

## Role of Clean Technology in Sustainable Manufacturing

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**Abstract:** Sustainable manufacturing is the backbone for the development of standard of living of the country along with its industrial growth. It is a process for meeting development needs while maintaining the stability, integrity and beauty of natural biotic systems such that societal consumption of natural resources is incommensurate with the rate which the nature can replenish itself. It can be more cost and time efficient, especially for small scale production and customized products. In order to have complete and efficient structure of sustainable manufacture it must produce green products by using clean technologies. The manufacturing industries which can integrate the aspect of clean technologies in their technical and financial decisions will hold an important role in winning the everlasting future race.

The main objective of this paper is to elaborate the concept and implementation of clean technologies in sustainable manufacturing which includes the process, models and impact assessment of green technologies.

The ideas presented in this paper will be quite useful for the researchers and industrialists who are interested in the field sustainable manufacturing.

**Keywords:** Sustainable Manufacturing, Environment, Clean & Green technology, etc.

### 1. Introduction

The industrialization during last two centuries has revolutionized in all aspects of human-beings. A natural keen desire for progress and economical growth has forced to utilize the natural resource without considering the consequences and the damage incurred or being incurred to the environment and society. The only goal remained was consumption/use of the natural resource and technology only for economical benefits and desired luxury without considering the co-existing creatures and nature. In this race the concept of peaceful life on the earth “live and let live others” have been forgotten. The consequences are the global warming which is heading toward uncertainties and is of serious concern not only to the life of human beings but to other living creatures which includes everything creatures and plants etc.

Though the industrialization has enabled us varieties of produces for our use, utilization and pleasure during the production of these produces the changes in the environment has been ignored. In earlier days, i.e. centuries back when industries were developed on the need base by and for the local people. And also due to low population, the pollution was minimal and also people were maintaining the ecological balance.

In the present era of fast industrialization with globalization, the drastic changes in the environment in the form of continuous pollution has been ignored until it has become intolerable and now it is at alarming stage of ecological imbalance resulting serious global warming. The future prediction about the nature and its living beings including a wise creature “The Man” would be a stage in which the survival would be very difficult unless Green Process is adopted.

The Clean Process should be developed based on the following parameters:

- Industrial Projects and Processes should be such that any environmental change is viewed with first priority of environmental improvement following by production and its benefits with an aim to have a contributory ratio of order of 51:49 respectively.
- Maximization of Output mix of environmental improvement, production, by-products, effluents, releases should be studied with the availabilities of all inputs such as raw materials, machines, processes, energy, men etc.
- Sensitivity analysis of the O R model should be studied by learning the range of input and output variables elements.
- Duality analysis of the model should be studied as a minimization problem
- Eliminated or minimized Environmental releases and effluents should also be studied in this O R Minimization Model.

Various such O R models be formed, solved and studied for enriching of the environment, maximization of output, eliminated of environmental releases or if any transforming it into by-products useful either to mankind or to natural use.

Thus clean process should have the accompanying attributes:

- In its normal operation, this quality of harmful material to be released into the environment should be converted into useful material before its release through a new technology use to create positive effect under ‘upset’ conditions (Scheduled start-up, scheduled or emergency shout down, scheduled or emergency load changes or other operating changes).
- Material handling, delivery to and from site should be assured without environmental damage/releases.

- Emergency responses (fire etc) should not release harmful substances should be supported with developed absorption environmental system.
- Personnel and workers should have updated intellectual and technical skills with an aim to maintain and up gradation of a high standard of environmental growth along with the production.

Now globally the governments and all big industrial houses have to realize the importance of such green technological development and its implementation.

The companies with their present/existing technology though they may hesitate to convert or change into the green technological process due to their financial constraint but should have or will have to work in the direction. The pressure to adopt/change should be self developed internal pressure whereas the external pressure that of government; public and consumer should be the secondary one and just to help them in streamlining the implementation.

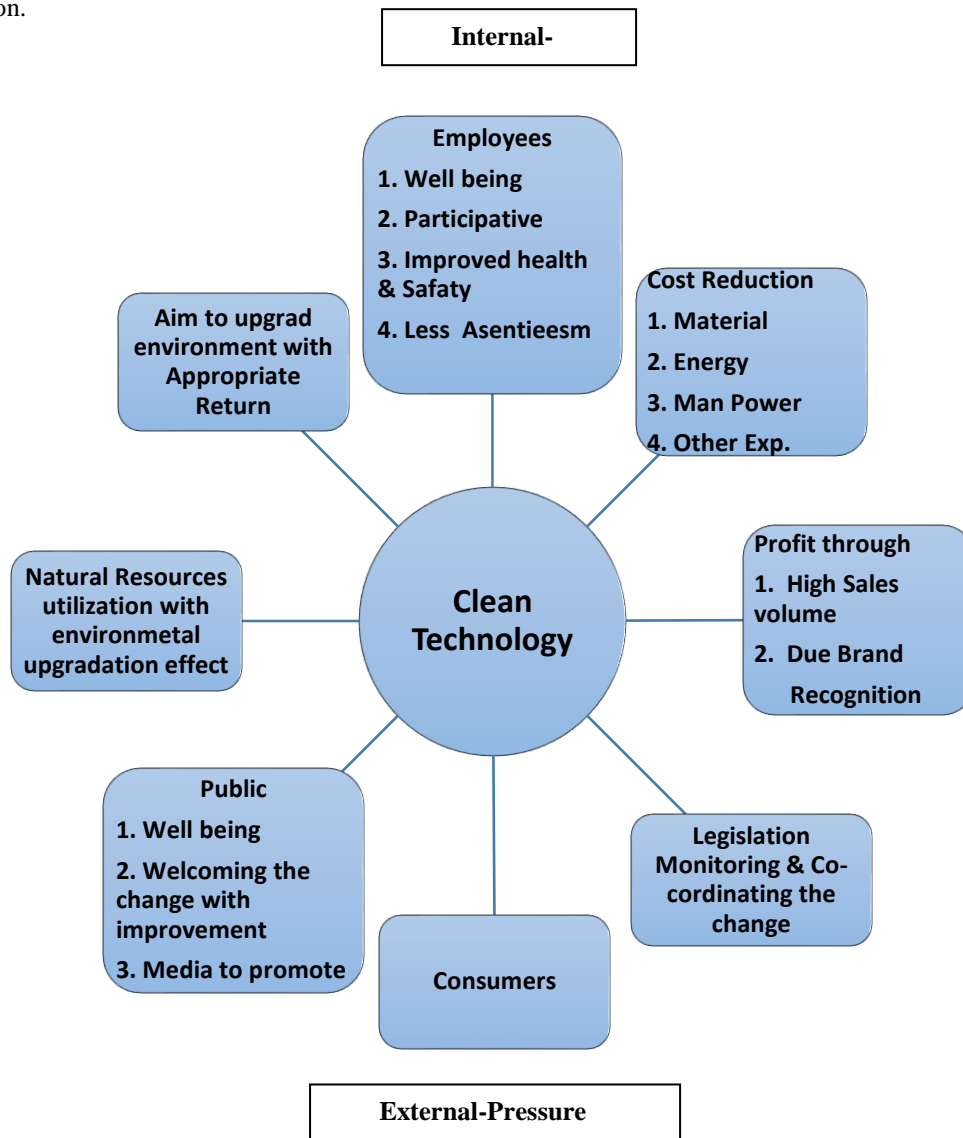


Fig 1: Clean Technology (1) Internal Process (2) External process

With the current alarming global warming all the big business houses will have to realize their due contribution and some have started working in that direction. But for some of the business houses these pressures are not adequate to incite them to move in this direction. For such companies some internal & external catalysts will help them to proceed in the direction.

Table 1: Internal & external catalysts

Internal Catalysts	External Catalysts
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<ul style="list-style-type: none"> <li>• <b>Upgrading of environment for well of all</b></li> </ul>	<ul style="list-style-type: none"> <li>• <b>New regulation &amp; promotion for venture</b></li> </ul>
<ul style="list-style-type: none"> <li>• <b>Quality production to increase market share</b></li> </ul>	<ul style="list-style-type: none"> <li>• <b>The cost of taxes &amp; Penalties</b></li> </ul>
<ul style="list-style-type: none"> <li>• <b>Actual cost of the finished product</b></li> </ul>	<ul style="list-style-type: none"> <li>• <b>The intensity of neighbor pressure for change</b></li> </ul>
<ul style="list-style-type: none"> <li>• <b>The waste elimination cost</b></li> </ul>	
<ul style="list-style-type: none"> <li>• <b>New technology/development or adaptation for utilization of certain waste.</b></li> </ul>	
<ul style="list-style-type: none"> <li>• <b>Cost of Raw Materials</b></li> </ul>	
<ul style="list-style-type: none"> <li>• <b>Difficulty in supply of Raw Materials</b></li> </ul>	
<ul style="list-style-type: none"> <li>• <b>Incident &amp; accident</b></li> </ul>	

**Clean Technology**

The concept of clean technology in fig 1 would be a manufacturing process which should result to:

- Improve the environmental condition or if not possible with then no pollution.
- Convert the effluents into harmless or useful to the nature.
- Make the most objective utilization of raw materials and energy and all this at a reasonable economic cost.

A clean technology means the integration of the environment and other resources in production in such a manner to produce better and the effluents as a means for enriching the environment.

In practice it is observed that the choice of technology is determined by economic, technical and strategic factors, which are if not friendly to the environment, should be reviewed and the negativity should be converted into positivity. In adaptation of the concept of clean technology many obstacles may come in a way of its implementation. One of the most important problems would be to find and set-up such a technology appropriate to the case that claims attention. The enterprises and centers of research (public or private ones) must make an effort to develop and offer varieties of such needed technologies. The national and international policies be reviewed and reframed in the light of this new concept. The public authorities and the public may also contribute to the implementation of such industrial units.

The enterprises and centers of research have to view this problem from its duality point of view. Every input's contribution in enriching the goal should be continuously reviewed & reanalysed with appropriate modification. The outputs contribution should be continuously monitored with appropriate out mix (products, by-products and effluents requiring keen attention to change them in useful by-products.)

Thus the technology be reviewed and developed from its duality aspects with a concept to enrich environment with appropriate balance in its preproduction and other economical aspects.

**Implementation of Clean Technology**

With a positive attitude of approach, the implementation of Clean Technology is possible in all types of industrial activities whatever the size of enterprise may be. The Clean Technology would constitute a group of methods which should be chosen for each case in relation with the specific constraint that industry may require with specific consideration and monitoring.

**Environmental Critical Examination**

As normal the Environmental Critical Examination would be a panel-based method relevant to a wide scope of processes including all operations and combinations of operations giving rise to chemical or physical transformations. The analysis methodology would also be an environmental analogue of Hazard and Operability studies,

The objective would be to:

- Take out or limit all wastes produced by a process prior to discharge, storage or removal.

- In organizing the wastes decrease, the significant emphasis should be on the disposal or minimization of ecologically harmful wastes.
- The minimized harmful effluent should be viewed as input to a new process with output as some useful products with environmental enriching effect.

In examining at another or a current cycle a first step would be to plan the technique for waste minimization keeping in view the priorities in term of their environmental desirability as shown in following fig 2.

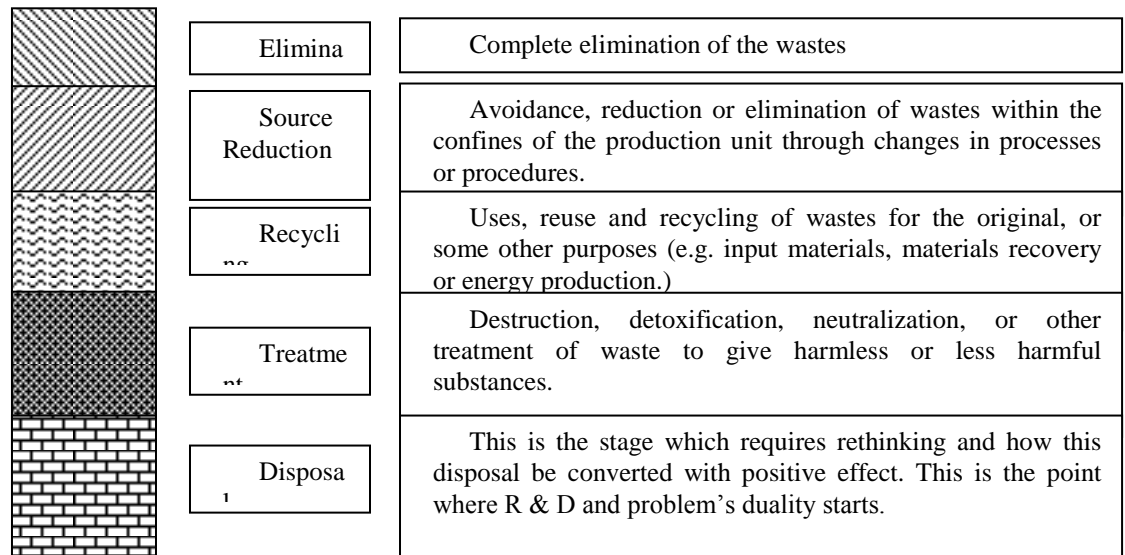


Fig.2: Environmental desirability steps

The environmental critical examination methodology would be:-

1. Recording of operations at each stage with data gathering
2. Critical examination of each stage with data analysis
3. Out comes with recommendations.

All the parts of the cycle applicable to its genuine or expected ecological changes are to be considered. Existing process optimization may be handled by computer systems with optimum yields and avoiding pollution through threshold monitoring with activating the alarms. The process modification should also be done in such a way so as not to disturb production its quantity and quality and the basic process should also remain unchanged. The modifications have purposes.

1. The case of waste as secondary raw material for other production process.
2. Recycling or recovery of residual fluids and emissions.

The new technological researches and Best Available Technologies be implemented



keeping in view availability of finance, techniques, and manpower etc. The process life cycle for the chosen process be assessed right from its initial stage, pilot runs, design and development, implementation i.e. start up operating stage till the termination and redesign stage arises.

#### Adaptation of Clean Production Process

**Fig. 3: Adaptation of Clean Production Process**

Though at a glance Adaptation of Clean Production Process may appear to be religious thought to be implemented but from the realistic point of view various factors are to be considered. What is the size of production unit? What is the attitude and philosophy of management for running the business? Etc. But with the alarming environmental changes the management would be willing to have and will have to adapt the green production process by either accruing the Best Available Technology or through their own R & D cell. And an appropriate balance between profit, production, protection and enrichment of the environment will have to be maintained. The Legislation as an external force to implement and achieve the motto will have to be enforced. Off course, for medium and small scale production houses will pose some difficulties but not the impossibility. With due monitoring and support by the legislation the required and desired realization can be achieved.

The adaptation of Clean Production process will have immense benefits. Among the many the first one would be Environmental Protection through Improvement Approach by sizable section of big industrial houses globally and would be becoming The Ideal for other to follow. The usual other benefits would be improvement of working conditions within the organization and outside too. A Best Available Technology supported with R & D will also result in saving of raw materials, energy and other resources, decreases in costs and damages, improvement in quality of products with new imbedded qualities features in the products and, of course, with high productivity with reasonable profitability.

So far, most Environmental Impact Assessment (EIA) activities have focused on the identification of effects to the physical environment, but now it is time to be viewed as "Total Environment Improvement Assessment" (TEIP). Gregory (et. al.) has identified the problems keeping in view the "impact Assessment" but the cited problems with many more should be treated as the contributory areas for the growth. The researchers are needed to further elaborate and develop the classifications, evaluations and its outcomes with due promotions and monitoring. With the availability of various software and many more should be developed to utilize available information to achieve the target i.e. "Environmental Improvement".

The persons studying TPLCI (Total Product Life Cycle Improvement), have to review the releases in the form of emissions during the production process as inputs which are to be converted to utilities. The TPLCI picture will look like as shown in the fig.4.

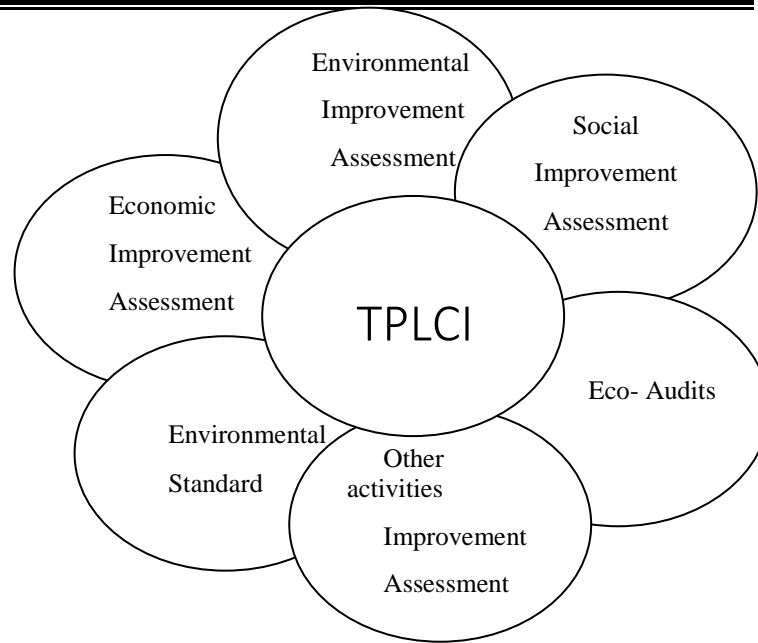


Fig.4: TPLCI Life cycle

Thus TPLCI opens a venue for critical examination, analysis, research and development in all its dimensions.

#### **Benchmarking New Technology**

- Make innovation a continuous process for new and advanced products and processes.
- Integrate digital product and process models throughout the product life cycle to ensure the success of the model based enterprise (MBE).
- Embrace and work to create interoperability throughout the manufacturing enterprise.
- Develop and implement successful processes for information management and ownership, including intellectual property (IP) issues.
- Work to develop resilient supply chains that can accommodate natural disasters and changes in players.

#### **Conclusions**

The clean technology would not only reconcile industrial production but will also give Total Product Life Cycle Improvement (TPLCI). Adopting the techniques of Clean Technology will not only be accompanied by economic, social, strategic and other advantages but will also be efficient in long runs because it will be in harmony with all its aspects including the needed and desired contribution for the forth coming generation.

Market, public and regulatory pressure burdens would be reduced on the manufacturers by adapting the clean technology and on the contrary they will also have their high Brand value. National and international standards setting bodies would also have to develop guidelines to promote sound product design proposals for search of new standard. The public concerns would be viewed as new inputs for further improvements in products and processes.

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