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Evaluation of Success Factors of ISO 14001- Based EMS Implementation and Ranking the Cement Industry Using the TOPSIS Method

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ABSTRACT

Environmental problems have earned high priority in a growing number of businesses due to market pressures and environmental regulations and green production has become important issue to manufacturers like cement industries.The important factors and sub-factors to the successful implementation of ISO 14001-based environmental management system (EMS) and benefits that can be gained from the implementation were recognized in our study and in this study we used the TOPSIS method, to find out the ranking of critical factors of successful implementation of ISO 14001-based environmental management system (EMS) and corporations in Cement Industry in Iran and the study was accomplished in Iran by experts in cement industries. So, in this article we want to introduce a frame work for assessment of effective implementation ISO 14001-based environmental management system (EMS) that can be useful with internal and external audit process and also the results of this study suggest that the most important critical sub-factors of implementation of ISO 14001 in cement industries in Iran are as follows: top management commitment and support, environmental specialist assistance,environmental legislation, training and awareness, and costs of maintenance and improvement.

KEY WORDS: ISO 14001, environmental management system (EMS), Sustainability, TOPSIS, cement industry

1. INTRODUCTION

The world consumption of cement is rising at an increasing rate creating significant levels of pollution (Avetisyan, 2008) and recently, there is a growing skepticism among consumers about the validity of “green” product claims (Blengini and Shields, 2010). The issue with environmental destruction has been one of the main problems both social and political in recent times (Da Silva and De Medeiros, 2004) and concerns about the sustainability and the protection of the natural environment have become increasingly significant issues amongst regulators, environmentalists and society in many countries (Ribeiro and Guzman, 2010). Sustainability is a significant issue which has been discussed in recent years and a large number of sustainability reports, exhibiting the increased significance of sustainability issues (La¨nsiluoto and Ja¨rvenpa¨a¨, 2008) andenvironmental management programs were organized to ensure the implementation of the environment friendly concept by employees (Yusoff and Lehman, 2009).So, companies can earn a green passport for a greater market (Baharum and Pitt, 2009) and the use of such environmental management practices presents new needs of information for public organizations and they need information about their environmental impacts and the results of the initiatives that are developed (Ribeiro and Aibar-Guzman, 2010). The environmental management becomes our every day’s care and increasingly numerous people care for the environment we live in (Kralj, 2008) and implementing an EMS can aids corporations improve their performance (Baharum and Pitt, 2009) and also the purpose of the ISO 14001 standard is to guide environmental improvements worldwide through a systematic approach to environmental management (Ann *et al.*, 2006) and ISO 14001 is a systemic requirement directed to changing business processes and procedures (Gonza´lez*et al.*, 2008). This research defines the concept of environmental management systems for the cement industry and in this study we have used TOPSIS method to recognize the most effective criteria of ISO 14001-based environmental management system (EMS) and ranking cement industries in Iran. This paper is organized as follows: Section 2 discusses the basics of sustainability, ISO 14001 and its benefits and EMS systems in cement industries, Section 3 discusses the important success factors of ISO 14001 implementation, Section 4 discusses the methodology, Section 6 discuses the study and Section 7 concludes the study.

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2. Basics of sustainability, EMS and ISO 14001 in cement industries

Using sustainability practices in cement production could benefit projects (Avetisyan, 2008) and with increasing public awareness in environmental protection, enterprises began producing more green products than last decade (Yeh and Chuang, 2011) and in today's global economy, organizations are more and more called upon to exhibit sound management of economic, social and environmental issues (Ann *et al.*, 2006). The sustainability paradigm provides a framework for addressing complex problems because it is both comprehensive and flexible (Blengini and Shields, 2010) and in this context, the role of sustainability is to find balance between economic, social, and environmental impacts of industrial operations (Avetisyan, 2008). Sustainable development struggles to improve the economy, environment, and society (Blengini and Shields, 2010) and ISO 14001certification is excellent for industries to embrace toward sustainable environmental management and benchmarking (amin and Sharmistha, 2010). In the cement industry the environmental impact of production operations has direct and indirect effects on the environment and since the cement industry is very energy intensive and a big contributor to spatial pollution, the environmental management systems could be implemented in this industry (Avetisyan, 2008) and approaches, such as cleaner production, environmental management systems and eco-efficiency, have been implemented for green management practices (Zhu and Sarkis, 2004). Environmental management systems based on ISO 14001 were developed to evaluate and improve the environmental behavior of corporations (Beltra´n*et al.*, 2010) and implementing an EMS can aids corporations improve their performance (Baharum and Pitt, 2009). The ISO 14001 establishes a reference model for the implementation of corporation environmental management systems, determined as those parts of global management systems that depict the organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for preparing, applying, reviewing and maintaining company environmental policies (Casadesu´s*et al.*, 2008) and ISO 14001 aids corporations to implement their commitment to environmental distinction, aids prevent multiple registrations, inspections, certifications, labels and conflicting requirements, and eliminates the need for certain regulatory "command and control" initiatives (Ann *et al.*, 2006).

3. The important success factors of ISO 14001 implementation

In this section we will explain the important success factors of ISO 14001 implementation. The choice of critical success factors is based on the main clauses of ISO 14001 and some researches that for effective design and implementation of ISO 14000-based EMS any organization must pay attention to them. Five main factors in this research are as follows: (1) Management approach, (2) Organizational change, (3) Technical aspects, (4) External and social aspects, and (5) costs. On this basis, 17 sub-factors were determined and classified in 5 main groups.

3.1 Management approach

The sub-factors that come under management approach are as follows: top management commitment and support (M_1), environmental policies and objectives (M_2), and management reviews (M_3).

Top management commitment and support (M_1): Environmental performance is a concern for managers (Zhu and Sarkis, 2004). In general, management support is a critical element of adoption and implementation of innovations in an organization, especially environmental systems and top management support can affect new system initiatives success by promoting employee empowerment, by facilitating employee involvement by promoting a cultural shift and increased commitment by the organization's staff (Zhu *et al.*, 2008).

Environmental policies and objectives (M_2): Environmental policy is a commitment of protecting the environment and improving environmental performance ceaselessly (Liyin*et al.*, 2006) and environmental considerations became a significant factor to the procurement policy (Yeh and Chuang, 2011). Implementation of ISO 14001 requires organizations to describe and document their environmental policy and assists the stipulated objectives and goals (Delmas, 2001) and companies are not only supposed to comply the environmental laws to sell their product, but they are also required to plan some micro strategies to decrease environmentally disturbing influence of their products to gain sustainable development, integrating all social, economic and environmental criteria is the biggest challenge (Verghese and Lewis, 2007).

Management reviews (M_3): Management review emphases on the EMS itself and its interrelationship with the operating of the company as a whole and these appear to be similar to Deming's plan-do-check-act cycle (Ann *et al.*, 2006) and the top management must review ceaselessly the company's EMS to ensure that the system is appropriate, sufficient, and effective (Sambasivan and Fei, 2008).

3.2 External and social aspects

The effective development and implementation of ISO 14001-based EMS is certainly influenced to a great extent by external and social aspects that include: market pressure (S_1), environmental legislation (S_2), customer requirements (S_3), and employee relations (S_4).

Market pressure (S_1): Consumer pressures and drivers may also exist and globalization may result in higher pressure and drivers for corporations to improve environmental performance (Zhu and Sarkis, 2004) and stakeholder

pressures such as customers and suppliers may also impact company environmental activities (Zhu *et al.*, 2008) and External pressures, on the use of certain hazardous materials, have been driving companies and governments to pay attention to the environmental improvement process (Lee, 2008).

Environmental legislation (S_2): Global environmental issues emerge along with the involvement of governments via green legislation and financial instruments (Sheu, 2011) and researches indicate that government regulation and legislation is a major driver for companies' environmental attempts. However, compliance with environmental legislation is no guarantee for improved environmental performance (Walker *et al.*, 2008).

Customer requirements (S_3): Customer satisfaction has been used as a factor of both organizational performance and operational performance of an organization (Padma *et al.*, 2008) and many companies are adopting EMS in response to pressure from their customers and they have already started to guide their suppliers to conform to the ISO 14001 standard (Sambasivan and Fei, 2008).

Employee relations (S_4): An organization committed to the environment is more likely to strengthen team energy and raise constancy and increase in the organization's ability to attract high quality employees (Chin *et al.*, 1999) and Without employee involvement, the system may not bring important improvements to the environment (Ann *et al.*, 2006).

3.3 Organizational change

The changes include: training and awareness (O_1), documentation control (O_2), emergency response and preparedness (O_3), communication (O_4), and preventive actions (O_5).

Training and awareness (O_1): The public's environmental awareness has increased through formal and informal environmental education channels (Zhu *et al.*, 2010) and staff should experience environmental awareness training to familiarize them with their responsibilities for implementing the EMS and with the overall environmental policy and objectives of the organization. This provides staff with the necessary skill and motivation for the effective implementation of the EMS (Chavan, 2005). So, training and awareness may guide to improvements in the environmental knowledge, skills and proficiency of staff (Pe´rez*et al.*, 2007).

Documentation control (O_2): All objectives, targets, policies, responsibilities and procedures should be documented along with information on environmental performance and documentation is applicable for verifying environmental performance to employees, regulators and the community (Chavan, 2005).

Emergency response and preparedness (O_3): For emergency readiness, the organization should establish and maintain procedures to recognize potential problems and respond to accidents and emergency conditions. It should also improve, establish and maintain procedures for preventing and mitigating the environmental effects that may be collaborated with accidents and emergency conditions (Chin *et al.*, 1999). These procedures must be checked periodically, reviewed periodically, and revised, if/when necessary, after the happening of accidents or emergency situations (Sambasivan and Fei, 2008).

Communication (O_4): Effective communication aids to increase environmental awareness among organization employees, improve the understanding about the organization's environmental policy, objectives, targets and programs; recognize environmental problems existed in organizational actions; and undertake corrective actions where necessary (Liyin*et al.*, 2006).

Preventive actions (O_5): Organizations shall establish, implement and maintain a procedure for dealing with potential nonconformities and for preventive actions organization shall evaluate the needs for actions to prevent nonconformities and record the result and review the effectiveness of preventive actions (ISO 14001, 2008).

3.4 Technical aspects

These include: production process enhancement (T_1),monitoring and measuring equipment (T_2), and environmental specialist assistance(T_3).

Production process enhancement (T_1): The existing production equipments and practices in most of the industrial companies, especially the small- and medium-sized enterprises, cannot satisfy the ISO 14001 requirements for achieving regulatory obedience and optimum environmental performance. Therefore, production processes need to be increased so that they become more environmentally friendly (Chin *et al.*, 1999).

Monitoring and measuring equipment (T_2): In implementing ISO 14000-based EMS, organizations need reliable monitoring and measuring equipment to regularly monitor and measure all actions that can cause important impact on the environment (Chin *et al.*, 1999). Also, organizations should monitor and measure process performance parameters to recognize deviation and control them effectively in order to attain the desired results (Padma *et al.*, 2008).

Environmental specialist assistance(T_3): There is a demand for a specialist's assistance and experts to understand and assess technical issues of the organization's operations that may have important environmental impacts (Sambasivan and Fei, 2008).

3. 5 Costs

The sub-factors that come under costs are as follows: costs of initial set up (C_1), and costs of maintenance and improvement (C_2).

Costs of initial set up (C_1) and *Costs of maintenance and improvement* (C_2): Environmental management practices can bring financial benefits for organizations as a result of increased product prices in addition to decreased costs (La¨nsiluoto and Ja¨rvenpa¨a¨, 2008) and to provide a clear and comprehensive picture on the capability and to consider trade-offs between costs and benefits for implementing ISO 14001-based EMS, the costs are significant (lee, 2008) and economic performance is typically the most important driver for corporations that wish to implement environmental management practices, especially for enterprises in developing countries (Zhu and Sarkis, 2004)

4. The TOPSIS method

Multi criteria decision making (MCDM) may be considered as a complex and dynamic process and most multi criteria methods require definition of quantitative weights for the criteria, in order to assess the relative importance of the different criteria (Opricovic and Tzeng, 2004). In a typical MCDM problem, multiple and generally conflicting criteria are simultaneously taken into account for making a decision (Shahanaghi and Yazdian, 2009). The main steps of multi criteria decision making are the following:

(a) Establishing system evaluation criteria that relate system capabilities to goals;
(b) Developing alternative systems for attaining the goals (generating alternatives);
(c) Evaluating alternatives in terms of criteria (the values of the criterion functions);
(d) Applying a normative multi criteria analysis method;
(e) Accepting one alternative as ‘‘optimal’’ (preferred);
(g) If the final solution is not accepted, gather new information and go into the next iteration of multi criteria optimization (Opricovic and Tzeng, 2004).

TOPSIS is a multiple criteria method to recognize solutions from a set of alternatives based upon simultaneous minimization of distance from an ideal point and maximization of distance from a nadir point (Olson, 2004).So, based on the concept that the chosen alternative should have the shortest distance from the positive ideal solution (PIS) and the farthest from the negative ideal solution (NIS) for solving a multiple criteria decision making problem. Briefly, the PIS is made up of all best values attainable of criteria, whereas the NIS is composed of all worst values attainable of criteria (Jadidi*et al.*, 2008) and TOPSIS has been applied to a number of applications (Olson, 2004).

The TOPSIS procedure consists of the following steps:

(1) Calculate the normalized decision matrix. The normalized value r_{ij} is calculated as:

$$r_{ij} = \frac{f_{ij}}{\sqrt{\sum_{j=1}^{J} f_{ij}^2}} \quad , \quad j = 1, \dots, J; i = 1, \dots, n, \quad (1)$$

(2) Calculate the weighted normalized decision matrix. The weighted normalized value v_{ij} is calculated as:

$$v_{ij} = w_i r_{ij} j = 1, \dots, J; i = 1, \dots, n, \quad (2)$$

where $w_i$is the weight of the ith attribute or criterion, and$\sum_{i=1}^{n} w_i = 1$.

(3) Determine the ideal and negative-ideal solution.

$$A^* = \{v_1^*, \dots, v_n^*\} = \{(max\ v_{ij} | i \in I'), (min\ v_{ij} | i \in I'')\}, \quad (3)$$

$$A^- = \{v_1^-, \dots, v_n^-\} = \{(min\ v_{ij} | i \in I'), (max\ v_{ij} | i \in I'')\}, \quad (4)$$

Where I' is associated with benefit criteria, andI'' is associated with cost criteria.

(4) Calculate the separation measures, using the dimensional Euclidean distance. The separation of each alternative from the ideal solution is given as: $D_j^* = \sqrt{\sum_{i=1}^{n} (v_{ij} - v_i^*)^2}\, j = 1, \dots, J$ (5)

Similarly, the separation from the negative ideal solution is given as:$D_j^- = \sqrt{\sum_{i=1}^{n} (v_{ij} - v_i^-)^2}\, j = 1, \dots, J$ (6)

(5) Calculate the relative closeness to the ideal solution. The relative closeness of the alternative a_j with respect to A^* is defined as: $C_j^* = \frac{D_j^-}{(D_j^* + D_j^-)} j = 1, \dots, J$ (7)

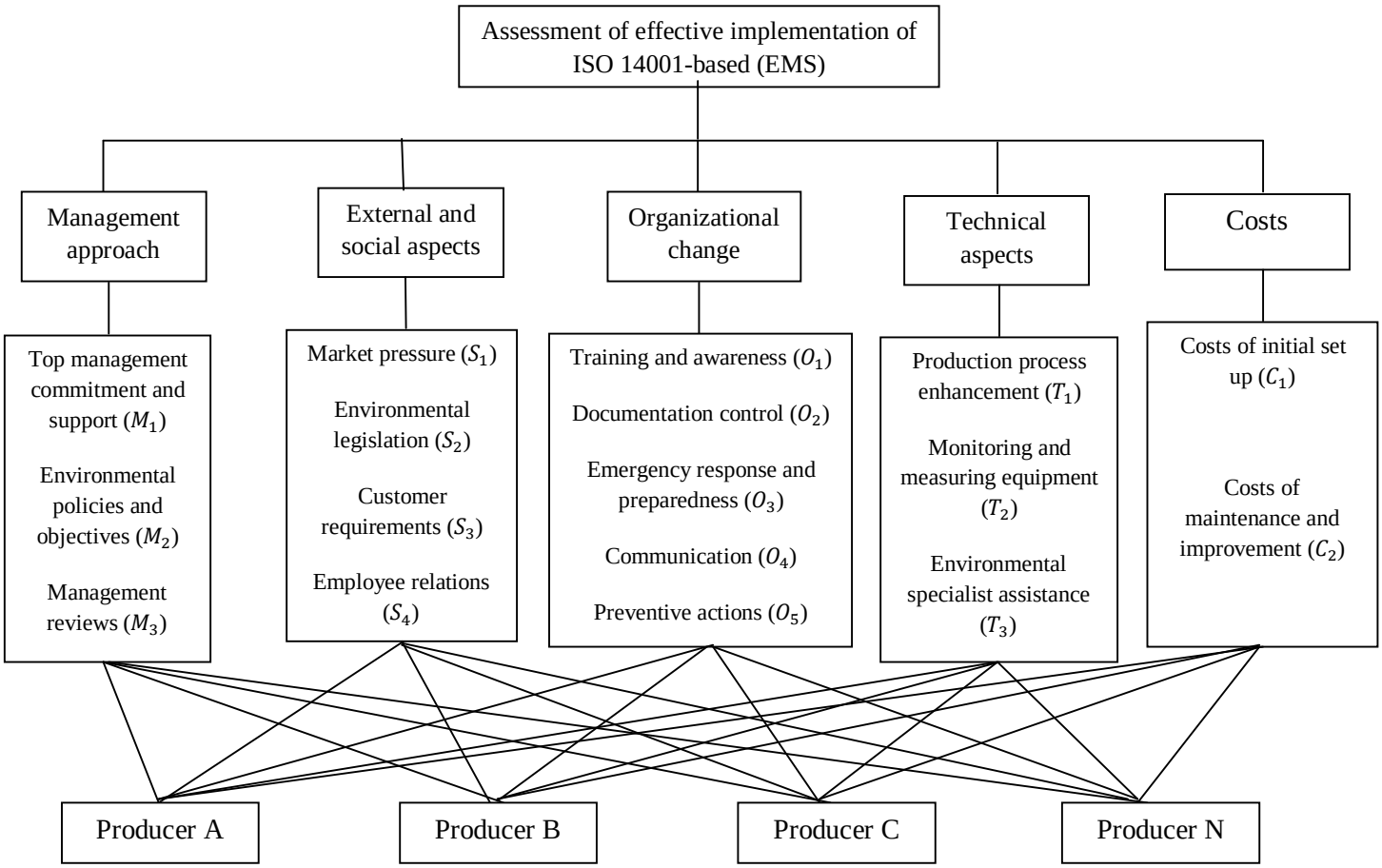
(6) Ranking (Opricovic and Tzeng, 2004).

5. RESULTS

In this study we used the TOPSIS method, to recognize the important factors and sub-factors to the successful implementation of ISO 14001-based environmental management system (EMS) and we used this method to find out the ranking of critical sub-factors and cement industries in Iran.

5.1 The TOPSIS model of research:

Figure 1-Environmental producer assessment model



In our study, first the relevant critical success factors (decision criteria) were recognized and then the relevant attributes (sub-criteria) that defined each of the critical factors were identified. Finally, we ranked cement industries in Iran by experts. The relevant data was collected by questionnaire and for this research a questionnaire was designed that included a section for general data of experts and a section for decision making matrix. All these experts were senior consultants of ISO 14001, that they were experienced in ISO 14001- based EMS implementing and worked in cement industries in Iran. 9 questionnaires were specifically sent to the experts of EMS systems. From 9 questionnaires, 7 questionnaires were responded and completed and since we are using TOPSIS to analyze the data, the results are not influenced by small sample size and in MCDM methods we collect the data in expert population and knowledge of experts is more important than the number of experts. According to TOPSIS algorithm's Activities, below results are obtained. In table 1 we observe decision making matrix that completed by 7 questionnaires were responded from experts.

Table1- Decision making matrix

Criteria / Producer	M_1	M_2	M_3	S_1	S_2	S_3	S_4	O_1	O_2	O_3	O_4	O_5	T_1	T_2	T_3	C_1	C_2
A	5.01	6.95	4.93	7.11	7	6.46	5.01	4.38	4.16	5.52	4.82	4	6.6	6.26	6.95	4.16	5.43
B	5.92	7.48	5.92	3.16	7.48	3.16	5	5.92	7.48	6.32	5.92	5	6.48	7.48	6.32	7.94	7.94
C	6.48	5.92	5.66	5.66	7.48	5.48	6.48	5.48	6	4.9	5.92	5.66	2.45	5.92	5.66	6.48	6.48

5.2 calculations of sub-criteria weights

Based on completed questionnaires, we calculated the weighs of sub-factors that are shown in table 2 and the weights arranged and ranked in table 3. So, we can see that the top five criteria are as follows: top management

commitment and support (**0.068**), environmental specialist assistance(**0.064**), Environmental legislation (**0.064**), Training and awareness (**0.064**), and Costs of maintenance and improvement(**0.063**).

Table 2- weights of sub-criteria

Criteria	M_1	M_2	M_3	S_1	S_2	S_3	S_4	O_1	O_2	O_3	O_4	O_5	T_1	T_2	T_3	C_1	C_2
Total	56	48	48	51	53	50	43	53	38	44	43	51	44	49	55	46	52
Weight	0.068	0.058	0.058	0.062	0.064	0.061	0.052	0.064	0.046	0.053	0.052	0.062	0.053	0.059	0.067	0.056	0.063

Table 3- ranked weights of sub-criteria

Criteria	M_1	T_3	S_2	O_1	C_2	S_1	O_5	S_3	T_2	M_2	M_3	C_1	O_3	T_1	O_4	S_4	O_2
Weight	0.068	0.067	0.064	0.064	0.063	0.062	0.062	0.061	0.059	0.058	0.058	0.056	0.053	0.053	0.052	0.052	0.046

From weights obtained, it can be concluded that the most important of the critical success sub-factors is the top management commitment and support (weight = **0.068**) and the least important is documentation control (weight = **0.046**). So, top management commitment and support is very important for successful implementation of ISO 14001-based environmental management system (EMS). The commitment of management starts from the formulation of the environmental policy and its communication to all the employees. The commitment of the management is also evident from frequent reviews of EMS to continuously improve the system (Sambasivan and Fei, 2008) and without the total participation of top management all attempts might fail (Padma *et al.*, 2008).

5.2 Ranking 3 cement producers

Based on the weights of sub-factors, and data were shown in table 1, three cement producers are ranked. For this calculation and ranking, we used TOPSIS 2005 and finally

from calculations were obtained, the ranking of 3 cement producers in ISO 14001- based EMS implementing in Iran based on relative closeness to the ideal solution are as follows: Producer A (0.633), Producer C (0.498), Producer B (0.448). So, we concluded:

Based on calculations were performed, it can be concluded that producer A is the best factory, in ISO 14001-based EMS implementation in 3 cement producer and this frame work is useful for assessment of effective implementation ISO 14001-based environmental management system (EMS) and we can use it in any organization.

6.DISCUSSION

In recent years a large number of companies implement ISO 14001- based EMS and the purpose of the ISO 14001 standard is to guide environmental improvements worldwide through a systematic approach to environmental management. In this study, we used the TOPSIS method, to find out the ranking of critical sub-factors of successful implementation of ISO 14001-based environmental management system (EMS) and we ranked 3 cement producers in Iran andthe literature review that conducted by different authors helped ensure the content validity and the this study is align with research ofRibeiro and Aibar-Guzman (2010),Sambasivan and Fei (2008), Casadesu´*set al.* (2008),Gonza´lez*et al.* (2008), Ann *et al.* (2006), Delmas (2001), and Chin *et al.*,(1999).

In this research, we had some limitations in our research and as the main contributions of this study are to recognize the factors and benefits of ISO 14001, the identification of them is very important. One limitation was the variables of this study and other researchers can use more variables in their study. Other limitation was sample size of experts and since we are using TOPSIS method to analyze the data, the results are not influenced by small sample size but it is better other researchers use larger sample size of experts and companies. For further studies, other criteria can be added to our models and such research can boost more awareness of other ISO 14001, green issues and environment management systems and our study provides a significant step into further research in environmental management systems and our observations may be completed over time with the same case study and other researchers can also use fuzzy TOPSIS or other Multi criteria decision making methods in their future researches.

7. Conclusions

Recently, companies pay more attention on environment and environmental issues have become a key determinant of performance in the marketplace and cement production is considered one of the major contributors to environmental pollution and the area that requires implementation of more efficient sustainability practices. In this

study, we used the TOPSIS method, to find out the ranking of critical sub-factors of successful implementation of ISO 14001-based environmental management system (EMS) and we ranked 3 cement producers in Iran. Based on our research, we concluded that the most important critical sub-factors of implementation of ISO 14001 in cement industries in Iran are as follows: top management commitment and support, environmental specialist assistance,environmental legislation, training and awareness, and costs of maintenance and improvement. So, ISO 14001 highlights on the commitment and support from top management for a successful implementation and without their support, failure of any EMS is probably. Also we introduced a useful frame work for assessment of effective implementation ISO 14001-based environmental management system (EMS) that we can use it in any organization.

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