

# Analysis of the Impact of Green Manufacturing in Indian Oil Co-Operation Limited, Noonmati, Guwahati, Assam, Using Anova

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**Abstract**— Due to increasing environmental pollution, green manufacturing processes are being employed in many industries today. Green Manufacturing not only reduces pollution but also contributes to sustainability management. A survey study was conducted in Oil India Limited, Noonmati, Guwahati, to analyze the impact of GM on the industry. A questionnaire was prepared and the data collected was evaluated using Minitab 16. The impact on the industry after implementing GM was studied and validated using one way analysis of variance, Factor Analysis and cronbach's alpha

**Index Terms**— factor analysis, Green manufacturing, one way analysis of variance, sustainability management

## I. INTRODUCTION

Green manufacturing is the method for manufacturing that minimizes waste and pollution achieved through product and process design. Its emphasis is on reducing, recycling and reusing components to efficiently build products. Application of green manufacturing has become an important aspect in the industries today.

The concept of Green Manufacturing came from Germany that requires importing companies to take responsibility and remove any packaging materials used for that product. In fact, the Germans have established a *de facto* global manufacturing standard instilling that, "any company wishing to compete globally must start making products that will comply with the green dictates of the huge European market." Green Manufacturing involves not just the use of environmental design of products, use of environmentally friendly raw materials, but also eco-friendly packing, distribution, and destruction or reuse after the lifetime of the product.

Green Manufacturing has many aspects including:

1. Reducing the toxicity of raw materials used in production.
2. Reducing energy consumption during the manufacturing process.
3. Recycling materials and scrap.
4. Reducing the amount of packaging in final products.

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## II. LITERATURE REVIEW

Rehman Minhaj Ahemad.A, Shrivastava R. R, Shrivastava Rakesh. L,(2013) highlighted the road map of a company for achieving performance improvement through GM implementation and its impact on organizational performance. They also pointed out strengths and weaknesses of GM implementation practices and overall performance using developed research instrument.

According to Mittal Varinder Kumar & Sangwan Kuldip Singh, Manufacturing firms consume energy and natural resources in highly unsustainable manner and release large amounts of green house gases leading to many economic, environmental and social problems from climate change to local waste disposal. A growing number of organizations have begun working towards implementation of Green Manufacturing (GM) because of increased concerns about the pollution increase, natural resources depletion and global warming. However, there are barriers which hinder the implementation of GM. In order to mitigate these barriers, the prioritization of barriers is essential as high-priority barriers can be taken up first to address the issue more effectively within the available resources.

According to Deif Ahmed M.,2011, Higher global awareness of environmental risks as a result of the new green movement is shaping new customer requirements in many places. In addition, the evolving green technology together with more eco-friendly product designs is helping in realizing the green manufacturing objectives in real practice.

Paula I.D., et al, 2014, Discussed about the waste and the methodology of green manufacturing that can be applied and can reduce the wastage and increase the use of sustainable energy. The implementation of Green Manufacturing may not only be good for the environment — it is often good business, as well.

## III. OBJECTIVE

- To provide a practical example of performance improvement of the Indian Oil and Petroleum Company that has implemented Green Manufacturing initiative and assess the Green Manufacturing implementation practices and performance improvement of the organization.
- The study was conducted in an industry that has already implemented this initiative. The study would help in evaluating the industry's GM implementation and overall business performance.

**IV. ABOUT THE INDUSTRY**

The Indian Oil Industry dates back to the time of the British Rule, when petroleum first became the global source of energy. The first oil deposits in India were discovered in 1889 near Digboi, Assam. The first well was completed in 1890 and the Assam Oil Company was established in 1899 to oversee production. Indian oil Cooperation Limited or IOCL is an Indian Government owned oil and gas cooperation, having its headquarters in New Delhi. It is the world's 119th largest corporation, according to Fortune Global 500 list and the largest public corporation in India by ranking the revenue. Indian Oil and its subsidiaries account for almost 49% share in the petroleum products market, 31% share in refining capacity and 67% downstream sector pipelines capacity in India. The Indian Oil Group of companies owns and operates 11 out of India's 23 refineries with a combined refining capacity of 80.7 million metric tonnes per year. In FY 2012 IOCL sold 75.66 million tonnes of petroleum products and reported a PBT of ₹37.54 billion, and the Government of India earned an excise duty of ₹232.53 billion and tax of ₹10.68 billion. [Wikipedia]. IOCL is one of the seven Maharatna status companies of India.

**Green energy initiatives**

Indian Oil has ambitious plans to broaden its energy basket with alternative energy options such as wind, solar, bio-fuels and nuclear power. The Corporation envisages setting up 260 MW of renewable energy (wind and solar) over the next five years. Wind power systems to the tune of 69.3 MW have been installed in the States of Gujarat and Andhra Pradesh. A 5-MW grid-connected solar power plant at Rawra, Rajasthan, is operational since 2012. Solar PV systems of about 1.3 MW have also been installed at various Indian Oil refineries, installations and offices across the country. Steps are underway to set up an additional 200 MW of wind power and 60 MW of solar power systems. As a major initiative in reducing carbon emissions, the Corporation has so far converted over 4,200 fuel stations to operate on solar energy with a cumulative installed capacity of 15 MW from these solar photo-voltaic power systems. Indian Oil's extensive retail network in rural areas was leveraged to sell over 3.60 lakh rechargeable solar lanterns to help replace the traditional kerosene wick lamps in rural households which are not yet connected to grid power. To serve as carbon sinks, Indian Oil has developed green belts with a tree cover numbering 2 million at its various installations. Indian Oil has 505 rain-water systems with an annual harvesting capacity of about 2.9 billion litres, covering a combined catchment area of 950 hectares. A comprehensive policy has been formulated for implementation of LED lighting in place of conventional lighting across all refineries, office buildings, townships, installations & fuel stations by the year 2017. Indian Oil has the largest captive plantation – covering 8,000 hectares – for bio-fuel production in India in the States of Chhattisgarh, Madhya Pradesh and Uttar Pradesh. To straddle the complete bio-fuel value chain, Indian Oil has formed two joint ventures, Indian Oil CREDA Bio-fuels Ltd. and Indian Oil Ruchi Bio-fuels LLP. Currently, ethanol production from

lignocellulosic sources such as rice straw, cotton stalk, bamboo, etc., is also being actively explored. [www.iocl.com]

**V. RESEARCH METHODOLOGY**

- A survey was carried out to find the overall performance of the Industry/Company before and after implementation of Green Manufacturing.
- Based on the evaluations the current situation of the industry's GM implementation and overall performance will be obtained.
- A questionnaire of two pages were designed consisting of the extent of relationship between various GM implementation practices and overall performance.
- 250 questionnaires were distributed and sent for survey, out of which 235 were evaluated.
- The research instrument validated by Minhaj Ahemad.A.Rehman was used for the compilation of data.
- Using Minitab the data obtained from the questionnaires were evaluated. Factors were extracted using Varimax rotation.
- A reliability test based on Cronbach's Alpha was used to assess whether the dimensions were consistent and reliable. ( Bulent Sezen and Sibel Yildiz Cankaya, 2013 ).
- One way Analysis of Variance (ANOVA) is conducted in this study to check the relationship of the factors taken into consideration

Table 1:

Mean and Proportionate Marks	
1.00 - 1.50	1(Not at all)
1.51 - 2.00	2
2.01 - 2.50	3
2.51 - 3.00	4 ( To a moderate extent)
3.01 - 3.50	5
3.51 - 4.00	6
4.01 - 4.50	7
4.51 - 5.00	8 (To a very large extent)

Table 1 consists of mean and proportionate marks. 1 indicates that the Company is having a weak relationship between the implementation factors and the performance measure, whereas 8 indicates that the relationship between the implementation factors and the performance measure is very strong.

**Assessment result – Factor 1: Organizational Capabilities**  
**Table 2: Assessment of Various Factors**

Question Nos.	Addressed items of the factors	Mean	Grand Mean	Max Marks
1	Organization Capabilities lead to improvement in financial, manpower and Operational performance	4.2	4.13	7
11	Organization Capabilities lead to continuous improvement and improvement in competitive advantage and stakeholder's enrichment	4.2		
22	Organization Capabilities lead to improvement in green SC performance	4		
<b>Assessment result – Factor 2 : Green Design Initiatives</b>				
	Addressed items of the factors	Mean	Grand Mean	Max Marks
2	Green design Initiatives lead to improvement in financial, manpower and Operational performance	4.03	4.00	6
12	Green design Initiatives lead to improvement in continuous improvement and improvement in competitive advantage and stakeholder's enrichment	3.85		
23	Green design Initiatives lead to improvement in green SC performance	4.12		
<b>Assessment result – Factor 3: Green Standards Adoption</b>				
	Addressed items of the factors	Mean	Grand Mean	Max Marks
3	Green Standard Adoption lead to improvement in financial, manpower and Operational performance	3.7	3.93	6
13	Green Standard Adoption lead to improvement in continuous improvement and improvement in competitive advantage and stakeholder's enrichment	3.95		
24	Green Standard Adoption lead to improvement in green SC performance	4.15		
<b>Assessment result – Factor 4 : Suppliers Management</b>				
	Addressed items of the factors	Mean	Grand Mean	Max Marks
4	Supplier Management lead to improvement in financial, manpower and Operational performance	3.72	3.79	6
25	Supplier Management lead to improvement in green SC performance	3.85		

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<b>Assessment result – Factor 5 Technology Innovation</b>				
	Addressed items of the factors	Mean	Grand Mean	Max Marks
5	Technology Innovation lead to improvement in financial, manpower and Operational performance	4	4.05	7
14	Technology Innovation lead to continuous improvement	4.1		
<b>Assessment result – Factor 6 GM Planning</b>				
	Addressed items of the factors	Mean	Grand Mean	Max Marks
15	GM planning lead to continuous improvement and improvement in stakeholder’s enrichment	3.82	3.82	6
<b>Assessment result – Factor 7 Green purchasing &amp; marketing</b>				
	Addressed items of the factors	Mean	Grand Mean	Max Marks
6	Green Purchasing & Marketing lead to improvement in financial, manpower and Operational performance	3.82	3.91	6
16	Green Purchasing & Marketing lead to continuous improvement and improvement in competitive advantage and stakeholder’s enrichment	3.9		
26	green purchasing & marketing lead to improvement in green SC management	4		
<b>Assessment result – Factor 8 Implementing RL</b>				
	Addressed items of the factors	Mean	Grand Mean	Max Marks
7	implementing RL lead to improvement in financial, manpower and Operational performance	3.92	4.01	7
17	implementing RL lead to continuous improvement and improvement in competitive advantage and stakeholder’s enrichment	4.02		
27	implementing RL lead to improvement in green SC management	4.1		
<b>Assessment result – Factor 9 Top management Commitment</b>				
	Addressed items of the factors	Mean	Grand Mean	Max Marks
8	top management commitment lead to improvement in financial, manpower and Operational performance	4.17	4.20	7
18	top management commitment lead to continuous improvement and improvement in competitive advantage and stakeholder’s enrichment	4.35		
28	top management commitment and Customer focus lead to improvement in green SC management	4.07		
<b>Assessment result – Factor 10 Customers Focus</b>				
	Addressed items of the factors	Mean	Grand Mean	Max Marks
19	Customer focus lead to continuous improvement and improvement in stakeholder’s enrichment	4.35	4.35	7
<b>Assessment result – Factor 11 Green Disposal initiatives</b>				

	Addressed items of the factors	Mean	Grand Mean	Max Marks
9	Green Disposal Initiatives lead to improvement in financial, manpower and Operational performance	3.9	3.92	6
20	Green Disposal Initiatives lead to continuous improvement and improvement in competitive advantage and stakeholder's enrichment	3.82		
29	green Disposal Initiatives lead to improvement in green SC management	4.05		
<b>Assessment result – Factor 12 Process management</b>				
	Addressed items of the factors	Mean	Grand Mean	Max Marks
10	Process Management lead to improvement in financial, manpower and Operational performance	3.7	4.02	7
21	Process Management lead to continuous improvement and improvement in competitive advantage and stakeholder's enrichment	4.17		
30	Process Management lead to improvement in green SC management	4.2		

Table 2 above shows the various factors and the mean obtained after assessment of the questionnaire data. Marks are then allotted to the factor according to the Grand mean obtained from Table 1.

**Table 3: Mean and P value of ANOVA**

Performance measure Critical success factor	Financial, manpower and Operational performance		Continuous improvement and improvement in competitive advantage and stakeholder's enrichment		green SC performance	
	Mean	P value	Mean	P value	Mean	P value
1. Organizational Capabilities	4.20	0.02	4.20	0.24	4.00	0.62
2. Green Design Initiatives	4.03	0.46	3.85	0.39	4.12	0.64
3. Green Standards Adoption	3.70	0.29	3.95	0.54	4.15	0.67
4. Suppliers management	3.72	0.01	0.00	0.00	3.85	0.99
5. Technology Innovation	4.00	0.15	4.10	0.73	0.00	0.00
6. GM Planning	0.00	0.00	3.82	0.00	0.00	0.00
7. Green purchasing and marketing	3.82	0.17	3.90	0.49	4.00	0.04
8. Implementing RL	3.92	0.73	4.02	0.46	4.10	0.46
9. Top management Commitment	4.17	0.08	4.35	0.09	4.07	0.02
10. customers Focus	0.00	0.00	4.35	0.00	0.00	0.00
11. Green Disposal Initiatives	3.90	0.76	3.82	0.58	4.05	0.40
12. process management	3.70	0.01	4.17	0.25	4.20	0.02

**Table 4: Factor and Reliability Analysis Result**

1. Organizational Capabilities	Factor Loading	Cronbach's Alpha	Mean	2. Green Design Initiatives	Factor Loading	Cronbach's Alpha	Mean
1	0.974	0.974	4.13	2	0.014	-0.751	4.00
11	0.296			12	0.069		
22	0.031			23	-0.129		

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<b>3. Green Standards Adoption</b>	<b>Factor Loading</b>	<b>Cronbach's Alpha</b>	<b>Mean</b>	<b>4. Suppliers management</b>	<b>Factor Loading</b>	<b>Cronbach's Alpha</b>	<b>Mean</b>
3	-0.075	<b>0.837</b>	3.93	4	0.147	<b>0.901</b>	3.79
13	-0.079			25	0.04		
24	0.837						
<b>5. Technology Innovation</b>	<b>Factor Loading</b>	<b>Cronbach's Alpha</b>	<b>Mean</b>	<b>6. GM Planning</b>	<b>Factor Loading</b>	<b>Cronbach's Alpha</b>	<b>Mean</b>
5	0.079	<b>-0.845</b>	4.05	15	-0.078	<b>-0.881</b>	3.82
14	-0.432						
<b>7. Green purchasing and marketing</b>	<b>Factor Loading</b>	<b>Cronbach's Alpha</b>	<b>Mean</b>	<b>8. Implementing RL</b>	<b>Factor Loading</b>	<b>Cronbach's Alpha</b>	<b>Mean</b>
6	-0.154	-0.81	3.91	7	-0.061	0.863	4.01
16	0.179			17	-0.059		
26	-0.19			27	0.016		
<b>9. Top management Commitment</b>	<b>Factor Loading</b>	<b>Cronbach's Alpha</b>	<b>Mean</b>	<b>10. Customers Focus</b>	<b>Factor Loading</b>	<b>Cronbach's Alpha</b>	<b>Mean</b>
8	0.51	0.802	4.20	19	-0.095	-0.862	4.35
18	-0.106						
28	0.198						
<b>11. Green Disposal Initiatives</b>	<b>Factor Loading</b>	<b>Cronbach's Alpha</b>	<b>Mean</b>	<b>12. process management</b>	<b>Factor Loading</b>	<b>Cronbach's Alpha</b>	<b>Mean</b>
9	0.031	0.742	3.92	10	-0.454	0.868	4.02
20	-0.019			21	-0.037		
29	0.001			30	0.191		

**Table 5: Effects of Organisational Capabilities**

Dependent variable												
Independent Variables	Financial, manpower and Operational performance				Continuous improvement and improvement in competitive advantage and stakeholder's enrichment				green SC performance			
	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level
<b>Organizational Capabilities</b>	4.41	2.20	2.00	98.04%	1.60	0.80	2.00	98.04%	0.41	0.21	2.00	98.04%
R Square	19.20%				6.41%				2.56%			
Adjusted R Square	14.83%				1.36%				0.00%			
F	4.40				1.27				0.49			

**Table 6: Effects of Green Design Initiatives**

Dependent variable												
Independent Variables	Financial, manpower and Operational performance				Continuous improvement and improvement in competitive advantage and stakeholder's enrichment				green SC performance			

	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level
<b>Green Design Initiatives</b>	0.95	0.47	2.00	98.04%	0.94	0.47	2.00	98.04%	0.25	0.13	2.00	98.04%
R Square	4.12%				4.94%				2.43%			
Adjusted R Square	0.00%				0.00%				0.00%			
F	0.79				0.96				0.46			

**Table 7: Effects of Green Standards Adoption**

Dependent variable												
Independent Variables	Financial, manpower and Operational performance				Continuous improvement and improvement in competitive advantage and stakeholder's enrichment				green SC performance			
	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level
<b>Green Standards Adoption</b>	1.31	0.65	2.00	98.04%	0.71	0.36	2.00	98.04%	0.24	0.12	2.00	98.04%
R Square	6.40%				3.26%				2.15%			
Adjusted R Square	1.34%				0.00%				0.00%			
F	1.26				0.62				0.41			

**Table 8: Effects of Suppliers management**

Independent Variables	Financial, manpower and Operational performance				green SC performance			
	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level
<b>Suppliers management</b>	5.32	2.66	2.00	98.04%	0.01	0.00	2.00	98.04%
R Square	22.20%				0.04%			
Adjusted R Square	18.00%				0.00%			
F	5.28				0.01			

**Table 9: Effects of Technology Innovation**

Dependent variable									
Independent Variables	Financial, manpower and Operational performance				Continuous improvement and improvement in competitive advantage and stakeholder's enrichment				
	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level	
<b>Technology Innovation</b>	1.95	0.97	2.00	98.04%	0.20	0.10	2.00	98.04%	
R Square	9.73%				1.72%				
Adjusted R Square	4.85%				0.00%				
F	1.99				0.32				

**Table 10: Effects of Green purchasing and marketing**

Dependent variable												
Independent Variables	Financial, manpower and Operational performance				Continuous improvement and improvement in competitive advantage and stakeholder's enrichment				green SC performance			
	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level
<b>Green purchasing and marketing</b>	2.00	1.00	2.00	98.04%	0.67	0.33	2.00	98.04%	2.79	1.39	2.00	98.04%
R Square	9.17%				3.79%				15.48%			
Adjusted R Square	4.26%				0.00%				10.91%			
F	1.87				0.73				3.39			

**Table 11: Effects of Implementing RL**

Dependent variable												
Independent Variables	Financial, manpower and Operational performance				Continuous improvement and improvement in competitive advantage and stakeholder's enrichment				green SC performance			
	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level
<b>Implementing RL</b>	0.42	0.21	2.00	98.04%	0.78	0.39	2.00	98.04%	0.89	0.45	2.00	98.04%
R Square	1.68%				4.12%				4.12%			
Adjusted R Square	0.00%				0.00%				0.00%			
F	0.32				0.80				0.80			

**Table 12: Effects of Top management Commitment**

Dependent variable												
Independent Variables	Financial, manpower and Operational performance				Continuous improvement and improvement in competitive advantage and stakeholder's enrichment				green SC performance			
	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level
<b>Top management Commitment</b>	3.05	1.52	2.00	98.04%	2.06	1.03	2.00	98.04%	4.78	2.39	2.00	98.04%
R Square	12.81%				12.06%				19.30%			
Adjusted R Square	8.10%				7.31%				14.98%			
F	2.72				2.54				4.42			

**Table 13: Effects of Green Disposal Initiatives**

Dependent variable												
Independent Variables	Financial, manpower and Operational performance				Continuous improvement and improvement in competitive advantage and stakeholder's enrichment				green SC performance			
	SS	MS	DF	Confidence	SS	MS	DF	Confidence	SS	MS	DF	Confidence



				Level				Level				Level
<b>Green Disposal Initiatives</b>	0.25	0.13	2.00	98.04%	0.40	0.20	2.00	98.04%	0.86	0.43	2.00	98.04%
R Square	1.44%				2.98%				4.81%			
Adjusted R Square	0.00%				0.00%				0.00%			
F	0.27				0.56				0.93			

**Table 14: Effects of process management**

Dependent variable												
Independent Variables	Financial, manpower and Operational performance				Continuous improvement and improvement in competitive advantage and stakeholder's enrichment				green SC performance			
	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level	SS	MS	DF	Confidence Level
<b>process management</b>	4.58	2.29	2.00	98.04%	1.88	0.94	2.00	98.04%	5.02	2.51	2.00	98.04%
R Square	20.46%				7.31%				19.02%			
Adjusted R Square	16.16%				2.30%				14.64%			
F	4.76				1.46				4.34			

### DISCUSSION

- Table 2 shows the assessment of various factors taken into consideration. There were 30 questions which were divided under 12 factors. After division, the mean and grand mean marks from the questionnaire were calculated. Using the scale of table 1, marks were given to each factor, indicating the level of relationship the company has between the implementation factors and the performance measure.
- Table 4 gives the factor and reliability analysis result found using factor analysis and ANOVA in Minitab.
- Cronbach's  $\alpha$  is obtained for each factors using factor analysis. The value of cronbach's  $\alpha$  in table 4 ranges from 0.742 to 0.974 which is considered to be good internal consistency
- Table 5 to table 14 shows the relationship between the dependent and independent variables. One way Analysis of Variance was used to measure the degree of freedom(DF), sum of square(SS), means square(MS), R Square, Adjusted R Square and F value.
- The result obtained showed positive relationship between the various factors as analyzed.

Based on the above analysis, the overall grade of the company was estimated as follows:

Numerical weightage assigned to each factor=8 marks

Number of factors taken into consideration=12

Maximum marks=12\*8

=96

Total marks achieved=78

% marks achieved=81.25%

### CONCLUSION

Due to increasing pollution and global warming, it has become a responsibility for the industries to implement environment friendly manufacturing process. Implementing GM is not just eco-friendly but it also has helped increase their average revenue. Recycling waste products too have proved to be profitable.

The study shows that the Company still has a long way to go. The study will help improve the implementation of green manufacturing in the Company.

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