire to facilitate all of the possible pair-wise comparisons among the factors. Table 1 shows a typical nine-point scale for an AHP questionnaire [29]. Our questionnaire is designed to measure all possible importance ratios among the factors.

Moreover, reliability that is one of the most important measuring features and shows how measuring tool shows the same results in the same conditions is calculated for the questionnaire. One of the assessing to the reliability methods is the Cronbach's Alpha calculating and interpreting. If Cronbach's Alpha is close to 1, it shows the more reliability. Reliability coefficient between 0.6 and 0.8 is considered acceptable and more than 0.7 is desirable. In this essay the Cronbach's alpha is calculated separately for each SWOT groups and for whole questionnaire.

Table 1 - pair wise comparison scale [29].

Definition	Intensity of importance
Equal importance	1
Weak importance	3
Strong importance	5
Very strong or demonstrated importance	7
Extreme or absolute importance	9
Intermediate value	2,4,6,8

4. Research methodology

When programming processes get complicated by various criteria, it is possible that the SWOT analysis will not be used properly. Therefore, it shows an undefined list, on modality and non-complete form of effective external and internal factors which are used in the organization [30]. To solve these problems, Kurttila et al. [15] and also Stewart et al. [31] used the combined AHP and SWOT analysis to create a new method for optimizing environmental analysis in SWOT method. Also in some papers, the SWOT analysis is expended on the base of Grand Strategy Matrix (GSM) [32].

This section is divided to two sections. In the first section, AHP methodology was used for defining final relative weights and prioritizing factors. The Analytic Hierarchy Process (AHP) is one of different methods for Multi Criteria Decision Making (MCDM) problems. AHP methodology, proposed by Thomas L. Saaty is one of the analytic methods of complicated decisions [29]. This method is based on pair-wise comparison and gives scenario checking ability to the managers [29]. As a matter of fact, AHP is a method helping managers till they are able to classify goals and ways in one complicated environment. AHP algorithm commonly consists of two parts. 1) Constructing the pair-wise comparison. 2) Prioritizing decision alternatives. The AHP methodology steps can be concerned as follows [33, 34].

Step 1: Establishing the hierarchical structure

In this step, the problem and decision goal are related to each other in the hierarchy form. Decision elements include decision alternative and criteria.

Step 2: Constructing the pair-wise comparison matrix

After designing hierarchy of decision problem, decision maker should construct matrixes set. The matrices of pair-wise comparisons (Eq. (1)) are obtained. In this matrix, the element $a_{ij} = 1/a_{ij}$ and thus, when $i = j$, $a_{ij} = 1$. Each element in an upper level is used to compare the elements in the level below with respect to it. This work is done by pair-wise comparison two by two and through dedicating numeral scores which shows priority and majority between two decision elements.

$$A = (a_{ij}) = \begin{bmatrix} 1 & w_1/w_2 & . & . & . & w_1/w_n \\ w_2/w_1 & 1 & . & . & . & w_2/w_n \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ w_n/w_1 & w_n/w_2 & . & . & . & 1 \end{bmatrix} \quad (1)$$

Step 3: Calculating the consistency

The AHP methodology provides decision makers with a useful way of checking and improving consistency. The Consistency Index (CI) measures the degree of logical consistency among pair-wise comparisons. Consistency Index (CI) is defined as follows [29]

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (2)$$

where n is the number of existing items in the judgment matrix problem.

Consistency Ration (CR) indicates that the amount of allowed inconsistency (0.1 or 10%). Higher than 0.1 means that the comparisons are less consistent. Smaller than 0.1 means the comparisons are more consistent. CRs above 0.1 means the pair-wise comparison should be revisited or revised. The consistency ratio is calculated using the following formula:

$$CR = \frac{CI}{RI} \quad (3)$$

The Random Index (RI) is the average CI value of randomly-generated comparison matrices using Saaty's preference scale. Table 2 shows the value of the RI for matrices of order (N) 1 to 15.

Table 2: Random Index (RI)

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.58

The AHP methodology steps are once implemented for each SWOT group and then the importance relative weight vectors (W_S, W_W, W_O, W_T) are obtained for each SWOT group. Among SWOT factors, those having the highest relative weight are selected from each SWOT group. Once again, the pair-wise comparisons will be done for AHP across SWOT groups and relative importance weights vectors (W_G) will be caught. Finally, the relative importance weight (W_F) will be caught for $W_i \in W_F$ for 48-fold SWOT factors. In the second section, the final relative weights from the AHP methodology are used in fuzzy-TOPSIS methodology. Finally, the final ranking will be prioritized.

4.1. *Fuzzy-TOPSIS*

For the first time, the TOPSIS method was defined by Hwang and Yoon [35]. Main attitude of this method inspired from the selected choice that has the most distance from the negative idea solution and the least distance from the positive ideal solution. Recently, a new method is presented for group deciding based on TOPSIS method [36]. Fuzzy-TOPSIS method as a matter of fact is the same TOPSIS method that is extended by the fuzzy logic. The benefits of this method are discussed in [37]. The application of this method for supplying selection in supply chain network is discussed in [38]. The fuzzy-TOPSIS method is used for prioritizing of strategies and it was based on SWOT analysis [39]. Also, the fuzzy-TOPSIS methodology is used in [40] for operational financial validation of container shipping companies in Taiwan. A methodology for solving MCDM problems with the TOPSIS method in fuzzy environment is proposed in [41], and an extended TOPSIS theory for solving MCDM problems with extensional fuzzy data is presented in [42].

In the current paper, fuzzy-TOPSIS methodology is applied for defining the final weights of SWOT factors and final prioritizing for determining strategy plan. In the next section, major concepts of fuzzy sets will be defined and fuzzy-TOPSIS methodology will be discussed and used.

4.1.1. Preliminaries

Definition 1. A fuzzy set Ã in X is characterized by a membership function $\mu\widetilde{A}(x)$ which associates with each point in X a real number in the interval [0,1], with the values of $\mu\widetilde{A}(x)$ at x representing the "grade of membership" of x in A [43].

Definition 2. The fuzzy set Ã on X, is said to be a convex fuzzy set if and only if for all $x, y \in X$ and$\lambda \in [0,1]$, and can be represented by:

$$\mu\widetilde{A}(\lambda x + (1-\lambda)y) \geq \min(\mu\tilde{A}(x), \mu\tilde{A}(y)) \quad \forall x, y \in X \ and\ \lambda \in [0,1] \tag{4}$$

And the fuzzy set Ã on X, is called normal, if the following equation is met [44, 45]:

$$\exists x_i \in X, \mu\tilde{A}(x_i) = 1 \tag{5}$$

Definition 3. A fuzzy number Ã is a convex, normalized fuzzy set $\widetilde{A} \subseteq R$ whose membership function is at least segmentally continuous as follows [46]:

$$\mu\tilde{A}(x) = \begin{cases} m(x) = x - a_1/a_2 - a_1 & , a_1 \leq x \leq a_2 \\ 1 & , a_2 \leq x \leq a_3 \\ n(x) = x - a_4/a_3 - a_4 & , a_3 \leq x \leq a_4 \\ 0 & , otherwise \end{cases} \tag{6}$$

Definition 4. The multiplication of a fuzzy number $\widetilde{A} = (a_1, a_2, a_3, a_4)$with a scalar $\lambda \geq 0$ is defined as follows:

$$\lambda\,\widetilde{A} = (\lambda a_1, \lambda a_2, \lambda a_3, \lambda a_4) \tag{7}$$

Definition 5. The normalized fuzzy number of each trapezoidal fuzzy number $\widetilde{A}_i = (a_{i1}, a_{i2}, a_{i3}, a_{i4})$ for $i \in I$, is defined as:

$$R_i = (a_{i1}/max\{a_{i4}\}, a_{i2}/max\{a_{i4}\}, \dots) \quad \text{For a profit criterion} \tag{8}$$

$$R_i = (min\{a_{i1}\}/a_{i4}, min\{a_{i1}\}/a_{i3}, \dots) \quad \text{For a cost criterion} \tag{9}$$

Definition 6. The distance between trapezoidal fuzzy number $A = (a_1, a_2, a_3, a_4)$and $B = (b_1, b_2, b_3, b_4)$ is defined as follows [47]:

$$D(\widetilde{A}, \widetilde{B}) = \sqrt{\frac{[(a_1-b_1)^2+(a_2-b_2)^2+(a_3-b_3)^2+(a_4-b_4)^2]}{4}} \tag{10}$$

4.1.2. The steps of the fuzzy-TOPSIS methodology

The steps of fuzzy-TOPSIS methodology are provided as following:

Step 1. Evaluation vector

Based on trapezoidal fuzzy numbers related to each linguistic variable mentioned in Table 3, for each factor of 48 factors, the trapezoidal fuzzy number is ascribed and evaluation vector E- is calculated as $\widetilde{e}_i = (e_{i1}, e_{i2}, e_{i3}, e_{i4})$.

Table 3 - One set of trapezoidal fuzzy numbers and adapted linguistic variables (adapted from [48]).

Linguistic variable	Trapezoidal fuzzy number
Extremely poor	(0,0,1,2)
Very poor	(1,2,3,4)
Poor	(2,3,4,5)
Medium poor	(3,4,5,6)
Fair	(4,5,6,7)

Medium good	(5,6,7,8)
Good	(6,7,8,9)
Very good	(7,8,9,10)
Extremely good	(8,9,10,11)

Step 2. Normalizing the related trapezoidal fuzzy numbers

Normalized trapezoidal fuzzy numbers is evaluated with respect to a profit criterion by using (8) and with respect to a cost criterion by using (9).

Step 3. Weighting normalized linguistic variable

In this step, the normalized fuzzy numbers are multiplied by relative weights from AHP methodology for each SWOT group and the weighted normalized trapezoidal fuzzy numbers will be estimated using (7).

Step 4. Distance estimation from Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS)

In this step, the Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS) are defined as follow:

$$FPIS = w_i \otimes (1,1,1,1) \qquad FNIS = (0,0,0,0) \qquad (11)$$

The estimating the distance from FPIS and FNIS based on (10) is done for each $i \in S, W, O, T$.

Step 5. Calculation of relative closeness coefficient (CC_i)

Finally, the relative closeness coefficient of each $i \in S, W, O, T$ with respect to intuitionistic fuzzy ideal solutions is computed using the following expression and the ranking the preference order of all factors are done.

$$CC_i = \frac{d_i^-}{d_i^- + d_i^+} \qquad (12)$$

5. Case study and discussion

The integrated AHP methodology with fuzzy-TOPSIS is applied to determine a strategy plan in electric power supply chain. In this regard, some interviews are done with several experts of electricity in the north-west of Iran. Table 4, shows SWOT factors in studied case. It should be noted that these factors include 12 strength, 15 weakness, 12 opportunity and 9 threat factors. These factors are identified and compared together by experts. The Cronbach's alpha is calculated separately for the whole questions and results shows the reliability is acceptable and desirable. The results are depicted in Table 5. The presented methodology in section 4 has been implemented for this case. The details of this implementation are described in this section.

Table 4 - SWOT factors considered for the case of Iran.

SWOT factors
Strengths
S1: Existence of integrated global network of electric energy transmission for increasing network stability
S2: Special geographical position due to the existence and accessibility to fossil fuel in electric energy generation in power plants
S3: Fruition of good potential for renewable energies for electricity generation
S4: Existence of proper training equipment in electrical companies
S5: Low changing level of personal in electrical companies
S6: Existence of analysis skills in utility majority (practical and profitable faces)
S7: Existence of proper synergy (co-increasing) between staff
S8: Having ISO certification and software generation license
S9: Managers' appetence for strategic planning and improving the Research and Development (R&D)
S10: Existence of promised and expert staff in public and private companies and active using of recommendation system
S11: Existence of regional electric companies with the aim of dividing control duties, regulation and monitoring electric regions in network

S12: Using advanced automation in various units of electric network

Weaknesses

W1: High electric energy losses in generation, transmission and distribution units

W2: Reach to the useful lifetime of some power plants

W3: High increasing rate of electric consumption and don’t have a proper energy management regulations

W4: Non-proper combination of electricity consumption

W5: Non-eligible electricity pricing system

W6: Non-existence authorized strategy for electricity expansion planning with economic, social and cultural issues

W7: Not using the distributed generation systems in electricity generation

W8: Not mentioning the external and internal investors to electricity industrial

W9: Not establishing the Total Quality Management (TQM) and marketing quality control plans

W10: Not establishing a proper motivation framework

W11: Not using the modern technologies and proper methodologies for maintenance programs

W12: The lack of documented system of promotion retirement and personnel replacement

W13: Not existing two-way relationship between consumers and producers to be informed about network condition

W14: damaged and non-standard equipment existence in many regions and not devoting enough budget for replacing it

W15: Not existence of knowledgeable and experienced consultant in electrical distributing networks

Opportunities

O1: Whole society depending to the electricity and its extending day by day

O2: Electricity substitution instead of other energy types

O3: Electricity generation guaranteed purchase from private companies with the justifiable price

O4: Using renewable energies such as Solar, Wind

O5: Conveniences providing such as rent, financial subsidies for fossil fuel resources (gas) for private investors in Distributed Generation (DG)

O6: Population structure, extending demands and the majority of the necessity of quantitative expansion of electric industry

O7: Electricity effect in innovating and increasing the energy efficiency in all energy-use industries

O8: Electric industry convergence with transmission and communication systems

O9: Modern economy based on digital systems and the necessity of quantitative and qualitative development of electric energy

O10: Biological challenges related to economic development, and electricity role in solving related issues

O11: Using the combined heat and power (CHP) technology

O12: Existence of experienced, knowledgeable electrical engineers in country

Threats

T1: Technical losses in transmission and distribution networks

T2: High residential and administrative consumption in comparison to industrial, agricultural and commercial consumption

T3: Boycotts existing

T4: Biological issues in fossil fuel power plants

T5: Drought effects on operation of hydro power plants

T6: Non-technical losses in distribution networks

T7: Not competitive unit transferring to the private companies

T8: Monopolization existence in electricity marketing

T9: Not participating demand side in solving electric industries issues solving

Table 5 - Validity and reliability of factors.

Group factors	N of items	Cronbach’s Alpha
Strengths	12	0.653
Weaknesses	15	0.851
Opportunities	12	0.834

Threats	9	0.835
All of factors	48	0.775

5.1. AHP within each SWOT group

First, the pair-wise comparisons are done for SWOT factors. Each group (S, W, O and T) consist of some factors, so this comparison has been done in 4 tables separately for each groups. The results are shown in Table 6 to Table 9.

5.2. AHP across SWOT groups

Among SWOT factors, those having the highest relative weight are selected from each SWOT group and once again, the pair-wise comparison has been done for AHP across SWOT groups. The results are shown in Table 10.

5.3. Final relative importance weights of SWOT factors

The Final relative weights, which are taken from AHP methodology, is represented for each of S, W, O, T factors in the second column of Table 11.

5.4. Illustration of fuzzy TOPSIS methodology steps

The fuzzy-TOPSIS methodology steps that are represented in section 4.1.2 are done for this case. The final coefficients are depicted in the third column of Table 10 and the factor prioritizing is represented in the fourth column of Table 11.

5.5. Final discussion

As a result of ranking in section 5, the final coefficients of SWOT factors are obtained and given in the third column of Table 11. According to the results, the "S1: Existence of integrated global network of electric energy transmission for increasing network stability" and "O1: Whole society depending to the electricity and its extending day by day" have the highest relative importance weight with 0.828302055, and "S3: Fruition of good potential for renewable energies for electricity generation", "O4: Using renewable energies such as Solar, Wind" and "O12: Existence of experienced, knowledgeable electrical engineers in country" have the next weights with 0.738796125. These results encourage the electric supply chain companies to improve the quality of services to the consumers, because of dependency of society to the electricity. Also, according to the environmental issues, using the renewable energies is important and so needs the governments support. The other important issue is that the renewable energies such as wind and solar don't pollute the environment and water resources. So, using the global network and electricity networks to transmit the electricity from clean energy resources to the consumers is more important, and needs the governmental support.

Table 6 - AHP within "strengths" group.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	W_S
S1	1	3	2	5	5	5	4	3	3	2	3	3	0.195848
S2	0.33	1	2	3	3	3	3	2	3	2	3	3	0.138136
S3	0.5	0.5	1	5	5	5	3	3	3	2	3	3	0.146336
S4	0.2	0.33	0.2	1	2	2	2	0.33	0.33	0.5	0.33	0.5	0.03923
S5	0.2	0.33	0.2	0.5	1	0.5	0.5	0.33	0.33	0.25	0.33	0.33	0.024184
S6	0.2	0.33	0.2	0.5	2	1	2	0.33	0.5	0.25	0.5	0.5	0.034367
S7	0.25	0.33	0.33	0.5	2	0.5	1	0.33	0.5	0.25	0.5	0.33	0.031807
S8	0.33	0.5	0.33	3	3	3	3	1	2	0.33	0.5	2	0.074072

S9	0.33	0.33	0.33	3	3	2	2	0.5	1	0.33	0.5	0.5	0.054162
S10	0.5	0.5	0.5	2	4	4	4	3	3	1	3	4	0.125077
S11	0.33	0.33	0.33	3	3	2	2	2	2	0.33	1	3	0.078306
S12	0.33	0.33	0.33	2	3	2	3	0.5	2	0.25	0.33	1	0.058477
CR													0.0552

Table 7 - AHP within "weaknesses" group.

	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W_W
W1	1	2	2	3	4	3	2	0.2	3	4	5	5	3	3	5	0.137791
W2	0.5	1	3	3	3	4	0.33	2	3	4	4	5	2	2	5	0.118298
W3	0.5	0.33	1	3	4	0.33	0.25	0.33	0.5	3	3	4	0.5	0.33	2	0.053445
W4	0.3	0.33	0.33	1	3	0.33	0.33	0.33	0.5	3	4	4	0.5	0.33	3	0.046855
W5	0.3	0.33	0.25	0.33	1	0.33	0.25	0.33	0.33	0.5	2	2	0.33	0.33	2	0.027109
W6	0.3	0.25	3	3	3	1	0.33	0.33	2	4	4	5	2	2	3	0.081011
W7	0.5	3	4	3	4	3	1	3	3	4	4	5	3	3	4	0.149418
W8	0.5	2	3	3	3	0.5	0.33	1	3	4	4	5	2	2	3	0.0986
W9	0.3	0.33	2	2	3	0.5	0.33	0.33	1	3	4	5	0.5	0.5	2	0.056264
W10	0.3	0.25	0.33	0.33	2	0.25	0.25	0.25	0.33	1	3	3	0.33	0.5	3	0.033455
W11	0.2	0.25	0.33	0.25	0.5	0.25	0.25	0.2	0.25	0.33	1	3	0.33	0.33	0.5	0.020803
W12	0.2	0.2	0.25	0.25	0.5	0.2	0.2	0.2	0.2	0.33	0.33	1	0.25	0.25	2	0.017807
W13	0.3	0.5	2	2	3	0.5	0.33	0.5	2	3	3	4	1	3	4	0.072858
W14	0.3	0.5	3	3	3	0.5	0.33	0.5	2	2	3	4	0.33	1	3	0.064764
W15	0.2	0.2	0.5	0.33	0.5	0.33	0.25	0.25	0.5	0.33	2	0.5	0.25	0.33	1	0.021522
CR																0.064163

Table 8 - AHP within "opportunities" group.

	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	W_O
O1	1	3	3	2	3	4	4	5	4	5	5	4	0.210436
O2	0.33	1	3	0.33	3	4	4	3	0.5	3	4	0.33	0.106517
O3	0.33	0.33	1	0.33	0.5	3	2	3	0.5	3	2	0.33	0.062292
O4	0.5	3	3	1	3	4	4	3	3	5	3	3	0.162643
O5	0.33	0.33	2	0.33	1	3	2	2	2	3	3	2	0.087927
O6	0.25	0.25	0.33	0.25	0.33	1	0.33	0.33	0.33	0.5	0.33	0.33	0.024082
O7	0.25	0.25	0.5	0.25	0.5	3	1	2	2	4	2	0.5	0.060654
O8	0.2	0.33	0.33	0.33	0.5	3	0.5	1	0.33	3	2	0.33	0.043543
O9	0.25	2	2	0.33	0.5	3	0.5	3	1	3	2	0.5	0.072644
O10	0.2	0.33	0.33	0.2	0.33	2	0.25	0.33	0.33	1	0.33	0.25	0.025433
O11	0.2	0.25	0.5	0.33	0.33	3	0.5	0.5	0.5	3	1	0.25	0.038604
O12	0.25	3	3	0.33	0.5	3	2	3	2	4	4	1	0.105226
CR													0.082407

Table 9 - AHP within "Threats" group.

	T1	T2	T3	T4	T5	T6	T7	T8	T9	W_T
T1	1	0.2	0.33	0.2	0.25	0.33	0.33	0.25	0.33	0.028514

T2	5	1	2	0.5	3	3	4	3	3	0.204054
T3	3	0.5	1	0.33	2	2	0.5	0.33	2	0.086077
T4	5	2	3	1	3	3	3	2	3	0.225496
T5	4	0.33	0.5	0.33	1	2	0.33	0.33	0.5	0.063808
T6	3	0.33	0.5	0.33	0.5	1	0.33	0.33	0.5	0.051346
T7	3	0.25	2	0.33	3	3	1	0.33	3	0.112612
T8	4	0.33	3	0.5	3	3	3	1	3	0.158207
T9	3	0.33	0.5	0.33	2	2	0.33	0.33	1	0.069886
CR										0.062134

Table 10 - AHP across SWOT groups.

	S1	W7	O1	T4	W_G
S1	1	0.25	0.33	2	0.1353937
W7	4	1	3	3	0.4928147
O1	3	0.33	1	3	0.2684104
T4	0.5	0.33	0.33	1	0.1033812
CR					0.075267

Table 11 - Final relative importance weights, closeness coefficients of SWOT factors and Ranking.

SWOT factors	W_F	CC_i	Ranking Order
S1	0.026516529	0.828302055	1
S2	0.018702718	0.644355561	3
S3	0.019812915	0.738796125	2
S4	0.005311482	0.451740356	6
S5	0.003274409	0.355644439	7
S6	0.004653011	0.355644439	7
S7	0.004306474	0.451740356	6
S8	0.010028913	0.548259644	4
S9	0.007333145	0.548259644	4
S10	0.016934589	0.644355561	3
S11	0.010602129	0.644355561	3
S12	0.007917382	0.548259644	4
W1	0.067905611	0.120155744	13
W2	0.058298743	0.136994285	12
W3	0.026338402	0.159494798	11
W4	0.023090809	0.159494798	11
W5	0.013359894	0.239640606	9
W6	0.039923241	0.191216561	10
W7	0.073635279	0.120155744	13
W8	0.048591556	0.136994285	12
W9	0.027727952	0.159494798	11
W10	0.016487318	0.239640606	9
W11	0.010252096	0.323797082	8
W12	0.008775698	0.50488646	5

W13	0.035905421	0.159494798	11
W14	0.031916403	0.159494798	11
W15	0.010606227	0.239640606	9
O1	0.056483261	0.828302055	1
O2	0.028590277	0.644355561	3
O3	0.016719867	0.548259644	4
O4	0.043655011	0.738796125	2
O5	0.02360054	0.644355561	3
O6	0.006463734	0.548259644	4
O7	0.016280126	0.548259644	4
O8	0.011687486	0.548259644	4
O9	0.019498274	0.548259644	4
O10	0.006826473	0.451740356	6
O11	0.010361725	0.451740356	6
O12	0.028243638	0.738796125	2
T1	0.002947847	0.239640606	9
T2	0.021095309	0.136994285	12
T3	0.008898797	0.191216561	10
T4	0.023312037	0.136994285	12
T5	0.006596552	0.191216561	10
T6	0.00530819	0.239640606	9
T7	0.011642002	0.159494798	11
T8	0.016355645	0.159494798	11
T9	0.007224862	0.136994285	12

6. Conclusions

One of the services in countries is the electricity which can be consumed as domestic, industrial, agriculture and etc. The electric energy flow from generation in power plants till final consumption has several stages which include generation, transmission, distribution and consumption levels. In this paper, the electric power supply chain is analysed. In this regard, the Strengths and Weaknesses (based on internal network conditions), Opportunities and threats (according to external conditions) are detected and valuated. For each stage of the supply chain, some questionnaires are prepared and several experts in the field of electric power are interviewed. Since a qualitative SWOT analysis can be insufficient to formulate an action plan, an integrated AHP methodology combined with fuzzy-TOPSIS is used to prioritize the defined SWOT factors with top priorities should be emphasized more. According to the priority results, the “S1: existence of integrated global network of electric energy transmission for increasing network stability”, and “O1: whole society depending to the electricity and its extending day by day”, have the highest relative importance weight, and so these are the most important items. The methodology and results presented in this paper are useful for Regional Electric Companies, Electrical Distribution Companies and Energy Efficiency Organization. The results show that the governments should support the renewable energies and global networks to procure the electricity needs with low environment pollution.

REFERENCES

[1] Hofbauer P, Wenninger C. Elastic collaboration for automotive supplier networks. Concurrent Enterprising (ICE), 17th International Conference on 2011; pp. 1-7.

[2] Drezner Z, Hamacher H.W. Facility Location: Applications and Theory. Springer Verlag Berlin and Heidelberg GmbH & Co. K; 2004.

[3] Lee Y.H, Kang K.H, and Lee B.K. Decomposition heuristic to minimize total cost in a multi-level supply chain network. Computers & Industrial Engineering 2008; vol. 54, pp: 945-959.

[4] Gosling J, Naim M.M. Engineer to order supply chain management: A literature review and research agenda. International journal of production economics 2009; 122(2), pp: 741-754.

[5] Mentzer John T. Supply chain management. 2nd edition. California: Thousand Oaks, Sage Publication; 2001.

[6] Chopra Sunil, Meindl peter. Supply Chain Management. 5th edition. New York: Prentice Hall; 2012.

[7] Cho D, Lee Y.H, Ahn S.H, Hwang M.K. A framework for measuring the performance of service supply chain management. Computers & Industrial Engineering 2012; 62: 801-818.

[8] Bhagwat R, Sharma M.K. Performance measurement of supply chain management: A balanced scorecard approach. Computers & Industrial Engineering 2007; 53: 43-62.

[9] Zhang G, Shang J, Li W. Collaborative production planning of supply chain under price and demand uncertainty. European Journal of Operational Research 2011; 215: 590-603.

[10] Chen Y.J. Structured methodology for supplier selection and evaluation in a supply chain. Information Sciences 2011; 181: 1651-1670.

[11] Hassanzadeh-Amin Saman, Zhang Guoqing. A three-stage model for closed-loop supply chain configuration under uncertainty. International Journal of Production Research 2012; Vol. 51, No. 5, 1 March 2013; 1405–1425.

[12] Awasthi A, Chauhan S. S, Goyal S. K. A fuzzy multi criteria approach for evaluating environmental performance of suppliers. International Journal of Production Economics 2010; 126(2): 370–378.

[13] Babaesmailli M, Arbabshirani B, Golmah V. Integrating analytical network process and fuzzy logic to prioritize the strategies – a case study for tile manufacturing firm. Expert Syst 2012; Appl.39: 925–935.

[14] Hunger J.David, Wheelen Thomas L. Essential of strategic management. 5th edition. Prentice Hall; July 29, 2010.

[15] Kurttila M, Pesonen M, Kangas J, Kajanus M. Utilizing the analytic hierarchy process (AHP) in SWOT analysis—a hybrid method and its application to a forest-certification case. Forest Policy Econ 2000; 1:41–52.

[16] Shrestha RK, Alavalapati JRR, Kalmbacher RS. Exploring the potential for silvopasture adoption in south-central Florida: an application of SWOT–AHP method. Agric Syst 2004; 81:185–99.

[17] Kajanus M, Kangas J, Kurttila M. The use of value focused thinking and the A'WOT hybrid method in tourism management. Tourism Manage 2004; 25:499–506.

[18] Shinno H, Yoshioka H, Marpaung S, Hachiga S. Quantitative SWOT analysis on global competitiveness of machine tool industry. J Eng, 2006; 17:251–8.

[19] Yüksel I, Dagdeviren M. Using the analytic network process (ANP) in a SWOT analysis—a case study for a textile firm. Inf Sci 2007; 177:3364–82.

[20] Gao CY, Peng DH. Consolidating SWOT analysis with nonhomogeneous uncertain preference information. Knowl-Based Syst 2011; 24:796–808.

[21] Lee KL, Lin SC. A fuzzy quantified SWOT procedure for environmental evaluation of an international distribution center. Inf Sci 2008; 178:531–49.

[22] Bas Esra. The integrated framework for analysis of electricity supply chain using an integrated SWOT-fuzzy TOPSIS methodology combined with AHP: The case of Turkey. Electrical Power and Energy Systems 2013; 44 : 897–907.

[23] Dwivedi p, Alavalapati JRR. Stkeholders' perceptions on forest biomass-based bioenergy development in the southern US. Energy Policy 2009; 37:1999-2007.

[24] Nagurney A, Liu Z, Cojocaru M.G, Daniele P. Dynamic electric power supply chains and transportation networks: An evolutionary vibrational in equality formulation. Transportation Research Part E 2007; 43: 624-646.

[25] Wang X.H, Cong R.G. Electric power supply chain management addressing climate change. Procedia Engineering 2012; 29: 749-753.

[26] Zhang D, Samsatli N, Hawkes A, Brett D, Shah N, Papageorgiou L. Fair electricity transfer price and unit capacity selection for microgrids. Energy Economics 2013; 36: 581-593.

[27] Lin Yi-Kuei, Yeh Cheng-Ta. Maximal network reliability with optimal transmission line assignment for stochastic electric power networks via genetic algorithms. Applied Soft Computing 2011; 11 : 2714–2724.

[28] Okoro O.I, Chikuni E. Power sector reforms in Nigeria: opportunities and challenges. J. Energy 2007; South. Afr. 18 (3): 52–57.

[29] Saaty T. The Analytic Hierarchy Process. McGraw-Hill: New York; 1980.

[30] Pearce John, Robinson Richard. Strategic Management. 14th edition. Hardcover; 2014.

[31] Stewart R, Moamed S, Daet R. Strategic implementation of IT/IS projects in construction: A case study. Automation in construction 2002; 11: 681-694.

[32] Chang Hsu- His, Huang Wen-chin. Application of a quantification SWOT analytical method. Mathematical and Computer Modelling 2006;Volume 43:Issues 1–2, Pages 158–169.

[33] Saaty T.L. Fundamentals of decision making and priority theory. 2nd ed. Pittsburgh PA: RWS Publications; 2000.

[34] Saaty T. L. Decision making with analytic hierarchy process. International Journal of Services Sciences 2008; 1(1): 83-98. <http://dx.doi.org/10.1504/IJSSCI.2008.017590>.

[35] Hwang C, Yoon K. Multiple attribute decision making: Methods and applications. Springer-Verlag; 1981.

[36] Yue Z. A method for group decision making based on determining the weights of decision makers using TOPSIS. Applied mathematical modeling 2012; No. 35(4): pp. 1926-1936.

[37] Shih S.H, Syur J. H, Lee S. E. An extension of TOPSIS for group decision making. Mathematical and computer modeling 2007; No. 45: pp. 801-813.

[38] Chen T. C, Lin T. C, Huang F. S. A fuzzy approach for supplier evaluation and selection in supply chain management. International Journal of production Economics 2006; No: 102(2), pp. 289-301.

[39] Ghorbani Mazaher, Velayati R, Ghorbani MM. Using Fuzzy TOPSIS to Determine Strategy Priorities by SWOT Analysis. Proceedings of the International Conference on Financial Management and Economics 2011; Singapore.

[40] Wang Yu-Jie. The evaluation of financial performance for Taiwan container shipping companies by fuzzy TOPSIS. Applied Soft Computing 2014; 22 : 28–35.

[41] Chen CT. Extension of the TOPSIS for group decision making under fuzzy Environment. Fuzzy Sets Syst 2000;114(1):1–9.

[42] Jahanshahloo GR, Hosseinzadeh LF, Izadikhah M. Extension of the TOPSIS method for decision-making problems with fuzzy data. Appl Math Comput 2006; 181(2): 1544–51.

[43] Joshi Deep, Kumar Sanjay. Intuitionistic fuzzy entropy and distance measure based TOPSIS method for multi-criteria decision making. Egyptian Informatics Journal 2014; 15: 97–104.

[44] Kaufmann A, Gupta M.M. Introduction to fuzzy arithmetic: Theory an applications. Van Nostrand Reinhold; 1985.

[45] Zimmermann H.J. Fuzzy set theory and its applications. 2nd Edition. Kluwer Academic Publishers; 1991.

[46] Chou SY, Chang YH, Shen CY. A fuzzy simple additive weighting system under group decision-making for facility location selection with objective/subjective attributes. Eur J Oper Res 2008; 189:132–45.

[47] Baykal Ismail Ozgur. Application of Multiple Criteria Decision Making Methods to the Personnel Selection Problem. Master,s Thesis, Industrial

Engineering Department, Galatasarary Univercity; Istanbul: Turkey; 2005.

[48] Li DF. Compromise ratio method for fuzzy multi-attribute group decision making. Applied Soft Computing 2007; 7: 807–17.