

The impact of green manufacturing to maintain environmental security & sustainability

Prof. Anjana Singha

Assistant Professor
Management and commerce studies
Garden City University

Abstract: Since countries become more industrialized and the manufacturing sector contributes to the wealth of a nation and, degradation of the environment seems inevitable. The increased concerns on the environment require manufacturing and innovations to be key indicators for sustainable growth. To meet the global demands, better manufacturing practices that do not harm the environment, manufacturers have to utilize innovative methods not only in their production, but how the whole supply chain is being managed. Innovative manufacturing approaches like green manufacturing and its concepts facilitate obtaining sustainability. Green manufacturing involves transformation of industrial operations in three ways: (1) using Green energy, (2) developing and selling Green products and (3) employing Green processes in business operations. The objective of the study is to find out how green manufacturing influences to improve the environmental performance. The scope of the study is some of the small medium and large scale manufacturing companies in Bangalore, India.

Keywords: Green manufacturing, Green process, Green products, Sustainability, Innovative methods.

1 INTRODUCTION

The manufacturing sector has a bigger role in the country's economy. The Ministry of Commerce and Industry, has set a target to increase the sector's contribution to the GDP to 25 percent from 16%. As the growth as well as environmental concerns need to be consider — the manufacturing sector must use green process with less harmful waste, use energy and resources efficiently, optimize the raw material use to minimize waste. The average global temperature would still increase by 0.6°C in this century even if all manufacturing activities are shut down.

'Green Manufacturing' or sustainable industrial activity is now the necessity of the hour. 92 percent of the companies surveyed are engaged in Green initiatives. Manufacturing companies that adopt Green practices not only are benefited with long-term cost savings, but also they can do brand enhancement with customers, better regulatory traction, greater ability to attract talent and higher investor interest. It is nothing but a long term commitment and making trade-offs against short term objectives.

Different sectors are motivated for adopting Green for varied reasons. Like regulatory compulsions (example: power), to establish stronger brand image, to stabilise rising energy costs, to meet increasingly stringent emission regulations. The impact of Green initiatives varies by the industry sector. For example, the power sector have the maximum impact on reducing CO₂ emissions followed by transportation and then the industrial sector through green initiative.

Consumers are increasingly adopting Green products and habits. Consumers prefers more in both especially in food and consumer durables in developed and developing countries. Many consumers are willing to pay amore for green products. However, the survey also revealed that there is still a huge gap in consumer awareness that Green companies must strive to bridge.

Green manufacturing may be successfully implemented when they will go beyond small standalone initiatives, and adopt an integrated framework. They need to plan for Green as a core part of business strategy, companies need to execute Green initiatives across the value chain by shifting towards Green energy, Green products and Green processes and lastly should communicate and promote Green initiatives to all stakeholders.

Green manufacturing in India is at the take-off stage. There has been significant policy development and adoption by the manufacturing industry in the area of Green energy, substantial scope in the areas of Green products and Green processes. Successful transformation into Green manufacturing will bring tremendous both tangible and intangible benefits, for the nation and as well as the business community.

Greenhouse gas (GHG) emissions have increased rapidly in the recent past and their growth is further accelerating. Global temperatures have increased by 0.74°C over the last century —the fastest warming observed in the history of Earth. This change is expected to have a severe impact on the global ecosystem, hydrological system, sea level and crop production and related activities.

The consumption of natural resources like wood, coal, oil, food, water, etc. is quickly rising with ever increasing population and industrialization, but their availability is shrinking. So there is an urgent need to adequately manage the use of these resources and to find and develop alternatives which are non-renewable.

Industrial waste with chemical composition can be potentially dangerous to health, and its disposal without treatment is leading to land and water pollution. The release of industrial effluents in rivers and other water bodies is destroying local habitats. As the demand and use of electronic products rise, e-waste is also becoming a major source of environmental pollution.

In recent decades, organizations concentrate to obtain optimization in operations from single organization to whole supply chain participants. However, implementation of innovative manufacturing techniques which are compatible with the environment is inevitable. Green supply chain management (GrSCM) is one of the approaches which monitor supply chain activities from the beginning to end. Green supply chain manufacturing is the best method for the organization to continue their business with maintaining environmental sustainability.

2 THEORETICAL BACKGROUND:

2.1 Green Manufacturing and Its Concepts

Green manufacturing employs new technologies and innovations to utilize energy and materials efficiently. And reflects a new manufacturing paradigm where endeavours to produce products with prevention of unnecessary output and consume less material. And prevent undesirable outputs in the production process. Therefore, green refers to environment friendly awareness. Green manufacturing includes sustainability in the social, environmental and economical objectives. Hazards reduction, saving resources by means of proper consumption and recycling are some examples which help to achieve sustainability. Waste management is one of the efficient approaches towards sustainable green manufacturing (Rusinko, 2007; Deif, 2011). Demonstrates waste generating processes in green manufacturing.

2.2 Sustainability in Manufacturing

sustainable manufacturing is defined by The U.S. Department of Commerce that the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound (Jayal et al., 2010). Sustainability in manufacturing has significant relationship between efficient resource utilization and some disciplines such as buildings and manufacturing facilities.

3. LITERATURE REVIEW:

Despeisse et al., (2012) claimed that some tools and techniques were developed to overcome this issue of Manufacturing activities and its facilities which are affecting sustainability and, made it complicated. But the question remained on how sustainable improvement can be obtained in manufacturing.

(Feng and Joung, 2009) claimed in his paper the designing system and supporting sustainability should be considered unsustainable manufacturing and suggested to apply reverse logistics processes to achieve sustainability in manufacturing.

Reich-Weiser et al. (2008) proposed a four part procedure which helps to determine appropriate metrics in sustainable manufacturing. The procedure includes determining the goal of the assessment, choosing a metric type, determining the manufacturing scope of assessment as well as the geographic scope.

Feng and Joung (2009) developed a framework for measuring sustainability in manufacturing. Environmental metrics in sustainability are Green Supply Chain Management, Green Design, Green Operations, Green Manufacturing & Remanufacturing, Reverse Logistics & Network Design, and Waste Management.

Sarkis et al. (2010) declared that social characteristics of sustainability are rarely considered but organizations have to pay attention to it.

3.1 Research gap:

Different literature explained different model, process and suggested reverse logistics also as a part of green manufacturing practice but there are very few literature where they explained thoroughly about how different activities of green manufacturing helps to maintain environmental sustainability. This gap made the researcher to do investigation to get the answer.

4 Research methodology:

4.1 Type of the study: The study is descriptive and explorative in nature.

4.2 Population:

There are around 10000 manufacturing industries in Electronic City area in Bangalore. But as this is a small study it included some SME 's who are involved in GSCM operations. Some of them who follows green manufacturing in their production the data is taken from their production and facility managers, engineers and supervisors respectively. Around 70 respondent's responses are taken and tested.

4.3 Data collection: Primary as well as Secondary data is taken. Primary data is collected through mail or Google sheets and secondary data is collected from different articles and internet links.

4.4 Questionnaire development:

Some close ended questions with nominal and ordinal type are mentioned hereby. Likert's Scale is used with 5 scale starting with strongly agree denoting 1 and strongly disagree denoting 5. The validity and reliability is checked with cronbach alpha 0.987.

4.5 Sampling technique: Random sampling and Convenience sampling is made according to the convenience of the researcher.

Some of the important and most relevant questions according to the study are mentioned and analysed as follows:

5. DATA ANALYSIS:

QUESTION	YES	NO
1. Do Your Organisation uses the recyclable material for manufacturing the product?	65%	35%
2. Do your Organisation controls the release of toxic substances in product life?	56%	44%
3. Do your Organisation follows lead free soldering in manufacturing?	50%	50%
4. Do green manufacturing in your Organisation help in water conservation?	68%	32%

ANALYSIS & INTERPRETATION:

1.65% of the organizations uses recyclable material for manufacturing the product whereas 35% do not use the same. The maximum number of respondents uses the recyclable product as they follow the green manufacturing. Thus using recyclable products they may generate less harmful waste which will give less harm to the environment.

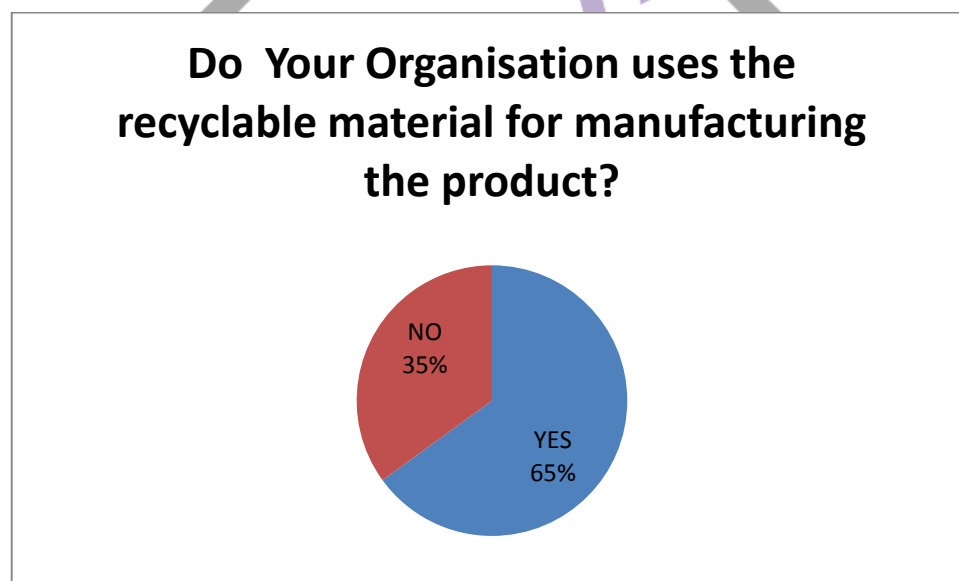


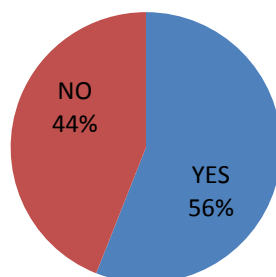
CHART1

2.56% of the respondents controls the release of toxic substances in product life whereas 44% of the organization does not have measure to control the release of toxic substances.

Maximum number of respondents use measures in their organization who will control the release of toxic gases or material while in use. Thus they may make the environment pollution free.

CHART 2

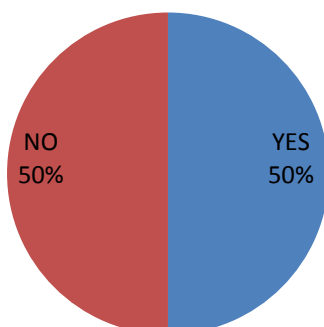
Do your Organisation controls the release of toxic substances in product life?



3.50% of the organization uses lead free soldering where as 50% does not use. So lead free soldering in manufacturing does not have significant influence in manufacturing which may lead towards improvement of environmental performance.

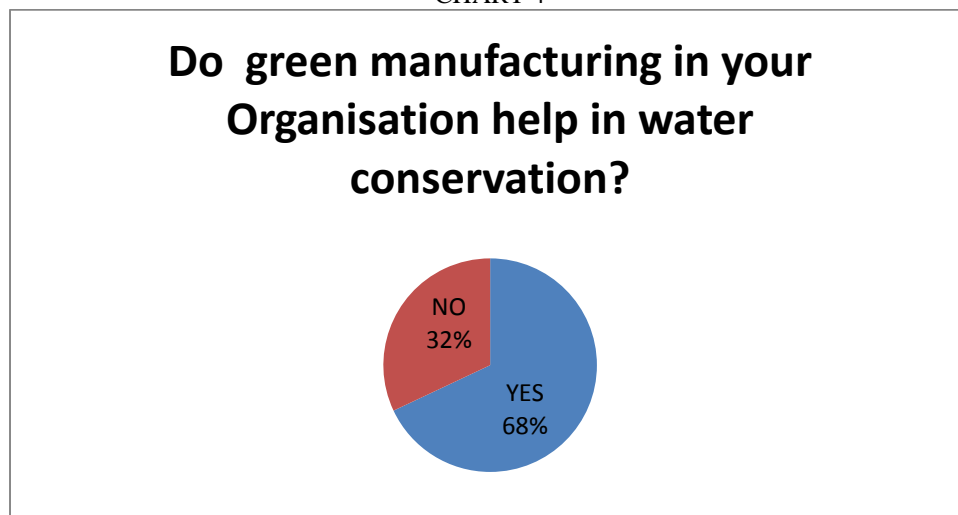
CHART 3

Do your Organisation follows lead free soldering in manufacturing?



4.68% of the organization help in water conservation whereas 32% does not into water conservation. Maximum organizations are involved into water conservation, they use different measure to save water, recycle the used water and also rain water harvesting.

CHART 4

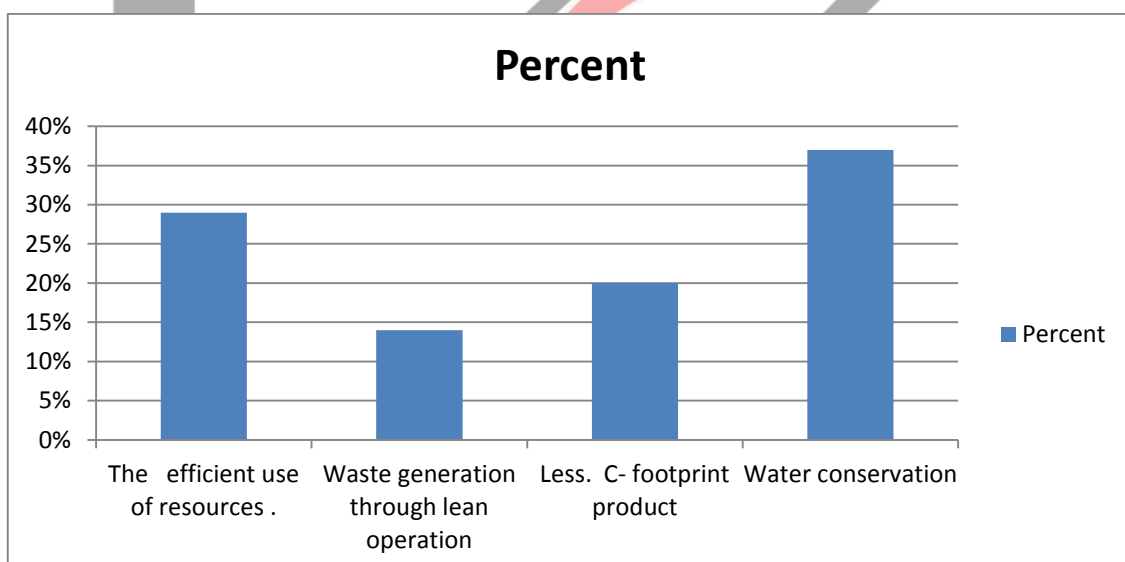


5. What green process do your organisation follows?

1. The efficient use of resources ☐ 2. Waste generation through lean operation ☐
 3. Less. C- footprint product ☐ 4. Water conservation ☐ 5. Other ☐

Scale	Grade	Frequency	Percent
The efficient use of resources .	1	20	29%
Waste generation through lean operation	2	10	14%
Less. C- footprint product	3	14	20%
Water conservation	4	26	37%
Other	5	0	0%
	Total	70	100.00

CHART 5



Analysis & Interpretation:

37% organization are involved into water conservation, followed by other green process like the efficient use of resources which is followed by 29% organization then less C footprint of around 20% organizations, waste generation through lean operation by 14%.

Companies followed different green processes according to their convenience, affordability and necessity. Maximum number of companies are involved into water conservation like water harvesting and water recycling if they have proper infrastructure. Then

the most followed green process is to use resource efficiently as most of the manufacturing industries need to use natural resources like different minerals, natural gas, coal which are non-renewable and some specific industry those material are the basic ingredient to produce the product in such cases efficient handling and controlling unnecessary waste will help to save the environment.

6 What kind of cleaner and renewable energy is used by your Organisation in production?

1 Electrical energy ☐ 2 Solar Energy ☐ 3. Wind energy ☐ 4 Biomass ☐ 5 CNG /Water energy ☐

Scale	Grade	Frequency	Percent
Electrical energy .	1	5	7%
Solar Energy	2	35	50%
Wind energy	3	15	21%
Biomass	4	2	3%
Water energy/CNG	5	13	19%
	Total	70	100.0

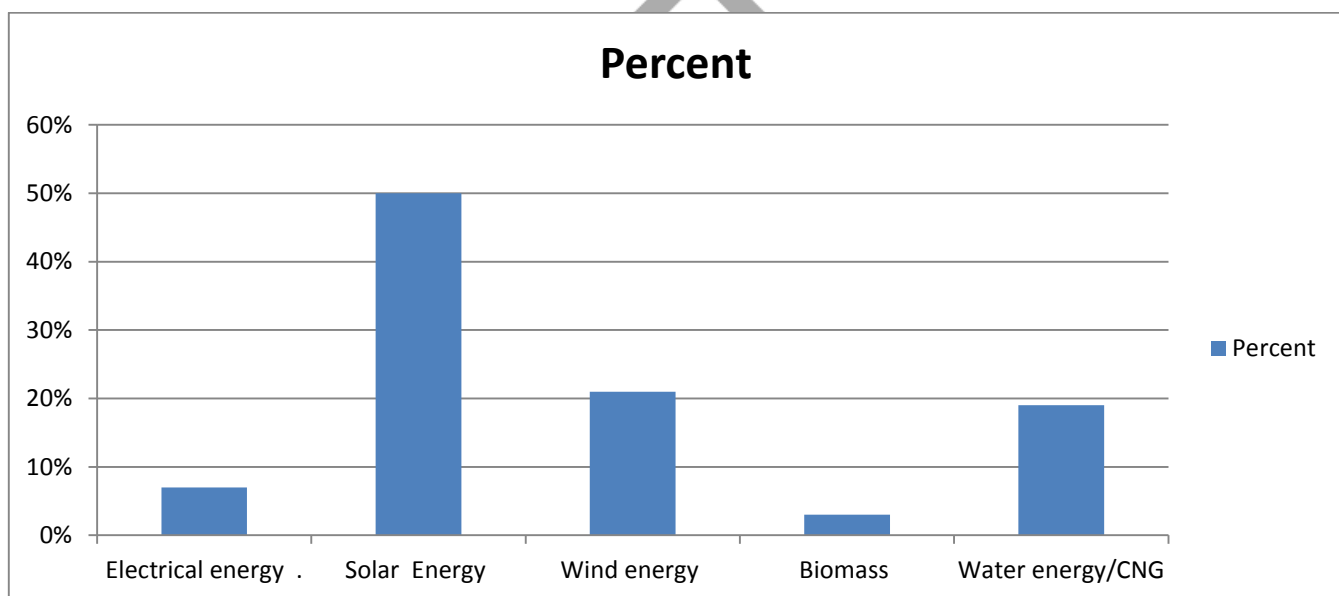


CHART 6

Analysis and interpretation:

50% Organizations from the sample of the study uses solar energy as their source, followed with 21% who uses the wind energy, 19% uses the water energy and the rest 7% uses the electrical energy. The organizations who follows green supply chain management practices uses renewable energy which are never ending and thus they are saving the non-renewable sources. Indirectly they are saving environment.

	S.A	A	N	.DA	S.DA
Organisation uses energy from Renewable sources like Sun, Wind, Water	17%	57%	11%	4%	10%
Your Organisation follows the process in manufacturing which will reduce the emission of pollutants.	14%	71%	6%	6%	3%
Organization produce product of low carbon footprint.	26%	46%	11%	3%	14%
Organisation should follow green process?	14%	51%	9%	6%	20%

Analysis and interpretation:

74% of the companies selected in study agreed that they use renewable energy to save the environment may be due to the reason they have affordability, required infrastructure or concern towards future generation. whereas 14% of the sample do not think it important to use those renewable sources unnecessarily, but 11% are neutral may be due to the reason that though they realize the necessity to avoid non-renewable energy in their process but they are helpless as it requires much investment for the infrastructure in terms of money, space and labour, technology which they can't bear.

85% of the companies different manufacturing process which will reduce the emission of pollutants but 9% do not feel it important to take that step and use such process to discharge less pollutants. But among the sample 6% though agree specially being a green company they should use the process which will discharge less pollutants but they can't implement it in their system due to lack of fund and required technology.

72% produce product of low C footprint whereas 17% are not at all produce product of low C footprint. 11% people are neutral in that respect they neither feel it's really require to produce product of low C footprint nor they completely denied the concept so maybe they are not directly involve in green production, they may collect green parts from different green partners.

65% agreed that organization should follow the green process as they know green process in green manufacturing organization obviously be used in those organization which follows green supply chain management practices and save environment from pollution, harmful waste. But 26% denied the same. whereas 9% are neutral in the statement may be because they don't produce green product but know its significance in environment improvement.

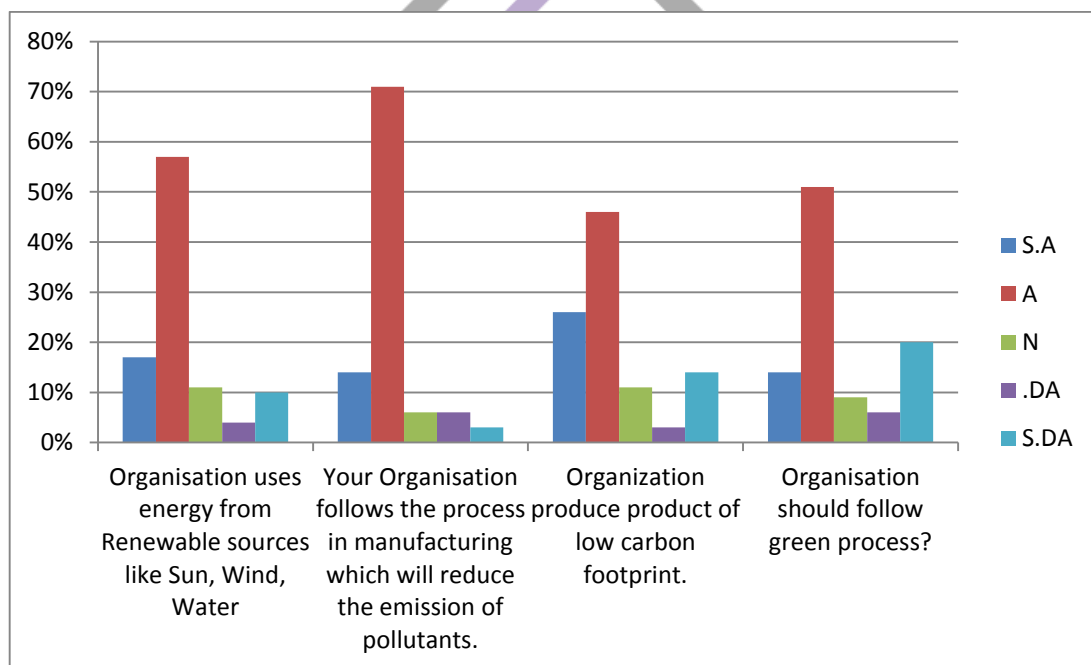


CHART 7

FINDINGS:

The above bar graph depicts that the statement which is strongly agreed by most of the respondents is that organization produce low C footprint, followed by using of renewable energy which also shows that conservation of natural resources. It shows that organization whatever manufacturing process are using to manufacture the product make the environment C less as well as conserve the natural resources and thus maintain environmental sustainability.

Most of the respondents of the study strongly disagree that organization should follow green process followed with the statement that organization produce low C footprint through green manufacturing. The column length of strongly disagree is higher than strongly agree in case of green process so we may conclude that most of people may have consent about green manufacturing but they are not satisfied with green process utilization in their organization.

Most of the respondents agreed that organization should follow the process which emits less pollutants, followed with using non-renewable energy source and leaving less C footprint. It depicts that as green manufacturing helps to reduce less harmful pollutants and non-renewable energy thus help to maintain environmental sustainability.

5.2 Result: The study tested the relation between green manufacturing and environmental performance through Pearson's and spearman's correlation method. Depending upon the list the following table is framed.

	Organisation uses energy from Renewable sources like Sun, Wind, Water	Your Organisation follows the process in manufacturing which will reduce the emission of pollutants.	Organization produce product of low carbon footprint.	Organisation should follow green process
Organisation uses the recyclable material for manufacturing the product	0.265	0.587	0.789	0.654
your Organisation controls the release of toxic substances in product life	0.654	0.987	0.879	0.741
Organisation follows lead free soldering in manufacturing	0.254	0.452	0.543	0.658
green manufacturing in your Organisation help in water conservation	0.752	0.354	0.523	0.657

FINDINGS:

- Organisation uses the recyclable material for manufacturing the product is well related with Organization produce product of low carbon footprint and should follow green process, but less related to Organisation uses energy from Renewable sources like Sun, Wind, Water..
- Your Organisation controls the release of toxic substances in product life is strongly related with Organisation uses energy from Renewable sources like Sun, Wind, Water, follows the process in manufacturing which will reduce the emission of pollutants, produce product of low carbon footprint and follow green process.
- Organisation follows lead free soldering in manufacturing is not well related with none of these environmental performances like producing product of low carbon footprint and follow green process, and also using non-renewable and Renewable energy sources like Sun, Wind, Water.
- Green manufacturing in your Organisation help in water conservation Organisation uses energy from Renewable sources like Sun, Wind, Water is highly related and also follow green process .But it is less related with Your Organisation follows the green manufacturing by reducing the emission of pollutants and producing product of low carbon footprint.

5.3 CONCLUSION:

The study has some following matters to conclude:

- ❖ Green manufacturing practice where recyclable material for manufacturing the product will help to reduce the C footprint and green process will ensure the less hazardous waste from industries, thus helpful in increasing environmental performance. But due to the huge expense in manufacturing own energy plant to use most of the organization are not able to contribute in using renewable energy in manufacturing.
- ❖ It indicates that organization follows green manufacturing helps to maintain environmental sustainability by reduction of harmful emission, leaving less C footprint in environment.

Green manufacturing technologies is not only for environmental obligation but also a growth catalyst. Developing and developed countries may eradicate poverty rapidly and achieve sustainable development effectively through green manufacturing. But leaders, society and leading businesses need to collaboratively engage in this transition. This new technology promoting energy and resource efficiency provide growth opportunities in new direction.. Government will also need to support the greening of manufacturing through institutional support and soft technology approaches. However there are many risks and challenges along the way for the industries as well as for the government but this will certainly help any establishment or country to become a green

economy with sustainable development. Manufacturing workers need to train on the principle of energy and resource conservancy is imperative. So that manufacturing sector avoids waste of resources and ensures a healthy environment. As investments in safety, energy reduction, pollution and quality control have shown tremendous cost reduction, the investments in green manufacturing will also have its own benefits.

REFERENCES

- [1] Bogue, R. (2007). Design for disassembly: a critical twenty-first century discipline. *Assembly Automation*. 27(4), 285-289.
- [2] Burke, S. and Gaughran, W.F. (2007). Developing a framework for sustainability management in engineering SMEs. *Robotics and Computer-Integrated Manufacturing*. 23, 696-703.
- [3] Cerdan, C., Gazulla, C., Raugei, M., Martinez, E., and Fullana-i-Palmer, P. (2009). Proposal for new quantitative eco design indicators: a first case study. *Journal of Cleaner Production*. 17, 1638-1643.
- [4] Deif, A.M. (2011). A system model for green manufacturing. *Journal of Cleaner Production*. 19, 1553-1559. Despeisse, M., Oates, M.R., and Ball, P.D. (2012). Sustainable manufacturing tactics and cross-functional factory modeling. *Journal of Cleaner Production*. 13(4), 373-385.
- [5] Dowlatshahi, S. (2010). The role of transportation in the design and implementation of reverse logistics systems. *International Journal of Production Research*, 48(14), 4199-4215.
- [6] Feng, S.C., and Joung, C.B. (2009). An Overview of a Proposed Measurement Infrastructure for Sustainable Manufacturing. *Proceeding of The 7th Global Conference on Sustainable Manufacturing*, Chennai India.
- [7] Jayal, A.D., Badurdeen, F., Dillon Jr, O.W., and Jawahir, I.S. (2010). Sustainable manufacturing: Modeling and optimization challenges at the product, process and system levels. *CIRP Journal of Manufacturing Science and Technology*. 144-152.
- [8] Lambert, S., Riopel, D., and Abdul-Kader, W. (2011). A reverse logistics decisions conceptual framework. *Computers and Industrial Engineering*, 61(3), 561-581.
- [9] Linton, J.D., Klassen, R., and Jayaraman, V. (2007). Sustainable supply chains: An introduction. *Journal of Operations Management*. 25, 1075-1082.
- [10] Min, H., and Kim, I. (2012). Green supply chain research: past, present, and future. *Proceeding, International Seminar on Industrial Engineering and Management* ISSN : 1978-774X
- [11] Logistics Research, 4, 39-47. MIT (2003). *Invention and Innovation for sustainable Development*: London, UK.
- [12] Mukhopadhyay, S.K., and Setaputr, R. (2011). Return policy in product reuse under uncertainty. *International Journal of Production Research*, 49(17), 5317-5332.
- [13] Nichter, S., and Goldmark, L. (2009). Small firm growth in developing countries. *World Development*. 37(9), 1453-1464.