A Study on Developing the Indicators of Energy Conservation and Carbon Reduction for Business

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Abstract

Global warming and climate change have raised the awareness and concern about the issue of energy consumption and CO_2 emissions of business. Although energy conservation and carbon reduction has been widely recognized as an effective solution to cope with climate change, but the aspect of CO_2 emission reduction still has not been incorporated in the mainstream business. Accordingly, the current study aims to develop and compute the weight of indicators of energy conservation and carbon reduction from business perspectives. This research acquires relatively more important criteria in business through the Delphi Method and reviewing literature, resulting in six major dimensions and eighteen criteria. The questionnaire was provided for each of the businesses that concern energy conservation and carbon reduction. Finally, this study combines AHP with DEMATEL to analyze the priority and causal relationships of the carbon reduction. The results generated by AHP show that three major criteria including reducing energy consumption, improving energy efficiency, and promoting energy conservation education should be placed in highest priorities, while the results provided by DEMATEL show that energy management systems of improving energy efficiency and increased use of renewable energy to reduce energy consumption are the two most worthy criteria to be emphasized and improved for carbon reduction by observing the causal relationships. Following the constructed indicators, the business firms have a clearer and easier template to contribute to the environment and society.

Keywords: Carbon reduction, Green supply chain management, MCDM, Energy conservation, AHP, DEMATEL

Introduction

Nowadays, global warming has generated many kinds of natural disasters worldwide and Intergovernmental Panel on Climate Change found that these disasters are very likely caused by the increases in global carbon dioxide concentration (IPCC, 2007) [15].

In 1997, after the United Nations officially released the Kyoto Protocol to disclose how to "stabilize atmospheric greenhouse gas (GHG) levels to an appropriate level to prevent dramatic climate change and its subsequent harm to humans," lively discussions on the severity of the earth's climate changes ensued (UNFCCC, 1997) [27]. Moreover, in 2009, 55 countries reacted an agreement for reducing carbon emissions during the World Climate Summit in Copenhagen. The European Union also adopted the Waste Electrical and Electronic Equipment (WEEE) and Restriction of Hazardous Substances (RoHS) regulations to clearly prohibit the use of six hazardous substances in products sold in Europe, and to require compliance with product recycling laws (EU, 2014) [5].

The Kyoto Protocol led to an awareness of energy conservation and carbon reduction, and governmental and entrepreneurial understanding that economic development should be conducted in a cooperative relationship with the environment rather than victimize it (Aggeri, 1999)[1]. Since environmental management became common issues for governments, enterprises and stakeholders, people have shown growing interest in cooperative approaches(New et al., 2002))[14]. Greenhouse gas emission studies, such as strategies for environmental management (Tseng, 2013; Lin et al, 2011.) [26] [12], carbon footprint calculation of inter-company green supply chain (Sundarakani, et al., 2010) [24], and internal inventory management for optimal carbon footprint (Hua et al., 2011) [9] also drew increasing attention.

Review of carbon footprint research showed that most studies focused on supply chain partnership, assessment or calculation of industrial carbon emission reduction (Sundarakani et al., 2010; Hua et al., 2011) [24] [9], but few studies pinpointed the mutual impact of reducing greenhouse gas emissions among different operations. Through the combination of multi-criteria analytical tools in AHP and DEMATEL, this study not only established an energy conservation and carbon reduction weighted index for enterprises, but also further clarified the causal relationships among various energy conservation and carbon reduction indicators. Such understanding enables enterprises to prioritize deplayment of resources into the best areas of creating significant impact, thereby enhancing the efficacy of their carbon footprint management.

2. Literature Review

To ensure competitiveness and fulfill mission of sustainable management, enterprises are moving toward energy conservation and carbon reduction, and restructuring their procedures and green innovations to become green businesses. Since the Framework Convention on Climate Change in 1992 and the Kyoto Protocol in 1997, nations around the world have a consensus on the reduction of green awareness of both consumers and enterprises. Consumers and enterprises have also increased over the past 2 decades. Consumers are beginning to opt for green products, while enterprises realize the close relationship between businesses and surrounding environment, and aim to create a shared value with stakeholders rather than merely pursue profits (Porter & Kramer, 2011; Chaabane et al., 2010) [17] [3]. Governments and enterprises have adopted numerous strategies in their greenhouse gas emission programs, such as increasing the use of renewable energy resources, reducing energy losses, improving fuel quality, and using greenhouse gas emission prevention technologies, while others have introduced low carbon technology industries and industry transformation (Wen and Tan, 2011) [28]. Together, governments and enterprises are cooperating to improve overall energy policies and industry energy supply chain (Zhang et al., 1994) [29]. Enterprises have developed green innovations to achieve energy conservation and carbon reduction, and from strategies to operations, the designing of green products and redesigning of green production processes have become the core strategies and competitive advantage for fulfilling the mission of sustainable management (Eiadat et al., 2008; Zhou et al., 2012; Lv et al., 2010; Pigosso et al, 2010; Scipioni et al., 2010) [4] [31] [13] [16] [22].

Governmental and entrepreneurial motives for promoting green innovations can be divided into external and internal factors. External factors mainly include legal regulations and stakeholder expectations, such as using green innovations to reduce waste, pollution tax and fine reduction in order to increase cost effectiveness (Requate and Unold, 2003; Requate, 2005; Lixin, Laya, Kannan, Roohollah and Ali, 2015) [20] [19][35]. However, enterprises are primarily motivated by internal attitude of green innovation to invest resources into becoming green businesses, and through resource management and environmental protection, both business and environmental performance can be simultaneously accomplished (Rehfeld et al., 2007; Renning et al., 2006) [18][21]. Entrepreneurial decision to conserve energy and reduce carbon is a multi-objectives decision-making managerial process. Managers must evaluate all production and management activities to prioritize their impact and contributions to energy conservation and carbon reduction (Lee, et al., 2009; Tseng, et al., 2013; Zhou, et al., 2011)[11][26][30].

In the past, multi-objectives decision-making tools such as AHP, Fuzzy AHP and ANP were frequently used by enterprises to examine energy conservation and carbon reduction. However, these methods assume mutual independence among the indicators (AHP, Fuzzy AHP) or only correlations (ANP), and ignored the possibility that causality might exist among the indicators.

Decision Making Trial and Evaluation Laboratory (DEMATEL) was developed originated from the Battelle Memorial Institute research center in Geneva. It is a widely-used technique which enables increasing application by scholars in different fields to help enterprises make decisions or resolve problems in complex or uncertain situations. For example, Büyüközkan and Çifçi (2012) [2] used Fuzzy ANP in establishing green logistics (5 indicators), green business operation activities (5 indicators) and business performance (4 indicators) dimensions and the mutual impact among these indicators, as well as their weightings on green supplier selection. Since the DEMATEL does not require data from a large sample and is capable of distinguishing the mutual impact and causality among indicators (Lee et al., 2009) [11]., it has the advantage of determining causal factors for improving performance. Hence many researchers view it as the optimal tool for many multi-criteria decision-making problems (Tzeng et al., 2007; Lin et al., 2011)[25][12].

3. Method

3.1 Research Method

Since AHP results only indicate the weight ranking of each criterion, this research combines AHP with DEMATEL to simultaneously determine the relational strength among the criteria and the weight of each criterion. The relational analysis values are plotted into a cause-effect diagram to determine the dominance of impact among the different criteria.

By using matrix and related mathematical theory of operations, DEMATEL determines causal relationships and degree of impact among all the elements. The causal relationships and degree of impact of these elements within a complex system are then represented by a matrix structure and causal diagram. Hori and Shimizu (1999)[8] asserted that DEMATEL can transform the causal relationships among criteria into a well-defined structural model, and is an appropriate method for managing internal mutual dependency among a series of criteria.

In this study, the indicators were selected based on literature reviews, and in-depth interviews were conducted with greenhouse gas reduction field experts and green industry scholars and experts. For data analysis, the analytic hierarchy process (AHP) was first applied to determine the relative importance among indicators, followed by the Decision Making Trial and Evaluation Laboratory (DEMATEL) to determine the degree to which each indicator could impact greenhouse gas reduction.

3.2Calcultaion Steps of DEMATEL Method

In this study, the DEMATEL procedure proposed by Fontela and Gabus (1976) [6] andTzeng et al. (2007) [25] is used:

Step One: Define criteria and identify relationships

Based on literature review and expert opinions, 6 dimensions and 18 sub-criteria appropriate to entrepreneurial carbon reduction were selected, and a questionnaire was constructed accordingly. Evaluation scale adopted in this study was developed by Fontela and Gabusin 1976 [6]. As Table 1 shows, it includes 4 different scales, 0,1,2, and 3 represent no influence, mild influence, average influence, and significant influence, respectively.

Table 1: Evaluation scale and its influence level for DEMATEL

Evaluation Scale	Influence Level
0	no influence
1	mild influence
2	average influence
3	significant influence

[+] means positive influence ; [-] means negative influence resource: Frontela and Gabus(1976)

Step Two: Create a direct relationship matrix

For n number of criteria, the relationship and degree of impact of the criteria are determined using pairwise comparison to produce a n × n direct relationship matrix, expressed as X=$[X_{ij}]$(i=1,2,3,…,n;j=1,2,3,…,n), where the diagonal elements are set to 0, and X_{ij} represent the degree to which Criteria i impacts Criteria j.

Step Three: Create a Normalized, Direct-influence matrix

Standardize the matrix of direct relationship obtained above. Multiply all the elements in the entire Matrix X (Code A) by S, as expressed in the following equation:

$D = A \times S$

$$S = \frac{1}{\max\limits_{1 \le I \le n} \sum_{j=1}^{n} a_{ij}}$$

where D represents normalized, direct-influence matrix.

Step Four: Calculate determinants of the Total Influence-relation matrix (T)

$$\lim_{k \to \infty} D^k = 0$$

As $\lim_{k \to \infty} D^k = 0$, the total influence-relation matrix T can be obtained from the following formula, $T = D(I - D)^{-1}$, I is a unit matrix.

Step Five: The row-column operation of the total influence matrix.

Sum of the individual columns and rows of the total influence-relation matrix (T) is to determine the total and D values of each row, and the total and R values of each column. The D-value represents the degree of direct or indirect impact of a criterion on other criteria, while the R-value represents the degree to which a criterion is impacted by other criteria. Then calculate the degree of relation (D+R) and degree of causality (D-R), where (D+R) represents the strength of relation and (D-R) represents the degree of influence or being influenced (strength of causality).

Step Six: Draw a causal diagram

Plot out the D+R and D-R values of each criterion, with D+R on the horizontal axis and D-R on the vertical axis. Then plot the causal diagram using the threshold value of each criterion (threshold value is the arithmetic mean of the sum total of the n x n criteria within the total relationship matrix (T)).

4. Results

4.1Results of AHP Analysis

Framework of developing the indicators of carbon reduction for business and AHP weighting rank (Figure 1, Table 2) of the 6 major dimensions and 18 criteria surveyed from the literature and revised by experts showed that efficient energy use is the most important factor considered by industrial experts. In terms of criteria, the experts believed that update of improve efficiency and energy consumption of production facilities is the most important criterion for achieving energy conservation and carbon reduction.

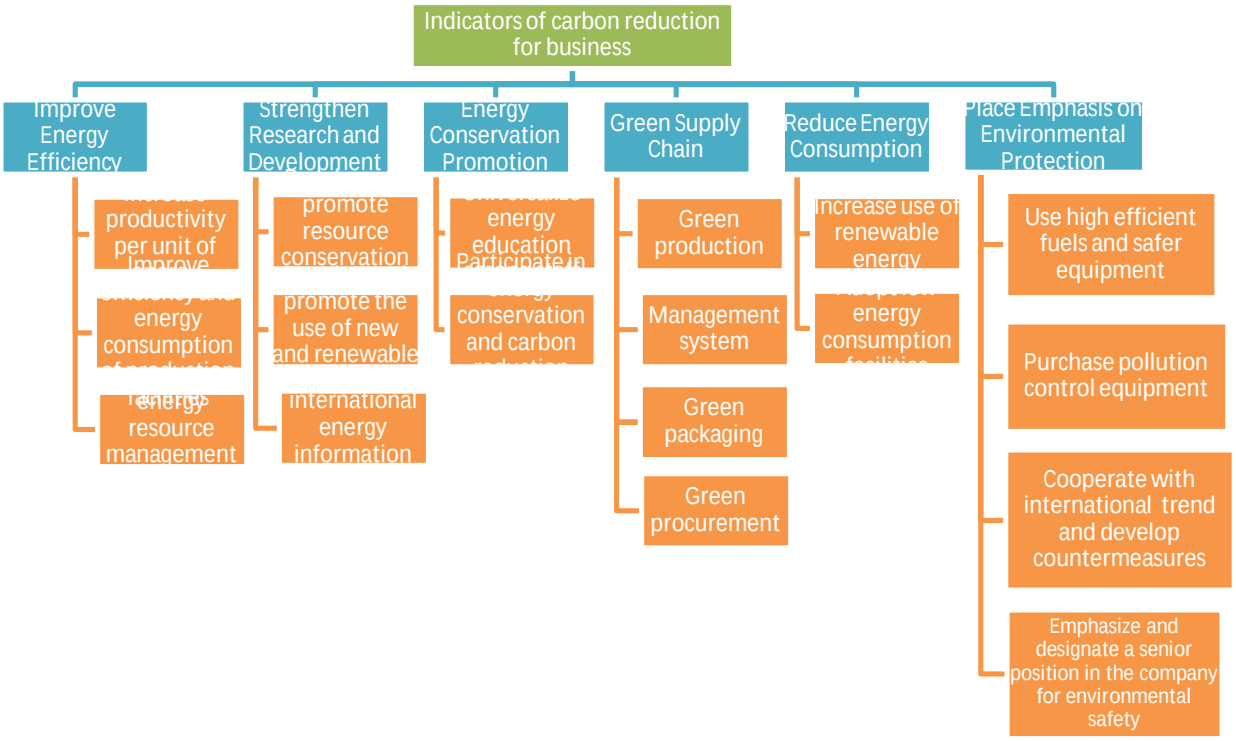

Figure 1: Framework of developing the indicators of carbon reduction for business

Table 2: Relative and Absolute Weights of Influencing Factors

Level 1	Indicator	Relative Weight	Absolute Weight	Dimension Rank	Criteria Rank	Rank
Improve Energy Efficiency(A)	Increase productivity per unit of energy	0.139	0.0278	2	3	12
	Improve efficiency and energy consumption of production facilities	0.192	0.3840		2	1
	Establish energy resource management system	0.669	0.1338		1	3
Strengthen Research and Development(B)	Develop and promote resource conservation technology	0.484	0.0527	5	1	6
	Develop and promote the use of new and renewable energy	0.133	0.0144		3	17
	Increase international energy information exchanges	0.383	0.0417		2	9
Energy Conservation Promotion(C)	Universalize energy education among staff	0.738	0.1306	3	1	4
	Participate in energy conservation and carbon reduction activities	0.262	0.0463		2	8
Green Supply Chain(D)	Green production	0.217	0.0186	6	3	15
	Management system	0.194	0.0166		4	16
	Green packaging	0.227	0.0195		2	14
	Green procurement	0.363	0.0312		1	11
Reduce Energy Consumption(E)	Increase use of renewable energy	0.178	0.0514	1	2	7
	Adopt low energy consumption facilities	0.822	0.2375		1	2
Place Emphasis on Environmental Protection(F)	Use high efficient fuels and safer equipment	0.299	0.0415	4	2	10
	Purchase pollution control equipment	0.089	0.0123		4	18
	Cooperate with international trend and develop countermeasures	0.142	0.0197		3	13
	Emphasize and designate a senior position in the company for environmental safety	0.470	0.0653		1	5

4.2 DEMATEL Result

After having the relative weightings of each greenhouse gas reduction indicator using AHP, DEMATEL is applied using Microsoft Excel to determine causality and relational strength among the 6 dimensions, namely "Improve Energy Efficiency(A)", "Strengthen Research and Development(B)", "Energy Conservation Promotion(C)", "Green Supply Chain(D)", "Reduce Energy Consumption(E)" and "Place Emphasis on Environmental Protection (F)", and their indicators (Table 3, Fig. 2).

Table 3 Combination of AHP and DEMATEL of Six Dimensions and Eighteen Indicators

Level 1	Indicator	Dimension rank	Indicator rank	rank	Dimension D+R	Correlation rank	Dimension D-R	Indicator D+R	Correlation rank	Indicator D-R
Improve Energy Efficiency	Increase productivity per unit of energy	2	3	12	12.440	2	0.533	78.831	2	-0.003
	Improve efficiency and energy consumption of production facilities		2	1				79.503	1	-0.748
	Establish energy resource management system		1	3				73.513	3	0.75
Strengthen Research and Development	Develop and promote resource conservation technology	5	1	6	11.615	4	-0.273	23.509	2	-0.213
	Develop and promote the use of new and renewable energy		3	17				24.146	1	0.452
	Increase international energy information exchanges		2	9				22.000	3	-0.239
Energy Conservation Promotion	Universalize energy education among staff	3	1	4	10.695	6	-0.053	0.222	1	0
	Participate in energy conservation and carbon reduction activities		2	8				0.222	1	0
Green Supply Chain	Green production	6	3	15	10.841	5	0.41	76.506	2	-0.968
	Management system		4	16				64.311	4	3.262
	Green packaging		2	14				77.574	1	0.189
	Green procurement		1	11				75.689	3	-2.09
Reduce Energy Consumption	Increase use of renewable energy	1	2	7	13.328	1	0.232	68.813	1	1
	Adopt low energy consumption facilities		1	2				68.813	2	-1
Place Emphasis on Environmental Protection	Use high efficient fuels and safer equipment	4	2	10	11.879	3	-0.848	14.350	2	0.96
	Purchase pollution control equipment		4	18				13.776	3	0.202
	Cooperate with international trend and develop countermeasures		3	13				12.125	4	-0.777
	Emphasize and designate a senior position in the company for environmental safety		1	5				14.414	1	-0.385

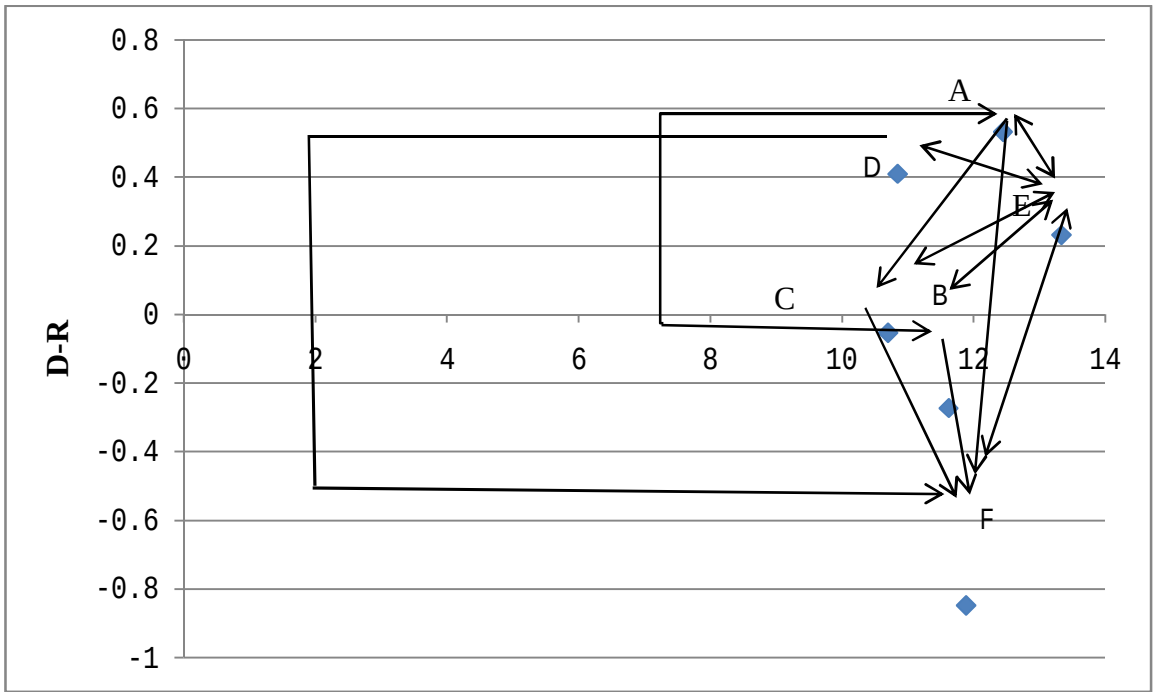

Figure 2: The digraph of causal relations among these six dimensions

First, Table 3 and Fig. 2 show the complex causal relationship among the 6 dimensions. Among 6 dimensions, the dimensions “Improve Energy Efficiency(A)”, “Reduce Energy Consumption(E)” and “Place Emphasis on Environmental Protection(F)” are more highly related (D+R value) to entrepreneurial energy conservation and carbon reduction. A negative D-R (causality) indicates that an enterprise is subjected to the influence of such a dimension, and hence has less room to improve that dimension. On the other hand, a positive D-R value indicates that the enterprise exerts influence on that dimension, and hence has greater discretion in improving that dimension. Of the 6 dimensions, “Improve Energy Efficiency (A)”, “Green Supply Chain (D)” and “Reduce Energy Consumption (E)” are causal dimensions. By making adjustments to Reduce Energy Consumption (E) and Improve Energy Efficiency (A) dimensions to increase reduction in energy consumption and energy efficiency per se, other dimensions can also be enhanced.

Second, the directionality in the causality diagram obtained from relational and causality analysis revealed important managerial significance.Figure2 shows that for "Improve Energy Efficiency (A)", the direction of influence mainly points toward other dimensions while only two influences point toward this dimension, indicating that "Improve Energy Efficiency (A)" unilaterally impacts other dimensions while remaining impervious to the impact of other dimensions. Therefore, intervening with this dimension will yield the greatest improvement. For example, improving the Improve Energy Efficiency dimension of an enterprise will directly impact its Energy Conservation Promotion and Place Emphasis on Environmental Protection dimensions while the resulting changes in these two dimensions will not impact the Improve Energy Efficiency dimension. The integrated results of AHP and DEMATEL (Table 2) suggest that enterprises prioritize “Improve Energy Efficiency (A)”, followed by “Reduce Energy Consumption (E)” and “Place Emphasis on Environmental Protection (F)”, respectively. The MCDM model enables managers to identify the greatest level of relationship or impact, and use that as a starting point for energy conservation and carbon reduction to increase incentive for developing green products and services

5. Conclusions

This study used questionnaires to determine how enterprises weigh energy conservation and carbon reduction items and their connections. We selected AHP and DEMATEL methodology to analyze the collected data. Using dimension or indicator weightings as a standard for improvement, enterprises can achieve the most direct effect within a short period of time. However, from a systemic perspective, the efficacy of a system is derived from the interaction among subsystems. In particular, when causal relationships exist among the subsystems, maximum impact on the overall goal cannot be achieved by merely intervening in a single affected subsystem.

Combined analysis of the 6 dimensions showed that except for "Green Supply Chain" (D), "Improve Energy Efficiency" (A) affected all the other dimensions of energy conservation and carbon reduction while "Reduce Energy Consumption" (E) affected all other dimensions. These two dimensions are dimensions of causality (relational value (D+R) is positive. Based on the analyzed results of degree of relationship, degree of causality and directionality, enterprises are recommended to first modify their "Reduce Energy Consumption" and "Improve Energy Efficiency" dimensions. In addition to having high relational value and being causal in nature, these 2 dimensions ranked highest in 6 dimensions and are therefore not only capable of enhancing energy consumption reduction and energy efficiency per se, but also facilitate improvement in other dimensions. For governments and enterprises, reducing energy consumption is one of the most important factors for sustainable urban development and sustainable production, thereby rendering increasing energy efficiency a relative second.

This study integrated the MCDM's, AHP and DEMATEL to weigh different dimensions and indicators of green innovations to help enterprises construct a quantitative assessment model for green innovations. Entrepreneurial production, human resources, strategies and development are interdependent. This study adopted AHP to construct major dimensions and indicators, and used DEMATEL to determine the associated mutual impact and degree of influence. As a result, enterprises can better deploy their resources to improve energy conservation and carbon reduction in a more productive ways. Analysis showed that first, reducing energy consumption and increasing energy efficiency will have the greatest impact on operating costs, and is therefore a priority factor in the development of green innovations. Second, valuing environmental safety can help enterprises comply with regulations and enhance company image and stakeholder relationship, and is therefore also a priority development.

AHP and DEMATEL have different assessment criteria for decision-making. AHP assumes mutual independence among the dimensions or indicators, and therefore uses different weights to evaluate the impact of individual dimension and criterion on the overall goal. On the other hand, DEMATEL is based on the premise of mutual influence among the dimensions or criteria, and prioritizes resource investment according to factors with the broadest range of influence. The relationship between environmental protection and the operational efficiency of enterprises have transformed from a trade-off relationship to a collaborative relationship. Under prevailing association of sustainable environmental development and energy, reducing energy consumption has become increasingly important than ever before. Improving the level and content of green innovations, enterprises can maintain their competitiveness and achieve their mission of sustainability.

Reference

[1] Aggeri, F., Environmental policies and innovation: a knowledge-based perspective on cooperative approaches, Research Policy, vol. 28, no. 7, (1999), pp. 699-717.

[2] Büyüközkan, G., &Ciftci, G., Evaluation of the green supply chain management practices: a fuzzy ANP approach, Production Planning and Control, vol. 23, no. 6, (2012), pp. 405-418.

[3] Chaabane, A. M., Sabri, O., &Parguel, B., Competitive advertising within store flyers: A win–win strategy? Journal of Retailing and Consumer Services, vol. 17, no. 6, (2010), pp.478-486.

[4] Eiadat, Y., Kelly, A., & Roche, F., Green and competitive? An empirical test of the mediating role of environmental innovation strategy, Journal of World Business, vol. 43, no. 2, (2008), pp.131-145.

[5] EU, 2014. <http://ec.europa.eu/environment/legal/implementation_en.htm>

[6] Fontela, E., &Gabus, A., The DEMATEL Observer, Switzerland Geneva: Battelle Memorial Institute Geneva Research Centre, (1976).

[7] Gungor, A., & Gupta, S.M., Issues in environmentally conscious manufacturing and product recovery: a survey, Computers & Industrial Engineering, vol. 36, no. 4, (1999), pp. 811-853.

[8] Hori, S., &Shimizu, Y., Designing Methods of Human Interface for Supervisory Control Systems, Control Engineering Practice, vol. 7, no. 11, (1999), pp. 1413-1419.

[9] Hua, G., Cheng, T. C. E., & Wang, S., Managing carbon footprints in inventory management, International Journal of Production Economics, vol. 132, no. 2, (2011), pp. 178-185.

[10] Hult, M., Tomas, G., & David, J., Strategic Supply Chain Management: Improving Performance Through a Culture of Competitiveness and Knowledge Development, Strategic Management Journal, vol. 28, no. 10, (2007), pp. 1035-1052.

[11] Lee, AH.I., Kang, H.Y., Hsu, C.F., & Hung, H.C., A green supplier selection model for high-tech industry, Expert Systems with Applications, vol. 36, (2009), pp. 7917-7927.
[12] Lin, Y., Tseng, M. L., Chen, C. C., & Chiu, A. S. F., Positioning strategic competitiveness of green business innovation capabilities using hybrid method, Expert Systems with Applications, vol. 38, no. 3, (2011), pp. 1839-1849.
[13] Lv, J., Ma, J.,& Li. J., The Influence of Low Carbon Economy on Corporate Social Responsibility, Asian Social Science, vol. 6, no. 11, (2010), pp. 233-238.
[14] New, M., Lister, D., Hulme, M., & Makin, I., A high-resolution data set of surface climate over global land areas, Climate Research, vol. 21, no. 1, (2002), pp. 1-25.
[15] Pachauri, R.K. & Reisinger, A., Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC, Geneva, Switzerland, (2007).
[16] Pigosso, D.C.A., Zanette, E.T., Filho, A.G., Ometto, A.R., & Rozenfeld, H., Ecodesign methods focused on remanufacturing, Journal of Cleaner Production, vol. 18, no. 1, (2010), pp. 21-31.
[17] Porter. M. E., & Kramer, M. R., The big idea. creating shared value: how to reinvent capitalism-and unleash a wave of innovation and growth, Harvard Business Review, January-February, (2011), pp. 1-17.
[18] Rehfeld, K-M., Rennings, K. & Ziegler, A., Integrated product policy and environmental product innovations: An empirical analysis, Ecological Economics, vol. 61, no. 1, (2007), pp. 91-100.
[19] Requate, T., Dynamic incentives by environmental policy instruments- a survey, Ecological Economics, vol. 54, no. 2-3, (2005), pp. 175-195.
[20] Requate, T., & Unold, W., Environmental policy incentives to adopt advanced abatement technology: will the true ranking please stand up? European Economic Review, vol. 47, no. 1, (2003), pp. 125-146.
[21] Renning, K., Ziegler, A., Ankele, K. & Hoffman, E., The influence of different characteristics of the EU environmental management and auditing scheme on technical environmental innovations and economic performance, Ecological Economics, vol. 57, no. 1, (2006), pp. 45-59.
[22] Scipioni, A., Mastrobuono, M., Mazzi, A., & Manzardo, A., Voluntary GHG management using a life cycle approach. A case study, Journal of Cleaner Production, vol. 18, no. 4, (2010), pp.299-306.
[23] Sözen, A., Gülseven, Z., & Arcaklioğlu, E.,Forecasting based on sectoral energy consumption of GHGs in Turkey and mitigation policies, Energy policy, vol. 35, no. 12, (2007), pp. 6491-6505.
[24] Sundarakani, B., de Souza, R., Goh, M., Wagner, S. M., & Manikandan, S., Modeling carbon footprints across the supply chain, International Journal of Production Economics, vol. 128, no.1, (2010), pp. 43-50.
[25] Tzeng, G. H., Chiang, C. H., &Li, C. W., Evaluating Intertwined Effects in E-learning Programs: A Novel Hybrid MCDM Model Based on Factor Analysis and DEMATEL, Expert Systems with Applications, vol. 32, no. 4, (2007), pp. 1028-1044.
[26] Tseng, M. L., Wang, R., Chiu, A. S. F., Geng, Y., & Lin, Y. H., Improving performance of green innovation practices under uncertainty, Journal of Cleaner Production, vol. 40, (2013), pp.71-82.
[27] UNFCCC, 1997. Kyoto Protocol http://unfccc.int/kyoto_protocol/items/2830.php accessed on 15/05/2014.
[28] Wen H. D., & Tan J. R., Low-Carbon Strategy with Chinese SMEs, Energy Procedia, vol. 5, (2011), pp. 613-618.
[29] Zhang, Q., Zhang, B. L., Liu, S.Y., Guo, X,H., & He, C. F., The present situation and characteristics of China's energy consumption, Energy Policy, vol. 22, no. 12, (1994), pp. 1075-1077.
[30] Zhou, Q., Huang, W.L., & Zhang, Y., Identifying critical success factors in emergency management using a fuzzy DEMATEL method, Safety Science, vol. 49, no. 2, (2011), pp. 243-252.
[31] Zhou, M., Pan, Y., Chen, Z., Yang, W., & Li, B., Selection and evaluation of green production strategies: analytic and simulation models, Journal of cleaner Production, vol. 26, no. 9, (2012), pp. 9-17.
[32] Abdullah, Lazim, and NorsyahidaZulkifli, Integration of fuzzy AHP and interval type-2 fuzzy DEMATEL: An application to human resource management, Expert Systems with Applications, vol. 42, no. 9, (2015), pp. 4397-4409.
[33] Uygun, Özer, HasanKaçamak, and ÜnalAtakanKahraman, An integrated DEMATEL and Fuzzy ANP techniques for evaluation and selection of outsourcing provider for a telecommunication company, Computers & Industrial Engineering, vol. 86, (2015), pp. 137-146.

[34] Sara, Juliana, Rob M. Stikkelman, and Paulien M. Herder, Assessing relative importance and mutual influence of barriers for CCS deployment of the ROAD project using AHP and DEMATEL methods, International Journal of Greenhouse Gas Control, vol. 41, (2015), pp.336-357.

[35] Shen, Lixin, et al. "A fuzzy multi criteria approach for evaluating green supplier's performance in green supply chain with linguistic preferences." Resources, Conservation and Recycling 74 (2013): 170-179.