ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 5, February 2016 in association with
HEERA COLLEGE OF ENGINEERING AND TECHNOLOGY, THIRUVANANTHAPURAM
Organizes
NATIONAL CONFERENCE ON ENGINEERING FOR LIFE (NCEL – 2016)
(12th -13th February 2016)

Eco-efficiency Barrier Assessment in Public Sector Automobile Firms in Kerala Using Interpretive Structural Modelling

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Abstract—**The automobile sector is swiftly increasing its market share worldwide in recent years. Due to increasing market share of the automobile sector, several environmental issues are also arising such as carbon emission, global warming etc. In such a plot, automobile manufacturers are facing dual pressure: one to save the environment and other to maintain the performance of the firm in the long run. The paper here focuses on assessing the barriers of eco efficiency in Kerala automobile firms. The objective is to identify the major barriers which negatively influence eco efficiency in public sector automobile firms .The models are developed using the data obtained from a research survey conducted among employees of Kerala Automobiles Limited. The barriers are ranked and the major & minor barriers influencing eco efficiency are determined through the questionnaire survey and the influence of these barriers on eco-efficiency has been spotted using interpretive structural modeling. By use of this model, crucial barriers affecting implementation of eco-efficiency preparations in an organization can be identified.**

IndexTerms*—*Ecoefficiency,Sustainable,Automobile, Barriers, Interpretive Structural Modeling.

I. INTRODUCTION

Sustainability has become an essential topic in automobile industry. Present and future generations are facing challenges like climate change, decreasing bio-diversity, increasing air-pollution etc. A large effort has been spent on this topic, to decrease the impacts caused by these factors on environment.

All definitions, tools and indicators have their own centre of attention, strengths and weaknesses, since each has been developed for its own cause. Existing tools often involve downsides such as a time-consuming assessment due to tool complexity or lacking applicability to other industrial sectors. In order to develop a sustainability assessment tool which is practically useful we should overcome the above mentioned issues.

Eco- Efficiency can also be a key driver of economic growth. A number of firms have begun to develop the next generation green practices in order to manage economic growth in future .In this study, eco-efficiency on corporate sustainability performance in the only one public sector automobile manufacturing company in Kerala i.e., Kerala Automobiles Ltd. (KAL), Trivandrum, Kerala is being analyzed..

II. LITERATURE REVIEW

Approximately fifty research papers have been reviewed and mostly were chosen after the year 2010 and onwards so as to bring the novel outcomes of this paper.

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A. Eco-efficiency

The world is now facing difficulties like climate change, energy consumption and economic Crisis. Now, the green growth is commonly used as a solution to overcome such difficulties. To achieve the green growth eco-efficiency is a very important key.

The concept of eco-efficiency was established by the World Business Council for Sustainable Development (WBCSD). Lager eco-efficiency means more products created with less environmental impacts (WBCSD, 2000).Based on this concept many studies have been conducted to calculate eco-efficiency of products. However, most common method for calculating eco-efficiency of the product uses the economic price of the product which can vary depending on the market statue. Therefore the real eco-efficiency could not be calculated[11].The term eco-efficiency was conceived by the World Business Council for Sustainable Development (WBCSD) in its 1992 volume "Changing Course" on the basis of creating increased goods and services while using fewer resources and creating less waste and pollution. According to WBCSD, there are seven elements that businesses can use to improve eco-efficiency.

1) Reduce material intensity.
2) Reduce energy intensity.
3) Maximize use of renewable resources.
4) Reduce dispersion of toxic substances.
5) Increase service intensity
6) Improve recyclability.
7) Extend product durability (WBCSD, 2000).

B. Sustainability

Mc Cann-Erickson defined that: Sustainability is a common term for each thing doing with responsibility for the world in which we live. It is an economical, social and environmental issue. It is regarding consuming differently and consuming efficiently. It also means sharing between the wealthy and the poor and protecting the global environment while not jeopardizing the needs of future generations[4]. The Brundtland Report defined sustainable development as development that meets the needs of the present generations without negotiating the ability of future generations to meet their needs.

Many automobile firms are now committed in adopting green initiatives in order to reduce the pressures and for better model by keeping their business in a sustainable manner, such as green supply chain management, reverse logistics, green marketing, green advertising and use of ecolabeling. Christo Ananth *et al.* [8] proposed a system, this fully automatic vehicle is equipped by micro controller, motor driving mechanism and battery. The power stored in the battery is used to drive the DC motor that causes the movement to AGV. The speed of rotation of DC motor i.e., velocity of AGV is controlled by the microprocessor controller.This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased. In the automobile segment there are various professionals who are involved in producing AFV's (Alternative fuel vehicles) continuously and other manufacturers are also planning to come in to this segment as the market is expanding due to environmental concern and sustainability issues [7].

III. Research Methodology

The paper is based on exploratory research techniques and systematic literature survey. The exploratory technique is used because there are less number of researches available in this field of study. The paper has been classified on the basis of the theme and further the most suitable findings, which is useful for this study has been chosen. In this research, questionnaire based survey has been employed to understand the barriers affecting eco-efficiency in government undertaken automobile firm's in Kerala[1]. The research on identification and ranking of barriers can be carried out in fourstages:

STAGE1: Secondary Literature Survey to identify barriers.
STAGE 2: Expert Review to refine barriers.
STAGE 3:ISM methodology to find the levels of barriers.
STAGE 4: Framing of ISM model.

A. Stage 1 -Summary of Barriers identified through Secondary Literature Survey

The variables which impact on the uptake of eco-efficiency can be divided into two sections. These are determinants of whether the implementation of eco-efficiency will be successful or not. Depending on their actions, these variables can either act as drivers promoting eco-efficiency or as barriers causing challenges to its embedment within the organization. Those actions which produce a positive result will be denoted by the term drivers and conversely those producing a negative effect as barriers. The literature search revealed a collated set of drivers and barriers to eco-efficiency. As the present study deals with only barrier assessment of eco-efficiency, the various barriers identified are listed below in table 1 :

TABLE1: BARRIERS IDENTIFIED

Sl.no	Barriers
1.	Lack of proper systems
2.	Lack of teamwork

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3.	Lack of support from top management
4.	Lack of awareness about environmental sustainability
5.	Lack of financial aids
6.	Lack of research & technical development (RTD)
7.	Lack of implementation of green practices
8.	Lack of proper waste management
9.	Reluctance to change
10.	Costly& inflexible environmental regulations
11.	Lack of pressure from government
12.	Lack of leadership
13.	Lack of motivation among work force
14.	Lack of adequate working environment
15.	Lack of carefulness towards sustainable approaches

B. Stage 2- Refining of Barriers through an Expert Review

The secondary literature survey resulted in identifying 15 barriers. These barriers were then refined through an expert review. The expert committee consisted of experts from PSU's and Engineering colleges. As per expert suggestion, few of the variables were removed. A questionnaire was then prepared based on the final list of barriers and circulated among various employees of Kerala Automobiles Limited for the main Survey[5]. The final list of 10 barriers after elimination & modification of variables are given below in table 2

TABLE2: BARRIERS REFINED

1	Lack of financial aid
2	Lack of top management support
3	Lack of presssure from government
4	Lack of awarnesss about environmental sustainability
5	Lack of carefulness towards sustainable development
6	Lack of research and technical development(RTD)
7	Lack of green practices implementation
8	Lack of metivation among workforce
9	Lack of leadership among workforce
10	Lack of teamwork
11	Lack of adequate working environment
12	Reluctance to change
13	Lack of proper waste management

C. Stage3- ISM methodology to find the levels of barriers

First proposed by J. Warfield in 1973, interpretive structural modeling (ISM) is an effective methodology for dealing with complex issues. It enables individuals or groups to develop a map of the complex relationships between the many elements involved in a complex situation. ISM is often used to provide fundamental understanding of complex situations, as well as toput together a course ofaction for solving a problem [7]. ISM is a combination of three modeling languages: words, digraphs and discrete mathematics, to offer a methodology for structuring complex issues. ISM is particularly useful and interpretive as judgment of working participants in a group for the study decides whether and how the variables are related [2]. The various steps, which lead to development of an ISM, are as follow [12]:

Step 1: identify issues/variables to be studied.

Step 2: then the contextual relationship among the variables identified in step 1, with respect to which pairs of variables are examined.

Step 3: to indicate pair wise relationship among variables, a structural self-interaction matrix (SSIM) is developed.

Step 4: from the SSIM a reachability matrix is developed. The matrix is checked for transitivity. The transitivity of the contextual relationships is a basic assumption made in ISM and it states that if variable X is related to variable Y and variable Y is related to variable Z, then variable X is necessarily related to variable Z.

Step 5: partitioning of levels is done of the reachability matrix obtained in Step 4.

Step 6: a directed graph is drawn based on the contextual relationships in the reachability matrix, and the transitive links are removed.

As mentioned earlier in Section 5, with the consultation of industry and the academia experts, the nature of the contextual relationships among the barriers was identified to implement eco-efficiency in Kerala Automobiles Limited. Following four symbols have been used for developing SSIM to denote the direction of relationship between two barriers i and j:

V—barrier 'i' will lead to barrier 'j';
A—barrier 'j' will lead to barrier 'i';
X—barrier 'i' and 'j' will lead to each other;
O—barrier 'i' and 'j' are unrelated.

SSIM has been developed on the basis of contextual relationships (Table 3).

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TABLE3- STRUCTURED SELF INTERSECTION MATRIX (SSIM) FOR BARRIERS

S.No	Barrier For Implementation	2	3	4	5	6	7	8	9	10	11	12	13
1	Lack of financial aid	V	O	A	O	O	O	O	A	A	O	A	A
2	Lack of top management support		A	A	O	O	O	O	O	A	O	O	A
3	Lack of presssure from government			O	A	O	A	O	O	O	O	O	A
4	Lack of awarnesss about environmental sustainability				O	O	O	O	O	A	O	A	A
5	Lack of carefulness towards sustainable development					O	O	O	O	A	O	A	X
6	Lack of research and technical development(RTD)						V	X	V	O	X	A	O
7	Lack of green practices implementation							A	A	O	A	A	V
8	Lack of metivation among workforce								X	V	A	A	O
9	Lack of leadership among workforce									X	A	A	O
10	Lack of teamwork										A	A	O
11	Lack of adequate working environment											V	V
12	Reluctance to change												V
13	Lack of proper waste management												

REACHABILITY MATRIX

The SSIM obtained from the previous section is converted into initial reachability matrix, which is a binary matrix, by substituting V, A, X, O by 1 or 0 and using following rules:

*a)*The (i, j) value in the reachability matrix will be 1 and (j,i) value will be 0, if (i, j) value in the SSIM is V.

*b)*The (i, j) value in the reachability matrix will be 0 and (j, i) value will be 1, if (i, j) value in the SSIM is A

*c)*The (i, j) and (j, i), both values will be 1 in the reachability matrix, if (i, j) value in the SSIM is X.

*d)*The (i, j) and (j,i), both values will be 0 in the reachability matrix, if (i, j) value in the SSIM is O

*e)*The initial and the final reachability matrices are shown in Table 4 and Table 5 respectively

LEVEL'S PARTITIONING

The level's partitioning is done to get the importance level of each barrier. From the final reachability matrix, the reachability and antecedent set [13,14] for each barrier have been obtained. The reachability set of a barrier is the set of barriers influenced by it and the barrier itself, whereas the antecedent set of a barrier is the set of barriers which may influence it and the barrier itself. Reachability set, antecedent set and intersection sets for all the barriers have been found. In the ISM hierarchy, the barrier having same reachability and intersection has been assigned as level 1 barrier-top level.

Level 1 is then discarded for the next iteration to find further levels. This iterative procedure is repeated till the level of each barrier is found. These levels have been summarized in Table

TABLE4-INTITIAL REACHABILITY MATRIX

S.No	Barrier For Implementation	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Lack of financial aid	1	1	0	0	0	0	0	0	0	0	0	0	0
2	Lack of top management support	0	1	0	0	0	0	0	0	0	0	0	0	0
3	Lack of presssure from government	0	1	1	0	0	0	0	0	0	0	0	0	0
4	Lack of awarnesss about environmental sustainability	1	1	0	1	0	0	0	0	0	0	0	0	0
5	Lack of carefulness towards sustainable development	0	0	1	0	1	0	0	0	0	0	0	0	1
6	Lack of research and technical development(RTD)	0	0	0	0	0	0	1	1	1	1	1	0	0
7	Lack of green practices implementation	0	0	1	0	0	0	1	0	0	0	0	0	1
8	Lack of metivation among workforce	0	0	0	0	0	1	1	1	1	1	0	0	0
9	Lack of leadership among workforce	1	0	0	0	0	0	1	1	1	1	0	0	0
10	Lack of teamwork	1	1	0	1	1	0	0	0	0	1	0	0	0
11	Lack of adequate working environment	0	0	0	0	0	1	1	1	1	1	1	1	1
12	Reluctance to change	1	0	0	1	1	1	1	1	1	1	0	1	1
13	Lack of proper waste management	1	1	1	1	1	0	0	0	0	0	0	0	1

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TABLE5-FINAL REACHABILITY MATRIX

S.No	Barrier For Implementation	1	2	3	4	5	6	7	8	9	10	11	12	13	Driving Power
1	Lack of financial aid	1	1	0	0	0	0	0	0	0	0	0	0	0	2
2	Lack of top management support	0	1	0	0	0	0	0	0	0	0	0	0	0	1
3	Lack of presssure from government	0	1	1	0	0	0	0	0	0	0	0	0	0	2
4	Lack of awarnesss about environmental sustainability	1	1	0	1	0	0	0	0	0	0	0	0	0	3
5	Lack of carefulness towards sustainable development	1	1	1	1	1	0	0	0	0	0	0	0	1	6
6	Lack of research and technical development(RTD)	1	1	1	1	1	1	1	1	1	1	1	1	1	13
7	Lack of green practices implementation	1	1	1	1	1	0	1	0	0	0	0	0	1	7
8	Lack of metivation among workforce	1	1	1	1	1	1	1	1	1	1	1	1	1	13
9	Lack of leadership among workforce	1	1	1	1	1	1	1	1	1	1	1	1	1	13
10	Lack of teamwork	1	1	1	1	1	1	0	1	1	1	1	1	1	13
11	Lack of adequate working environment	1	1	1	1	1	1	1	1	1	1	1	1	1	13
12	Reluctance to change	1	1	1	1	1	1	1	1	1	1	1	1	1	13
13	Lack of proper waste management	1	1	1	1	1	0	0	0	0	0	0	0	1	6
	Dependance Power	11	13	10	10	9	6	7	6	6	6	6	6	9	105/105

TABLE6-VARIOUS LEVEL OF BARRIERS

S.No	Level	Barrier
1	1st	Lack of top management support
2	2nd	Lack of financial aid
		Lack of presssure from government
3	3rd	Lack of awarnesss about environmental sustainability
4	4th	Lack of carefulness towards sustainable development
		Lack of proper waste management
5	5th	Lack of green practices implementation
6	6th	Lack of metivation among workforce
		Lack of leadership among workforce
		Lack of teamwork
		Lack of adequate working environment
		Reluctance to change
		Lack of research and technical development(RTD)

D. Stage4- Framing of ISM Model

Once all levels are found, these levels have been summarized in Table 6. From the final reachability matrix Table 5, the model is generated by vertices and edges [3].

In this model development, the top level factor is positioned at the top of the digraph and second level factor is placed at second position and so on, until the bottom level is placed at the lowest position in the digraph. Digraph is converted into an ISM model by replacing nodes of the factors with statements. Christo Ananth et al. [8] proposed a system, this fully automatic vehicle is equipped by micro controller, motor driving mechanism and battery. The power stored in the battery is used to drive the DC motor that causes the movement to AGV. The speed of rotation of DC motor i.e., velocity of AGV is controlled by the microprocessor controller.This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased. Out of 13 barriers, six are lying at the bottom level and one is lying at top level of ISM model. 'Lack of research and technical development(RTD)', 'Lack of metivation among workforce', 'Lack of leadership among workforce', 'Lack of teamwork', 'Lack of adequate working environment', 'Reluctance to change' are lying at the bottom level of model. 'Lack of top management support' is lying at the top level of model. Rest six barriers i.e. 'Lack of pressure from government', 'Lack of financial aid', 'Lack of awarnesss about environmental sustainability', 'Lack of carefulness towards sustainable development','Lack of green practices implementation', 'Lack of proper waste management' are lying in between top and bottom levels.
After removing the transitivity's as described in the ISM methodology, ISM model has been made as shown in Fig. 1

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ISSN 2394-3785 (Online)
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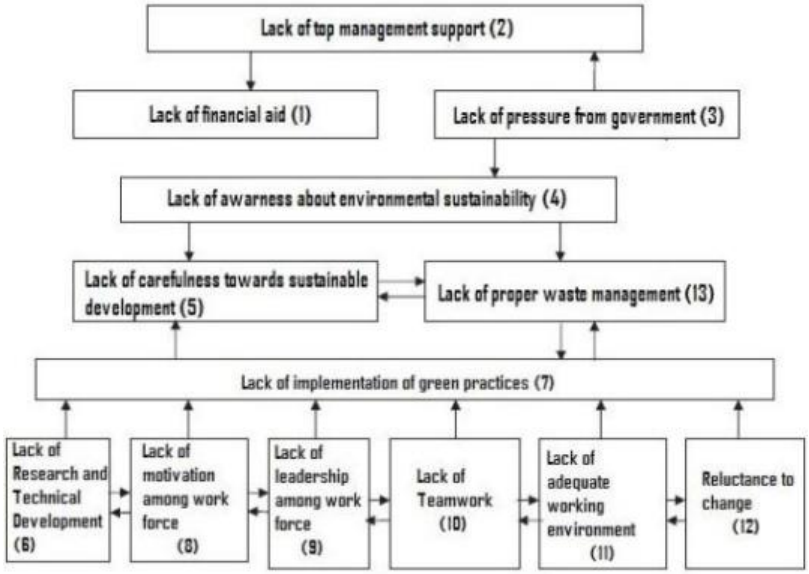

Figure 1-ISM Model for barriers to implement eco-efficiency

IV. CONCLUSIONS

The paper proposes a research model for analyzing the influence of barrierson eco-efficiency in Kerala Automobiles Limited

The predominant barrier influencing eco-efficiency in Kerala Automobiles Limited was found to be the lack of top management support. If the top management offer sufficient support and motivation for the workers, then the eco-efficiency can be improved in the firm.

From this study, we conclude that eco-efficiency is a importantConcept to analyze the combined environmental and economic performance of an automobile firm. The concept can help to assess the relative importance of environmental conservation and financial value of the generation, and thus provide insightsof how to improve its environmental performance in the economically most feasible way. This concept has also proved that it can be applied on different levels. This concept may even help to make decisions in controlling carbon emission in case of the industry concerned in this study.

Though the major factors in various cases are identified, there can be more factors depending on the regions and population under consideration.

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ISSN 2394-3785 (Online)
Available online at www.ijartet.com
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