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Cost Benefit Analysis of Cleaner Production Technologies in India

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MOEF IGIDR WORLD BANK

“COST BENEFIT ANALYSIS OF CLEANER PRODUCTION TECHNOLOGIES IN INDIA”

A study sponsored by the EERC for the World Bank and the Ministry of Environment and Forests

FINAL REPORT

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CONTENTS

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EXECUTIVE SUMMARY

Introduction

The challenge of environmental degradation and the need for industrial sustainable development brings forth a growing awareness in the industrial sector to do more than clean up existing pollution. Environmental protection policy has traditionally included the pollution control technology that captures waste at the end of pipe and its disposal through dilution or burial. But in recent years the limitations of this approach have become increasingly evident due to rising awareness of global environmental risks, growth of waste volumes, and the limits of waste disposal to land, sea and air, together with the realization that end- of-pipe solutions to pollution simply displace the problem elsewhere or create entirely new environmental hazards. This prompts leading firms and researchers to look for a new model of industrial activity based on the minimization of waste, energy saving and the reduction of resources used in production. This is through the concept of Cleaner Technologies, which is an integrated pollution control and prevention approach that conserves resources, minimizes waste generation and energy use and is based on the comprehensive analysis of process and product impacts on the environment. [Christie et. al., 1995]

OBJECTIVES:

The objectives of the study are:

a. To carry out a cost-benefit analysis of cleaner production technologies including the related spill-over/spin-off effects.

b. To evaluate the impact of cleaner production technologies in some selected Indian Industries like agrochemicals, pharmaceutical, electroplating and chemicals & dyes*.

c. To identify the background and driving forces for the development and use of cleaner technologies as well as the barriers to them.

d. To infer the implications of this study for corporate (and also new industries) and macro policies including the local economy.

e. To identify the types of training and sources of training relating to cleaner technologies.

f. To identify the characteristics of organizational citizenship.

SCOPE OF THE STUDY:

The study covers agrochemicals, electroplating, pharmaceuticals and dyes & chemicals in the states of Maharashtra and Gujarat. Initially, five industries / sectors were proposed over a wider geography of the country. However, during the first project workshop of vetting proposals, we were advised to confine the study to two sectors in Gujarat and Maharashtra. Accordingly, the study was confined to agrochemicals and electroplating. Subsequently, as we could get only two case studies of an electroplating unit, the pharmaceutical sector was selected in its place as clarified at the review workshop. As the work progressed in Gujarat later, we could get sample cases only from the dyes and chemicals sector.

METHODOLOGY AND DATA SOURCES:

The analyses have been attempted at three levels, viz.: first, at the micro level or the level of the firm, to ascertain economic rationality in terms of the direct costs and benefits associated with the CT exercise. Secondly, as regards the immediate environment, i.e. the indirect or spin - off effects by way of merit goods and thirdly, at the public goods level, where the surrounding area population perceptions were expressed through contingent valuation.

The tools of *Cost Benefit Analysis* like payback period and NPV have been employed to assess the CT exercises. However, the NPV method has been used only in cases where the payback period is beyond 3 years. Also, the *Waste* *measurement index* (WMI) has been computed wherever relevant and possible. All these have been based on both quantitative and qualitative data gathered with the help of a detailed questionnaire [see annexure - I] and interviews. Respondents were also asked to assign ranks to specific aspects like driving forces and barriers. The rankings were then weighted on the basis of scores assigned by three independent experts. In certain cases, the firms were asked to assign scores ranging from very low to very high.

This has been supplemented by an analysis of *Merit goods* such as an improvement or otherwise in health, demonstration effect, awareness of workers, quality of air & water, noise and organizational citizenship. An evaluation of *Public goods*, as relevant to a better environment through cleaner technologies, has been attempted with the help of the Contingent Valuation Method (CVM). Willingness to Pay (WTP) was assessed via this technique..

A second questionnaire was designed for the purpose of the CVM survey covering the surrounding area population to gauge the willingness to pay contingent upon a better environment being made available with CT adoption and implementation [see annexure -II].

The only option was to resort to Case Studies in the absence of a representative sample in the industries under study. This is because; some industries like fertilizers are characterised by an oligopoly market structure and in some others there are not many firms who have implemented cleaner production technologies. To begin with, a pilot study was undertaken with a case study each in two industries viz.: fertilizers and electroplating. This was presented and discussed at the review workshop. The comments and suggestions made therein were incorporated and the questionnaire revised accordingly for the final survey. Meetings were arranged with relevant Industries Associations and the project objectives, scope etc. were explained with a view to seek their co-operation for the survey. A one - day seminar was organised jointly with TBIA, SIES-IIEM and MPCB in Vashi, Navi Mumbai on June 9, 2000.

Summary of Findings:

It is encouraging to note that in most cases where cleaner production technologies were implemented, the *cost benefit analysis* shows that the firms have benefited by and large, both quantitatively and qualitatively. The quantitative benefits are reflected in the short payback periods; in some cases even as short as a few days to few months. There have been no production interruptions whatsoever, in the adoption and implementation of cleaner technologies. In all the cases, firms have implemented CT exercises during shutdown periods and or adequate inventory was built up in a few cases where shut down extension was anticipated. Therefore, there were no adjustment costs incurred during the switchover to CT measures. Best efforts to obtain imputed values were made wherever found relevant for e.g. fabrication, use of land, manpower etc.

In respect of *corporate citizenship*, it is heartening to note that most of the firms studied fare reasonably well. In some cases the responses have been very encouraging with high scores.

In terms of *merit goods* or qualitative benefits and spin - off / spill - over effects, there have been positive impacts on the quality of air, water, and demonstration effect and employee attitudes. In very few cases, positive health impacts has been perceived and reported. In many other cases, there may have been health benefits as a result of reduction in dust /emissions, effluents, and odor and yet the firms have not been able to link it to the CT measures or health records.

The major *driving forces* behind adoption of cleaner technologies as revealed by the study are top management commitment, better safety and health, efficiency drive and corporate image. However, in respect of small scale industrial units studied in Gujarat, market forces or related factors such as efficiency and quality considerations scored high ranks. While it is reasonable to expect that market forces should primarily drive the ***adoption*** of CT, top management commitment appears to pay a decisive role when it comes to ***implementation.*** This perhaps may have been the reason why the ranking pattern did not essentially change even after weighting done on the basis of scores obtained from independent experts. Most companies covered in this study did not experience any significant barrier while implementing CT measures. In some cases however, the lack of funds for long term investments amidst pressure for obtaining quicker returns has been viewed as a problem while adopting CT.

The study also reveals that *training* has received due attention in most of the large scale units. Greater attention has however, seems to be on in-house training and that too on-the-job type. Among the sources of training and information in-house staff have been found very useful followed by journals /media, Universities/R&D organizations and Industry Associations.

The study also reveals that in most cases the cleaner production technologies implemented are not only environmentally friendly but also less hazardous. Let us take the example of Gharda chemicals in Maharashtra. All the 5 changes studied have led to better environmental conditions and less hazardous than before.

a. The recovery of TCSA with the help of a distillation unit is less hazardous as in the present system the release of TCSA vapors is minimised.

b. The second modification reported is the recovery of DMA raffinate which is less hazardous and environmentally friendly

c. Recovery of organic waste which was earlier being incinerated. This is less hazardous as incineration is a process which can lead to various toxic gases if it is carried out without proper secondary air pollution control devices like scrubbers.

d. Recovery of unreacted iso butylene and hexane , earlier these were let off into the atmosphere. The present technology is much safer as these gases are being recovered with a compressor and purification system

e. CMA recovery is less hazardous again as the recovery is done by cyanide destruction and pH adjustment. Cyanide is one of the most hazardous substances.

In some cases the new technology 's main benefit is energy conservation and has no influence on the hazardous nature of the process.

Coming to the *'public goods'* evaluation aspect, *the CVM survey* has been confined to the surrounding area population around the Thane - Belapur Industrial belt. The evidence in general, supports the theory and experience obtained in other countries in that larger proportions of the higher income groups display willingness to pay in comparison to their 'poorer' counterparts. However, in certain specific locations [Airoli, parts of Vashi, Koper Khairne and Nerul - i.e. the comparatively 'better - off' areas in terms of income earned], evidence to the contrary is also obtained, where one does not see any real positive correlation between higher incomes and higher WTP. At the very lowest end of the income spectrum, the response is negative indicating perhaps, that the environment does not figure in their calculus of priorities at the subsistence level. Also, across the entire region, the higher the education level, the greater the proportion expressing WTP, thus implying that a positive correlation exists between the two. However, irrespective of one's income or educational qualifications the overriding view that prevails is that the "polluter should pay". A pressing need for more effective governmental intervention and control is also stressed. Thus all in all, one feels that the whole Contingent Valuation exercise was a worthwhile one since it gives one at least some indication with respect to WTP subject to certain riders as also an insight into people's perceptions about the environment, roles of the industry and the government.

Concluding Remarks and Recommendations:

While summing up, it is heartening to note that cleaner production technologies exercises are not only desirable from the environmental point of view as a pre-emptive strategy, but also make good economic sense. As has been seen in many cases, such exercises have added to the bottomline by conserving resources like energy, raw materials and manpower, improving yield and reducing treatment/disposal costs. The study should go a long way in promoting widespread adoption/implementation of Cleaner production technologies in other industries so that tangible progress is made in the direction of sustainable development. It is also observed that there are significant gains accruing from the merit goods viewpoint as well.

By way of *policy implications*, we may add that best efforts should be made to promote cleaner technologies through suitable incentives, setting up state- wise information clearing houses on CT. This is especially important given that many firms have indicated lack of funds for long term investment, and lack of information on tested technologies. In the present legal framework on environmental protection, there are no laws encouraging waste minimisation, recovery and recycling. The Government of India can make cleaner production a major focus area by amending the existing Environment Protection Act - 1986.

Also, efforts at the level of the *Industry Associations* need far more strengthening and the emphasis needs to be shifted more towards facilitating CTs and Green Rating rather than mere abatement to meet regulatory requirements. As of now, green rating seems to be confined to NGOs like the Centre for Science and Environment (CSE). Moreover, they should develop networking with their counterparts elsewhere, government agencies and others like the Global Reporting Initiatives need to be undertaken in order to move closer to the creation and development of a clearing house for speedier exchange of information on CT and accelerate the demonstration effect. The present state of affairs at the disposable points, whether individual ETPs or common ETPs, leaves much to be desired. Arguments such as, 'disposal is safe through long pipelines to the Gulf of Cambay because there are no micro-organisms there', may not be tenable for long. Worse still, in some places people privately admit that ETPs are viewed only as a cost item and are functional only when pollution control authorities are likely to visit the plant, remaining shut the rest of the time. As for incinerators, cases are not infrequent where one is told they do not work.

It is all the more imperative, therefore, to make sincere and serious efforts towards CT alternatives such as exploring opportunities for using biotechnology, reed-bed technologies etc., in a big way as attempted in other parts of the world. Surely, prevention is better than cure!

Limitations of the Study:

While concluding it is important to note that no generalization can be attempted as the study is not based on statistical representation of the sectors/industries covered but confined to case studies. First and foremost, there are only a few firms within industries like fertilizers and agro-chemicals i.e., they have an oligopoly- type market structure. Secondly, within this limited number of players itself, the firms which have implemented CT are still fewer. Thirdly, even in cases where CT implementation has taken place there is strong resistance to part with data and relevant information. The reason often cited is that it is a company. policy not to reveal details of technology, process flow charts and input structure. Some of the firms, which have participated in this study, have requested for confidentiality and anonymity. However, despite giving such assurances as to confidentiality and anonymity, some firms have given only net savings and not pre-CT and post-CT input requirements.

In the CVM survey, the differing pattern based on *relative proximity* to polluting industries and *gender* could not be ascertained. Here too, there was a lot of resistance to spare time for the face to face interview with the enumerators.

Scope for Future Work:

The study could be extended to other major energy/resource intensive industries like power, refineries and iron & steel and also to other states. Further, efforts can be made to obtain time series data wherever possible so that IRR and ERR could be estimated. Besides, recourse may be made to normative costs if available in cases where actual data is not forthcoming.

Lastly, to supplement surrounding area population survey, repertory grid analysis can be attempted with the help of community workshops . This can give us better picture of relative importance assigned to environmental quality by different social strata of people at different locations.

Chapter 1: INTRODUCTION

1.1 BACKGROUND:

With the intensive use of non-renewable resources in industrial products and services accompanying modern lifestyles, the problems of pollution, global warming, ozone depletion and climatic change have become more acute. Hence, the need for sustainable development and the rising awareness associated with it.

Since environmental damage can seriously affect the well being of people, especially the poor, solutions or technologies that can minimize such damages are very essential. Economic prospects would be bleak if environmental issues are not handled responsibly; at the same time ecological measures that disregard economic efficiency are a threat to prosperity and sustainable development. Thus, the need for newer scientific approaches like Cleaner Technology, which contrasts sharply with traditional pollution control measures, in that, the latter aim to mitigate damage after it occurs while the former emphasizes the adage “prevention is better than cure,” instead. It is increasingly being recognized that Cleaner Technology is a proactive, preventive, effective and cheaper approach that aims to eliminate pollution at the source to conserve raw materials, energy and water through efficient production processes. It also aims to reduce the environmental impact of the products throughout their life cycle, from the first extraction of raw materials to their ultimate disposal.

A recent estimate of environmental damage in India shows the environmental costs to be 4.5% ($10 billion) to 6% ($13.8 billion) of GDP. A breakdown of this estimate shows urban air pollution costs to be $1.3 billion a year, health costs due to water pollution to be $5.7 billion per year, deforestation costs to be $214 million per year and productivity loss due to land degradation costs to be $2.4 billion. In addition to this some costs are due to biodiversity loss or pollution from hazardous waste. (Human Development Report, 1998)

It is against this backdrop that the World Bank and MOEF, India, have sponsored this study through the EERC as part of the Environment Capacity Building project, in April 1999.

1.2 OBJECTIVES:

The objectives of the study are:

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1.4 METHODOLOGY AND DATA SOURCES:

The analyses have been attempted at three levels, viz.: first, at the micro level or the level of the firm, to ascertain economic rationality in terms of the direct costs and benefits associated with the CT exercise. Secondly, as regards the immediate environment, i.e. the indirect or spin - off effects by way of merit goods and thirdly, at the public goods level, where the surrounding area population perceptions were expressed through contingent valuation.

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Chapter 2: LITERATURE REVIEW

Studies on Clean Production Technologies: A Review

2.1 INTRODUCTION:

Environmental Pollution on a global scale has led to issues like global warming, acid rain, biodiversity loss, ozone layer depletion due to chloro fluoro carbons, etc. With the current trends in population growth and industrialization, wastes and pollutants are released faster than what the earth can absorb and natural resources are consumed faster than can be restored. (Human Development Report, 1998)

The current literature survey is an attempt to scan the various Cleaner Technology steps implemented on a worldwide scale in some of the industrial sectors and capture their essence to facilitate better understanding and appreciation of the issues involved and their implications for research, policy and implementation. However, studies dealing exclusively with Cost Benefit Analysis are scarce and even in those very few cases a thorough Cost Benefit Analysis covering the direct quantifiable as well as the indirect non-quantifiable aspects was found to be lacking. We have therefore not confined ourselves to reviewing the literature on Cost Benefit Analysis alone but extended it to include studies relating to Clean Technology as a whole, the purpose being not to miss the related dimensions that might be of significance to the direct and indirect quantitative and qualitative aspects of the analysis to be undertaken subsequently during the course of the project.

A few examples of the successful implementation of cleaner production technologies in the industrial world are Dow Chemical's WRAP (Waste Reduction Always Pays) program that has cut emissions of 58 pollutants by more than half since 1985, 3M's pollution that has been cut by 90% world wide etc. Payback period in many cases is only in terms of weeks or days. Pilot projects in China, in 51 companies spanning 11 industries, found that Cleaner Production techniques cut pollution by 15-31% and were five times as effective as traditional methods. In order to promote its catalytic role with governments, industry, research organizations and other relevant institutions, UNEP (United Nations Environment Program) launched the Cleaner

Production program in 1990, which resulted in the establishment of a network that will allow the transfer of environmental protection strategy.

2.2 CONCEPTS OF CLEANER TECHNOLOGY:

Evolution and Need

The challenge of environmental degradation and the need for industrial sustainable development brings forth a growing awareness in the industrial sector to do more than clean up existing pollution. Environmental protection policy has traditionally included the pollution control technology that captures waste at the end of pipe and its disposal through dilution or burial. But in recent years the limitations of this approach have become increasingly evident due to rising awareness of global environmental risks, growth of waste volumes, and the limits of waste disposal to land, sea and air, together with the realization that end- of-pipe solutions to pollution simply displace the problem elsewhere or create entirely new environmental hazards. This prompts leading firms and researchers to look for a new model of industrial activity based on the minimization of waste, energy saving and the reduction of resources used in production. This is through the concept of Cleaner Technologies, which is an integrated pollution control and prevention approach that conserves resources, minimizes waste generation and energy use and is based on the comprehensive analysis of process and product impacts on the environment. [Christie et. al., 1995]

What is Cleaner Production?

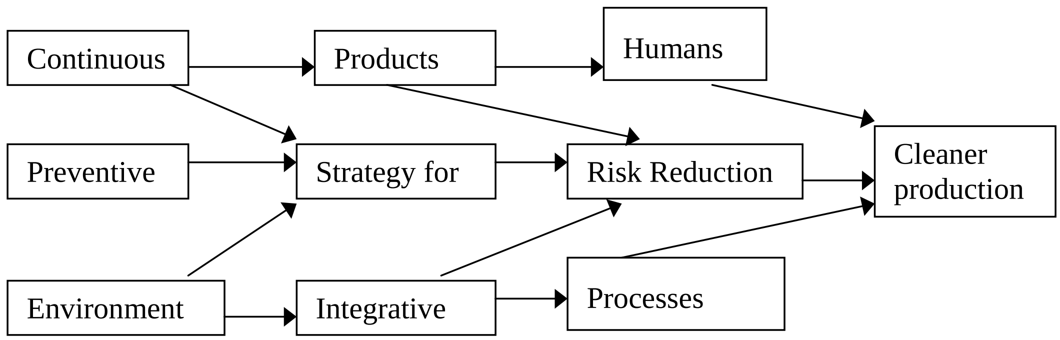
The definition for Cleaner Production put forth by the UNEP is as follows:

- Cleaner Production is the continuous application of an integrated preventive environmental strategy to processes and products to reduce risks to humans and the environment.

- For production processes, Cleaner Production includes conserving raw materials and energy, eliminating toxic raw materials and reducing the quantity and toxicity of all emissions and wastes before they leave a process.

- For products, the Cleaner Production strategy focuses on reducing impacts along the entire life cycle of the product, from raw material extraction to the ultimate disposal of the product. [UNEP, 1994]

Essential Elements of a Cleaner Production Strategy



The Role of Life Cycle Analysis in Cleaner Technology

One of the important advantages of Cleaner Technology is that it involves the concept of Life Cycle Analysis or product stewardship that analyzes the product's entire life cycle from cradle to grave. i.e. from the production stage to its ultimate disposal as waste (Bayer report, 1997). The combined study of the interlinked stages of pre-manufacturing, manufacturing, use, reuse, maintenance, recycling and final waste disposal can be carried out through the Life Cycle Analysis. Thus a Life Cycle Analysis framework can be used to assess the potential improvement activities to identify, when a change results, in effect, in the shifting of burdens among the environmental segments or to another stage of the life cycle. This also identifies the unwanted secondary impacts of any activity, which lead to the selection of the best alternatives based on a broader perspective. [Curran, 1995].

Life Cycle Analysis is in fact a "corporate mass and energy balance" and is the most important environmental management tool based on the law of thermodynamics, that there can be no loss of material or energy in the process. Company life cycle analysis is based on the principle that incoming and outgoing material and energy streams must be in equilibrium. A failure to achieve equilibrium indicates generation of waste. This tool is integrated in the environmental management system concept, covering the entire company, including site selection, raw material consumption, production and ultimate disposal of the product.

It also enables the identification of the stages, which give rise to the greatest environmental damage, and this may not always be the processing or manufacturing stages. For example, in the case of chemicals like agro-chemicals or detergents, the main environmental damage can occur after use rather than during production.

In the light of this principle, in 1992, Nortel (Northern Telecom, a global telecommunications manufacturing firm, Canada) initiated a Product Life Cycle Management (PLCM) program that committed the company to factoring resource efficiency into all stages of the product life cycle. It addressed supplier management, built environmental improvement into the design phase of new products, implemented process and material innovations and alternatives in manufacturing and provided alternative solutions for product disposition. It aimed to create customer value through lower lifetime costs by product efficiency and value-added recycling of products at the end of their life. [Prentis et. al., 1996].

Cleaner Technology: Global Scenario

In order to gain an awareness of Cleaner Production activities that are taking place in the international arena, the different programs across the globe were looked upon, as part of the survey. The most prominent attempt among them is the National Cleaner Production Centers established in approximately 20 developing countries jointly by the UNEP and UNIDO. UNEP's Cleaner Production program helps to create an awareness at the global level. The first meeting of the Cleaner Production working group was held in April 1990 in Copenhagen where the representatives of various industries and institutions explained the mission of short and long-term goals of pollution prevention. [Hillersborg, 1991].

The Clean Development Mechanism (CDM) of the Kyoto Protocol has two major objectives: to assist developing countries to achieve sustainable development and to allow industrialized countries to use certified emission reductions. These CDM projects can effectively make use of Cleaner Technologies. [Cherian, 1998]. The studies are broadly classified under Developed and Less Developed countries.

Cleaner Technology in Developed Countries

Studies showed that private sector industries in developed countries have made significant progress towards Cleaner Technology due to the evolution of government policy tools over the last two decades. Accessibility and dissemination of information has played a critical role in the conversion towards Cleaner Production Technologies in areas such as toxic release inventories, ecolabelling and industrial audits. [Hammer et. al., 1994]

Of late, governments in the developed countries have begun to target their environmental strategies on products rather than on processes, at the starting point. The Life Cycle Analysis is being introduced to determine where in the product cycle (encompassing manufacture, transport, use and disposal), is it possible to reduce or substitute for raw material inputs and to eliminate pollution and wastes most effectively at the least cost. An increasingly important element of this product-based environmental strategy involves ecolabelling. Now there are 30 ecolabelling systems, either in operation or in the planning stage, around the world, which shows that interest in it is extending well beyond the OECD Countries. [Long, 1994]

The Risk Reduction Laboratory in the U.S. conducted a pilot program with 6 states and one local govt. to evaluate promising Pollution Prevention technologies. The participating states included California, Illinois, Minnesota, New Jersey, Washington, and New York. A total of 41 evaluations were carried out during a five-year period from 1989 to 1994. The aim of the program was to encourage technology that could enable industries to operate beyond or above the regulatory compliance by greatly reducing or eliminating the hazardous wastes and releases. The findings of this WRITE (Waste Reduction Innovative Technology Evaluation) program indicated that the expenditure incurred in the adoption of such clean technologies could be recovered within a short pay back period. [Licis, 1995].

Some case studies conducted in the different sectors of oil refining, petrochemicals, fine chemicals, pharmaceuticals, dairies, brewing, sugar, paper mills and electroplating firms in Denmark, Ireland and in the U.K., (Clayton et. al., 1999) showed that regulatory pressure together with pressures within civil society mainly contributed to environmental improvements. In some contexts, the key factor was economic pressure to stimulate greater resource efficiency. An important point noted was that the use of end-of-pipe controls on environmental hazards remained deeply entrenched within the perceptions of industrialists as well as regulators. Cost saving pressure was found to be an important motive for cleaner innovations.

In the refinery sector, the environmental awareness and minor process modification was mainly due to the pressure from regulatory bodies to curb nitrogen discharges. In the petro-chemical sector, waste minimization approaches brought about more radical changes in process technology. In the fine chemical sector too, regulation as well as cost minimization were the main driving forces for environmental performance. In the pharmaceutical sector, their internal waste sources were used in an economically optimum manner thereby adopting a Cleaner Technology approach.

In the dairy sector, the amount of water used and the Biological Oxygen Demand content in the effluent were the major focal points for wastewater management. The Dutch company evolved an energy saving and process technology strategy towards Cleaner Production whereas the Irish company adopted a product development strategy. They preferred a waste minimization approach rather than an end-of-pipe one. The brewery sector was under severe regulatory pressure and hence more inclined towards end-of-pipe solutions. Factors like the need for increased production capacity at the units, concern about water and energy use, tighter license limits and restrictions on available space, prompted the Sugar sector to adapt to Cleaner Technology options. In the paper mill sector, many Cleaner Technology options are tested and successfully implemented and the main barriers appeared to be limited dissemination of expertise together with the difficulties of retrofitting new developments into old plants.

The study also emphasizes the need for Cleaner Technology to encompass product innovation, thereby modifying or substituting for further environmental gain. Hence it extends the concept of Cleaner Technology into Supply Chain Management and Industrial Ecology, thus creating a range of options for the firms. The ultimate goal of industrial ecology is to eliminate all waste by capturing and utilizing the output from every operation as an input to another operation, which in turn forms the essence of Cleaner Technologies.

In Hong Kong, the government is tightening its control on environmental pollution and factories are under increasing pressure to comply with stricter standards. Most of them are small in size, located in multi-storey buildings where the installation of pollution control equipment is difficult. Cleaner Production methods could provide an attractive alternative to expensive new equipment since they eliminate pollution control costs and reduce manufacturing costs. [Lin, 1994]

In the regions of Latin America and the Caribbean, thirty-three countries have/ are preparing waste management legislation; waste minimization initiatives have been limited and usually based on weak or unenforceable effluent standards. A few centers in Mexico and Brazil are focusing on Cleaner Production and the UN initiates most of these programs. Some of the key barriers here are low technical knowledge of Cleaner Production in productive sectors, low industry commitment to Cleaner Production, low enforcement capacity and strong emphasis on End-of-Pipe regulation.

In the European regions, the pollution by small and medium scale industries, when compared with their larger counterparts, are proportionately higher. However, these smaller sectors are more flexible in their ability to innovate and alter their production systems and products and hence the Cleaner Technology concept would be more suitable for these sectors. [Nielsen et. al., 1994]. In countries like Poland, the Cleaner Production movement began in the early 90s with the assistance of the UNEP. The Cleaner Production Declaration was issued, based on which a company organizes its own plan of action and the results are surprisingly very much positive. [Nowak, 1994].

In regions like Poland, even though pollution charges could encourage Cleaner Production Technology, enforcement is weak. Moreover, subsidies are given for raw material and energy consumption, which act as a disincentive for Cleaner technology. Inspite of this, a training programme in Poland and the Czech Republic, involving some 200 companies, has successfully resulted in a 15% to 25% reduction in total pollution discharges with no investment and a further 35% reduction with good pay-back investment. However, many obstacles like lack of financing, lack of leadership and motivation etc. prevent the full-scale adoption of Cleaner Production Technology. One of the main barriers here is the lack of industry commitment due to limited interest among most enterprises, lack of policy framework in respect of incentives and focus on end-of-pipe measures and a culture of non-compliance. [Santos et. al., 1998]

Cleaner Technology in Developing Countries

Among the less developed countries, India, China and Thailand are the major ones that have adopted Cleaner Technologies in various industrial sectors. In these regions, existing policy initiatives are largely targeted towards pollution control. In India, Cleaner Production was given a boost in 1992 with the government's policy statement for the abatement of pollution, which provides assistance to small scale industrial units, enabling the adoption of the best available technologies and the development of mass based standards to encourage waste minimization and environmental audits. However, if one considers the recent furore in Delhi over the relocation of the polluting industries that are situated in areas not in conformity with the city's master plan, one sees how anything that is left too long to fester, becomes increasingly more difficult to manage (Agarwal, 2000). For four years, no serious governmental action was taken, and now with the Supreme Court's insistence that some effective action be taken immediately, no one seems to know quite what to do. In fact the heavily polluting industry being asked to relocate is primarily in the small-scale sector. In India small-scale industries contribute half of the country's industrial output and nearly 38% of its exports. Still, only a fraction of the 3 million small scale industry units actually adhere to environmental norms, even though they are responsible for approximately 65% of the total industrial pollution load. Three major obstacles for Cleaner Technology adoption in India are lack of finance, lack of easily accessible and reliable Cleaner Production information and a seeming lack of political will and motivation. In China, the need to shift from End-of-Pipe control to Cleaner Technologies was recognized at China's second national conference on Prevention and Control of Industrial Pollution (Oct 1992). Using part of a World Bank soft loan, the government has undertaken a Cleaner Technology demonstration project with the assistance of the UNEP to build local capacity to identify and implement Cleaner Production opportunities in Chinese industries. Along with these countries, some African countries have also initiated Cleaner Technology programs.

The Asian Productivity Organization (APO), an intergovernmental regional organization, established in 1961, has developed the concept of green productivity aimed at instituting Cleaner Production systems in the process of increasing overall productivity. With a view to formulating concrete measures and actions for the green productivity movement, the APO has instituted a new program called the Special Program for Environment (SPE). [Yamada, 1996]. Some of the relevant sector-wise case studies in these countries are given below:

Some examples can be cited in **Indian** industries where Cleaner Technology options have been successfully implemented with the help of organizations like the UNEP and UNIDO. The DESIRE (Demonstration in Small Industries for Reducing Waste) project (1993-94), funded by the UNIDO Energy and Environment branch and implemented by the National Productivity Council, focused on opportunities for reducing waste in Small Scale Industries. Its objectives included the demonstration of waste minimization opportunities and benefits, developing a systematic method for waste management, identifying obstacles to & incentives for Waste Management and formulating Waste Management policies. Three industrial sectors were targeted - agro-residue based pulp & paper, textile dyeing & printing and pesticide formulation. Four units from each sector participated in the project and a total of 450 waste minimization options were identified. Despite certain barriers, 300 of these were implemented or were in progress at the close of the 15-month project period. Results showed a savings of 35.8 million (US$ 1.2 million) and a significant pollution load reduction in all sectors. [Chandak, 1994].

Technical assistance has been provided by the UNEP to six small-scale Textile Dyeing and Printing Industrial units in Surat and Ahmedabad. All participating units employed highly comparable equipment. Wastewater generation and energy consumption were their major environmental concerns. Applicable Waste Management solutions include *Rationalization/Optimization of Production*, which minimizes the number of operations and chemicals used and *Technology Changes and Standardization* of the Production Procedures. In the first 5 months of the project, 102 Waste Management options were identified in four units, of which one-third were implemented immediately. The others required some time due to the lack of funds. [Berkel et. al., 1994].

The building materials industry in India is a major user of natural resources, energy, manpower and capital and the construction sector is the largest contributor of CO_2 emissions (22% of the total). Burnt bricks are the most popular building material in India. This industry is based upon widespread production activity, which is energy intensive, resource depleting and highly polluting. The environmental regulations made a lot of brick kilns close down. All this necessitated the implementation of Cleaner Brick Production using the Vertical Shaft Brick Kiln technology, which was adapted in China. First such kiln was set up in Datia, India. India demonstrated a potential savings of 120 tons of CO_2 per million bricks produced. Thus with a capital investment of $11,000, it is possible to achieve an annual saving amounting to 100 tons of coal for each kiln. These measures simultaneously allow for a cleaner work place and prevent the accumulation of noxious gases. Energy and Environment monitoring teams at all kiln sites have been engaged to ensure the reliability of the technology in terms of high environmental performance. [Kumar et. al., 1998].

Steel, even though an environmental friendly product, its production operations pose a threat to environment due to pollutant emissions. Hence Steel Authority of India Ltd., (SAIL) has switched from end-of-pipe technology to cleaner production to enhance their environmental performance. The replacement of the single conversion single absorption sulphuric acid plant with the double conversion double absorption plant at Bhilai Steel Plant has brought down SO_2 emissions from 10 - 12 Kg/ton to nearly 1.71 Kg/ton of acid produced. The replacement of open-hearth furnaces by basic oxygen furnaces has brought about energy conservation and pollution prevention. To tackle water pollution, over 264 control devices were installed. An integrated steel plant produces upto 500-700 Kg by-products and sludge for every ton of steel. This has been reduced by 50% from the previous levels by the implementation of Cleaner Technology. The use of coke in blast furnaces was reduced by the use of coal injection, which reduces emissions considerably. New techniques like the production of high-tech steels through the thermo mechanical control process also bring about 9% reduction in energy consumption in the rolling mill stage. The concept of Life cycle analysis or Cradle to grave analysis was also adopted which helped SAIL to move closer to the twin objectives of resource optimization and sustainable development. [Kakkar, 1998].

A study in the Cement Industry showed that the adoption of the vertical roller mill instead of a ball mill for grinding, helped to improve significantly energy savings and efficiency. [Mohanty et. al., 1998]

According to the R&D wing of Kirloskar AAF Ltd., fly ash can be used for decolorizing industrial effluents. Silicon and Aluminum Oxide, the main constituents of fly ash are capable of absorbing colors from industrial effluents. Kirloskar AAF Ltd. has converted fly ash powder (mainly emitted from thermal plants, paper & pulp industry, tanneries, dyeing units etc.) into granular media to facilitate the filtering process. This granular media can be recycled after specific treatment. The technology mainly works for industrial effluents from dyestuff, rayon fiber and paper & pulp mills at a lower cost. [TERI Information Monitor, 1999]

The National Cleaner Production Center in Delhi sponsored by the UNIDO and UNEP has carried out intensive cleaner production training in the pulp & paper sector. In this sector, Cleaner Production means conserving fiber raw materials, chemicals, water and energy, eliminating the use of toxic chemicals and reducing the quantity and toxicity of all emissions and waste before they leave a process. According to them, more than 65% of the wastage problems in the small-scale industries are attitudinal in nature. [Sharma, 1999]

The European Union-India Joint Environmental Education Progrram (EU-In-JEEP) was undertaken to promote interaction between India & European countries in the field of Preventive Environmental Management (PEM). The network of educational institutes involved in this project include two European institutes i.e. the International Institute of Industrial Environmental Economics (IIIEE) at Lund University, Lund, Sweden and the Centre for Regional Development (CRD) at the University of Twente, Netherlands and Indian Institutes i.e. Indian Institute of Technology, Bombay (IIT-B), and India and Environmental Protection Training & Research Institute (EPTRI), Hyderabad, India. This Program is funded by the commission of European Communities and is coordinated by the IIIEE at Lund University. The key objectives of this program include providing education on preventive environmental management related issues, establishing study centers in India for educating students and representatives from industries and developing tools for implementation i.e. data base, newsletters, manuals etc. and establishing a continuous transfer of knowledge between India and European countries in the field of PEM.

In 1992, **China** was estimated to be producing 14.4 million tons of dust, 16.85 million tons of SO_2 and 36 million tons of wastewater. [ENFO News, 1997]. Hence in 1993, the World Bank funded an Environment Technical Assistance Project to the National Environmental Protection Authority (NEPA) of China. The UNEP's Cleaner Production Program helped in the development and implementation of the project, the goals of which include: to develop and test a systematic approach to Cleaner Production Technologies and design policies for its implementation and to prove its potential in 25 to 30 Chinese companies.

Beijing Chemical Factory No.3 is one of the key enterprises in the Beijing Chemical Industries Corporation. Since its foundation in 1965, it has become one of the main manufacturers of fine chemicals in China. The plant has specialized in the production of additives for the processing of high polymer materials (PVC, poly-olefins, paints etc.). During 1993 a Cleaner Production assessment took place at the penta-erythritol plant of Beijing Chemical Factory. This plant accounted for over 40% of the wastewater discharges (Chemical Oxygen Demand-load) from the entire factory. A total of 20 Cleaner Production options were identified and evaluated during the project, of which 13 were tried out in the first two years. Some of the changes included the use of a *Charging Program Control System* to speed up the addition of raw materials thereby increasing the synthesis efficiency, *Replacement of Centrifuges* to better the separation characteristics and *Installation of Vacuum Pumps* to recover the product lost with the wastewater. The economics show that the investment required for the implementation of the first batch of 9 Cleaner Production options was less than 1,200 U$ whereas the cost savings due to increase in efficiency was approximately 30,000 U$ annually. Thus the results show that in Chinese companies Cleaner Production options have resulted in very practical solutions for environmental problems faced by the participating companies [Tu, 1998].

The Fuyang General Distillery (FGD) in China can produce 20,000 tons of consumable alcohol with a total industrial value of 72 million yuan per year. The main waste of FGD is organic pollutants from alcohol production. Chemical Oxygen

Demand and Biological Oxygen Demand load are 54,000 mg/l and 26,000 mg/l, which equals 15,120tons of Biological Oxygen Demand and 7280 tons of Chemical Oxygen Demand per year. After a careful Cleaner Production audit, 102 suggestions and options were made, of which 24 were mainly focussed on. These options were further classified as none/low cost (45.8%), middle cost (20.8%), high cost (33.3%) options. After implementing the low and some mid-cost options, the Chemical Oxygen Demand load has been reduced by 30% and the consumption of fresh water/ton of alcohol has been decreased by 28%, which brings economic benefits of 1.68 million Yuan. If the high cost options are implemented, the Chemical Oxygen Demand load will be reduced by 40% more and steam consumption /ton of alcohol will be reduced by 30% more. The annual extra cash flow will be about 4 million yuan. Thus, in this case, Cleaner Production is the optimum way to realize both economic and environmental benefits, which will reduce pollution more effectively than End-of- Pipe. [Yongqiang, 1995].

Shanghai is one of China's largest industrial cities where some of the main polluters include power generation, iron and steel, chemical and textile industries. Here Cleaner Production is regarded as one of the principal means of upgrading older industries and thus controlling industrial pollution. One example is the combined supply of electricity, steam and gas developed at the Baoshan Steel Complex. At the Shanghai Coke Plant, an ion-exchange membrane technology was developed for use in manufacturing alkali, using liquefied sulphur to produce sulphuric acid, thereby replacing the traditional process that employed a sintering furnace. The Shanghai Resin Plant and Tianchu Monosodium Glutamate Plant have also taken initiatives to develop cleaner production processes and have obtained remarkable environmental results. Since 1995, the promotion of Cleaner Production has become one of the major tasks of the Municipal Corporation. [Shuping, 1998].

Rapid industrialization and urbanization have resulted in severe problems of environmental degradation and natural resource depletion in Thailand. Since the Command & Control approach adopted by the Royal Thai Govt. did not succeed, a number of projects and activities were initiated primarily in the non-governmental sector for the promotion of the Cleaner Production concept in Thai industries, especially in the small and medium industries. This was helped by a Cleaner

Production project supported by the Danish Cooperation for Environment and Development (DANCED, 1996-98), whose objective was to introduce and incorporate Cleaner Production concepts mainly in metal finishing, textile, food canning and other such small scale enterprises. During two years, a total of 41 Cleaner Production audits were carried out, during which, more than 185 different Cleaner Production options were identified. The project has supported 24 CP demonstration projects were 62 Cleaner Production options have been implemented. The results achieved show water savings upto 80%, energy savings upto 60%, chemical savings upto 80% and increase in production efficiency upto 10%. [Parasnis et. al., 1998].

The adoption of Cleaner Technology in a Thai textile-knitting factory reduced its wastewater by about 1300m^3/day by the recovery of hot water, standardization and control of liquor ratio and modification of the bleaching procedure. [Buengsung, 1994]. Furthermore the Thai government is trying to incorporate the principles of Cleaner Production as an integral part of the ISO 14000 Environmental Management System, thereby increasing the sustainability of Cleaner Production in Thailand. [Bunyagidj, 1996].

RAKTA, which is the largest pulp and article mill in Egypt, uses rice straw as the main raw material. Its production process is characterized by high levels of pollution, which is discharged into the sea. Hence it was chosen for the Cleaner Production program by the UNEP. R&D activities developed a system for the chemical recovery of rice straw black liquor, which reduced pollution by 90% and induced savings in NaOH upto 80%. [Hamza, 1992].

In Tanzania, 12 companies from the sub sectors of cement, food & beverage processing, soap, textile, glass and fiber processing were selected for the purpose of demonstrating the Cleaner Production concept. Through a wide range of prevention or waste minimization techniques, a total of 169 Cleaner Production Technology options were established.

The concept and principles of Cleaner Technology were implemented in other African countries like Tunisia, Zambia, Zimbabwe, Ethiopia etc. [Migiro, 1996].

The Network for Industrial Environmental Management (NIEM) aimed at promoting better environmental management and natural resource utilization in the paper and pulp industry in Asia. The network was established in 1987 and consists of research institutions, government agencies, industrial associations and individual mills in China, India, Indonesia, Malaysia, Philippines, Thailand and Vietnam. The key activities have been to initialize and support Cleaner Production Technology assessments in 36 mills in NIEM countries and to demonstrate the feasibility and advantages of adopting Cleaner Technology. The source of waste generation and its reasons were identified and options for minimization were generated. These studies showed that only 15% of the implemented Cleaner Production measures needed some kind of technological change. [Svenningsen, 1998].

2.3 ECONOMICS OF CLEANER TECHNOLOGY:

The economic notion of resources is rather anthropocentric- i.e. from the economic perspective, the economic value of any resource is defined by human needs and their relative scarcity. The implications thereby being that natural resources have no intrinsic value (Attfield, 1998) and as such their economic values are ultimately determined by consumer preferences. Thus the total value of natural resources are underestimated as in truth they do possess intrinsic values that cannot be captured through market or extra - market information. As such environmental concerns can no longer be divorced from economic policy at either the macroeconomic or microeconomic level. Sustainable development is defined as development, which meets the needs of the present without compromising the ability of future generations to meet theirs. Thus there is no doubt that the economics of sustainability reach far beyond the neo - classical emphasis on the efficient allocation of scarce environmental resources and hence it requires that the issues of fairness, equity and distribution be explicitly considered. [These issues have a time dimension (often involving several human generations) and include considerations of the well being of species other than humans.] So if sustainable development is to be pursued environmental concerns will necessarily have to be integrated into the economic policy. Macroeconomic policies in use are command and control and market based instruments like taxes, permits and other incentives. As environmental management has gained access to the global markets, companies around the world are viewing sustainable development as a plank to build on competitive advantage.

But to most Indian business leaders environment is a cost rather than a concern and environment activity, a missionary activity.

Environmental economists regard environmental goods as public goods and attach values to the unpriced services provided by the natural environment.

Now for products where a market exists, individuals exercise choice by comparing their Willingness to Pay (WTP) with the price of the product under consideration. They purchase the goods or services when their WTP equals or exceeds the price and not otherwise. However markets cannot allocate resources efficiently where markets do not exist. Many environmental resources are not transacted at all through market processes or the markets in which they are exchanged are incomplete in some way. [The prices (demand) in the case of environmental assets are, if not impossible, difficult to obtain directly through the usual market mechanism.] This failure of the markets to exist for many environmental resources is often a reflection of the fact that the resources in question are public goods. Thus viewed this way, decision making based on WTP must reflect the individuals' preferences for the good in question.

“Most environmental problems are traceable to the common property nature of environmental resources. Common property ownership of resources such as the atmosphere has traditionally meant no ownership at all and free access to all users.” (Seneca and Taussig 1984:103)

Now an externality arises when the use of a property or resource is difficult to exclude. This difficulty may arise from either one of two sources:

- The resource by its very nature may be non- - rival in consumption and therefore subject to joint consumption.

- The transaction cost of internalizing the externality may be excessively high due to natural or technical reasons (Coase, 1960)

Thus one can generalize the lack of excludability (non-exclusiveness) as the root cause of an externality (Randall, 1983). Most, if not all environmental resources are externality ridden for this very reason.

The main economic consequence of externalities is that in their presence there is a divergence between the private and social evaluation of costs and benefits (Turvey, 1963). Therefore, under these conditions, resource allocation through a market mechanism that is solely based on the consideration of private costs and benefits, would be inefficient when viewed from the perspective of society at large. This is essentially because in the process of production, very often, the assumption made is that the use of air or rivers etc. to dispose of production waste happens at no cost and is therefore not included in private costs. Thus ‘no disposal’ cost forms part of the supply curve. However, in reality, this waste discharge causes damage costs (beyond a certain threshold level). This damage cost represents the monetary value of the pollution damage imposed on society by the firm. Thus the suggestion here is that the market if left alone would lead to a lower environmental quality and this is a clear case of market failure, for the market if left alone, lacks any mechanism by which to account for external costs and or benefits. The allocation of environmental goods and services through market mechanisms then leads to sub - optimal results.

According to Nordhaus [1993], environmental pollution damages are the negative impacts that the users of the environment experience as a result of the degradation of that environment. From a purely economic perspective, the management of environmental quality or pollution control is easily understood if the problem is viewed as minimizing total waste disposal costs and this originates from two distinct sources:

1. *Pollution control (abatement) cost:* the cost arising from society’s clean up effort to control pollution using some kind of technology. It represents direct monetary expenditure by a society for the purpose of procuring resources to improve environmental quality or control pollution. It is not an externality.

The marginal control cost curve represents the monetary value of all resources (labour, capital, conventional natural resources) used by private and public concerns to control environmental damage or to improve the environmental quality. It thus represents the supply curve for environmental goods and is positively sloped, implying that the pollution control (clean up) cost increases as higher levels of environmental quality are attained (produced).

2. *Pollution damage cost:* It results from the damage caused by the untreated waste discharged into the environment and represents therefore the total monetary value of all various damage resulting from the above mentioned. It is an externality.

The marginal pollution damage cost curve actually represents what people are WTP to avoid damage or to improve environmental quality at the margin. It thus also represents the demand curve for environmental quality. It thus makes sense that a preference for higher environmental quality is consistent with an increase in society's WTP to avoid damage. It is negatively sloped (as per the law of demand - i.e. decline in society's WTP as higher levels of environmental quality are sought.)

Thus the economic problem of interest is to minimize the total disposal costs with full recognition of the implied trade off between its two components - i.e. control and damage costs, because from an economic point of view, any amount of investment (expenditure) on pollution control technology will make sense only if society is compensated by the benefits to be realized from the avoidance of environmental damage resulting directly from this specific investment.

Therefore during this exercise the trade off between economic goods and environmental quality or degradation needs to be carefully assessed, taking into consideration the opportunity costs for all alternative uses of the environmental asset in question.

Now, *Abatement costs* are used to denote the cost of reducing the quantity of residuals being emitted into the environment, or of lowering ambient concentrations. This Abatement cost normally differs from one source to another depending on a variety of factors and there is an upper limit on these costs. The extreme option for a single plant or pollution source is to cease operations, thereby achieving a zero level of emissions. If the source is a single small plant within a large industry, the cost of closing it down may not be that large. But if we consider the abatement costs for an entire industry as a way of achieving zero emissions it would have enormous costs. Most of the environmental policies, especially at the state or central levels are aimed at controlling emissions from group of pollution sources, not just single polluters. In this case the aggregate, abatement costs can be calculated which could bring about the least costly way of achieving reductions in emissions that leads to threats like global warming.

All this necessitates the need for the development of analytical tools to provide environmental, economic and social information to the policy process. Cost Benefit Analysis is a primary analytical tool to evaluate the direct and indirect benefit as well as costs and also for the economic evaluation of public programs in natural resource management and other such environmental projects. It has become an integral part of Environmental Impact Analysis process meant to evaluate the impacts of public and private developments on environmental resources.

Cleaner Production Technology, which is at the implementation stage in majority of the firms, requires economic evaluation in order to bring out the cost and benefits. Only then it can be publicized among the entrepreneurs focusing the qualitative and quantitative benefits. In fact this Cost Benefit Analysis is very essential to know about the cost-effectiveness, risk reduction and other spill over and spin off effects. The listing of the benefits also encourages other similar firms to work out the idea. Today, natural environment management is becomingly an increasingly important issue to manufacturing firms. Simultaneously though for their managers, there also does exist the challenge of implementing changes to improve competitiveness. To meet this challenge a new construct - the Environment - Technology Portfolio- embedded in the resource based view of the firm and manufacturing strategy was developed. (primarily this refers to the pattern of investment in environmental technologies in manufacturing over time.) (Klassen and Whybark, 1999). Thus management research and conceptual thinking on environmental issues expanded from a narrow focus on the concept of pollution control (Bragdon and Marlin, 1972) to include a larger set of management decisions, programs, tools and technologies that incorporate environmental issues into financial considerations (Hunt and Auster, 1990). However, managers still find it difficult to implement the combination of environmentally and competitively sound improvements (central tenet of social development) - (World Commission on Environment and Development, 1987). Before looking in detail at the analytical techniques let us focus our attention to some of the Cost Benefit Analysis conducted in Indian industries by the Asian Productivity Organization.

Cost Benefit Analysis - Case Studies

The Asian Productivity Organization selected two industrial sectors namely, The Viscose Rayon Industry (M/s Harihar Polyfibres, Kumarpatnam, Karnataka, a company of GRASIM Industries Ltd.) and Small Agro Residues-based Pulp and Paper Mills (M/s Rawal Paper Mills, Rae Bareilly, Uttar Pradesh). (Sakurai, 1995)

Small Agro Residues-based Pulp and Paper Mills

Rawal Paper Mills decided to adopt Cleaner Production Technology due to various factors like high wastewater treatment costs (Rs.1,200/tonne of paper) and raw material costs (Agro Residue Rs.2,000/tonne and chemical Rs.3,000/tonne) together with reduction in subsidies on agro products and raw materials, pressure from Central Pollution Control Boards, local NGO's, and to cope up with reduction in production capacity in summer due to water shortage.

After the adoption of Cleaner Technology, there was an increase in the overall production capacity by about 2 tones/day (8%) with an increase in the profits by about Rs.4,000/day. An 18% reduction was obtained in the total solid waste generated, and a 46% reduction in the water pollution load. The efficient utilization of steam and proper insulation of condensate lines brought down the particulate emissions by 8.5%. Thus the total environmental impact of Rawal Paper Mills operations after implementation of Cleaner Technology measures was 58% of that before its adoption. Some of the quantitative and or qualitative benefits of Cleaner Technology listed out were

- Reduction in the color of treated effluent by 75%
- The reduction in the size of the treatment plant by approximately 40%
- Popularity among the Non-Governmental Organizations and regulatory bodies as 'environmentally conscious'
- The reduction in the sludge amount by 35%
- The firm's capacity utilization of 50% in summer due to water shortage could be increased to 64% with reduced water requirements.

Viscose Rayon Pulp Industry

The continuous increase of prices of the basic raw material wood, together with other inputs towards the early 1980s made Harihar Poly Fibers think about the importance of achieving drastic reductions in the cost of pulp production if rayon fiber was to be made available to the textile industry at economic prices. The enactment of Water Pollution Control and Air Pollution Control Acts further increased the pressure on the industry. Harihar Poly Fibers realized that the adoption of Cleaner Production technology would serve the dual purpose of cost reduction as well as pollution reduction. Other factors that contributed to the introduction of the Cleaner Technology program were building up of public and local Non-Governmental Organization's pressure, increasing competition from other synthetic fibers and imported pulp, increasing requirement for improving product quality and greater worker awareness and desire for a better working environment.

Cleaner Technology adoption enhanced production capacity basically through improved yield, reduced fibre loss and increased effective capacity of each section through better equipment efficiency. The production capacity was increased from 162 tones/day (1983) to 188 tones/day (1993). With Cleaner Technology implementation, the solid waste generation from the process was reduced by about 37% and the solid waste load from treatment facility was reduced by 55%, with an overall reduction of 45%. About 52% reduction was obtained in the wastewater pollution load and about 88% reduction was obtained in the air pollution load. Thus the total environmental impact was reduced by 55% in 1993 compared to that in 1983.

Some of the major quantitative and qualitative benefits of Cleaner Technology adoption in Harihar Poly Fibers include:

- Increase in overall production capacity by 16%
- Increase in worker productivity by 10%
- Reduction in raw material consumption in the case of wood by 3% and in the case of processing chemicals by 15-20%

- Cleaner Technology measures has reduced the chance of an accident proneness in the unit

- Safety norms are carefully observed through regular audits

- The level of small particulate matter in the surrounding environment has been reduced

- Increase of local area economic activity

- Additional direct employment has been generated for 35 people by the two units utilizing waste from Harihar Poly Fibers

- Improved downstream drinking water quality due to proper treatment of effluents and reduced pollution load

- Reduced levels of noise pollution

Dow's midland, a chemical company had identified some 17 profitable pollution prevention projects, which helped in the reduction of chemical wastes and emissions, some by more than half. They involved a total capital investment of $3.1 million and will provide annual estimated savings of $5.4 million. [Greer, 2000].

These studies indicate the immense potential as well as the constraints of Cleaner Technology options in industries. They highlight the importance of technical expertise in the process modification stages, increased financial support from the government, strict intervention of regulatory forces, education and awareness programs etc. This also points out the necessity of such detailed cost and benefit studies in other large and small-scale industrial sectors in India.

In order to conduct Cost Benefit Analysis and pilot surveys, different analytical tools are used and a brief outline of these tools and methods are summarized here. The costs of reducing emissions or complying with the standards are included as *added expenditures.* The benefits in Cost Benefit Analysis are also related to willingness to pay, in that, the benefits of something are equal to what people are willing to pay for it, remembering the provisions about the distribution of income and the availability of information. For marketed goods it might be easy to estimate the willingness to pay.

But for non-marketed goods this becomes difficult and recourse is made to methods like Contingent Valuation. [Field, 1997].

As Carson [2000] puts it, Contingent Valuation is a survey-based method frequently used for placing monetary values on environmental goods and services not bought and sold in the marketplace. It is the only feasible method for including passive use considerations in an economic analysis, a practice that has engendered considerable controversy.

In a study on valuation methods by Richards [Richards, 1994], it is recommended that, where no direct market exists, two or more methods should be used to value a conservation benefit in-order to find a plausible range of values. If environmental benefits are not valued separately when one is assessing direct-use values, higher bound estimates can be justified on the basis that they underestimate the overall benefits.

Pearce [1997] states in his study that in countries like U.S., the direct costs of federal environmental, health and safety regulation appear to be to the order of $200 billion annually or about the size of all domestic non-defense discretionary spending, whereas the benefits are less certain. If we are conducting the Cost Benefit Analysis for a particular case, then priorities can be reallocated so that the same cost can be put to save more lives or more lives can be saved at a much lower cost. Thus economic efficiency can, in fact, be measured by the difference between costs and benefits, which helps to put the resources to maximum use.

According to Arrow et. al. [1996], the benefits and costs of proposed policies should be quantified and the best estimates should be presented along with a description of the uncertainties. Moreover, Cost Benefit Analysis is based on the values to be assigned to program effects - favorable or unfavorable. Such values should be those of the affected individuals and not the values as perceived by economists, moral philosophers or others. Thus Cost Benefit Analysis can provide an exceptionally useful framework for consistently organizing disorganized information and thus can greatly improve the process and outcome of policy analysis.

However, Davies [1997] argues that in the absence of market price for environmental resources, it is actually difficult to assign prices, which are so essential for a Cost

Benefit Analysis. So when the prices are assumed, there is no way of knowing their proximity to the real scenario. A good Cost Benefit Analysis can at least help the policy makers to look into all aspects of the environmental problem, which will create awareness among them to form suitable environmental regulations beneficial to the public.

Graciela [1997] goes on to say that a major drawback in the environmental costs pointed out by the industrialists is the *long run sustainability* associated with it. i.e. anything discounted at 3-6% has no significance after 50-100 years and some of the most important environmental problems like risks from nuclear power plants; global warming and biodiversity destruction assume significance only over such long span of time. In order to overcome these difficulties and to have a fair treatment of the present and future, tools or concepts like sustainable Cost Benefit Analysis are developed which render the long run problems irrelevant. Ray [1997] emphasizes the need for a balance between the policy makers' views and the environmentalists' views that are essential in order to find a viable alternative in the case of environmentally sensitive issues. Often the costs of environmentally friendly policies are over estimated. The serious cases of industrial and municipal pollution can often be mitigated or even avoided at relatively low costs.

Since the industrial revolution, increased use of fossil fuels and CO_2 emissions have been linked with economic growth. These factors have made drastic climatic changes on a global scale and brought up issues like Global Warming. This is taken care of by employing Carbon tax on the polluters. But analysis shows that majority believes mitigation to be more expensive. [Schmalensee, 1993]

Englechardt [1994] identifies technical alternatives as the first step in conducting Cost Benefit Analysis of Pollution Prevention strategy, to minimize the waste associated with a production process. Industries generate different types of solid, liquid and gaseous hazardous waste related with the various production process. Hence identification of the pollution prevention strategy for a particular process is challenging. The main objective of industrial process design is to increase the process efficiency by minimizing the waste of valuable material. As per the law of thermodynamics, all productivity is accompanied by waste generation and hence pollution prevention strategy must be oriented to consider the industrial productivity.

The productivity and waste can be measured in terms of energy or mass. The industrial process design must be sustainable both economically and environmentally. The evaluation and selection of pollution prevention alternatives is carried out by benefit-risk analysis. Such an evaluation can be carried out as per the perspective of the public, firm and on a local, regional or global scale.

"The tragedy of the commons as a food basket is averted by private property or something formally like it. But the air and water surrounding us cannot be readily fenced and so the tragedy of the commons as a cesspool must be prevented by coercive laws or taxing devices that make it cheaper for the polluter to treat his pollutants than to discharge them untreated." (Hardin, 1968:1245)

According to Beder [1996], there are two main types of economic instruments used for pollution control. *Price based measures that* use charges, taxes and subsidies to persuade polluters to reduce their discharges and *Rights based measures* that creates rights to use environmental resources, or to pollute the environment, up to a predetermined limit and allow these rights to be traded. Economic instruments aim to make environmentally damaging behavior cost more. Under these market-based policies, instead of telling the polluters what to do they are made to think about how expensive it will be to continue with their old practices. Traditionally, Governments have favored the legislative or command and control approach for achieving environmental policy. Similarly, entrepreneurs also have preferred direct regulation because of concerns that charges would increase their costs. The common price-based method adopted is a *charge/price* that the polluter pays for polluting the environment. Essentially there are 3 legal approaches for regulating the environment (i.e. the focus here is on the legal system to deter the abuse of the environment): The first is *Liability laws* – the approach followed by the U.S. and several other countries. The court sets monetary fines on the basis of the perceived damage to the environment. Liability laws basically operate on the premise of economic incentives. Also they tend to have a 'moral' appeal because they are based on the premise of punishing the perpetrator of the damage - i.e. the 'polluter pays principle' is strictly applicable. The major drawback of using a system based on this though is the high transaction cost involved especially when the parties concerned in the dispute are numerous. However the main idea here is to make the polluters liable for the damage they cause (Starett and Zeckhauser, 1992). Then we have *Property Rights* or *Coasian Methods* as they are also called. This uses the legal system to assign and enforce property rights. The last option is *Emission Standards*, which are set and enforced through legally mandated laws. Environmental economists have argued that external costs and benefits (externalities) that are not taken account of in market transactions should be internalized by adjusting prices so that the firm producing the goods or services causing the external cost is obliged to pay for it. Thus pollution charge in-turn will increase the cost of production to the company. All these makes the manufacturers think about reducing pollution at the source itself or rather *green production*. This is achieved by either changing the production processes or by adding pollution control equipment to the production processes. These changes may help the firm save a lot of money over the long term.

Barett et. al. [1997] connects it by saying that in order to encourage the firms in this direction of environmental effectiveness, economists proposes incentives. i.e. financial assistance is provided which helps the firms to go beyond the legal compliance by engaging in continuous innovation and improvement of production technologies.

Environmental economists generally regard environmental goods as public goods. Economic valuation of environment is undertaken to reveal the true social costs of utilizing scarce environmental resources and assets. (The difficulty arises because most environmental attributes have no substitutes or complements traded through the ordinary market and hence it is impossible to assess non-use values using implicit prices.) Two general approaches exist - the direct and indirect approaches. The former includes Contingent Valuation (where people are asked to state directly what they are willing to pay for some change in the provision of goods/services or to prevent a change and/or what they are willing to accept to forego a change or tolerate the change) and Contingent Ranking Methods (is similar to contingent valuation except that questioner is content to obtain a ranking of preferences which can later be anchored by the analyst in a real price observed in the market), where people are asked directly to state or reveal their strength of preference for a proposed change. In the latter case the preferences for environmental goods are revealed indirectly when an individual purchases marketed goods to which the environmental good is related in some way. The Contingent Valuation method as the name implies involves questionnaires eliciting the willingness of respondents to pay for hypothetical projects or programs with the help of sample surveys. The name refers to the values revealed by respondents, which are contingent upon the constructed or simulated market presented in the survey. A carefully selected sample from the relevant population is asked to respond to a series of specific questions about their WTP contingent on changes in the availability and or the quality of an environmental amenity. They are directly asked about their WTP for environmental effects to be provided by the project in two broad alternative ways:

- The open ended format and/or
- The dichotomous choice - yes/no format (also known as the 'Referendum-type' questions)

In Contingent Valuation, closed-ended format questions (though they are not without their problems) are considered to be better than open-ended willingness to pay questions. i.e. It is better to ask people whether they are ready to pay an 'x' amount rather than asking how much they are willing to pay as the former is easier to answer and is also more likely to encourage answers which are closer approximations of the 'truth'. The respondents must also be made aware of the available substitutes and their budget constraints. [Spash, 2000]

The history of Contingent Valuation [Portney, 1994] is that Hotelling first introduced the *travel cost approach*, which suggested charging the visitors coming to a park. The methodology to be adopted included, first the description of a scenario or program that the respondent is being asked to value upon and it gives a clear picture of the good that the respondent is being asked to value. It also elicits information on the socio-economic characteristics of the respondents and also about their environmental attitudes or recreational behavior. It further includes follow up questions to see whether the respondents understood and believed in the information in the scenario. Thus contingent valuation methods measure precisely what the analysts want to know – the individual's strength of preferences for the proposed change and can be used for non-marketed as well as marketed goods and services. This would be ideal if people behaved truthfully. The central problem with this approach, however, is whether the intentions people indicate before the change will accurately describe their behavior after the change. Thus the Contingent Valuation Method for all its advantages, is not without its potential biases that could undermine the validity of the preference information thus gathered. For one the respondents may refuse to respond to survey question(s) or they may not reveal their 'true' WTP for strategic reasons - i.e. they may do so if they think there is a 'free - rider' situation. (Bohm, 1979). This is referred to as the *Strategic bias*. Secondly the survey result depends on the information provided to the respondents. Therefore what people are willing to pay for environmental assets depend on the quality and quantity of the information accessible or provided to them, including the way questions are constructed. In this case every effort and precaution was taken to provide the respondents with credible and realistic information about the contingent market. However unlike a perfectly competitive market which can assume perfect information, (i.e. the economic agents are assumed to be provided with full information regarding any market transactions and as possessing perfect foresight about future economic events) a market involving environmental public goods (e.g. improved air or water quality) enjoys no such luxury primarily because ‘uncertainty’ forms a vital consideration in the economics of sustainability. This is known as the *Information bias*. Lastly there exists the *Hypothetical bias* which refers to the fact that the respondents are not making 'real' transactions and in this situation they tend to be sensitive to the instruments used for payment (entrance fee, sales tax, income tax, payroll tax etc.) However, the main point still remains that contingent valuation captures the existence or non-use values, (non-market valuation) which other methods fail to measure.

To increase the accuracy of responses, ‘verbal protocol analysis’ is used wherein people are asked to think aloud as they answer a questionnaire reporting everything that is going through their minds. Schkade & Payne [1994] have done such a Contingent Valuation survey that asks for Willingness To Pay to protect migratory waterfowl from drowning in uncovered wastewater holding ponds from oil & gas operations. The numbers elicited in a contingent valuation study are theorized to measure the economic value for the resource. This way we gather information about how people form their preferences. The most common strategy was to acknowledge that something must be done and then trying to figure out an amount. Most were trying to equate it with donations to charities. Anyhow the findings strongly suggest that people are not easily in touch with underlying preferences about the type of commodity asked about. Environmental risk communication is an essential part of environmental change evaluation. If a task confuses respondents, then interesting signals can be lost in the resultant noise. If a task misleads the respondents then their evaluations mislead the investigator, producing conclusions that cannot be replicated. However when research has policy implications, the respondents themselves are at risk since their views could be missed or misinterpreted. [Fischhoff, 2000].

Conjoint analysis is another acceptable method for the determination of in-kind compensation for resource damages. It permits acceptable trade-offs between ecosystem services and between services and money. [Farber and Griner, 2000]. Another approach is based on the assessment of values using Multi-attribute Utility Analysis. This approach offers respondents tools for thinking about uncertain values. Conjoint Analysis is related to Multi-attribute Utility Analysis in that both techniques ask a respondent to directly confront how different levels of one attribute trade-off against different levels of other attributes. When citizens are willing to pay for the existence of visibility over the Grand Canyon, whether they will visit it or not, are they buying clean air or psychic satisfaction? Usually the surveys that investigate non-use values never ask how much individuals would pay for the psychic satisfaction or warm glow they expect to experience as a result of various policies. Instead, these surveys enquire about willingness to pay for the policy itself. [Sagoff, 1998].

According to Cameroon [1997], in a Contingent Valuation study, the researchers specify a particular good clearly so that the respondents can determine how much they would be willing to pay if that good had been for sale. A contingent market is created and the aggregate Willingness To Pay summed up to provide a measure of the non- market benefit of providing that environmental good which can be used in cost benefit analysis of management options. Of course, it has been argued that this asking of hypothetical questions is problematic. However, the major advantage of the Contingent Valuation approach is its potential to emerge as a general procedure for assessing the total economic value of any type of environmental asset as it deals with both use and non-use values. Its main characteristic is that it provides inputs to the analyses of changes in the level of the provision of public goods, bads and especially of environmental 'commodities' that have the characteristics of non- - excludability and non- - divisibility. Sometimes, the target population could reject the hypothetical proposed project that is put forth because the investment is not producing a 'good' on net for the average person. This is perhaps because the negative externalities generated by the investment are so severe and widespread that the current without project situation is preferred. Alternatively, those surveyed could exhibit such a strong case of 'status quo bias' that they require a subsidy and an environmental improvement to move away from the current situation voluntarily (Adamowicz et. al, 1998). This behaviour seems irrational and at odds with the utility theoretic basis of Contingent Valuation. However, a plausible cause of this result is that those surveyed don't believe the scenario because they are cynical about the possibility that an actual investment in environmental quality will be made. Surveys show that some of the most important factors respondents thought about when considering their Willingness To Pay response were their income and financial commitments (31%), concerns about general environmental quality (17%) and doing their fair share (13%). Thus contingent valuation can take the role of a component of cost benefit analysis.

Some of the disadvantages of contingent valuation surveys pointed by Haneman [1994] include response effects (i.e. It includes patience and interest from the part of respondents) and embedding effect (i.e. respondent's willingness to pay will be the same even if you have one lake or several lakes to preserve). Even-though Contingent Valuation has many limitations it is one of the best ways of consulting the experts - i.e. the public to know about the value they place to the environmental resources or damages.

As observed in a study by Diamond et. al., [1994], there also exists a variation in willingness to pay across individuals and across surveys. i.e. One would expect self-described environmentalists and individuals with higher incomes to have larger willingness to pay but both do not occur. These income effects are in fact much lower than the measured income elasticities for charitable giving. Another variation noted is either in the order of a question or if a question is asked along with another question. When willingness to preserve the visibility at Grand Canyon was surveyed the response was five times higher when this was the only question as compared to a situation where it was one of the questions and third in the order.

Another point made by the same author is the 'welfare analysis', which considers whether Willingness To Pay were an accurate measure of preferences when we consider welfare implications. This brings out the willingness of an individual to preserve an environmental amenity because of the concern for others. Thus if people care about each other's utilities, they care about the costs borne by others as well as benefits received by others. i.e. it must include both external costs as well as external benefits.

The author goes on to say that even though Contingent Valuation has its own advantages and disadvantages while applied to the environment it places a monetary value on the consequences of pollution discharge, which is a cornerstone of the economic approach to the environment. Data shows that Contingent Valuation is currently used all over the world both by Government agencies and the World Bank for assessments of topics including transportation, sanitation, health and environment. Cost Benefit analysis perceives economic valuation in terms of market prices. There was an important shift to this, which contributed directly to the emergence of non- market valuation that brought up the debate in that while, Contingent Valuation can point to the behavioral patterns of respondents Cost Benefit analysis cannot. Hence the need to supplement the latter with the former.

As stated in the beginning, India is losing about 4% to 6% of the GDP due to environmental degradation [Human Development Report, 1998]. Among the industrial sectors, major polluters are the small-scale industries such as foundries, chemical manufacturing and brick making units. Thermal power plants generating fly ash also pollute the environment. Another point made by the study is that 74% of country's rural population bears 84% of the exposure burden. This is due to burning of fuels in the kitchen which emits 30 times more suspended particulate matter (SPM) than the WHO guidelines. 2.5 million premature deaths are reported in 1997 due to indoor and outdoor pollution. In a study related to the Willingness To Pay for Borivli National Park, the respondents were asked whether India should pursue development programs that hurt the environment, if environmental costs are small. Their response pattern was as follows - 72 (14.6%) strongly disagreed, 148(30%) disagreed, implying that they were rather ‘green’ and inclined strongly towards environmental protection, while 90(18.2%) were neutral, 161(32.6%) agreed and 23(4.7%) strongly agreed that India should pursue development programs if environmental costs were low. Some of them pointed out that they should have to pay now to invest in the environment to benefit the future generations. When respondents were presented with scenarios of damage, 47% were ‘very concerned’ and 42.9% were a ‘little concerned’ and only 10.1% claimed that they were not concerned. The study revealed that a high WTP in terms of both cash and kind exists in the metros for contributing towards the upkeep and improvement of Borivli National Park. [Hadker et. al., 1997]

Thus the purpose of environmental economic evaluation is to reveal the true costs of using up scarce resources. Pearce [2000] points out that economic evaluation is important for decision-making purposes. Moreover, economic values reflect individuals Willingness To Pay either for benefits or to avoid costs [Sagoff, 2000]. But a problem associated with environmental costs is their intergenerational incidence. i.e. their effects come only in the future generations. An intragenerational incidence is based on the incomes of those expressing their Willingness To Pay. This income effect is an important factor when we consider the less developed countries. In an argument to Arrow et. al’s paper, Rob Davies points out that for many of the poorest countries the immediate environmental problems are land degradation, siltation, deforestation etc. which arise from population pressure and poverty. These problems can ultimately be tackled only with growth promoting policies that can be implemented only by a non-myopic government. According to Davies, the economic measures of the value of time, of health and of life itself are likely to be low for the poor and efficiency assessments are therefore likely to place a low value on regulations designed to save their time or lives or improve their health. Hence in such cases income inequalities are likely to be significant. Due to this a cost benefit analysis conducted in such countries must be thoroughly exhaustive and should be able to capture such income effects as well as other social and behavioural problems.

Nevertheless, end-of-pipe solutions can be a short-term economic strategy for industrial environmental management whereas Cleaner Technology can help in meeting the environmental challenges by reducing generation of pollution at every stage of production to enhance profitability.

2.4 SCIENTIFIC & TECHNOLOGICAL ASPECTS:

Cleaner Technology can be considered as a strategic element in manufacturing technology for present and future products in the industrial sector. Since the need of the hour is the development of cost effective technologies, an environmentally friendly alternative to conventional end - of - pipe pollution control is the process modification or cleaner production approach. Cleaner Technology call for an integrated approach to design, manufacture and use of a product and are cost effective in the long run than clean - up technologies. Cleaner Technology takes thermodynamics seriously to create a closed loop in the production whereby waste generation is minimized in processes and to the extent possible the resulting products are fed back into production at the end of their lifetime in order to be recycled or reused in reconditioned form. [Christie et. al., 1995]

The effectiveness of this clean technology towards the achievement of zero waste and total environmental management can be measured by ***Waste measurement index, [WMI]*** which can be written symbollically as**:**

$$\text{WMI} = \frac{\text{WASTE}}{(\text{Waste + By-Product + Product})} = \frac{\text{WASTE per unit output}}{\text{Total (Unit) Output}} \times 100$$

Thus WMI is invariant to the level of output or capacity utilization.

3M's Medical product division in Brookings, South Dakota along with the rest of 3M organization uses this ratio to determine the effectiveness of its pollution efforts [Denton, 1994].

Some of the technological innovations of various industrial sectors are briefed below:

Petroleum Refining: use of Central Vacuum system for source reduction of oily sludge, installation of vent filters on FCC catalyst hoppers, recovery of phenolics from spent caustics on site through acidification and phase separation, recycling spent alumina catalyst as raw material for alumina-based products. [Freeman, 1995]

Electroplating: Some of the Process Alternatives with respect to Chemical Industries are also throwing light on Cleaner Technologies Utilization of drag-out rinses by returning back to the process tank and substitution of plating by the use of non-cyanide zinc plating process. A project in the state of Victoria is promoting the use of alternate methods of metal recovery from the electroplating and metal finishing industries. A study of dumping the waste vs. metal recovery has shown that cost saving and disposal problem of waste from the metal finishing and electroplating industry can be eliminated by the option of recovery of metal. But this is not economically viable in the case of small-scale industries. It is envisaged that commercial fruition of this alternative is gradual and will be complicated by the problems and idiosyncrasies of individual companies. [Reeve, 1991]

Textiles: Use of alternate dyes like copper-free for producing green shades, use of alternate desizing agents (enzymes that degrade starch ethanol)

Paper & Pulp: Use of bacterial pellets to control odor; extended delignification; use of deformers; steam stripping of foul condensates; use of weak wash for scrubbing fluids in air pollution control systems; delignification by oxygen

Pharmaceuticals: Substitution of isopropyl acetates for toluene and implementation of recovery schemes; replacement of two-solvent extraction system with a single environmentally more benign solvent.

Iron & Steel: Recycling of spent pickle liquor; recovery of iron scrap and implementation of close-looped systems

In the case of metal finishing industry due to increasingly stringent regulations, a lot of waste minimization efforts have to be carried out to comply with standards. Hazardous substances are present in rinse wastewaters, which include toxic heavy metals, and in some cases cyanide. Different models are created and then calibrated and used in economic evaluation of various waste minimization options that focus on saving in water use and wastewater treatment and sludge generation. [Smith et. al., 1994]

Chemical industry: Cleaner Technology can be considered as a strategic element in the manufacturing technology for present and future products in the chemical industry. Cleaner Technology options can be applied to membrane separation processes. Pressure driven membrane processes are successfully applied to the treatment of wastewater with a high concentration of salts. Wastewater in electroplating industry has been successfully treated using Electrodialysis. Phenol and other such organic solvents at highly diluted concentrations can be separated by organophilic membranes in the process of per evaporation at relatively low temperatures, off gases in the chemical, petrochemical & pharmaceutical industries, which contain gasoline, benzene, toluene, styrene, ethers, esters, hydrocarbons, chlorinated hydrocarbons, or alcohols can be treated by means of membrane technology. Even though limitations regarding selectivity or the flux densities of permeation are there; membrane technology can fulfil some demands of Cleaner Production. [Paul et. al., 1998]

2.5 LEGAL ASPECTS OF CLEANER TECHNOLOGY:

The traditional approach adopted by the policy makers is the *Command And Control* approach, which brings about compliance to the set standards thereby improving the environmental quality. Standards appear to give regulators a degree of positive control to get pollution reduced but their effectiveness depend on successful enforcement. However this traditional approach was found to be weak in almost all parts of the globe, which necessitated the need for pollution control policies that are cost-effective in the long run. In most cases the same standards apply to all sources of a particular pollutant. One complication in setting up legal standards is that pollution from carbon emission anywhere in the world changes the concentration everywhere. Hence there must be collective emission policies all over the world to get expected results [Weyant, 1993]. But pollution control can be cost-effective when marginal abatement costs are equalized across sources. Thereby Cleaner Technologies have a greater role to play wherein the pollution can be emitted at the source itself. The studies show that specific measures for Cleaner Technology adoption are increasingly emphasized by the legal bodies of developed countries like US and UK whereas the legal policies of developing countries like India merely state about the adoption of waste minimization techniques through best available technologies.

A study in the US paper and pulp industry identified three key characters that bring about zero discharge innovations as strictness, flexibility and limiting uncertainty. It says that when stringent policy rarely allows firms to lead to technological innovation and zero discharge, a flexible one allows them to determine how to meet environmental goals and achieve standards. The uncertainty factor throws light on the fact that over time firms has to increasingly internalize their environmental externalities and hence is more likely to direct the innovative efforts towards pollution prevention technologies. [Bohm et. al., 1998]

As per the opinion of EPA administrator they have learnt the inherent limitations of treating and burying waste since it is only a problem solved in one part of the environment, which may become a new problem in yet another part of the environment. So the best option is curtailing pollution closure to its point of origin so that it is not transferred from place to place. Hence Incorporation of pollution prevention becomes inevitable using important tools like increasing energy efficiency and providing stronger incentives for Cleaner Production. The EPA pollution prevention policy statement was signed on June 15, 1993, which outlines the strategy for implementing the pollution prevention act and provides a starting point for a new approach to environmental protection. Some approaches adopted by EPA are Common Sense Initiative, Source Reduction Review Project and Pollution Prevention in Enforcement Settlement Policy.

The Common Sense Initiative is designed to achieve greater pollution protection at a less cost by industry basis rather than going through pollutant-to-pollutant basis. The first size US industries selected to environmental regulation is Auto assembly, Metal finishing and plating, Petroleum refineries and Printing industries. The Source Reduction Review Project is a program to review key regulations mandated by the Clean Air and Water Acts & the Resource Conservation and Recovery Act and to evaluate the pollution prevention alternatives during the regulatory development process. Through the Pollution Prevention in Enforcement Settlement Policy, the agency strongly encourages the incorporation of Pollution Prevention conditions into settlements. At present every US state has some sort of organization to encourage the adoption of Clean Technologies and Pollution Prevention strategies within their border. Clearly Pollution Prevention in US is a corporate effort between the US EPA and the various state Pollution Prevention programs. The industries are also beginning to realize the economic as well as environmental benefits of Clean Technology. Some such examples are 33/50 Program, Green Light Program, Energy Star Computers etc. These Pollution Prevention programs initiated in US by EPA has shown positive response in preventing the environmental degradation as well as cost saving by the adoption of various strategies. [Freeman, 1995].

In addition to the above measures, the OCPF (Organic Chemical, Plastics and Synthetic Fiber) Regulation also prompts the companies to develop effective pollution control methods, which are advocated by the M. W. Kellogg company. [Stephenson et. al., 1993]

India enacted an Environment (Protection) Act in 1986, which is a comprehensive and unique one. Under its schedule VI-annexure 1, it states that the state Pollution Control Boards should encourage industries to go in for waste minimization and waste utilization by the Best Available Technologies. [The Environment (Protection) Act & Rules, 1986]. Some of the recent news items show the increasing pressure exerted by the Indian legal bodies for the betterment of the environment:

"The Supreme Court orders the closure of 39,000 polluting industrial units operating illegally in the polluting areas of Delhi to close their operations, based on a Public Interest Litigation filed by M.C. Mehta. Any relocating facility or other concessions was also rejected". [Jha, 1996]

"A Supreme Court's order directs the closure of all hazardous industries in Delhi region which includes Shriram Foods and Fertilizers, Birla textiles, Swatantra Bharat Mills and Hindustan Insecticides". [Chakrabarty, 1996].

"Steel Authority of India Ltd. invests Rs. 2250 crores for pollution control and clean technologies, to meet the increasingly stringent regulations made down by the Govt. to control pollution through gaseous emissions, effluent discharge, and disposal of toxic waste. The program includes replacing the existing facilities with new ones if needed urgently or bring about new modifications". [Sagar, 1998].

Since technology based regulation can sometimes encourage and also stifle technological innovation, pollution prevention is better than pollution control.

Enhanced flexibility for achieving environmental goals, coupled with strong compliance assurance mechanisms, including enforcement can spur private sector innovation that will enhance environmental protection at a substantially lower cost both to individual firms and to society as a whole [Census of Manufacturing, 1995]. Hence at such a point of time we must be aware of the importance of cost effective pollution control technologies like Cleaner Production which can take us a better way towards improving our Environmental Quality.

2.6 BEHAVIOURAL /SOCIAL ASPECTS OF CLEANER TECHNOLOGY:

The concept of Environmentalism arose in the recent decades around the globe and it argues that economic growth and environmental protection can go hand in hand. In the 1970s and 1980s managers developed environmentally safe practices as an aspect of their corporation's 'social responsibility' primarily because of the threat of legal (abiding by governmental laws) and or social (role of social activists) sanction, the reason being environmental issues were then managerially framed as being fundamentally external to business interests. Thus they were viewed as restraints to corporate affairs, emerging from sources separate from the key drivers of the market system. Today, however, with corporate environmental practice entering the realm of corporate strategy through a host of other institutional drivers, these views are obsolete. In fact from the 1990s onwards, environmental protection and economic competitiveness are becoming increasingly intertwined. Thus what was once driven primarily by pressures separate from core business objectives is now driven by interests that exist within a firm's economic, market political and social environments and that share concerns at the core of business decision making (i.e. environmentalism is being transformed from something external to the market system to something that is central to the core objectives of a firm). Corporate environmental practice today is becoming less of an environmental issue and more of an issue of strategy, marketing, finance, human relations, operational efficiency and product development. As such it can no longer be viewed as a necessary evil or as a cost of doing business as now it is a part of the business environment and has tremendous potential in this quarter (Hoffman, 2000). In 1970, economist Milton Friedman's ("The Social Responsibility of Business is to increase its profits,") labeling of the view – 'corporations should go beyond regulation to protect the environment' – as 'pure and unadulterated socialism', is reflective of the prevalent heretic view held in the business channels of those times. This is very different from the present day scenario where its becoming the conviction of corporate strategy, being proposed as pure and unadulterated capitalism by business realm academicians such as Michael Porter and C. Van der Linde ("Green and Competitive: ending the stalemate," 1995). Thus the environmental activists have succeeded in bringing about a universal awareness to the issue of environmental degradation, which affects our quality of life. Air and Water pollution are increasing the incidence of diseases and ailments. In-order to have environmentally sustainable development higher growth and environmental awareness must go hand in hand. This can be achieved only with an optimal mix of public and private co-operation.

Most industrial production processes depend upon natural resources for both inputs and disposal of wastes. Environmental problems arise when input demand is beyond the regenerative capacity at the source or when wastes overwhelm the recycling or absorptive capacity at the sink. The pressure on the source or sink is determined by the efficiency of the process, which among other things depends on the kind of technology applied. Thus Cleaner Technology or Cleaner Production may be defined as environmentally sound technologies or low waste or no waste technology. It aims at achieving waste prevention and minimization by reducing the consumption of raw materials, modification and upgradation of the process, so that optimal utilization of natural resources is achieved and a preventive approach rather than a corrective one to pollution is adopted. Thus Cleaner Technologies or Environmentally Sound Technologies is much more than hardware development or upgradation of a process – it is a complex arrangement with social and cultural attitudinal shifts. [Maudgal S., 1998]. Several corporates (primarily in the developed world) are seeing the wisdom in developing strategies that allow them to achieve economic prosperity, environmental quality and social equity simultaneously. However, though the concept of Environmental Management (EM) has entered the reality of business practice, its integration into the latter is far from complete. So also with the concept of 'social development' which has entered the lexicon of corporate dialogue, but whose integration has far from begun. The reason being, that at its core, the defining values of sustainable development are more challenging to imbibe than the existing institutional beliefs about economic efficiency. In fact, if corporations accept these values, the issue stands to challenge many underlying assumptions of the market economy and pushes towards redefining the objectives of companies that act within it.

Thus though EM has finally arrived and it looks like its here to stay, the next big challenge involves integrating social issues into traditional EM tools. (Nancy Bennett, program officer for the UNEP's Industry and Environment office.) (Hoffman, 2000)

Cleaner Technology adoption can become a policy for its successful implementation. Generally an environmental assessment is carried out in order to support a policy decision. This in turn requires citizen participation, which gives the local people an opportunity to know and comment on the technology adopted that may help in bringing about modifications. In fact shareholders, investors, banks, insurance companies, trade associations, academic institutions, religious institutions etc. are all major drivers in effecting a change in corporate practice towards the implementation of safer environmental practices (Hoffman, 2000). With respect to citizen participation, the idea of a citizen jury was introduced in a study for local air pollution assessment in the city of Sheffield, England. The participants and the public were involved in dynamic interactions and discussions. The findings suggest that the local knowledge that was very helpful could be used in further improvements and modification of the assessment system. [Peter et. al., 1999].

In a study by Henriques et. al. (Henriques et. al., 1999), in the Canadian industries cluster analysis was carried out to determine whether environmentally committed firms differ from less environmentally committed firms in their perceptions of the relative importance of different stakeholders in influencing their natural environmental practices. Firms were classified into four environmental profiles, namely *reactive* (characterized by no management involvement, attitude that environment management is not necessary, no environmental reporting, no employee training and involvement in environmental issues), *defensive* (piecemeal involvement of management, environment issues dealt with only when necessary, try to satisfy environmental regulations, little employee training), *accommodative* (some involvement by top management, considers environment management as a worthwhile function, internal reporting but little external reporting, employee training and involvement to some extent) and *proactive* (top management is involved in environmental issues, environmental management is an important business function, internal and external reporting, environmental training and involvement is encouraged). From a total of 400 firms, 182 were under reactive cluster with some support for the formation of an environment committee with all other points showing negative clusters, 46 were under defensive clusters and tended to have environmental plans and Environmental Health and Safety units with no environmental training to employees, no environment committee and written environment plan, 48 firms were identified as accommodative with a negative cluster only in areas of Environmental Health and Safety unit and communication to shareholders and 124 firms were classified under proactive group with a negative cluster only for environment committee and a positive cluster for all other points. For further analysis the stakeholders were classified into *regulatory* (govt. & trade associations), *organizational* (those directly related to an organization), *community* (including community groups, environmental organizations) and *media*. Results are as shown:

Firms	**Stakeholders**			
	Regulatory	Organizational	Community	Media
Reactive	4	4	4	1
Defensive	3	3	4	3
Accommodative	1	2	2	2
Proactive	2	1	1	4

[Ranks are 1-highest, 2-next highest, 3-low, 4-very low]

The study throws light upon the attitudinal variations of different firms on the relative importance of various stakeholders and suggests that for an increased environmental consciousness the managers can either be provided with incentives or environmentally aware managers can be hired. This points out that firms must be made aware of the relative importance of innovative techniques that help them in cost saving in the long run. Cleaner Technology options like substituting non-hazardous materials in place of hazardous ones wherever possible in the production process, recovering or separating oils, solvents and other useful materials from waste, performing regular maintenance to prevent leaks etc. can be implemented even at the grass root level that helps these firms to move towards environmentally conscious manufacturing [Encology, 1999]. Dyckhoff (2000) also draws attention to a similar classification with respect to the natural environment, pointing out to the four basic types of Corporate Strategy as put forth by Jacobs (1994). This was also based on the extent and intensity of environmental protection carried out by the concerned organisation.

1. *Repulse - oriented strategy*: 'No environmental protection.'

This comes in at one end of the continuum and is an expression of a defensive or even a criminal (there is no guarantee in some cases of adherence to legal requirements) environmental policy. The basic thought here is that, "If possible , we will do nothing."

2. *Output- oriented strategy*: 'Additive environmental protection.'

This strategy is less defence. It meets legal requirements and is primarily concerned with the application of additive (end - of - pipe) technology. The basic idea here is, " We will only do as much as necessary."

3. *Process- oriented strategy*: 'Production - integrated environmental protection.'

This is a preventive strategy, following the principle of, "We will do as much as possible." There is a transformation here from a defensive to an offensive environmental policy and legal norms are fulfilled more than is necessary with the existing production processes being modified by the installation of clean technology.

4. *Cycle- oriented strategy*: 'Product - integrated environmental protection.'

This preventative strategy follows the doctrine of, "We do as much as possible at our place as well as at other places." Thus the maximum protective measures can only be attained when strategies also include indirect activities and hence close co - operation with all the participants along the product life cycle becomes essential.

Another study by Florida (1996) brings out the various attitudes of firms towards environmentally conscious manufacturing. A zero emission survey data shows 15% of firms to actively pursue zero emission manufacturing and 85% to rely on reduced emission strategies. Majority of the firms reported zero emission manufacturing as in their early stages of development and currently it functions as a goal or target rather than a standard practice. Another survey result of emission reduction achieved as a result of pollution prevention is as follows:

40%	respondents obtained a reduction of	1-10%
40%	- do -	11-25%
12%	-do-	26-50%
7%	-do-	51-100%
1%	-do-	0%

In order to create awareness about this relatively new technique of Cleaner Technology among the manufacturing firms, financial institutions as well as the public, the demonstration of the technology and the development of a management information support system are necessary. This helps in identifying the facilities and limitations of the technology. Hence awareness campaigns on Cleaner Technology options supported by demonstration projects and training has been proposed as elements of capacity building. In order to facilitate a wider reach across firms, a fora has to be established where these options will be demonstrated, enabling enhanced viability and providing hands on training. While these programs augmented the information base of the participants, they also provided an opportunity to explore the possibilities of expanding the interface of interaction between a resource and end user. [Gopichandran R. et. al., 1998].

According to Naduthotty [Naduthotty, 1998], public opinion is important to know about the ultimate benefits of Cleaner Technology implementation in terms of the socio-economic angle. The tool of Contingent Valuation Method can be effectively used in order to know about the attitudinal preferences. Through proper education of the masses, opposition to environmental control methods based on exaggerated notions of costs can be overcome since such controls bring considerable benefits and inflict no more than bearable costs.

In relation to this, the concept of environmental reporting gains importance. In fact this is becoming more common in business with 35% of the world's 250 largest corporations now issuing environmental reports (study by KPMG and the Institute of Environmental Management) (Kolk, 2000). Several companies are voluntarily embracing 'green reporting' because it makes good business sense. However, it being still relatively new, in order to help address the probable ensuing confusion, the Coalition for Environmentally Responsible Economies (CERES) sponsored the Global Reporting Initiative which published structured but flexible guidelines that promise to bring some much needed efficiency and consistency to the green reporting process. Bristol - Myers Squibb (health and personal care products giant) and Royal Dutch/ Shell have both taken green reporting very seriously, devoting substantial resources in order to do it well. Though they have opted for different paths to build their environmental reporting capabilities, both are reaping important business benefits as a consequence and have set a precedence worth emulating.

Business leaders at the recent World Economic Forum in Davos, voted global climate as the most pressing issue confronting the world's business community today (Packard and Reinhardt, 2000). Thus in this millenium, industry needs to redefine traditional concepts of efficiency, quality, ethics and social responsibility so as to align them with the emerging scenario. For instance, traditionally, efficiency primarily implied the process of optimising input output ratios, while today it implies the optimisation of an intricate network of processes for the long-term sustenance of performance standards. In fact the global trend of using cleaner technologies would favour 'late' developing India - CRISIL and Hagler Bailey estimate that Clean Development Mechanisms can bring up to $ 39 Billion of investment to India in the renewables and transport sectors. (Ganguly, 2000). Indian enterprises can greatly benefit in this millenium if they adopt a different, more positive and more proactive approach to the challenges posed by environmental issues. Barring a few Exceptions, the prevalent attitude continues to be that environmental concerns impose costs that are best avoided. This is a fairly natural attitude because as discussed earlier, these costs can be fairly readily externalised and imposed on someone else. However, a shift from this negative to positive approach will be advantageous not only to society at large, but also to the corporate world. The Japanese experience is a case in point. Forty years ago they too pursued this negative approach. But in the 1960s, public pressure forced industry to stop externalising environmental costs (a primary trigger being the Minamata disaster) and this resulted in effective pollution control regulations in Japan. Consequently, today they are the world leaders in the efficient use of material, energy and information resources, thus gaining a significant competitive advantage from this source, leading several economists to believe that this whole change in approach is what fuelled the ensuing economic growth in their economy. If one was to compare the situations in Japan and India, the latter uses approximately five times as much energy for a billion rupees worth of GDP as the former do. Such waste implies not only environmental damage, but also lack of competition in the global market (Gadgil, 2000). Thus today the whole issue of corporate governance (and global benchmarks with respect to it) is in focus and it is no longer sufficient to just succeed in the market place alone for sound corporate practices can achieve the creation of real value as against just a shiny balance sheet (Skaria, 1999). In the words of K.K. Kaura, (CEO, ABB -1999), "Governance goes beyond external shareholders. As responsible corporate citizens, organisations need to widen their linkages with issues of social development especially in the fields of education, health, environment and community development. In all these areas, the practice of ethical values underlines and strengthens the character and image of the corporation."

2.7 DRIVING FORCES AND BARRIERS:

Since different driving forces and barriers could not be sourced to a single study, a consolidated summary obtained from the various articles in the UNEP Industry and Environment Journal is presented here:

Driving Forces

Regulations: This forms one of the major forces for firms to think about pollution prevention. Due to the increasing pressure from governmental policies and Non Governmental Organizations the pressure on the firm increases so as to switch over to environmentally conscious manufacturing.

Enlightened Management: In some cases the management would be open to new ideas of environmental stewardship, which makes a shift towards greener production.

Lower Cost of Production: Cleaner Technology is cheaper as compared to other pollution prevention methods. Hence some firms adopt it to lower their cost while facing stiff competition from others. Also mounting cost of raw materials, energy, water treatment etc. makes the firms think in this direction.

Demand from Workers: The increasing demand from supervisory staff and workers in order to tackle the problems of safety, space, lower emissions etc. makes the management think about alternative solutions like Cleaner Production. A study by

Florida (1996), showed the relative involvement from different levels in pollution management as

Top Management	- 81.1%	Suppliers	- 49.1%
Engineers	- 75%	Customers	- 37.7%
Production Workers	- 64.6%	Consultants	- 28.3%
R&D staff	- 55.2%	Environmental Organizations	-20%

These results show that production workers were more important to the company's pollution efforts than their R&D staff.

Better Image of Corporate Performance: A number of firms have incorporated Environmentally Conscious Manufacturing or product stewardship (as in some proactive companies) in their agenda in-order to get a better market for their environmental friendly products and also to create a better public image.

Following other examples: by getting inspiration from other companies where this Cleaner Production is already implemented in a cost effective manner

Quality Improvement: Some firms with a vision for sustainability introduce Cleaner Production methods to improve the quality of their own system and products.

Incentives: In some countries, the government provides soft loans or incentives for the firms adopting Cleaner Production. This can also act as a driving force.

A study by Vickers et. al., (1999) categorizes regulation, marketing or green consumerism, technical efficiency and quality considerations and the values of those within the organization as four dominant stimuli for Cleaner Technology adoption.

BARRIERS

Poor monitoring: is one of the main barriers to cleaner technology. Usually many industries consider monitoring to be unnecessary or too expensive and this results in the lack of reliable data. Without adequate data about operating parameters and material flow successful adoption of Cleaner Production is not possible in the long run. Even though this does not require major investment it needs resources in the form of time and trained manpower.

Top Management Commitment: The endorsement of top management is crucial for the successful adoption of Cleaner Production technology so that the enterprise is allocated with adequate resources, manpower, time and access to the information. Cleaner Production options emphasize more on people changing their attitudes and habits rather than firms changing technology. In the past Cleaner Production adoption was hampered since it was equated with high cost Environmentally Sound Technologies.

Environmental Legislation and Enforcement: These activities are either weak or short - term oriented by fixing standards for emission and effluents. Long-term strategies are completely lacking.

Lack of Incentives: There are no adequate funds or incentives or loans from banks or other financial institutions, which helps the industries to promote the adoption of Cleaner Production. In developing countries a major obstacle with the adoption of Cleaner Production is lack of funding resources both externally and internally. Up-front funding is required to establish the most basic prerequisites of a cleaner production approach but the investment is less attractive when the benefits appear only in the long term. Banks are cautious about funding projects they find difficult to evaluate in terms of economic soundness [Hafez, 1994].

Lack of Adequate Training: Cleaner Production awareness campaigns for industry, government, funding agencies, banks and the public are scarce. In order to get the full benefits of Cleaner Production access to the specific and general information has to be given to the management and staff members.

2.8 CONCEPTS AND TAXONOMY OF CLEANER TECHNOLOGIES:

Generically different Cleaner Technologies

Generically different cleaner technologies refer to modes of transformation in which the feedstocks are non-hazardous/renewable, conversion processes are highly efficient, and the product is environmentally benign (eg. biodegradable). i.e. It refers to entirely new production processes that have to be installed apart from the existing ones. In many instances biotechnology is combined with innovative chemical technology in devising generically different cleaner technologies.

Some salient examples of such technologies are: Production of Flyash based Zeolites, Biotechnological Production of Biosurfactant, Production of Biodegradable Plastics from Industrial Wastewaters, Biochemical Conversion of Lignocellulosic substrates to Cellulase, Liquid Glucose, and Value-Added Chemicals

Generically-different Cleanup Technologies

Generically-different cleanup processes deal with cost-effective recovery of water/chemicals/value-added byproducts from wastes; or provide improved efficiency based low-cost solutions to environment pollution-control problems. Some salient examples are: Biobeneficiation of Coal containing High Pyritic sulphur and Ash, Desulphurization of Gaseous Fuels and Emissions, Biotechnological Recovery of Hydrocarbons from Oily Sludges, Oil Spill Remediation & Treatment of Petroleum Refinery wastewaters, Bioremediation of Mine Spoil Dumps, Low-cost, Non-noble Metal based Catalytic Converter for Auto-exhaust Emission Control and Diesel Particulate Filter

Electroplating

Some of the Process Alternatives with respect to Chemical Industries are also throwing light on Cleaner Technologies Utilization of drag-out rinses by returning back to the process tank and substitution of plating by the use of non-cyanide zinc plating process. A project in the state of Victoria is promoting the use of alternate methods of metal recovery from the electroplating and metal finishing industries. A study of dumping the waste vs. metal recovery has shown that cost saving and disposal problem of waste from the metal finishing and electroplating industry can be eliminated by the option of recovery of metal. But this is not economically viable in the case of small-scale industries. It is envisaged that commercial fruition of this alternative is gradual and will be complicated by the problems and idiosyncrasies of individual companies.

The EPA Design-for-the Environment Program Printed Wiring Board Project (PWB) is a voluntary cooperative relationship among agreement between EPA, industry, academia, public interest groups, and other stakeholders to evaluate the risk, performance, and cost of substitutes for high-priority uses of toxic chemicals in PWB production. The first project focussed on "making holes conductive (MHC)," the process of applying a conductive layer to the surface of drilled through-holes prior to electroplating. The evaluations are then documented through the development of a Cleaner Technologies Substitutes Assessment (CTSA), a report, which brings together the data on each of the alternatives for comparison. The Center has recently commenced another CTSA for the PWB industry focussing on the hot air solder leveling process, which uses lead-based solder.

Hexavalent chromium is an extremely toxic substance, which proves difficult to treat from industrial wastewater. High Velocity Oxy-Fuel (HVOF) thermal spray technology is a dry process that produces a dense metallic coating whose properties are equivalent to chrome plating with hexavalent chromium. This combustion process melts a metal powder that is continually fed into a gun using a carrier gas and propels it at high speeds towards the surface of the part to be coated. The high speed of the spray produces a coating impact that can be used as an alternative to chromium plating. The only waste stream produced by HVOF is from overspray. Since it contains only the pure metal or alloy, it is feasible to recycle or reclaim it as a raw material. By using HVOF annual costs will decrease, along with air emissions, hazardous waste generation and associated disposal costs. The estimated payback period for using HVOF is 2-4 years, depending on the size of operations.

Another substitution option for hexavalent chromium plating are the use of trivalent chromium plating or the use of sulfuric/boric acid anodizing (SBAA) process. In this case only minor process changes are needed for trivalent chromium plating and waste trivalent chromium is much easier to precipitate from wastewater. It is a direct replacement for the chromic acid anodizing process used on Aluminium production process. In this process the overall level of chromium needing treatment is much less than that in conventional finishing operations. SBAA operating costs are similar to existing chromium plating operations.

Textiles: Use of alternate dyes like copper-free for producing green shades, use of alternate desizing agents (enzymes that degrade starch ethanol)

Paper & Pulp: Use of bacterial pellets to control odor; extended delignification; use of deformers; steam stripping of foul condensates; use of weak wash for scrubbing fluids in air pollution control systems; delignification by oxygen

Pharmaceuticals: In this sector substances involved in production are extremely diverse. Many are flammable and toxic and waste is produced at each step of the product synthesis. Substitution of isopropyl acetates for toluene and implementation of recovery schemes; replacement of two-solvent extraction system with a single environmentally more benign solvent are some of the technologies used.

Iron & Steel: Recycling of spent pickle liquor; recovery of iron scrap and implementation of close-looped systems

Green Chemistry initiative aims at developing chemical processes and products, which reduce the use of and creation of hazardous substances. Its introduction by EPA began in 1991 and a successful example is the chemical industries response to Ozone depleting Chloro Fluro Carbons, following Montreal Protocol. It emphasizes the use of real time, in-process monitoring to minimize waste before it is formed and adaptation of traditional chemical analytical techniques to reduce or eliminate the need for using hazardous substances in processes or in analytical procedures. 3M increasingly advocate these principles. [Anastas et. al., 1999]

In the case of **metal finishing industry** due to increasingly stringent regulations, a lot of waste minimization efforts have to be carried out to comply with standards. Hazardous substances are present in rinse wastewaters, which include toxic heavy metals, and in some cases cyanide. Different models are created and then calibrated and used in economic evaluation of various waste minimization options that focus on saving in water use and wastewater treatment and sludge generation.

Saving Water and Reducing Wastewater Discharges at a Metal Finishing Plant, Latvia

Background

Founded in 1866, the State Joint Stock Company "Lokomotive" is a large plant in Latvia that builds and refurbishes diesel locomotives from Central and Eastern European customer. The plant is vertically integrated and includes operations for manufacturing and remanufacturing electric motors, steel casting, forging, machine shops, electrical shops, and metal finishing. Lokomotive employs over 2,700 persons including 2,200 production workers.

Cleaner Production Principle

Recovery, Reuse and Recycle; Process modification

Cleaner Production Application

Water conservation during locomotive cleaning operations

As part of the refurbishing operations at Lokomotive, the locomotives are cleaned with steam and hot water in a specially designed booth. Wastewater generated from the cleaning operations is contaminated with oil, grease, paint, and solid materials. The wastewater is sent to the plant's wastewater treatment facility before discharge to the city sewer. In the past, the steam and hot water used in the cleaning operations were generated from the plant's fresh water supply. Costs associated with this practice include the cost of fresh water, wastewater treatment costs and environmental fees based on the amount of contaminated wastewater discharged from the plant.

During the waste minimization project, it was determined that treated effluent water from the company's metal finishing operations could be used in place of fresh water for locomotive cleaning. Previously, the metal finishing effluent water was treated and discharged to the city sewer. To implement the project, the company installed water storage tanks, piping, and other related equipment. The majority of the necessary equipment was available on-site.

Water conservation at metal finishing shop

Lokomotive operates a metal finishing shop as part of its locomotive building and refurbishing operation. In the past, the facility consumed excessive amounts of water and discharged large amounts of wastewater because it lacked up-to-date processes, equipment and procedures for rinsing of parts.

During the waste minimization project, a comprehensive evaluation of the rinsing operations at Lokomotive was conducted to identify opportunities for reducing water consumption and wastewater discharges. Following improvements were identified and implemented which are basically simple low cost equipment modifications, changes in operating practices, and process control.

- Countercurrent rinsing methods were adopted to improve water use efficiency
- Conductivity controllers were installed on rinse water baths to supply water only when conductivity exceeds preset parameters.
- Rinse water feed spargers (perforated pipes) were installed for better mixing of fresh water to the rinse water bath.
- Dwell time over metal finishing tanks was increased to reduce carry over of plating solution into the rinse baths.
- Flow meters with hand controls and hand-operated valves were installed on water lines to measure and control the flow rate of water to the rinse tanks.

Environmental and Economic Benefits

Water conservation during locomotive cleaning operations

As a result of the project, the company reduced its fresh water consumption by 20,000 m^3/year and reduced its wastewater discharges by the same amount.

The modification cost $4,500, resulted in a saving of $10,600 a year, and had a payback period of less than six months.

Water conservation at metal finishing shop

As a result of the waste minimization project, the company reduced fresh water usage by 8,700 m^3/year and decreased wastewater discharges by the same amount. The project also reduced the amount of heavy metals discharged to water and land and decreased the amount of environmental fees paid by the plant.

It resulted in yearly savings of $11,000 per year and a payback period of less than eleven months.

Chemical industry:

The chemical industry has always been seen, as a high risk industrial sector since many of the chemical substances are flammable, toxic and processed under special conditions. Cleaner Technology can be considered as a strategic element in the manufacturing technology for present and future products in the chemical industry. Cleaner Technology options can be applied to membrane separation processes. Pressure driven membrane processes are successfully applied to the treatment of wastewater with a high concentration of salts. Wastewater in electroplating industry has been successfully treated using Electrodialysis. Phenol and other such organic solvents at highly diluted concentrations can be separated by organophilic membranes in the process of per evaporation at relatively low temperatures, off gases in the chemical, petrochemical & pharmaceutical industries, which contain gasoline, benzene, toluene, styrene, ethers, esters, hydrocarbons, chlorinated hydrocarbons, or alcohols can be treated by means of membrane technology. Even though limitations regarding selectivity or the flux densities of permeation are there; membrane technology can fulfil some demands of Cleaner Production. [Paul et. al., 1998]

Some of the CT developments in chemicals sector include

- Membrane electrolysis for fine chemical intermediate synthesis
- Processes using enzymes
- Fermentation route for biodegradable plastic production
- Transportable formulation plant for industrial explosives
- Aquabase paint system
- Hydrogen Peroxide for cleaner oxidation
- Clean alternatives to chlorinated and aromatic solvents
- Pressure swing adsorption to recycle hydrocarbons
- Production of single isomer using chiral technology
- Increased charging density, repair of leaks, minimization of chemicals use, proper material inspection and handling
- Non-calcium chromite roasting, absorption heat pump and inert-gas stripping

Case study: The Cork plant of IRL chemicals (UK), uses natural gas to produce ammonia, urea and liquefied carbon dioxide. The ammonia process is a standard production process facilitated by the unusual purity of the local natural gas.

Urea is produced by reacting ammonia with carbon dioxide to form ammonium carbamate, which is converted to urea and water at high temperature and pressure. Since all the carbamate is not converted in the reactor, it must be recycled, which is done in a stripper where the carbamate is recycled as ammonia and carbon dioxide. The remaining ammonia, carbon dioxide and carbamate are distilled off at reduced pressure. Pressure is reduced to atmospheric and the remaining vapours are flashed off leaving a 75% urea solution. The urea concentration is increased using a two stage evaporator to 99.7% which is essentially a melt of urea. This is sprayed downwards from the top of a high tower in the form of small droplets which cool and solidify to give almost spherical particles, which can also granulate to form larger particles.

Some environmentally motivated projects have been undertaken on the urea plant which include:

- Extra storage capacity, which will accommodate the drained-down contents of the process in the event of a process shut down.

- Improved desorption and hydrolysis, which will reduce normal emissions and facilitate the recovery of the stored drained-down material after process re-start. This was achieved by the installation of new trays on the two desorption columns followed by a new heat exchanger on the hydrolyser whereby the exit material from the column was used to heat the inlet stream, thereby improving energy efficiency.

- Improved condensation of the vapors from the rectifiction column, which will reduce normal air emissions and also facilitate the recovery of drain down material.

Thus the project involved a combination of internal recycling, improved techniques and incremental change in process technology. The alternative considered, the installation of a wastewater treatment plant to treat process condensate from the urea plant, was not pursued because both the economic and environmental cost-benefit assessments were considered to favor source reduction.

Chemical works "Blachownia" is located in the Southern part of Poland, near the Upper Silesian industrial region. One of the largest producers of chemicals, "Blachownia" has been offering a wide range of chemical products for domestic and foreign markets for over 40 years. Today, the company manufactures products derived from coal and coke, chemicals, polyethylene, and chemical synthesis products.

During the distillation process of coke tars at "Blachownia," one of the recovered fractions is naphthalene oil. The naphthalene oil faction is initially stored in two intermediate tanks from which it is pumped periodically to two storage tanks at the tar distillation plan. After an appropriate amount of naphthalene is accumulated, it is then transferred to a large storage tank at the naphthalene distillation plant for further processing. This operating practice of frequent pumping between two storage areas, and finally into the naphthalene distillation plant, resulted in significant product loss and excessive steam and power consumption needed for heating of storage tanks and collector pipes at the tar distillation plant.

Heavy organic wastes formed in "Blachownia's" benzol recovery plant undergo neutralization followed by coagulation with aluminum sulfate. After suspension separation, the wastes are sent to the central wastewater treatment plant. During this operation, about 600 tons/year of sediment is formed which is periodically incinerated in rotary burners. The sediment handling process is extremely troublesome and expensive. During the waste minimization project, experiments were conducted to identify a more efficient procedure for the treatment of wastes from the benzol recovery plant. To implement the project, an aeration system was installed as part of the preliminary waste purification process.

E. At "Blachownia," wastewater from the coke tar recovery plant contains significant amounts of tar compounds. The wastewater passes through two layers of coke filters where the tars are collected. In the past the tar filter media containing tar compounds was burned in an incinerator. Because over-fired coke could not be reused to feed the filters, the facility was required to purchase 130 tons/year of new coke to replace the spent filter media. The filter media exchange operations, including tar combustion, lasted two to three months. Moreover, the required coke for the filter is relatively expensive.

During the waste minimization project it was determined that the bales of compressed rye or wheat could be substituted for coke as the filter media for the coke recovery process. Implementation of this project significantly decreased filter media and operating costs, improved working conditions for plant operators and eliminated over-fired coke waste (130 tons/year).

Environmental and Economic Benefits

A. During the waste minimization project, reuse of wash water in the cooling water loop of the carbochemical plant was investigated and found to be feasible. Implementation of the project resulted in a decrease in the consumption of fresh water by 114,000 m^3/year. The amount of wash water discharged to the facility's central wastewater treatment was also reduced by the same amount.

Payback period <1week

B. As a result of the project, the facility reduced naphthalene emissions to the atmosphere by 1200 kg/year. In addition, the facility reduced its power consumption by 7875 kWh/year and its steam consumption by 800 tons/year.

Payback period < 3 weeks

C. A collection system carries the air containing traces of organics to special catalytic burners for incineration. This process modification eliminated the incineration of sediments and significantly decreased operation costs.

Payback Period <3 weeks

D. The fast and reliable information about the composition of process streams has increased the yield of benzene, toluene, and light resin from raw benzol by 0.2

percent, 0.3 percent, and 0.1 percent, respectively. In addition, the facility has reduced its consumption of sulfuric acid from 85 to 80 kg/ton of product.

Payback Period is 2 months

Dye & Pigment manufacturing

Pollution Prevention & Control

- avoid the manufacture of azo dyes and provide alternative dyestuff to users such as textile manufacturers
- meter & control the quantities of toxic ingredients to minimize wastage
- reuse byproducts from the process as raw materials or as raw material substitutes in other processes
- use automated filling to minimize spillage
- use equipment. Wash down waters as make-up solutions for subsequent batches
- return toxic materials packaging to supplier for reuse, where feasible
- find productive uses for off-specification products to avoid disposal problems
- use high pressure hoses for equipment cleaning to reduce generation of waste water
- label & store toxic & hazardous materials in secure bunded areas

Pesticide Formulation Industry

Some cleaner production options in this sector include:

- Cleaning and maintenance of spray nozzles and reuse of rinse solvents
- New types of formulations and installation of fluid coupling assembly

- Premixing of fillers and solid active pesticides before pulverizing and dedicating equipment to one type of product

2.9 SUMMARY AND ISSUES RAISED:

Summary

The literature survey has covered a wide range of studies dealing with Cleaner Technology and a whole gamut of related issues such as conceptual, techno-economic, institutional and those concerned with implementation. In general, it is revealed that Cleaner Technology is becoming increasingly significant in the recent years as reflected by the attention it has been receiving by researchers, policy makers and industry. The survey begins with a discussion on the concepts of Cleaner Technology. It then proceeds to address the issues like economic, scientific and technological, legal and behavioral dimensions. Studies concerning economic aspects suggest the need for an economic evaluation of Cleaner Technology by way of a rationale and guide to policy and decision-making. At the same time, the difficulties in gauging intergenerational comparisons are pointed out. Also, issues like obtaining correct values in contingent valuation surveys are found to be very involved ones. The case studies covered show the effectiveness of Clean Technologies and strengthen the case for their adoption. The section on scientific and technological aspects summarizes the developments and availabilities of Cleaner Technologies in a cross- section of industries. Coming to legal dimensions, a comparative picture on the prevailing state of affairs in the developed and developing countries emerges. Also, it drives home the need for effective pollution control regulations taking due care not to stifle innovation. Studies on behavioral/social aspects focus on the need for better awareness on the part of the society as a whole by providing better information and interface networks. The last section highlights on the driving forces and barriers related to Cleaner Technology adoption.

Issues raised by the survey

Cleaner Technology in general and Cost Benefit Analysis in particular are extremely important to stress upon the adoption of environmentally conscious manufacturing and its evaluation. Even though the studies analyzed here gives a good coverage on the industrial process level costs and benefits of Cleaner Production, the analysis is confined to the short-term costs and benefits of proximate relevance. Majority of them covers only the direct and quantifiable technological and economic effects. The indirect or qualitative aspects like the social and attitudinal effects and other spill over effects are not touched upon. This suggests the need to take up a detailed cost benefit analysis encompassing all the related dimensions that might be of significance. They range from quantitative to qualitative and spill over effects in addition to the direct and measurable ones. Over and above the manufacturing and process costs of various enterprises, such a study should also cover different attitudinal responses towards indirect effects like the money lost due to health damages, loss of recreational value of a particular environmental good etc.

The linkage between Cleaner Technology and sustainable consumption has to be highlighted and popularized. In short, the Cleaner Production has to be advertised more by bringing out its unique features and benefits in order to publicize it among the entrepreneurs. The concept of Sustainable Product Development has to percolate down to the level of organizations. Cleaner Technology can be integrated with policy options tailored according to local circumstances and relevance. Financial backing can be improved for the firms pursuing Cleaner Production. It can also be linked to the health and safety aspects in order to gain a wider acceptance. Information network on Cleaner Production around the globe can be strengthened and made easily accessible. Effective ways have to be identified to communicate the sustainable production and consumption message to CEO's and other corporate decision-makers emphasizing their potential in enhancing profitability, risk reduction and other associated benefits. This again goes to reinforce the case for propagation of a detailed cost benefit analysis for the adoption of Cleaner Technology options in enterprises and makes them available for wider circulation. Finally, the role of the State assumes special significance in developing countries like India where it needs to play an active role in inducing and facilitating the adoption of Cleaner Technologies.

Chapter 3: COST BENEFIT ANALYSIS OF CLEANER PRODUCTION TECHNOLOGIES [DATA ANALYSIS IN RESPECT OF CASE STUDIES FROM MAHARASHTRA AND GUJARAT]

3.1 Maharashtra: Case Studies From Maharashtra:-

CASE STUDY 1: LARSEN AND TOUBRO LTD.

3.1.1 Paint Shop:

Description of Cleaner Technology Adoption:

This study was carried out in the paint shop of the switch gear components unit. Previously L&T was using the spray painting method. They have recently switched over to the powder coating method in July 1999. While in the spray painting method raw materials used were paints and solvents, in the new method of powder coating epoxy polyester powder is used. In terms of waste generated it was paint sludge in the previous method whereas in the new method there is negligible amounts of waste [micro amounts of trivalent and hexavalent chromium]. This has also resulted in considerable reduction in the cost of disposal of wastes. While the paint sludge disposal cost Rs.1,000 / month, it has now come down to Rs.100 / month in the new process. Considerable savings have also been realised in the use of energy, manpower and water.

COST BENEFIT ANALYSIS:

COSTS of CT:

Initial Investment in equipment; Rs. 80 lakhs

Land cost	=	nil
Construction cost	=	nil
Total Investment	=	Rs.80 lakhs

Operation Cost

Manpower cost	=	Rs. 12 lakhs
Energy cost	=	Rs. 5 lakhs
Raw material cost	=	Rs. 29.1225 lakhs
Total Operating cost	=	Rs. 46.1225 lakhs

BENEFITS of CT:

Raw material savings; for 1.5 lakh square metres / annum

Spray painting method:

Cost of

1. Primer - 33,350 litres = Rs. 21.344 lakhs
2. Paint - 30,000 litres = Rs. 24.9 lakhs
3. Thinner - 25,000 litres = Rs. 8.25 lakhs

Total cost = Rs. 54.494 lakhs

Powder coating method:

Powder quantity required for the same surface area 17,650 Kg

Cost = Rs. 29.1225 lakhs

Savings = Rs. 25.3715 lakhs

Energy Savings

Energy cost: Spray painting method; Rs. 5.36 lakhs

Powder Coating method; Rs. 5.00 lakhs

Savings = Rs. 0.36 lakhs

Manpower Savings

Spray painting required 14 persons

Hence Costs @ Rs.2 lakhs / annum = Rs. 28 lakhs

Powder coating requires 6 persons

Hence Costs @ Rs.2 lakhs / annum = Rs.12 lakhs

Savings = Rs.16 lakhs

Water savings: 30 cu mt / month = Rs.0.012 lakhs

Net Savings = Rs. 41.7435 lakhs

Pay back period = 1.92 years [23 months]

Other Benefits:

As to the impact of CT on the health of employees no perceivable changes were observed going by the company's health records. Additionally, in the previous process, there used to be a problem of workers exposure to thinner and paint which required to be closely monitored. In the new process, there is no such risk of exposure.

Hazardous Nature of Technology:

Powder coating method is less hazardous technology as exposure to primers, paints and thinners have reduced. The trivalent and hexavalent waste though toxic is produced only in negligible micro amounts.

Waste measurement Index: waste generated per unit of production or output

Before CT :

$$WMI = \frac{\text{Waste}}{\text{waste + by-product + products}} \; 100 = \frac{0.0064}{0.0064 + 0 + 1} = 0.64$$

After CT:

$$WMI = \frac{0}{0 + 0 + 1} \approx 0$$ Since pollutants are negligible .

However, it should be noted that the pollutants [trivalent and hexavalent chromium] are toxic in nature though quantitatively negligible.

DRIVING FORCES AND BARRIERS

Driving Forces

The rankings assigned by the company sources were weighted based on the average of the scores given by three independent experts.Among the driving forces behind adoption of cleaner technologies, top management ranked first, followed by government regulation and better safety and health. The other influencing factors revealed were risk aversion, image, market forces, quality and efficiency drive in that order. The following table shows the ranking pattern.

Driving Forces	Ranks	weights	Weighted ranks
Market forces	7	3.3	6
Image	4	3.7	5
Risk Aversion	3	4.3	4
Quality drive	6	4,3	7
Efficiency Drive	8	4.3	8
Top management commitment	1	3.3	1
Better safety and health	5	2.0	3
Government Regulations	2	1.7	2

Barriers

There do not seem to be significant barriers to the adoption of cleaner technologies. In the lower end of intensity scale however, employee resistance and public opinion figured.

The Main Barriers faced while implementation of Cleaner Technology such as:

NATURE	DESCRIPTION	INTENSITY				
(a) Legislative		L	V.L	M	H	V.H
(b) Institutional						
(c Educational						
(d) Public Opinion			✓			
(e) Employees’		✓				
(f) Others, specify						

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

Among the other problems cited were lack of capital required for investment purposes due to recessionary market conditions and lack of integrated systems/service from suppliers.

TRAINING:

It appears, training has received a lot of attention in the company, as is revealed by the table below. All types of training like awareness programs , technical training , training in environmental management systems and on the job training have been undertaken. Also, Lead assessor training including auditor's training have been given. It is gratifying to note that the various training programs have covered different levels of employees ranging from shop floor, engineers to management.

Environmental awareness courses for management	✔
Environmental awareness courses for engineers	✔
Environmental awareness courses for shop floor staff	✔
Technical training for engineers	✔
Technical training for shop floor staff	✔
Training in environmental management systems	✔
No formal training, all done on-the-job	Both
Others, specify	Auditors training and Lead assessor training

Among the sources of training and information on cleaner technologies, in house staff has been found very useful. This was followed by universities / R&D organizations, conferences/seminars, consultants and journals / press.

CORPORATE CITIZENSHIP:

The firm scores high in respect of corporate citizenship as well. Most parameters such as extent of employee improvement, level of motivation towards cleaner technologies, shared vision and values, exposure to professional literature and latest developments have been ranked either high or medium on a five point scale. The scale ranges from very low, low, medium, high and very high.

3.1.2 Electroplating Unit:

Description of Cleaner Technology Adoption:

The firm chosen from the electroplating industry is Larsen & Toubro Ltd. Mumbai. The electrical switchgear manufacturing unit of the company has facilities for electroplating mild steel components used in their L.T. switchgear. The electroplating facilities installed by the company are only for captive requirements.

The company has three electroplating lines one each for zinc plating, Silver Plating and Nickel plating. Cyanide was being used in both Zinc electroplating and Silver electroplating processes. Since cyanide is a hazardous chemical, the company was looking for an alternative process to avoid the use of cyanide. In the first quarter of 1998 it obtained technical know-how of acid zinc process as an alternative to cyanide zinc process thus eliminating the use of cyanide for zinc plating. However, the use of cyanide still continues for silver plating for want of technical know-how for an alternative process.

The change over to acid zinc process involved only minor modification and additions of equipment to the zinc plating line but the process chemicals have totally changed. While the equipment additions did cost around Rs. 6 lakhs, there is no significant difference in the total cost of process chemicals used before and after implementing the above process change. There has been no change in manpower requirement also. However, there is a substantial reduction in energy consumption, which was 69,120 kwh per annum before the shift in the process as against only 5,400 kwh per annum after the shift. The above energy consumption is in respect of zinc plating line only which produces at present around 168 tonnes of zinc plated components per annum. The raw materials consumed in the above production are zinc anodes (300 kg), zinc plating chemicals (4,320 kg) and degreasing chemicals (2,800 kg).

For treatment of waste water, there is a common effluent treatment plant for all the three electroplating lines viz., zinc, silver and nickel. The total quantity of wastewater generated by zinc plating line is 20,000 litres per day. There has been no change in the quantity of wastewater after the process modification but it is now free from cyanide on account of discontinuing the use of this chemical. However, the wastewater stream from silver plating line has cyanide in it which is treated in the effluent treatment plant. The cyanide in the wastewater is destroyed by using sodium hypochlorite. The consumption of this chemical has come down from 156 tonnes per annum to 72 tonnes per annum after the use of cyanide was discontinued for zinc plating. Thus the shift in the zinc plating process from cyanide to acid process has resulted in an annual saving of 84 tonnes in the consumption of sodium hypochlorite which is valued at Rs. 4.20 lakhs.

The new zinc plating process has not made any positive or negative impact on the quantity of treated wastewater that is discharged. The treated wastewater has always been well below the permissible limit with no contents of chromium, cyanide, sulphide and oil & grease. It is also well within the norms prescribed by PCB in respect of biochemical oxygen demand (BOD) and Chemical Oxygen Demand (COD) with levels of 13 mg/l and 32 mg/l respectively.

The acid zinc process has substantially improved the quality of zinc plating. The corrosion resistance period has gone up by three times as revealed by Salt Spray Corrosion Resistance Test.

BENEFITS of CT:

The benefits accrued to the company due to implementation of cleaner technology for zinc plating are as under:

Saving in Energy and material per annum:		**Value (Rs.)**
Energy saving of 63720 Kwh @ Rs. 5/- per KWh	:	3,18,600
Saving in consumption of sodium hypochlorite to the tune of 84 tonnes @ Rs. 5000/- per ton	:	4,20,000
Total savings (in value term/year)	:	7,38,600

Pay Back Period:

The total investment on machinery for conversion to acid zinc process was Rs. 5,93,000 as against a benefit of Rs. 7,38,000 per annum. Hence the payback period here is less than 10 months.

Nature of new Technology:

The new process is comparatively less hazardous as in the earlier process electroplating was carried out with cyanide which is a very toxic compound. In the present process of Zinc plating the main chemicals are Zinc acid and degreasing chemicals which are comparatively less toxic.

Waste Measurement Index:

Waste measurement index has been computed for the zinc plating line and the results are as follows:

For 168 tons of zinc plating , 20,000 litres of wastewater is generated

i.e. per tone of zinc plating, 119 litres or 0.119 kl of wastewater is generated

$$WMI = \frac{0.119 \times 100}{1 + 0.119 + 0} = 10.63$$

Since WMI far exceeds 1, there is ample scope to reduce the quantum of wastewater.

The main driving force behind implementing CT in zinc plating was saving in the cost of energy (Rs. 318,000/-) and raw material (Sodium Hypochlorite of worth Rs. 4,20,000/-) adding upto Rs. 7,38,000/- which is substantial. Even otherwise, the company adheres to stringent pollution control methods.

Driving Forces:

Among the driving forces, the government regulations weigh the most, followed by consideration for quality, risk aversion, better safety and health and top management commitment. Better efficiency and image of the company as being environmental friendly are also considerations next in the order of importance. The company feels that Industry Associations and Conferences and seminars are very useful in identifying cleaner technologies. The next useful source is suppliers of CT themselves.

Barriers:

The company faced no barriers in implementing the cleaner technology in zinc plating.

It would like to adopt a similar technology in the case of silver electroplating also whereby the use of cyanide can be eliminated, but could not get the technical know-how so- far.

Other Benefits:

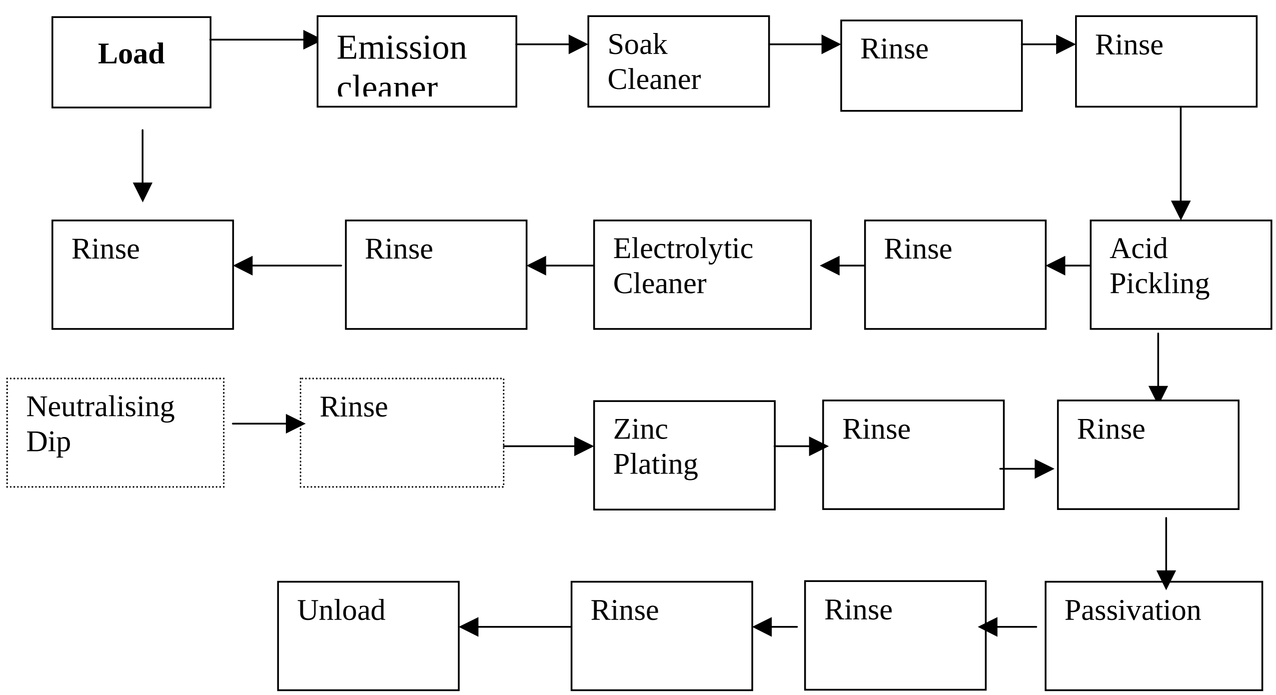
According to the officials consulted in the company, strict pollution control measures through CT or otherwise contribute significantly to improved health and safety standards, better quality of air and water, and enhance awareness among the workers about the importance of pollution free environment. The company carries out environmental impact assessment studies, environmental audits and audits for production process regularly. It has also undergone Certification Audit and was recommended for ISO 14000. The company has also plans to implement Life Cycle Analysis for its products after three years from now.

TRAINING:

Coming to the training aspects, the shop floor staff has been trained on environmental as well as technical aspects including on-the-job training. Also, training in Environmental Management System has been undertaken.

Process flow diagram:

Zinc Plating:



Note: Dotted boxes represent the additional units after the modification

CASE STUDY 2: BHARAT FERTILIZERS LTD.

This firm is a major manufacturer of chemicals and fertilizers located on the western coast. It had installed a Purge Gas recovery Unit a few years ago as a CT measure. The company has two Ammonia plants, one having a capacity of 350 TPD commissioned in 1965 and the second having a capacity of 900 TPD and commissioned in 1985.

In the ammonia synthesis loop, argon impurity was building up and this loop had to be drained frequently to control the ammonia synthesis gas purity. While purging this loop, some ammonia (3.29 % in the first plant and 3.45 % in the second plant) used to escape into the atmosphere. In another section of each of the plants where a gas mixture containing ammonia is left out to the atmosphere, is the let down tank where product ammonia pressure is let down before the transfer to storage. Here venting is done to remove the inerts present as a result of which some more ammonia (7.21% in the first plant and 6.88% in the second plant) used to escape into the atmosphere.

3.2.1 Installation of Purge Gas Recovery Plant:

A Purge Gas Recovery (PGR) unit was set up in 1995 at a cost of about Rs. 43 crores to achieve the dual benefits of reducing the ammonia let out to the atmosphere as well as conserve energy through the recycle of recovered nitrogen-hydrogen mixture to the synthesis gas. This also reduced the consumption of associated gas, the feed stock for producing ammonia, for the same production rate. The PGR unit has a capacity to handle 9500 NM^3 per hour of gas.

Other Benefits:

a) This plant recovers totally 6.9 TPD of liquid ammonia and thus reduces ammonia pollution.

b) An additional ammonia of 53 TPD is obtained from the recovered hydrogen and nitrogen from PGR which are sent back to the synthesis section of the second ammonia plant. Here the total energy consumption for producing 53 tonnes of ammonia is 187.22 MKcal less than the energy required in normal course when associated gas is used.

c) The use of purge gases in the production of 53 tonnes of liquid ammonia per day saves the consumption of associated gas to the tune of 50000 NM^3 per day.

d) Also, the purge gases contains argon gas which is recovered from PGR unit along with Ammonia (NH_3), hydrogen (H_2), Nitrogen (N_2). The quantity of argon gas recovered per day is 15 tonnes which is marketed, whose value equivalent is Rs. 2,52,450/ per day.

The ammonia produced by the company is not marketed. It goes into the production of urea and nitrophosphate fertilizers.

COST BENEFIT ANALYSIS:

COSTS:

Initial Investment Cost [in Rs.]

Equipment cost for	
Purge gas recovery unit	= Rs. 43 crores
Land cost	= nil
Construction cost	= nil
Total Investment	= Rs. 43 crores

Operation Cost [in Rs]

Maintenance cost	= nil
Manpower cost	= Rs. 0.30 crores
Energy cost	= Rs. 2.807 crores
Total operating cost	= Rs. 3.107 crores

BENEFITS:

Raw Material Savings

Argon gas recovered	=	15 tonne/day
Annual value of Argon gas @ Rs. 16,830/t		
(16,830 x 15 x 300)	=	Rs. 7.56 crore
Ammonia recovered	=	59.97 TPD
Annual value @ Rs. 7,100		

(59.97 x 7,100 x 300)	=	Rs. 12.77 crore
Savings on Associated gas	=	56790 NM^3/D
Annual value of gas saved @ 2700 per '000 NM^3(2,700 x 56.79 x 300)	=	Rs. 4.60 crore
Total	=	Rs. 24.93 crore
Net Benefits	**=**	**Rs. 21.823 crore**
Payback period	**=**	**~ 2 years [23.6 months]**

Nature of new Technology:

This technology that is the installation of the purge gas recovery plant is very safe and cleaner technology. All the ammonia which is a hazardous gas which was previously being let out will be trapped and brought back into the system. [Ammonia has a threshold limit value of only 25 ppm]

3.2.2 Revamping of rear end [synthesis section] to low pressure system:

This scheme has just been introduced in year 1999 and has given rise to substantial reduction in energy and water consumption due to reduction in pressure and temperature. In the old process for ammonia synthesis the purified synthesis gas enters the synthesis loop at about 350 Kg/cm^2 whereas in the new process, the synthesis loop has been designed for a maximum pressure of 120 Kg/ cm^2. The new system has a series of condensers and catalysts. The normal operating pressure of the loop is approximately 107 Kg/ cm^2. This reduction in pressure of the synthesis gas brings about a temperature reduction from 30^0C to -33^0C, reduction in energy consumption from 10.8 Mn Cal/Mton to 9.4 Mn Cal/Mton and reduction in water consumption from 2700 m^3/day to 2100 m^3/day. Other advantages are power consumption is reduced drastically since steam is used, leakages are minimized and less number of accidents since no oil is used in the centrifuge. Initial investment for this change is Rs.100 crores and the estimated payback period is 5 years.

COST BENEFIT ANALYSIS:

COSTS:

Initial Investment Cost [in Rs.]

Equipment cost [Catalyst units and condensers etc.]	= Rs. 100 crores
Land cost	= nil
Construction cost	= nil
Total Investment	= Rs. 100 crores

Operation Cost [in Rs.]

Manpower cost	= same as before
Energy consumption	
Before CT	=10.8 million cal/ton
After CT	=9.4 million cal /ton
Water Consumption	
Before CT	= 2,700 cubic metre/day for 300 tons of NH_3
After CT	= 2,100 cubic metre /day for 350 tons of NH_3

i.e. Consumption per unit has come down from 9 cumts/day to 6 cumts/day

BENEFITS:

Energy Savings

Reduction in temperature	
Before CT	= 30degree centigrade
After CT	= -33 degree centigrade
Reduction in pressure	
Before CT	= 350 kg/cm2
After CT	= 100 Kg/cm2
Savings in energy due to the above changes	= 1.4 million cal/ton

Water Savings	= 1050 cubic metres/day
Net Benefit	= monetary values could not be obtained

Pay back period

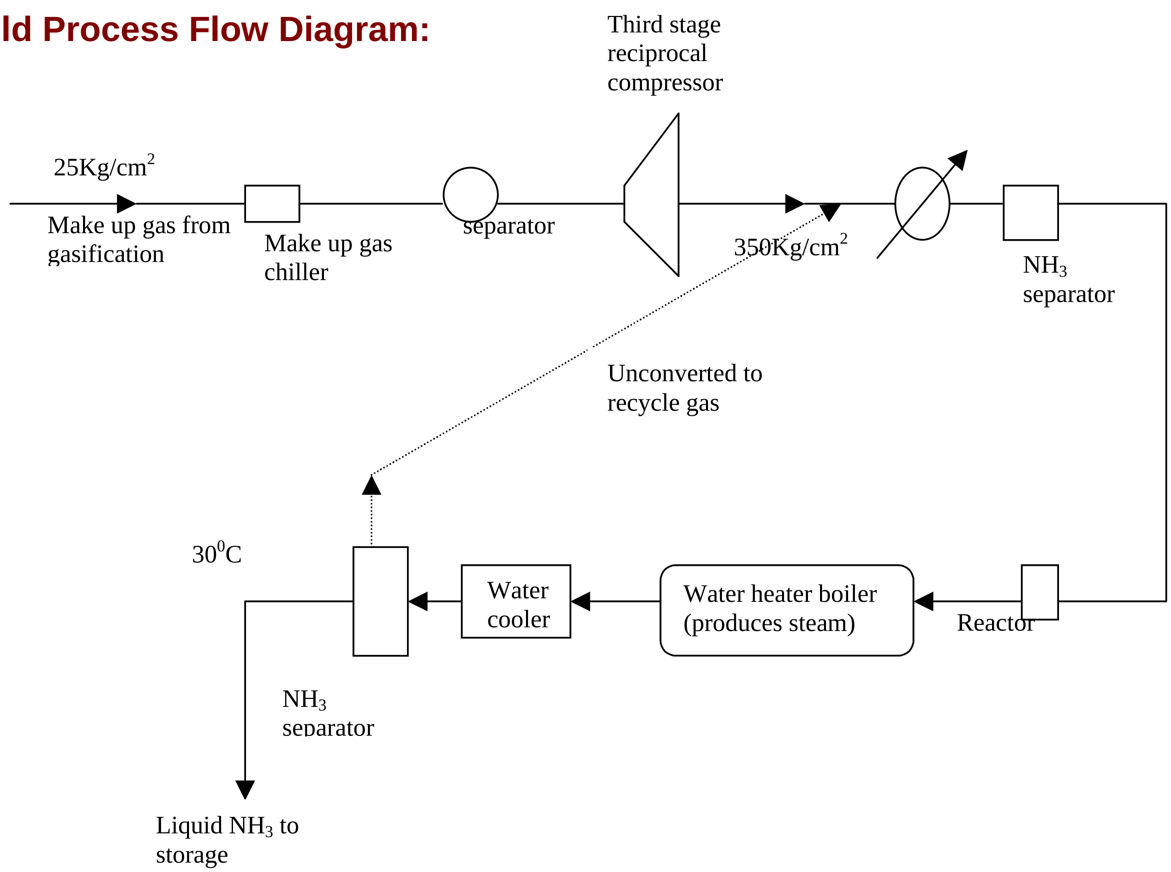
[expected by the company] **= 5 years**

Waste measurement Index:

$$\text{Before CT, WMI} = \frac{0.009}{0.009 + 0 + 1} 100 = 0.89$$

$$\text{After CT, WMI} = \frac{0.006}{0.006 + 0 + 1} 100 = 0.59$$

Old Process Flow Diagram:



Nature of New Technology

The new technology that is the revamping of rear end synthesis section to low pressure system is more environmentally friendly as less energy is used. It is less hazardous also as there is minimisation of leakages, and less number of accidents as no oil is used in the centrifuge.

3.2.3 Ammonia plant Modifications:

CT exercise involved installation of several equipments such as Turbine for Benfild pump, make - up gas chiller, LT guard vessel, 7 CT fan blades, downsizing of CT pump motors, and replacement of HK - 40 reformer tube with manurite tubes. This has resulted in an advantageous reduction in energy consumption.

COST BENEFIT ANALYSIS:

COSTS:

Initial Investment Cost [in Rs.]

Equipment cost	= Rs. 9.79 crores
Land cost	= nil
Construction cost	= nil
Total Investment	= Rs. 9.79 crores

Operation Cost difference [in Rs.]

Manpower cost	= same as before
Energy consumption	= - Rs. 2.05 crores
Water Consumption	= nil
Total difference	= - Rs. 2.05 crores

BENEFITS:

Energy savings	= Rs. 2.05 crores

Net benefit	**= Rs. 2.05 crores**
Pay back period	**= 4.75 years**

Given that in general, it is the practice in industry to assume the life of the equipment as 10 years and the discount rate at 15%, the NPV has been worked out and is given below:

Present value [PV]	**= Rs 10.288 crores**
Net Present Value [NPV]	**= Rs. 0.04983 crores**
Benefit -cost ratio	**= 1.04**

3.2.4 Ammonia plant [second modification]:

Subsequently, another CT exercise was carried out in the following year 1999 in the same plant. This involved the replacement of LP [W.K] rotor of synthesis gas compressor by full bladed rotor and 105/36 ata PRDS i.e. it was replaced with fast opening tight shut off PRDS. This has also given rise to energy savings.

COST BENEFIT ANALYSIS:

COSTS:

Initial Investment Cost [in Rs]

Equipment cost	= Rs. 5.71 crores
Land cost	= nil
Construction cost	= nil
Total Investment	= Rs. 5.71 crores

Operation Cost difference in lakhs

Manpower cost	= same as before
Energy consumption	= - Rs. 8.68 crores
Water Consumption	= nil
Total difference	= - Rs. 8.68 crores

BENEFITS:

Energy savings	= Rs. 8.68 crores

Net benefit	**= Rs. 8.68 crores**

Pay back period = 0.66 years [8 months]

Driving Forces:

The ranking given by the company sources have been weighted by the average of the scores assigned by three independent experts and the weighted ranks are obtained on this basis. The main driving force for cleaner technology implementation is top management commitment. This is then followed by a second set of driving forces like better safety and health and government regulations . The third set of driving factors consists of risk aversion and better image . Finally, the fourth set of driving factors are market forces, quality and efficiency driven considerations.

Driving Forces	Ranks	weights	Weighted ranks
Market forces	6	3.3	6
Image	4	3.7	5
Risk Aversion	2	4.3	4
Quality drive	7	4,3	7
Efficiency Drive	8	4.3	8
Top management commitment	1	3.3	1
Better safety and health	3	2.0	2
Government Regulations	5	1.7	3

Barriers:

The main barrier is lack of legislation with regard to the cleaner technology, scarce financial incentives and processing delays at the ministry level. Other barriers of lesser significance include lack of education, non-availability of relevant and proven technologies, employee resistance because of higher workload, poor service and or lack of integrated systems from suppliers.

Management Practices:

Training related to cleaner technology implementation includes:

a) Environmental awareness course for management

b) Environmental awareness course for engineers

c) Environmental awareness course for shop floor staff

d) Technical training for engineers

e) Training in environmental Management System

Of these various sources of training, the most useful according to company sources are suppliers of CT and conferences and seminars followed by Industrial Association, Universities, R & D organizations, Consultants, Business Environmental Networks, Journals, Press and other companies, external Training organizations and In-house staff.

Other Benefits:

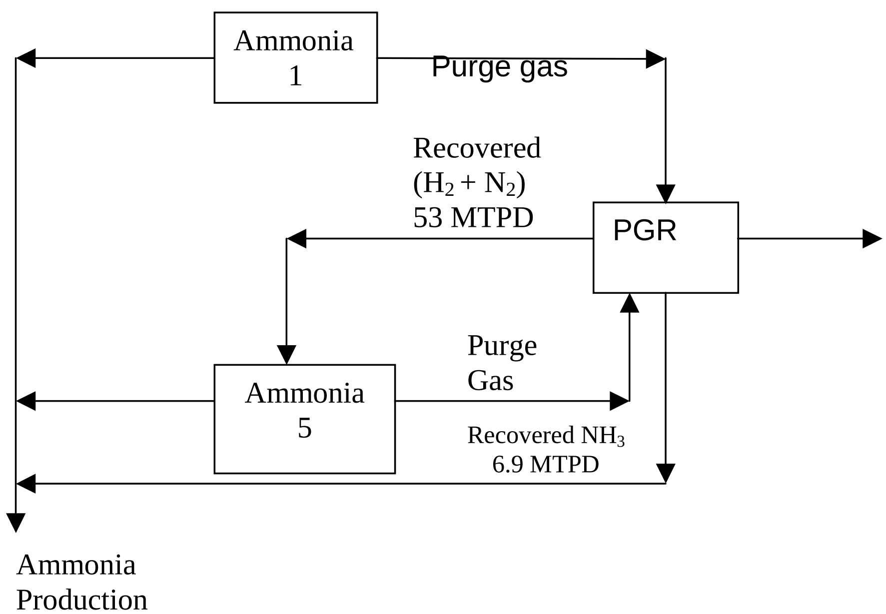
Improved safety standards and better quality of air and improved image of the company were very significant benefits. Improved water quality, reduction in noise, demonstration effect improved awareness among workers constituted other significant benefits. Improved health standards is indicated as a relatively less significant benefit.

Nature of new technology:

Both the above modifications of the ammonia plant are more environmentally friendly as less energy is consumed. No difference as such has been reported on the hazardous nature of the processes.

Process flow diagram:

Purge Gas Recovery Plant



CASE STUDY 3: GHARDA CHEMICALS LTD.

Description of Cleaner Technology Adoption:

The company produces agro-chemicals like Isoproturan and its formulations, cypermethric acid chloride [CMAC], cypermethrin & alphamethrin and oxyclozanide at its Dombivli plant. CT exercises undertaken by the company are:

- **Recovery of TCSA** : TCSA is one of the main raw materials for producing oxyclozanide at the plant. It is being completely recovered now with the introduction of steam distillation recovery system.

- **Recovery of DMA raffinate** : [raffinate is refined liquid oil produced by solvent extraction of impurities]. DMA raffinate off - gases are now completely recovered with the introduction of the compressor and purification system.

- **Recovery of organic waste:** Earlier the Organic waste generated during reduction of the impure nitrocumene had to be incinerated. Now crude nitrocumene is purified by continuous fractionation and the organic waste is recovered and sold as solvent

- **Recovery of unreacted iso- butylene and hexane** : Off - gases from the reaction which were earlier let off into the atmosphere are now recovered completely with the introduction of the compressor and purification system

- **Recovery of CMA:** CMA is completely recovered from the cypermethrin aqueous effluent, which was earlier going to the ETP. CMA recovery is done by cyanide destruction and pH adjustment.

COST BENEFIT ANALYSIS:

3.3.1 Recovery of TCSA:

Initial Investment Cost = nil

Land cost = nil

Construction cost = nil

Erection cost = Rs. 0.45 lakhs

Total Investment = Rs. 0.45 lakhs

Operation Cost

Maintenance cost = nil

Manpower cost = nil

Operation cost **=** nil

[The distillation unit consists of one reactor, one filter and a centrifuge which were all available as part of the production process. The recovery through distillation involved only the idle time and rescheduling and hence no costs were incurred. Initially however for the purpose of the erection, about three weeks of contract labour (15 workers) was involved.]

BENEFITS

Raw Material Savings :

Recovery of 0.0388 kg per kg of output resulted in savings of Rs. 9.68 lakhs

Net savings = Rs. 9.68 lakhs

Payback period ≈ 16.7 days

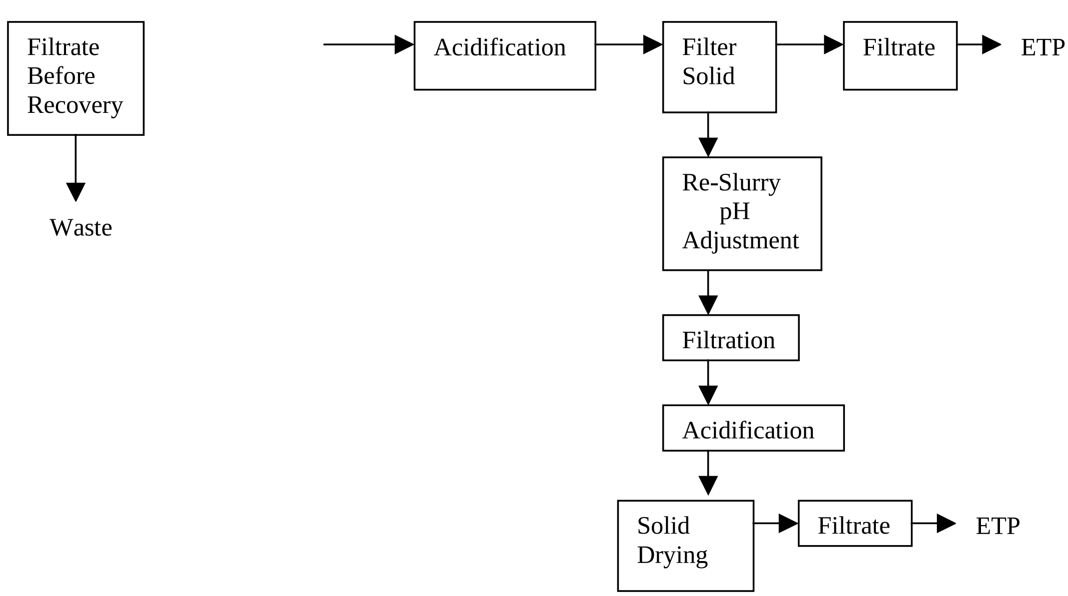
Waste measurement Index:

Before CT, WMI = $$\frac{0.0388}{0.0388 + 0 + 1} 100 = 3.74$$

After CT, WMI = $$\frac{0}{0 + 0.0388 + 1} 100 = 0$$

Process flow chart:

Before Implementation After Implementation



3.3.2 Recovery of DMA raffinate:

Investment Costs:

Initial Investment in equipment cost	= Rs.10 lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= Rs.10 lakhs
Operating Cost	
Maintenance	= Rs.0.90 lakhs
Energy cost	= Rs.16.74 lakhs
Manpower cost	= Rs. 4.5 lakhs
Total	= Rs. 32.14 lakhs

Benefits :

There is recovery of < 0.00035 kg per kg of output, which may not be significant. Attempts to arrive at values did not succeed. It appears the CT exercise may have been undertaken mainly for environmental reasons rather than economic ones. (check if it has resulted in decrease in costs or increase in the revenue!)

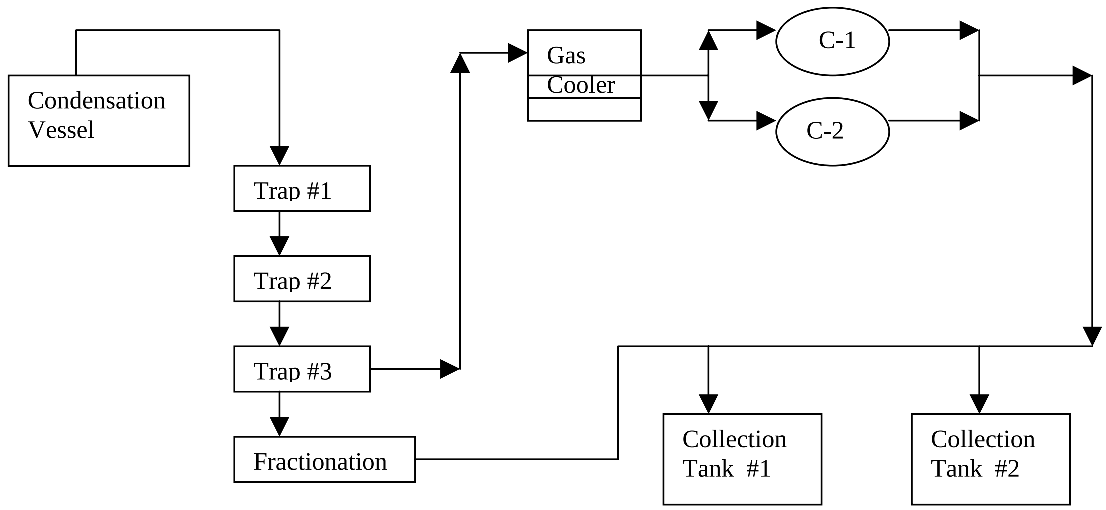
Waste measurement index:

$$\text{Before CT , WMI} = \frac{0.00035}{0.00035 + 0 + 1} 100 = 0.035$$

$$\text{After CT , WMI} = \frac{0}{0 + 0.00035 + 1} 100 = 0$$

Process flow chart:

Before Implementation After Implementation



3.3.3 Recovery of organic waste:

Investment Cost [Rs.]

Equipment	-	Rs. 3.5 crores
Land	-	nil
Construction	-	nil
Total Investment	-	Rs. 3.5 crores

Operating Cost [Rs.]

Maintenance	-	Rs. 4.5 lakhs
Energy	-	Rs. 8.5 lakhs
Man power	-	Rs. 6.3 lakhs
Total operating Cost	-	Rs. 19.3 lakhs

Benefits :

Value of recovered organic waste which is being sold as solvent is Rs. 91.58 lakhs.

Net Benefit = Rs. 72.28 lakhs

Payback period = 4.8 years [4 years and 10 months]

Based on the discussions with company sources, the life of the equipments is taken as 10 years and the cost of capital 15% and the NPV computed accordingly:

Present Value [PV]= Rs. 361.81 lakhs

NPV = Rs.11.81 lakhs

B/C ratio = 1.03

Waste measurement index:

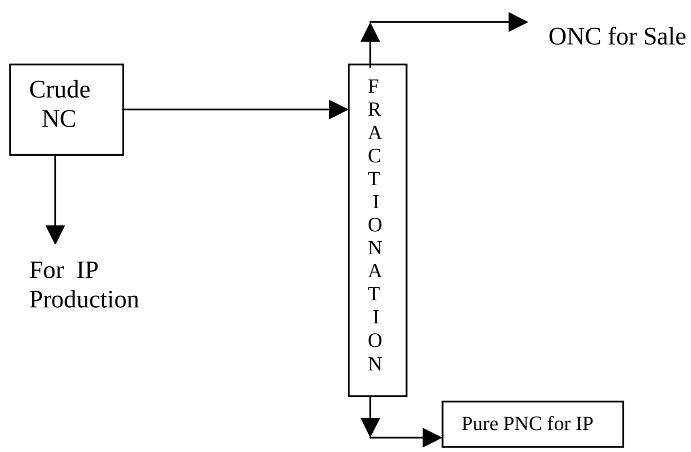
$$\text{Before CT , WMI} = \frac{0.33}{0.33 + 0 + 1} 100 = 24.8$$

$$\text{After CT , WMI} = - \frac{0}{0 + 0.33 + 1} 100 = 0$$

In this case, although the payback period appears to be relatively high ,there is complete elimination of waste and full recovery thus adding to the bottom line. Therefore, the investment of Rs.3.5 crores is fully justified.

Process flow chart:

Before Implementation After Implementation



3.3.4 Recovery of unreacted iso- butylene and hexane:

Unreacted iso- butylene and hexane [off gases] in the production of CMAC at plant 3 is compressed, purified and recovered by installing a 25 HP compressor

Investment Cost [Rs.]

Equipment	-	Rs. 2.00 lakhs
Land	-	nil
Construction	-	nil
Total Investment	-	Rs. 2.00 lakhs

Operating Cost [Rs.]

Maintenance	-	Rs. 0.50 lakhs
Energy	-	Rs. 5.00 lakhs
Man power	-	Rs. 4.50 lakhs
Total operating Cost	-	Rs. 10.00 lakhs

Benefits :

Pollutant load is reduced from 1980 kg per year [3 kg/ton of output] to **nil** now.

Net Benefit = Total reduction of pollutant load

Payback period is not quantifiable

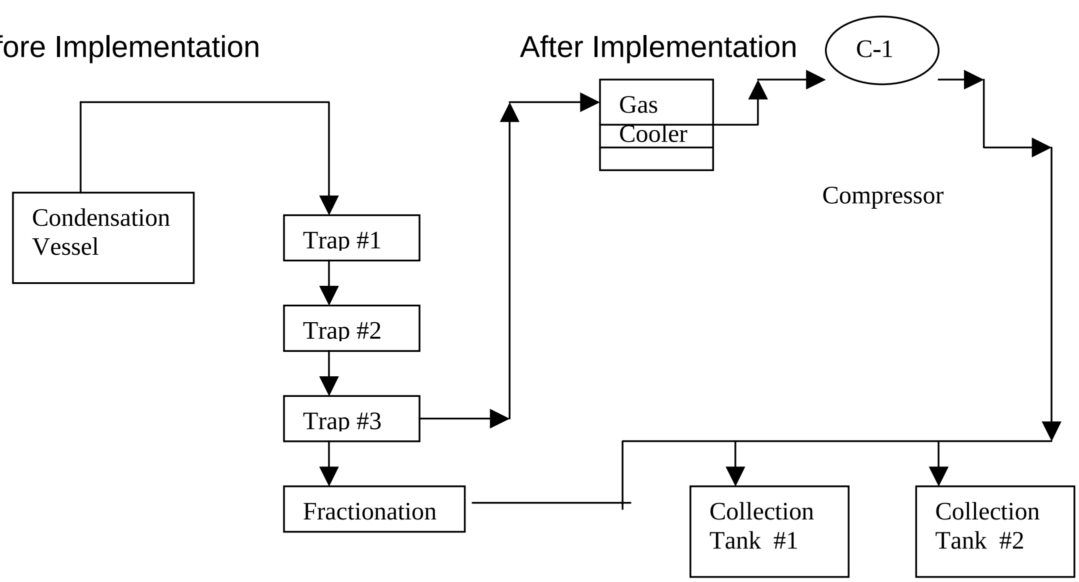
Waste measurement index:

$$\text{Before CT , WMI} = \frac{0.003}{0.003 + 0 + 1} 100 = 0.299$$

$$\text{After CT , WMI} = \frac{0}{0 + .003 + 1} 100 = 0$$

Process Flow chart:

Before Implementation After Implementation



3.3.5 Recovery of CMA:

Now there is complete recovery of CMA is completely recovered from the cypermethrin aqueous effluent, which was earlier going to the ETP. CMA recovery is done by cyanide destruction and pH adjustment.

Investment Cost [Rs.]

Equipment	-	Rs. 2.00 lakhs
Land	-	nil
Construction	-	nil
Total Investment	-	Rs. 2.00 lakhs

Operating Cost [Rs.]

Maintenance	-	Rs. 0.25 lakhs
Energy	-	Rs. 0.5 lakhs
Manpower	-	Rs. 1.8 lakhs
Total operating Cost	-	Rs. 2.55 lakhs

Benefits :

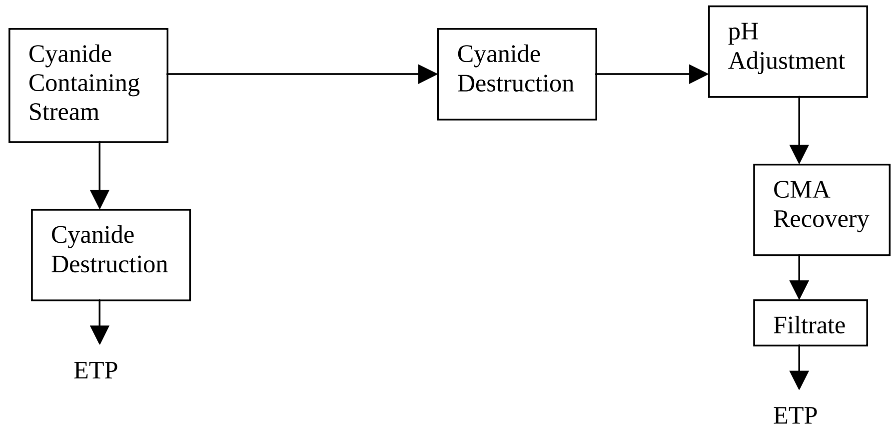
Net Benefit = Rs. 42.02 lakhs/ annum

Payback period = 18 days

The overall benefit seems to be in terms of raw material savings, energy and improved recovery to the extent of 5% each.

Process Flow chart:

Before Implementation After Implementation



Other Benefits:

As a result of further upgradation of the existing systems, the entire operation has now become more environmentally friendly. Consequently, very significant improvements are seen in health standards, safety standards, quality of air, water quality, awareness among workers and attitude towards industry. Reductions in noise and demonstration effect were the other significant benefits observed.

Nature of new Technologies:

1. The recovery of TCSA with the help of a distillation unit is less hazardous as in the present system the release of TCSA vapors is minimised.

2. The second modification reported is the recovery of DMA raffinate which is less hazardous and environmentally friendly

3. Recovery of organic waste which was earlier being incinerated. This is less hazardous as incineration is a process which can lead to various toxic gases if it is carried out without proper secondary air pollution control devices like scrubbers.

4. Recovery of unreacted iso butylene and hexane , earlier these were let off into the atmosphere. The present technolgy is much safer as these gases are being recovered with a compressor and purification system

5. CMA recovery is less hazardous again as the recovery is done by cyanide destruction and pH adjustment. Cyanide is one of the most hazardous substances.

DRIVING FORCES AND BARRIERS

Driving Forces

The ranking given be the industry sources have been weighted by the average scores assigned by 3 independent experts.Among the driving forces behind adoption of cleaner technologies, top management commitment ranked first, followed by government regulations and better safety & health. The other influencing factors revealed were risk aversion, efficiency drive, quality, market forces and image. The following table shows the ranking pattern.

Forces	Ranking	weights	Weighted ranks
Market forces	7	3.3	6
Image	8	3.7	8
Risk Aversion	4	4.3	4
Quality drive	6	4,3	7
Efficiency Drive	5	4.3	5
Top management commitment	1	3.3	1
Better safety and health	3	2.0	3
Government Regulations	2	1.7	2

Barriers

Among the barriers cited by the company while implementing CT were mainly public opinion, legislative approvals for modifications and employees resistance in that order. Public opinion has been perceived as a major barrier due to expectation regarding cleaner technology, employment availability and quality products at competitive costs. One may not, however, agree with this perception as the argument cuts both ways. The barriers cited may as well be the driving forces under certain circumstances.

As for the adoption of CT per se, there do not seem to be any problems.

NATURE	DESCRIPTION	INTENSITY				
		L	V.L	M	H	V.H
(a) Legislative			✓			
(b) Institutional						
(c Educational						
(d) Public Opinion					✓	
(e) Employees' resistance		✓				
(f) Others, specify						

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

TRAINING:

It appears, training has received high attention in the company, as is revealed by the table below. All types of training like awareness programs , technical training, training in environmental management systems have been undertaken. It is gratifying to note that the various training programs have covered different levels of employees ranging from shop floor, engineers to management.

Environmental awareness courses for management	✓
Environmental awareness courses for engineers	✓
Environmental awareness courses for shop floor staff	✓
Technical training for engineers	✓
Technical training for shop-floor staff	✓
Training in environmental management systems	✓
No formal training, all done on-the-job	--
Others, specify	--

Among the sources of training and information on cleaner technologies, in-house staff, external training organisations and conferences/seminar have been found very useful. This was followed by universities / R&D organisations, industry associations, suppliers of CT, consultants and journals / press. Sources like other companies and business and environmental networking have not been found useful by the company

CORPORATE CITIZENSHIP:

The firm scores high in respect of corporate citizenship as well. Most parameters such as extent of employee improvement, level of motivation towards cleaner technologies, shared vision and values, exposure to professional literature and latest developments, and sponsorship for long-term and short-term training programmes have been ranked high. In particular, in-house professionals, well-equipped R&D, and ongoing training programs such as ISO 9001 were found useful.

CASE STUDY 4: EID PARRY [1] LTD.

Description of Cleaner Technology Adoption:

The company produces pesticides such as endosulfan, Monocrotophos, fenvalerate and cypermethrin. The plant under study is situated at Thane Belapur Industrial belt in Navi Mumbai. From 1994 to 1998, three CT measures were carried out in the endosulfan plant.

3.4.1 Installation of Vent condensers:

In 1994, vent condensers using -12 degree centigrade, brine were installed in the endosulfan reactor 2 to reduce the vent loss of CTC solvent. This led to the recovery of 150 tons of CTC {i.e. 50% of what was used earlier annually}

3.4.2 Installation of Graphite Scrubber system:

The company was earlier spending Rs.10,000/day for neutralising the Hcl gas produced as a byproduct in the manufacture of endosulfan. To avoid this expenditure , the Graphite scrubber system was installed in 1995. It enabled the plant to recover 1000 tons of HCl gas as 30% HCl acid solution. Also, it has resulted in the effluent release by approximately 40%, i.e. from 10,500 kg/day to 6050 kg/day.

3.4.3 Substitution of CTC with Toluene:

In 1998, use of CTC as a solvent was substituted with the use of toluene in reactor 1 [at the first stage of operation]. While CTC is expensive, carcinogenic, ozone depleting and inflammable , Toluene is not. While 200 MT of CTC was used earlier, only 150MT of toluene is used now. This has led to substantial savings.

COST BENEFIT ANALYSIS:

3.4.1 Installation of Vent condensers:

Initial Investment Cost in Rs.

Equipment cost	= Rs. 10.5 lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= Rs. 10.5 lakhs

Operation Cost [Difference]

Maintenance cost	= nil
Manpower cost	= nil
Energy cost [additional]	**=** Rs. 2.3 lakhs
Water Cost	= nil

Total operating cost [additional] = Rs. 2.3 lakhs

Benefits: in Rs.

Solvent recovery Savings = Rs. 45 lakhs/year

Net Benefit = 42.7

Payback period = 2.95 months [< 3 months]

Waste measurement index:

Before CT , WMI = $\frac{0.15}{0.15 + 0 + 1}$ 100 = 13.04

After CT , WMI = $\frac{0.075}{0.075 + 0.15 + 1}$ 100 = 6.12

3.4.2 Installation of Graphite Scrubber system:

Initial Investment Cost in Rs.

Equipment cost = Rs. 15.6 lakhs

Land cost = nil

Construction cost = nil

Total Investment = Rs. 15.6akhs

Operating Cost

Maintenance cost = nil

Manpower cost = nil

Energy cost **=** nominal

Water Cost = nil

Total operating cost = nil

Benefits: in Rs.

Savings in Disposal cost = Rs. 33 lakhs

Earlier cost, before CT

@ 10,000/day

After CT it is nil

Net Benefit = Rs. 33 lakhs

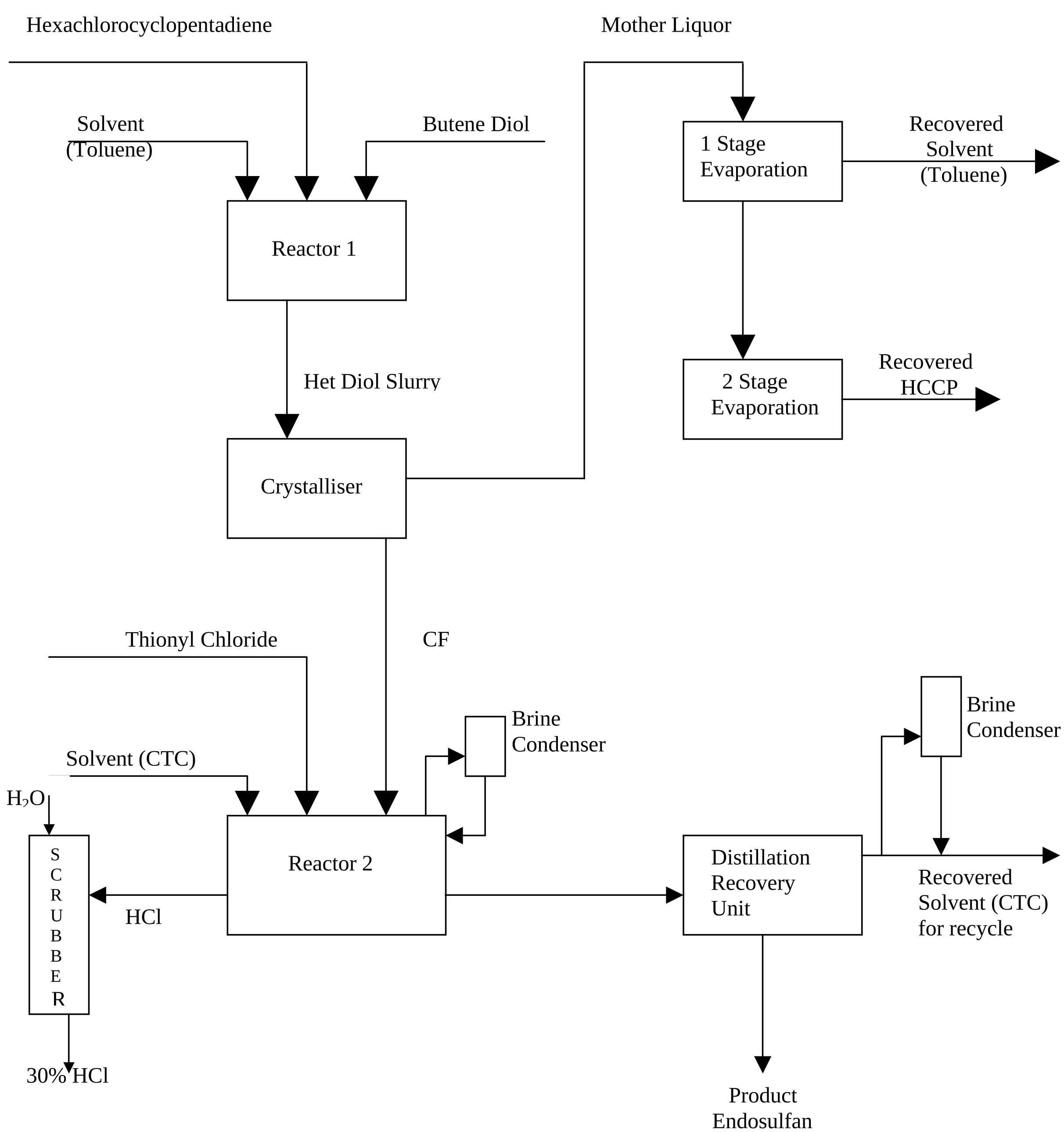
Payback period = 5.7 months [< 6 months]

Waste measurement index:

$$\text{Before CT, WMI} = \frac{0.173}{0.173 + 0 + 1} 100 = 14.76$$

$$\text{After CT, WMI} = \frac{0.099}{0.099 + 0.074 + 1} 100 = 8.44$$

Process Flow chart:



3.4.3 Substitution of CTC with Toluene:

Initial Investment Cost in Rs.

Equipment cost	= nil
Land cost	= nil
Construction cost	= nil
Total Investment	= nil

Operation Cost

Maintenance cost	= nil
Manpower cost	= nil
Energy cost	**=** nominal
Water Cost	= nil
Total operating cost	= nil

Benefits: in Rs.

Solvent recovery Savings:

Cost of 200MT of CTC	= Rs. 60 lakhs
Cost of 150MT of toluene	= Rs. 22.5 lakhs
Savings /annum	= Rs. 37.5 lakhs

Net Benefit = Rs. 37.5 lakhs

Payback period = A few weeks [installation time]

Consequent upon CT implementation, there have also been capacity improvements in the endosulfan plant from 3.3million tons to 5.5 million tons per annum in addition to the reduction in the pollutant load, cost of waste disposal, savings from raw material substitution and savings from loss reduction of CTC. Moreover, there was no down- time in the operations and hence no interruptions/production loss.

Other Benefits:

Demonstration effect has been found to be very significant as a result of CT implementation. Significant improvements are also seen in health standards, safety standards, quality of air, and awareness among workers. However, no improvements have been observed in respect of water quality and noise levels.

Nature of New Technology :

a. Installation of vent condensors has led to the recovery of 150 tons of toxic CTC. Hence it is less hazardous

b. Installation of the graphite scrubber system is another example of a safer technology as it recovers 1000 tons of HCL gas as 30% HCL solution. The effluent generation has also reduced from 10,500 kgs/day to 6050 kgs/day.

c. Substitution of CTC with Toluene , this solvent substitution is comparatively safer as though toluene is also hazardous , CTC is more hazardous, carcinogenic and inflammable.

DRIVING FORCES AND BARRIERS

Driving Forces

The ranking given by the company sources have been weighted by the average of the scores assigned by three independent experts to obtain the weighted ranks. Among the driving forces behind adoption of cleaner technologies, top management ranked first, followed by better safety and health, and Government regulations in that order. The other influencing factors revealed were efficiency drive, Image, Market forces, risk aversion, quality. Other factors cited by the company are mounting cost of raw materials, energy, water and the concern for waste minimisation. The following table shows the ranking pattern.

Forces	Ranking	Weights	Weighted ranks
Market forces	6	3.3	6
Image	5	3.7	5
Risk Aversion	7	4.3	7
Quality drive	8	4,3	8
Efficiency Drive	3	4.3	4
Top management commitment	1	3.3	1
Better safety and health	2	2.0	2
Government Regulations	4	1.7	3

Barriers

The company did not face any barrier in the implementation of CT.

NATURE	DESCRIPTION	INTENSITY				
		L	V.L	M	H	V.H
(a) Legislative						
(b) Institutional						
(c Educational						
(d) Public Opinion						
(e) Employees' resistance						
(f) Others, specify						

L=low, V.L=very low, M=moderate, H=high, V.H=very high

As for the adoption of the CT itself, problems cited were pressure for short-term returns on investment, lack of strategic approach to environmental issues and lack of commitment from middle management.

TRAINING:

When it comes to training , no formal training has been undertaken by the company. By and large, it has been confined to on- the- job training.

Environmental awareness courses for management	-
Environmental awareness courses for engineers	-
Environmental awareness courses for shop floor staff	-
Technical training for engineers	-
Technical training for shop floor staff	-
Training in environmental management systems	-
No formal training, all done on-the-job	✓
Others, specify	-

Among the sources of training and information on cleaner technologies, in house staff, have been found very useful. This was followed by Industry associations, conferences and seminars.. Other external sources have not been found useful. No recourse is taken to the practice of hiring consultants.

CORPORATE CITIZENSHIP:

The firm scores very high in respect of corporate citizenship as well. Most parameters such as extent of employee improvement, level of motivation towards cleaner technologies, shared vision and values, and sponsorship for long term and short-term training programmes have been ranked very high. As for exposure to professional literature and other latest developments, it has been assigned a medium rank.

CASE STUDY 5: KNOLL PHARMACEUTICAL LTD.

Description of Cleaner Technology Adoption:

The firm produces drugs like ibuprofen tablets, antacid liquids and laxative liquids, with annual production capacities of 1320 million tablets and 4,500kl respectively. The liquid plant was set up in June 1996 whereas the tablet plant was set up in April, 1999. Products are sold in domestic as well as export markets. Two CT measures have been adopted, one in the tablet plant in April 1999, and the other in the liquid plant in May 2000. The plant is located in Verna, Goa.

3.5.1 Tablets Plant:

In the tablet processing stage, conventional coating pans were replaced by neocota coating systems resulting in aqueous coating of tablets in place of

Isopropyl alcohol. (IPA) based coating solution. Consequently, the IPA emission has been eliminated. Moreover, by way of direct benefit to the company it has resulted in raw material savings of Rs.25 lakhs/annum as neocota coating system is cheaper than IPA solution.

COST BENEFIT ANALYSIS:

3.5.1 Tablets Plant:

Initial Investment Cost in Rs.

Equipment cost	= Rs. 1.35 crores
Land cost	= nil
Construction cost	= nil
Total Investment	= Rs. 1.35 crores

Operation Cost [Difference]

Maintenance cost	= nil

Manpower cost = nil

Energy cost **=** nil

Water Cost = nil

Total operating cost = nil

Benefits: in Rs.

Raw material

Savings/annum = Rs. 25 lakhs

Net Benefit = Rs. 25 lakhs

Payback period = 5.4 years

In general, the industry practice is to assume the life of equipments as 10 years and the cost of capital is 15%. The NPV has been computed on this basis:

Present Value [PV] = Rs.125.47 lakhs

NPV = -Rs. 9.53 lakhs

B/C ratio = 0.93

Waste measurement index:

The IPA emissions waste is 260mg/m3 for 842 million tablets. For the purpose of computing WMI we have taken one million tablets as the unit.

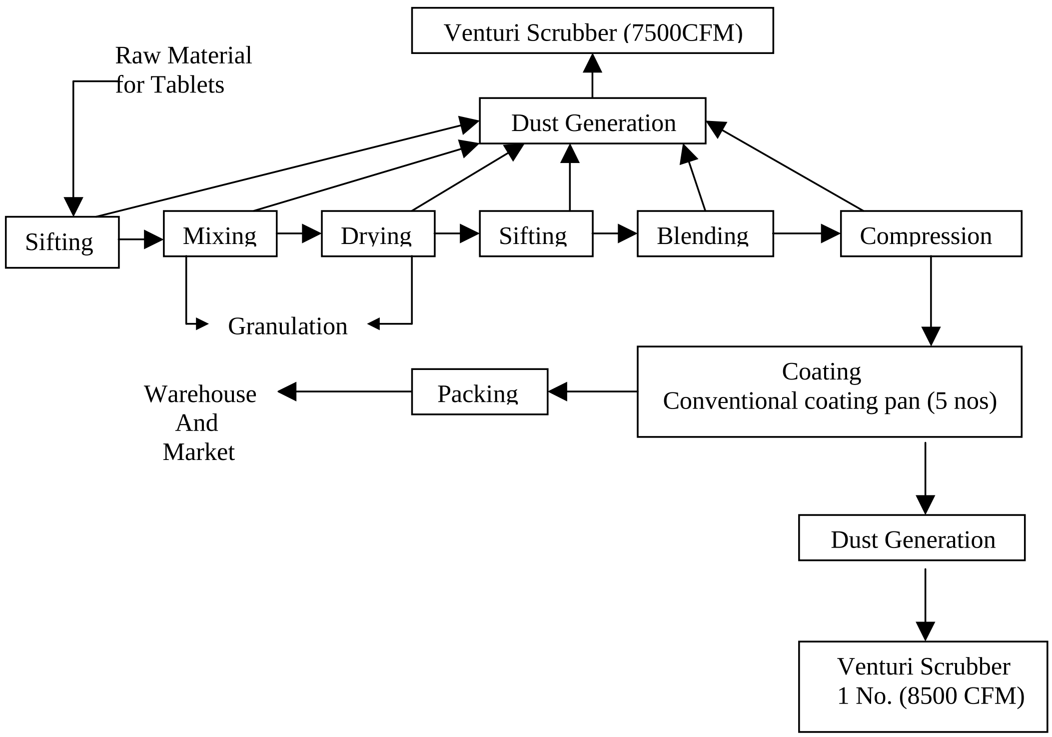
$$\text{Before CT, WMI} = \frac{0.309}{0.309 + 0 + 1} \quad 100 = 23.6$$

$$\text{After CT, WMI} = \frac{0}{0 + 0 + 1} \quad 100 = 0$$

Process flow chart:

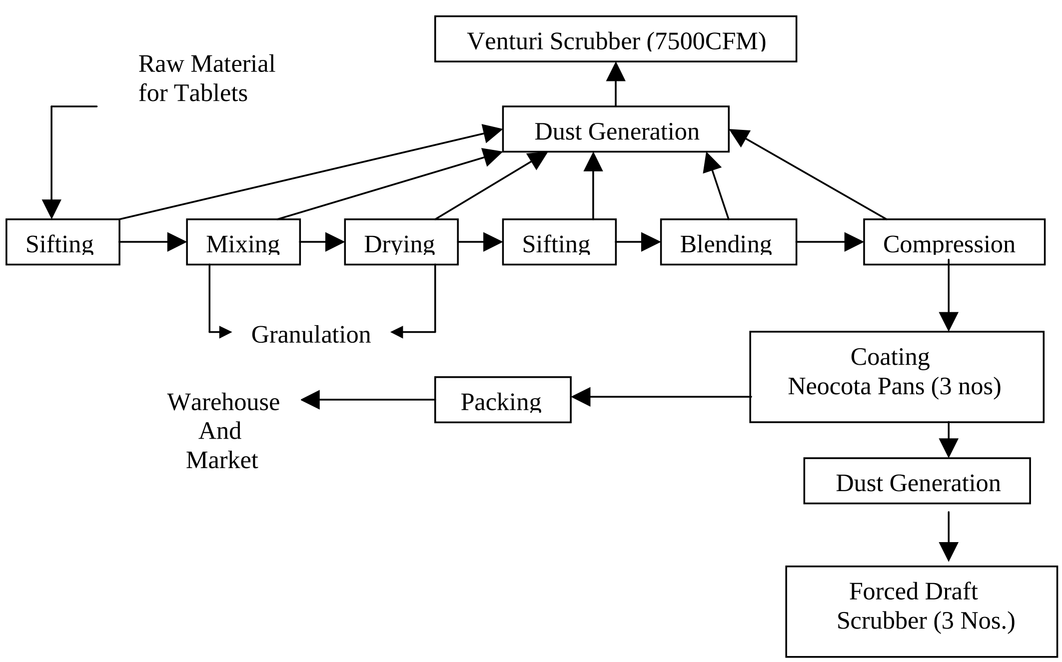
Production of tablets-old technology

1.Coating process is isopropyl alcohol based
2.common scrubbers for all coating pans



Production of tablets-new technology

1.Coating process is water based
2.Coating in closed Neocota pans & separate scrubbers for each pan



3.5.2 Liquids plant:

In the processing stage, bottle washing machine wastewater is now being used as makeup water for the cooling towers. This is basically a recycling/recovery exercise.

COST BENEFIT ANALYSIS:

3.5.2 Liquids Plant:

Initial Investment Cost in Rs.

Equipment cost	= Rs. 0.6 lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= Rs. 0.6 lakhs

Operation Cost [Difference]

Maintenance cost	= nil
Manpower cost	= nil
Energy cost	= nil
Water Cost	= nil
Total operating cost	= nil

Benefits: in Rs.

Water savings [7600 kl/annum]

Savings/annum	= Rs. 2 lakhs
Net Benefit	**= Rs. 2 lakhs**
Payback period	**= 3.6 months**

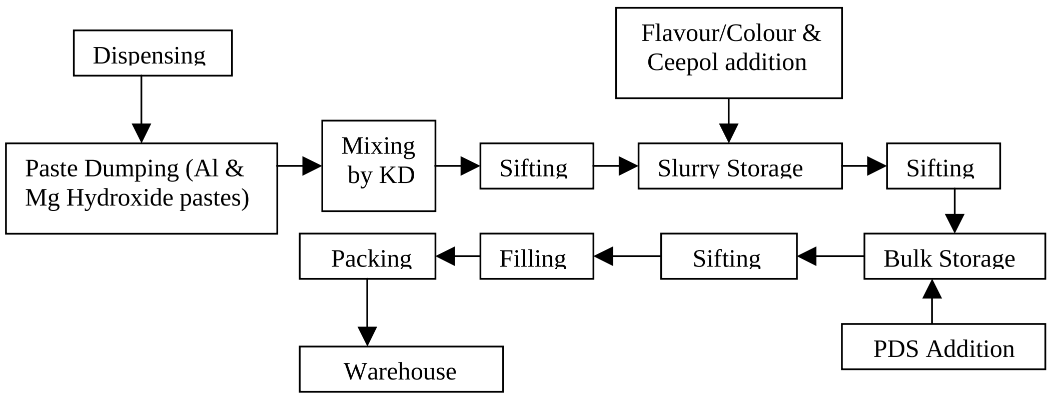
Waste measurement index:

$$\text{Before CT, WMI} = \frac{2.46}{2.46 + 0 + 1} \; 100 = 71.1$$

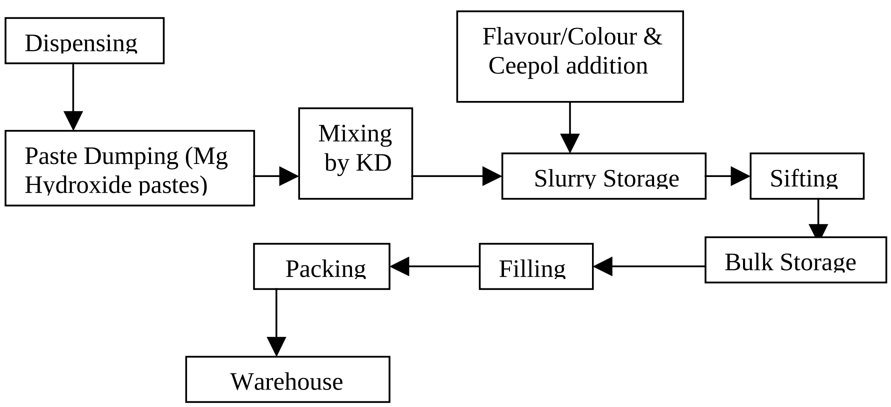
$$\text{After CT, WMI} = \frac{0}{0 + 0 + 1} \; 100 = 0$$

Overall, there have been substantial savings in raw materials and water use . Also there has been reduction in the pollutant load and wastage. Further, the operational safety has improved.

Process flow chart: for production of liquids-antacids:



Process flow chart: for production of liquids-laxatives:



Other Benefits:

There has not been perceptible impact on the health of the employees as IPA emissions were did not emanate at the work place. The IPA emissions were exhausted and passed through scrubber earlier. Despite such a perception by the management, it would be proper to infer that the total elimination of emissions goes only to contribute in improving health standards. By way of other benefits, it has been observed that there have been improvements in safety standards and quality of air in addition to reduction in noise. The relative importance of these factors however, has not been indicated.

DRIVING FORCES AND BARRIERS

Driving Forces

The ranking given by company sources have been weighted by the average scores given by three independent experts and the weighted ranks arrived at. Among the driving forces behind adoption of cleaner technologies, safety and health considerations scored the highest rank followed by top management commitment and government regulations. The other driving forces were risk aversion, efficiency drive, quality, image and market forces in that order.

Forces	Ranking	Weights	Weighted ranks
Market forces	8	3.3	8
Image	7	3.7	7
Risk Aversion	3	4.3	4
Quality drive	6	4,3	6
Efficiency Drive	4	4.3	5
Top management commitment	2	3.3	2
Better safety and health	1	2.0	1
Government Regulations	5	1.7	3

Barriers

The company did not face any barrier in the implementation of CT.

ATURE	DESCRIPTION	INTENSITY				
		L	V.L	M	H	V.H
(a) Legislative	–					
(b) Institutional	–					
(c Educational	–					
(d) Public Opinion	–					
(e) Employees' resistance	–					
(f) Others, specify	–					

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

As for the adoption of the CT itself, no problems were reported.

TRAINING:

No useful information was reported.

CASE STUDY 6: JOHNSON & JOHNSON LTD.

Description of Cleaner Technology Adoption:

Company is engaged in the production of health care products such as baby oil, baby cream, baby powder, adhesive dressings and sanitary products. The plant is situated in Mulund, Mumbai.

By way of CT exercise, the company has replaced the reciprocating air compressor with a screw compressor in October, 1996. The latter consumes less energy and hence results in substantial savings.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= 5.4 lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= 5.4 lakhs

Operation Cost [Difference]

Maintenance cost	= nil
Manpower cost	= nil
Energy cost	= nil
Water Cost	= nil
Total operating cost	= nil

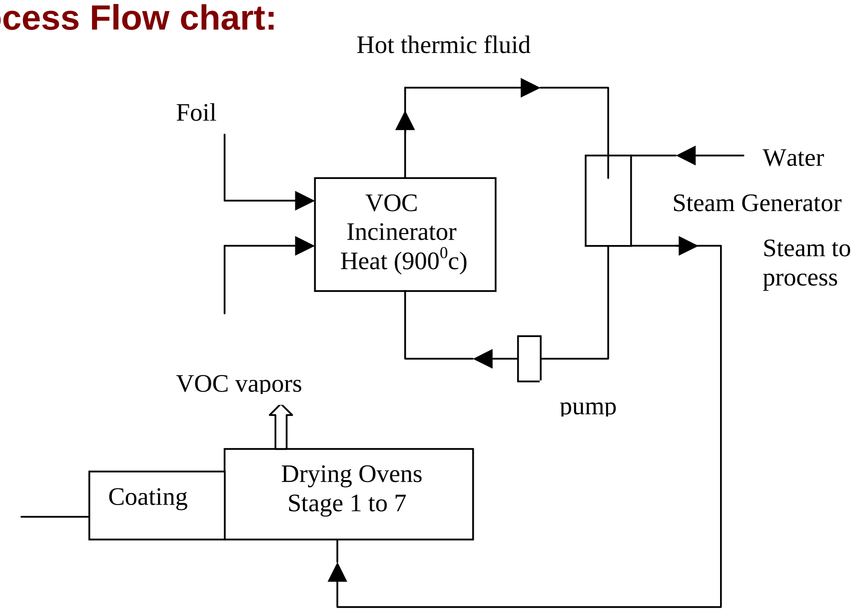
Benefits: in Rs.

Energy savings 55,785KWh	
@ Rs.3.75	= 2.09 lakhs
Net Benefit	**= 2.09 lakhs**
Payback period	**= 2.6 years [2 years and 7 months]**

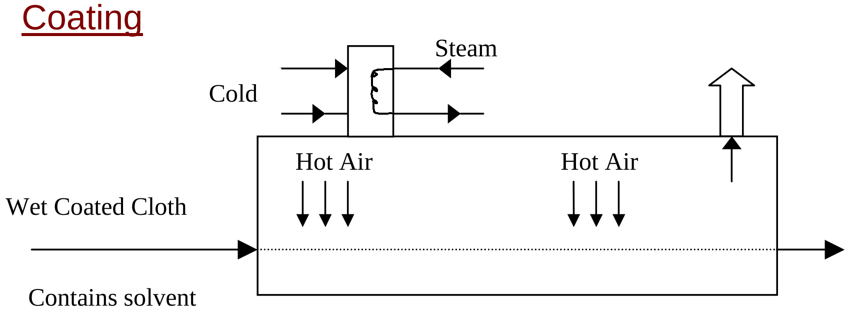
Waste measurement index:

Not applicable

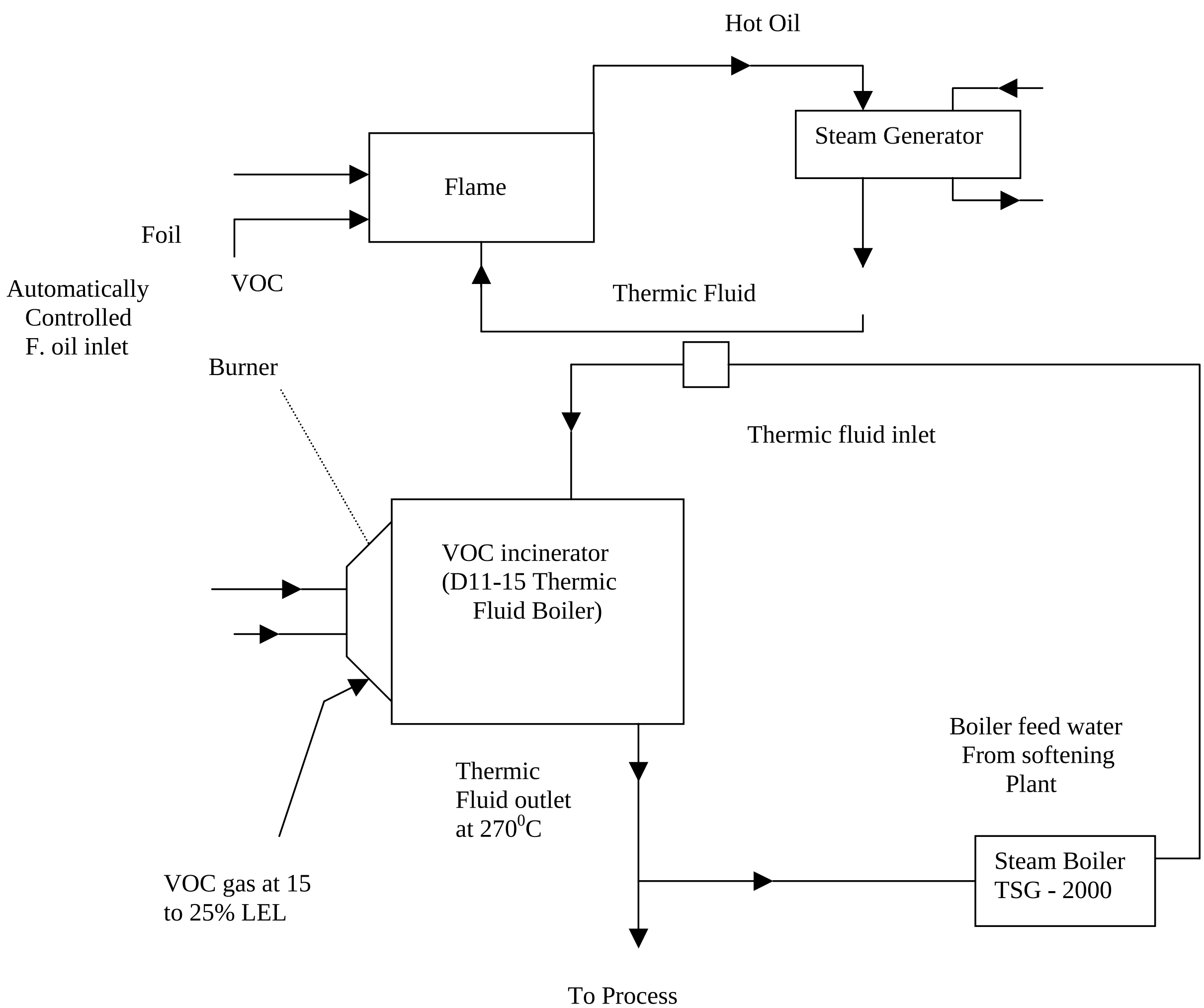
Process Flow chart:



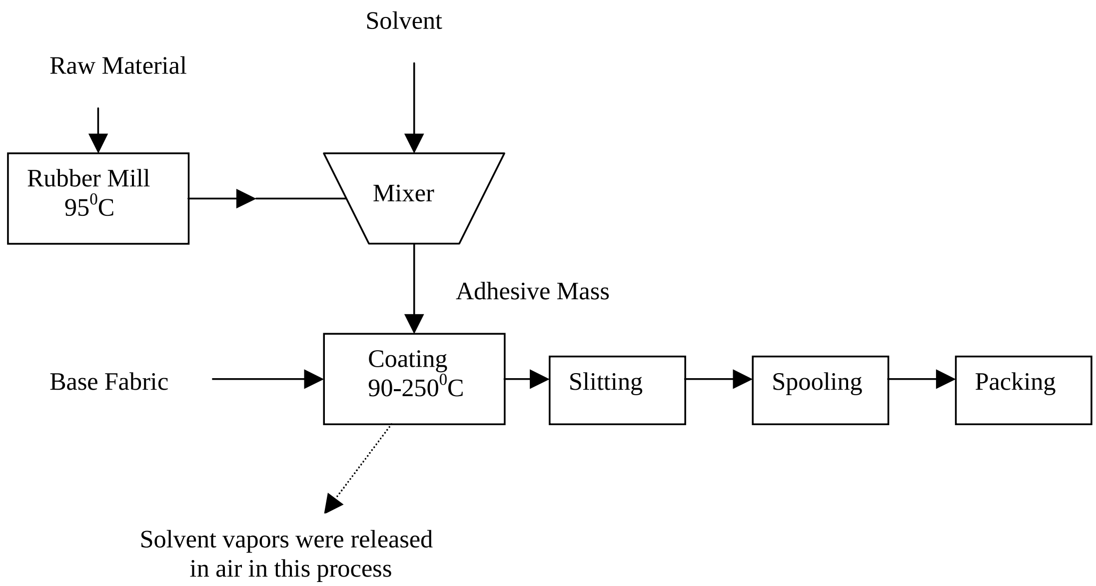
Coating



VOC Incinerator / Boiler



Surgical Plaster



Other Benefits:

The only benefit reported is improved awareness among workers, which is considered very significant by the company

Nature of New Technology :

a. The present technology is cleaner and less hazardous as Isopropyl emissions are eliminated

b. In the liquids plant the bottle washing machine waste waters is now being used as makeup water for the cooling plant. This is an ecofriendly change as water is conserved. It has no implication on the degree of hazard in the process.

DRIVING FORCES AND BARRIERS

Driving Forces

The ranks given by company sources have been weighted by the average of the scores assigned by the three independent experts and the weighted ranks computed. Among the driving forces behind adoption of cleaner technologies, top management ranked first, followed by better safety and health and government regulations in that order. The fourth rank goes to efficiency drive followed by image, market forces, risk aversion and quality drive

Forces	RANKING	Weights	Weighted ranks
Market forces	6	3.3	6
Image	5	3.7	5
Risk Aversion	7	4.3	7
Quality Drive	8	4,3	8
Efficiency Drive	3	4.3	4
Top management commitment	1	3.3	1
Better safety and health	2	2.0	2
Government Regulations	4	1.7	3

Barriers

The company did not face any barrier in the implementation of CT.

NATURE	DESCRIPTION	INTENSITY				
		L	V.L	M	H	V.H
(a) Legislative						
(b) Institutional						
(c Educational						
(d) Public Opinion						
(e) Employees' resistance						
(f) Others, specify						

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

As for the adoption of the CT itself, problems cited were pressure for short term returns on investment, lack of strategic approach to environmental issues and lack of commitment from middle management.

TRAINING:

When it comes to training, no formal training has been undertaken by the company. By and large, it has been confined to on- the- job training.

Environmental awareness courses for management	
Environmental awareness courses for engineers	
Environmental awareness courses for shop floor staff	
Technical training for engineers	
Technical training for shop floor staff	
Training in environmental management systems	
No formal training, all done on-the-job	✓-
Others, specify	--

Among the sources of training and information on cleaner technologies, in-house staff, have been found very useful. This was followed by industry associations, conferences and seminars.. Other external sources have not been found useful. No recourse is taken to the practice of hiring consultants.

ORGANIZATIONAL CITIZENSHIP:

The firm scores very high in respect of organizational citizenship as well. Most parameters such as extent of employee improvement, level of motivation towards cleaner technologies, shared vision and values, and sponsorship for long-term and short-term training programmes have been ranked very high. As for exposure to professional literature and other latest developments, it has been assigned a medium rank.

CASE STUDY 7: ELDER PHARMACEUTICALS LTD.

Description of Cleaner Technology Adoption:

This firm is located in Nerul, Navi Mumbai. The main product is formulation capsules[like Ampicillin, Amoxycillin, cloxacillin, I-vitamin].

Installation of the AF-40 automatic capsulation machine *:*

In the earlier semi-automatic filling machine, 5 persons were required for each machine, [one for loading empty capsule loading on plate, one for powder filling in capsule, one for rectifying empty capsule plate, two for inspection and polishing of filled capsules]. Formerly, there were 4 semi-automatic machines, which are replaced by three automatic machines.

After the automatic machine was installed in February 2000, capsule loading, rectification and polishing and inspection have all become automatic and only person is required to oversee these tasks. Additionally, the quality of filled capsules and yield have improved. Also, now that the machine is fully covered with fibre glass , workers are not exposed to the powder. The environment is also that much cleaner.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= 1 crore
Land cost	= nil
Construction cost	= nil
Total Investment	= 1 crore

Operation Cost [Difference]

Raw Material cost	
Maintenance cost	= nil
Manpower cost	
[Reduction in manpower	= -7. 56 lakhs/annum
Energy cost	= nil
Water Cost	= nil
Total operating cost	= -7.56 lakhs/annum

Benefits: in Rs.

Raw material savings = 8.385 lakhs

[Avoidance of granulation,

Avoidance of excipients like DCP,

Ethyl cellulose and IPA, cost of empty capsules saved]

Savings due to reduction rate by 1% = 9.72 lakhs

Energy savings = nil

Net Benefit = 25.665 lakhs

Payback period = 3.9 years

[The pay back period should in fact be shorter as there is improvement in the rejection rate by 1% during the production of antibiotics which is not quantified because of the erratic output of antibiotics being excessively dependent on hospital orders.]

In general, industry practice is to take the life of the equipment as 10 years and the cost of the capital 15%. On this basis the NPV has been worked out:

Present Value[PV] = Rs. 128.81 lakhs

NPV = Rs.28.81 lakhs

B/C ratio = 1.29

Waste measurement index :

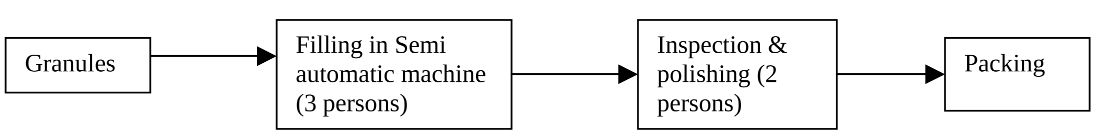
$$\text{Before CT , WMI} = \frac{0.02}{0.02 + 0 + 1} 100 = 1.96$$

$$\text{After CT , WMI} = \frac{0.01}{0.01 + 0 + 1} 100 = 0.99$$

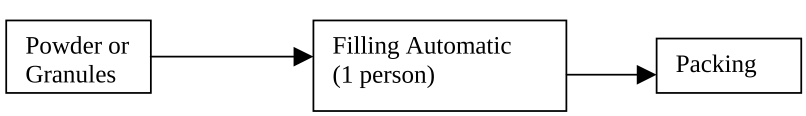
Thus there is improvement in the Waste management to the extent of 50%

Process Flowchart:

Earlier



Present



Other Benefits:

Workers were earlier exposed to capsulation dust and were using masks, though they had no complaints on health grounds. However, there was some possibility of developing resistance to antibiotics due to frequent exposure to antibiotic dust.

The other benefits reported very significant are improvement in quality of air due to elimination of the flying dust. This is followed by improved safety standards, demonstration effect and improved awareness among workers, which are considered significant. The other benefits reported as somewhat significant are improved water quality, reduction in noise and improved health standards.

Nature of New Technology:

The new modification in this unit involved the installation of a AF-40 fully automatic capsulation machine in place of a semi automatic machine. The present machine is fully covered with fibre glass as a result of which there is no dust exposure to the workers. This is less hazardous as the workers are not exposed to dust.

DRIVING FORCES AND BARRIERS

Driving Forces

The ranking assigned by company sources have been weighted by the average of the scores given by three independent experts and the weighted ranks obtained.Among the driving forces behind adoption of cleaner technologies, better safety and health ranked first, followed by quality, regulations, efficiency drive, Image, top management commitment and risk aversion in that order.

Driving Forces	Ranking	Weights	Weighted ranks
Market forces	-	3.3	-
Image	4	3.7	5
Risk Aversion	6	4.3	7
Quality Drive	1	4.3	2
Efficiency Drive	3	4.3	4
Top management commitment	5	3.3	6
Better safety and health	2	2.0	1
Government Regulations	7	1.7	3

Barriers

The company reported employee resistance as the only barrier in the medium category while implementing CT.

NATURE	DESCRIPTION	INTENSITY				
		L	V.L	M	H	V.H
(a) Legislative	_					
(b) Institutional	_					
(c Educational	_					
(d) Public Opinion	_					
(e) Employees' resistance	_			✔		
(f) Others, specify	_					

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

As for the adoption of the CT itself, problems cited were lack of capital for investment and pressure for short-term returns on investment.

TRAINING:

As for training , environmental awareness courses and technical training were undertaken for the shop-floor staff.

Environmental awareness courses for management	
Environmental awareness courses for engineers	
Environmental awareness courses for shop floor staff	✔
Technical training for engineers	
Technical training for shop floor staff	✔
Training in environmental management systems	-
No formal training, all done on-the-job	-
Others, specify	--

Among the sources of training and information on cleaner technologies suppliers of CT have been found very useful by the company. Also found useful are in-house staff, industry associations other companies and conferences and seminars. Sources like consultants, business & environmental networks and the journals/media were not found useful. It is also reported that no recourse was made to sources like universities/R&D organisations and external training organisations.

CORPORATE CITIZENSHIP:

The firm fares reasonably well in respect of corporate citizenship as revealed by the high ranking assigned to shared vision/values and level of motivation towards CT. The extent of improvement of employees has been given a medium rank. Lastly exposure to professional literature /other latest developments and sponsorship for short - term/long - term training programmes have been ranked very low.

CASE STUDY 8 : RPG LIFE SCIENCES LTD:

Description of Cleaner Technology Adoption:

RPG Life Sciences is located in Navi Mumbai, along the Thane Belapur Road. The company manufactures 15 items in the bulk drugs category.

Installation of Membrane Diffuser Technology:

The air grid system was used earlier in the biodegradation of liquid effluents. Now it has been replaced by the membrane diffuser. In the air grid system, there was no even distribution of air and also there was a problem of choking of pores through which air is passed resulting in air loss. In the latest technology adopted, i.e. membrane diffuser, there is even distribution of air and only one roots blower is needed as against 2 in air grid system. Also, there is no choking problem. The new System Maintains required dissolved oxygen in the treated effluent. Consequently there is energy saving.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= 3 lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= 3 lakhs

Operation Cost [Difference]

Raw Material cost = nil

Maintenance cost = nil

Manpower cost = nil

Energy cost **= -**2.10 lakhs

Water Cost = nil

Total operating cost = -2.10 lakhs/annum

Benefits: in Rs.

Raw material savings = nil

Energy savings = 2.10 lakhs /annum

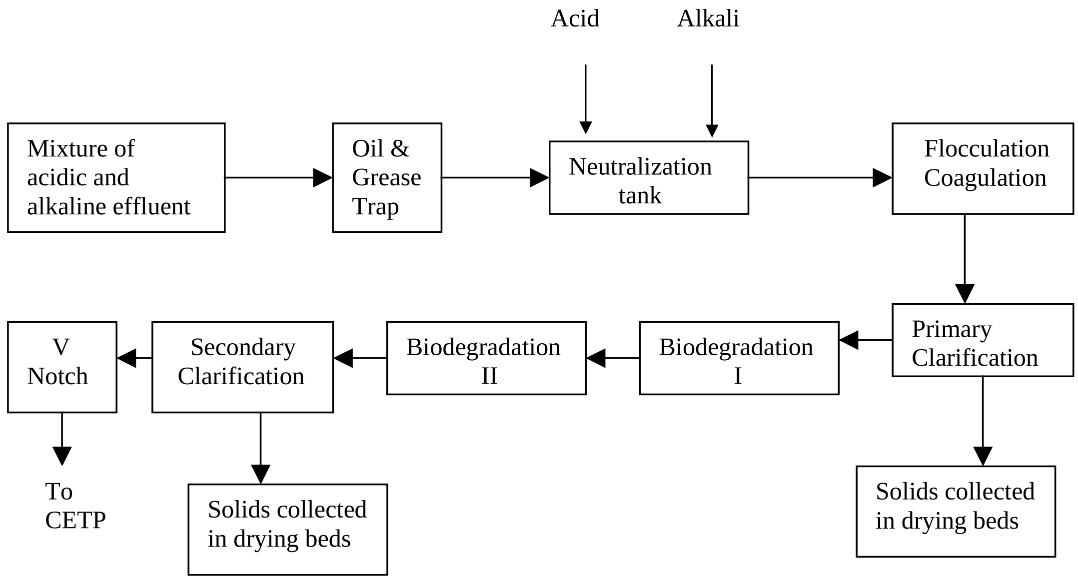
Net Benefit = 2.10 lakhs

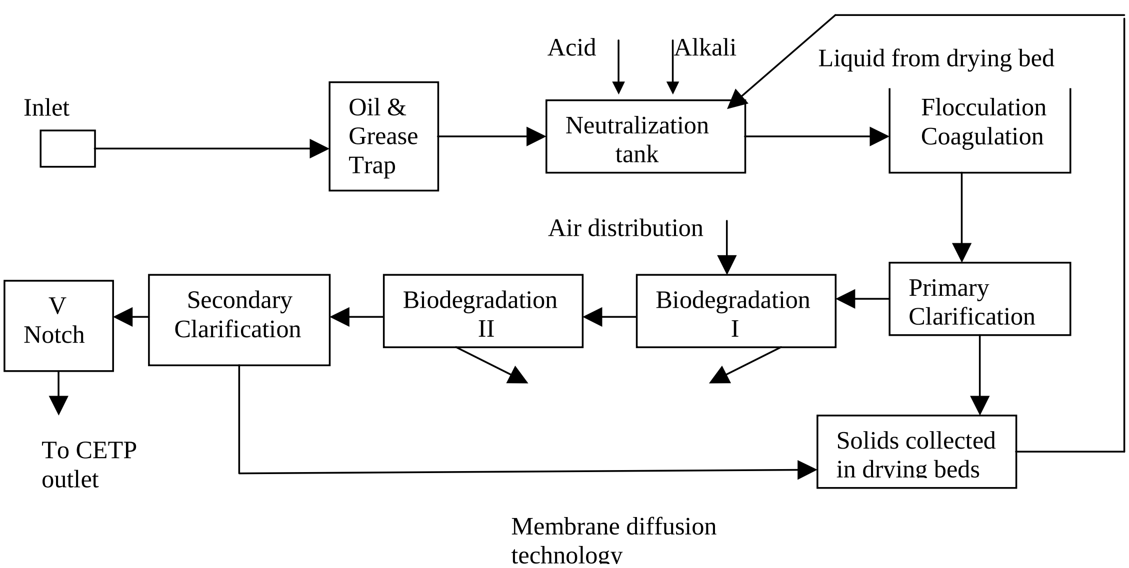
Payback period = 1.43 years [17 months]

Waste measurement index:

Not applicable

Process Flowchart:
RPG Life Sciences





Other Benefits:

The other economic benefits reported are improved awareness among workers, which is considered very significant. Next, demonstration effect has been reported as significant. The company did not report any other benefit.

Nature of New Technology:

Installation of membrane diffusor technology involves only a change in the aeration process and does not affect the hazardous nature in any way , as this leads to energy savings it is ecofriendly.

DRIVING FORCES AND BARRIERS

Driving Forces

The ranking given by company sources have been weighted by the average of the scores assigned by three independent experts and the weighted ranks have been obtained. Among the driving forces behind adoption of cleaner technologies top management commitment ranked first followed by image and efficiency drive. No mention is made regarding the other forces.

Forces	Ranking	Weights	Weighted ranks
Market forces	-	3.3	-
Image	2	3.7	2
Risk Aversion	-	4.3	-
Quality Drive	-	4.3	-
Efficiency Drive	1	4.3	1
Top management commitment	3	3.3	3
Better safety and health	-	2.0	-
Government Regulations	-	1.7	-
Others	-		-

Barriers

The company reported no barriers while implementing CT.

NATURE	DESCRIPTION	INTENSITY				
		L	V.L	M	H	V.H
(a) Legislative	_					
(b) Institutional	_					
(c Educational	_					
(d) Public Opinion	_					
(e) Employees' resistance	_			✔		
(f) Others, specify	_					

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

As for the adoption of the CT itself, problems cited were none.

TRAINING:

All types of training listed below were carried out at various levels.

Environmental awareness courses for management	✔
Environmental awareness courses for engineers	✔
Environmental awareness courses for shop floor staff	✔
Technical training for engineers	✔
Technical training for shop floor staff	✔
Training in environmental management systems	✔
No formal training, all done on-the-job	✔
Others, specify	--

Among the sources of training and information on cleaner technologies suppliers of CT and consultants have been found very useful by the company. Also found useful are in-house staff, industry associations other companies , external training organisations and conferences & seminars, Journals & media. Finally , in the not useful category business/environmental networks and Universities/R&D organisations were cited.

CORPORATE CITIZENSHIP:

The firm fares very well in respect of corporate citizenship as revealed by the very high ranking assigned to shared vision/values. High rank was assigned to factors like the extent of improvement of employees, level of motivation towards CT, exposure to professional literature/other latest developments and sponsorship for short -term and long - term training programmes.

3.2 Gujarat: Case Studies From Gujarat:-

CASE STUDY 1: A&M LTD.

Description of Cleaner Technology Adoption:

A&M Ltd. is situated in Valsad. Their main products are agrochemicals namely phorate technical, malathion technical, Temephos, phorate 10G, Cythion EC, Temephos EC. They are sold in domestic as well as export markets

CT exercises were carried out in Temephos and Phorate product lines. While in the former Solvent usage was reduced by eliminating the dead pockets in pipe lines and equipments, in the latter, primary pack is being changed from HMHD to trilaminated pouch. Existing filling machines were replaced by new ones.

Temephos product line:

Solvent usage was reduced by eliminating the dead pockets in pipelines and equipments.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= nil
Land cost	= nil
Construction cost	= nil
Total Investment	= nil

Operation Cost [Difference] in Rs.

Raw Material cost = 90.000

[earlier it was 4,50,000/annum which is now reduced to 3,60,000/annum]

Maintenance cost	= nil
Manpower cost	= nil
Energy cost	= nil
Water Cost	= nil
Disposal cost	= 54,000

[reduced from 90,000/annum earlier to 36,000/annum now]

Total operating cost difference = 1,44,000

Benefits: in Rs.

Raw material savings	= 90,000
Savings in disposal cost	= 54,000
Net Benefit	**= 1,44,000**
Payback period	**= Immediate**

Waste measurement index:

$$\text{Before CT , WMI} = \frac{0.075}{0.075 + 0 + 1} \quad 100 = 6.98$$

$$\text{After CT, WMI} = \frac{0.06}{0.06 + 0 + 1} \quad 100 = 5.66$$

The waste measurement index has come down to some extent. Overall, there has been some savings in raw materials as also reduction in the disposal cost. However since there is no investment whatsoever, the benefits accrued go only to add to the bottom line.

Phorate 10G product line :

Primary pack is being changed from HMHD to trilaminated pouch. Existing filling machines were replaced by new ones.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= 20 lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= 20 lakhs

Operation Cost [Difference] in Rs.

Raw Material cost	= nil
Maintenance cost	= nil
Manpower cost	= 20,00,000

[Before CT - 50.00,000

After CT - 30,00,000]

Energy cost **=** 39,600

[Before CT - 2,37,600

After CT - 1,98,000]

Water Cost = nil

Disposal cost = nil

Total operating cost difference = 20,39,600

Benefits: in Rs.

Energy savings = 39,600

Savings in Manpower = 20,00,000

Net Benefit = 20,39,000

Payback period = 0.98 year [< one year]

Waste measurement index:

Not applicable

Overall, the benefits have been substantial due to change of packaging material as well as the filling machines. Also, earlier there was spillage due to leaky bags and odour during long storage both of which are now avoided.

In the case of pesticide, even during transportation leakage could be hazardous especially during monsoon.

Other Benefits:

No significant change is reported in respect of the impact on the health of the employees going by the health records. In terms of other economic benefit, items reported as significant are improved safety standards, quality of air and water quality. Next in the line come demonstration effect and a general improvement in health standard.

Nature of New Technology:

a. In the Temphos product line as the solvent usage was reduced due to the modification it can be considered as less hazardous.

b. In the phorate 10G product line only modification is the change of packaging material. The positive point here is that leaky bags are no longer seen so spillage has been reduced leading to better safety conditions.

DRIVING FORCES AND BARRIERS

Driving Forces

The ranking given by the company sources have been weighted by the average of the scores given by three independent experts and the weighted ranks computed accordingly. Among the driving forces behind adoption of cleaner technologies, top management ranked first, followed by better safety and health, government regulations and quality considerations in that order. This is followed by efficiency drive, risk aversion, image and market forces.

Forces	Ranking	Weights	Weighted ranks
Market forces	8	3.3	8
Image	7	3.7	7
Risk Aversion	6	4.3	6
Quality Drive	4	4,3	4
Efficiency Drive	5	4.3	5
Top management commitment	1	3.3	1
Better safety and health	2	2.0	2
Government Regulations	3	1.7	3

Barriers

The company did not face any barrier in the implementation of CT.

NATURE	DESCRIPTION	INTENSITY				
		L	V.L	M	H	V.H
(a) Legislative	_					
(b) Institutional	_					
(c Educational	_					
(d) Public Opinion	_					
(e) Employees' resistance	_					
(f) Others, specify	_					

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

As for the adoption of the CT itself, problems cited were lack of capital for investment due to recessionary conditions, uncertainty about regulatory framework [perhaps the frequent amendments], long payback period amidst pressure for short term returns on investment and lack of integrated systems/service from suppliers of CT.

TRAINING:

When it comes to training , environmental awareness courses have been conducted for the management cadre, engineers, the shop floor staff.

Environmental awareness courses for management	✔
Environmental awareness courses for engineers	✔
Environmental awareness courses for shop-floor staff	✔
Technical training for engineers	
Technical training for shop-floor staff	
Training in environmental management systems	
No formal training, all done on-the-job	
Others, specify	--

Among the sources of training and information on cleaner technologies, other companies have been found very useful. This is followed by external training institutes, in-house staff, conference and seminar, business and environmental networks and journals and press.

CORPORATE CITIZENSHIP:

In respect of the above, the achievement is medium in so far as the extent of improvement in employees, level of motivation towards CT and shared vision/values are concerned. It is reported low for exposure to professional literature and other latest developments, and sponsorship for short term and long term training programmes.

CASE STUDY 2: A & I LTD.

Description of Cleaner Technology adoption:

A and I Ltd manufactures bulk chemicals and dyes. The plant is located at Valsad, Gujarat. A number of CT measures have been implemented.

Colours Division - Phosgenation Reaction:

A new phosgenation plant has been put up with improved design, for the manufacture of non-benzediene dyes. This has been necessitated by the ban on benzediene dyes. This involved an investment of Rs.30 crores. The special features of the new plant are

- Change in design of the agitator
- Only fresh intermediates are used by synchronizing the production of intermediates with the final product. Earlier the intermediates used in the reaction were stored after their preparation and then used for phosgenation. This used to cause their decomposition, which is now pre-empted.

Consequently, yield of the final product improved from 88.3% to 93.4%. Secondly, The Chemical Oxygen Demand [COD] of the effluent is reduced since relatively more output is recovered from the effluent/batch. Thirdly, due to improved design of the phosgenator, the batch time is reduced and as a result, both utility consumption and phosgene consumption are now reduced. Lastly, effluent going to ETP is reduced as less phosgene consumption in turn requires less caustic soda [NaOH] in the scrubber.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= Rs. 35 lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= Rs.35 lakhs

Operation Cost [Difference] in Rs.

Raw Material cost	= - Rs.12.85 lakhs
Maintenance cost	= nil
Manpower cost	= nil
Energy cost	= - Rs. 5.27 lakhs
Water Cost	= nil
Disposal cost	= - Rs. 2.77 lakhs
[Due to reduction in COD]	
Total operating cost difference	= - Rs. 20.89 lakhs

Benefits: in Rs.

Raw material savings	= 12.85 lakhs
Energy savings	= 5.27 lakhs
Savings in Manpower	= nil
Savings in disposal cost	= 2.77 lakhs
Savings due to recovery of product due to improved yield	= 31.74 lakhs

Net Benefit **= 52.63 lakhs**

Payback period **= 8 months**

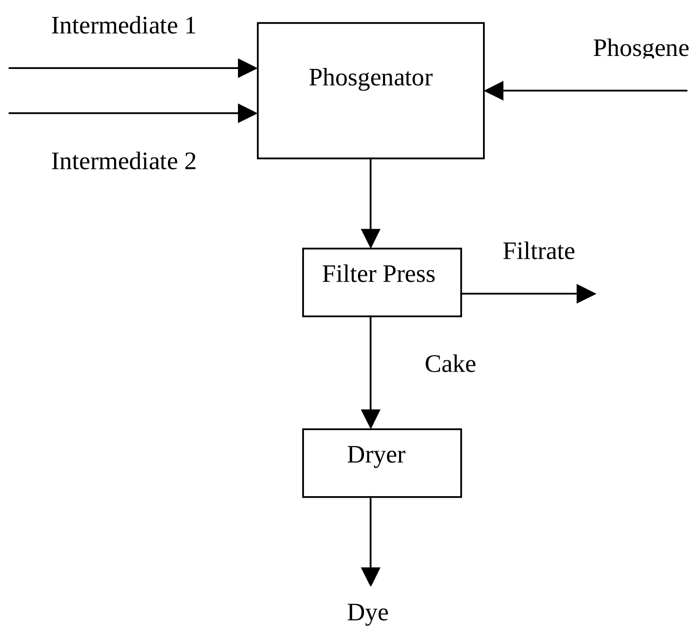
Waste measurement index:

$$\text{Before CT , WMI} = \frac{0.117}{0.117+0+1} \quad 100 = 10.47$$

$$\text{After CT, WMI} = \frac{0.051}{0.066+0.051+1} \quad 100 = 4.57$$

The waste measurement index has come down by 60%, which is a significant decline. Although, this CT exercise is undertaken mainly to meet the regulatory requirement [as benzediene dyes are banned in India], it has given rise to substantial benefits.

Process Flow chart:



Agrochemical Division:

The solvent Monochlorobenzene [MCB],going as waste earlier is now recovered in the settling tank, which was already there. Previously, the effluents collected in this tank were going to the ETP through underground pipes at the bottom. Now these pipes are closed so that the MCB collected in the tank settles down and only the waste water from the process overflows and is drained to the ETP. The MCB recovered is then taken to the distillation unit for purification. Thus there is a recovery of 4 to 5 tons of MCB/year and simultaneous reduction in the pollutant load.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= nil
Land cost	= nil
Construction cost	= nil
Total Investment	= nil

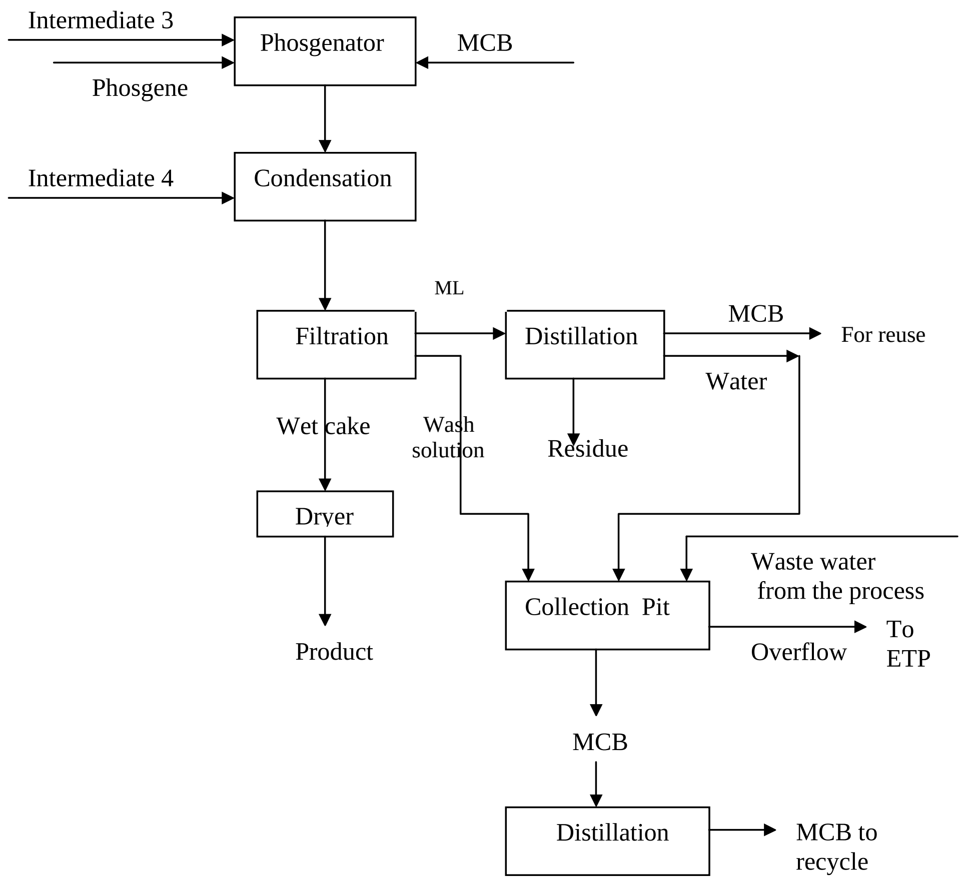
Operation Cost [Difference] in Rs.

Raw Material cost	= -1.5 lakhs
Maintenance cost	= nil
Manpower cost	= nil
Energy cost	= + 9000
[increase in energy cost to run the distillation unit]	
Water Cost	= nil
Disposal cost	= -1.15
[Reduction in COD of effluent resulting in reduced treatment costs in the ETP]	
Total operating cost difference	= - Rs. 2.56 lakhs

Benefits: in Rs.

Raw material savings	= 1.5 lakhs
Energy savings	= nil
Savings in Manpower	= nil
Savings in disposal cost	= 1.15
Net Benefit	**= 2.56 lakhs**
Payback period	**= immediate**

Process Flow chart:



Nature of New Technology:

a. In the colors division, the installation of the new phosgenation plant has led to less phosgene consumption and less storage of intermediates. Thus is less hazardous.

b. In the agrochemical division Monochlorobenzene [MCB], which is a hazardous chemical is being taken to the settling unit and then recovered in the distillation unit. The process is safer now as no MCB is going to ETP.

DRIVING FORCES AND BARRIERS

Driving Forces:

The ranks assigned by the company sources have been weighted by the average of the scores given by three independent experts and the weighted ranks have been computed.Coming to the driving forces safety and health was accorded the highest priority followed by top management commitment, government regulations and risk aversion in that order. Other factors reported are Image, quality, efficiency drive, continuous improvement and market forces

Driving Forces	Ranking	Weights	Weighted ranks
Market forces	8	3.3	8
Image	4	3.7	5
Risk Aversion	3	4.3	4
Quality Drive	5	4.3	6
Efficiency Drive	6	4.3	7
Top management	2	3.3	2
Better safety and health	1	2.0	1
Government Regulations	7	1.7	3

Barriers

The main barriers faced by the company while implementing CT have been getting permission from authorities and marketing of recovered methyl chloride. In terms of intensity, the former has been ranked low and the latter moderate.

NATURE	DESCRIPTION	INTENSITY				
		L	V.L	M	H	V.H
(a) Legislative	_	✔				
(b) Institutional	_					
(c Educational	_					
(d) Public Opinion	_					
(e) Employees' resistance	_					
(f) Others, specify	Marketing of recovered methyl chloride			✔		

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

As for the adoption of the CT itself, problems cited were lack of capital for investment due to recessionary conditions, uncertainty about regulatory framework

[perhaps the frequent amendments] and the many unproven CTs.

TRAINING:

When it comes to training , environmental awareness courses have been conducted for the management cadre, engineers, the shop-floor staff. Also, technical training has been undertaken for the shop-floor staff. In addition, training in environmental management systems were carried out.

Environmental awareness courses for management	✔
Environmental awareness courses for engineers	✔
Environmental awareness courses for shop-floor staff	✔
Technical training for engineers	
Technical training for shop-floor staff	✔
Training in environmental management systems	✔
No formal training, all done on-the-job	
Others, specify	--

Among the sources of training and information on cleaner technologies, in-house staff has been found to be very useful. In the next category, Universities / R&D Organisations, conferences and seminars, consultants and journals and press have been found useful.

CORPORATE CITIZENSHIP:

Responses to the parameters comprising corporate citizenship is encouraging as has been revealed by the "very high" and "high" rankings according to them. While shared vision and values has been assigned very high rank, other factors like the extent of improvement of employees, level of motivation towards CT, exposure to professional literature & other latest developments and sponsorship for short-term & long-term training programmes have been given a high rank.

CASE STUDY 3: GUJARAT INSECTICIDES LTD.

Description of Cleaner Technology adoption:

The unit is located in Ankleshwar. The main products of the company are Carbendezim, Cypermethrine, Fenvalrate, Quinoxalinol, Quinalphose, Metaphonoxi benzaldehyde. They cater to domestic as well as export markets. The Company belongs to a very progressive group and has undertaken a number of CT exercises, each of which is analysed below.

Brine Plant:

Brine plant is a chilling plant, which is installed, in the utility sector for improving solvent recovery. This has led to reduction of air pollution by reducing solvent losses [Hx and acetone] and as a result energy is saved . This involved an upgradation of the plant

COST BENEFIT ANALYSIS:

Initial Investment Cost [in Rs.]

Equipment cost	= 18.5 lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= nil

Operation Cost [Difference] in Rs.

Raw Material cost	= nil
Maintenance cost	= nil
Manpower cost	= nil
Energy cost	= - 13.57 lakhs/year
Water Cost	= nil
Disposal cost	= nil
Total operating cost difference	= 13.57 lakhs

Benefits: [in Rs.]

Raw material savings	= nil
Energy savings	= 13.57 lakhs
Savings in Manpower	= nil
Savings in disposal cost	= nil
Net Benefit	**= 13.57 lakhs**
Payback period	**= 1.36 years[16 months]**

Phenol Storage:

Exposure to phenol is reduced which in turn prevents accidents. Air pollution is minimised by avoiding transferring of phenol by air pressure. This was handled earlier in drums resulting in handling costs and spillovers. Now they are stored in tanks, thus avoiding the losses due to spillovers and handling costs.

COST BENEFIT ANALYSIS:

Initial Investment Cost in	Rs.
Equipment cost	= 10 lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= nil

Operation Cost [Difference] in Rs.

Raw Material and handling cost	= -8.67 lakhs
Maintenance cost	= nil
Manpower cost	= nil
Energy cost	= nil
Water Cost	= nil
Disposal cost	= nil
Total operating cost difference	= - 8.67 lakhs

Benefits: in Rs.

Raw material and handling savings	= 8.67lakhs/year
Energy savings	= nil
Savings in Manpower	= nil
Savings in disposal cost	= nil
Net Benefit	**= 8.67 lakhs**
Payback period	**= 1.15 years[14 months]**

Aluminium Chloride [Alcl3] Charging:

Procuring $AlCl_3$ in bigger packs to reduce handling loss and installing closed mechanical system for bulk handling has led to reduced air pollution . This is because of reduction in dust due to bulk charging. Number of bags handled has now come down from 74 to 2 bags/batch. Exposure of human beings to dust is also reduced.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= 7.50lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= nil

Operation Cost [Difference] in Rs.

Raw Material and handling cost	= -1.355 lakhs
Maintenance cost	= nil
Manpower cost	= nil
Energy cost	= nil
Water Cost	= nil
Disposal cost	= nil
Total operating cost difference	= -1.355 lakhs

Benefits: in Rs.

Raw material and handling savings	= 1.355 lakhs/year
Energy savings	= nil
Savings in Manpower	= nil
Savings in disposal cost	= nil
Net Benefit	**= 1.355 lakhs**
Payback period	**= 5.5 years**

Based on the discussions with management, the life of the equipments is taken as 10 years and the cost of the capital 15%. The NPV has been computed accordingly:

Present Value[PV] **= Rs. 6.8 lakhs**

NPV **= -Rs.0.7 lakhs**

B/C ratio **= 0.91**

Substitution of furnace oil with Natural Gas:

Furnace oil is replaced with natural gas as fuel. As a result, low Nitrogen oxides [Nox] emissions is achieved that is 45-50 ppm, leading to a major improvement in the stack emissions.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost = 45 lakhs

Land cost = nil

Construction cost = nil

Total Investment = nil

Operation Cost [Difference] in Rs.

Raw Material and handling cost = nil

Maintenance cost = nil

Manpower cost = nil

Energy cost = -24.73 lakhs/year

Water Cost = nil

Disposal cost = nil

Total operating cost difference = -24.73 lakhs

Benefits: in Rs.

Raw material and handling savings = nil

Energy savings = 24.73 lakhs/year

Savings in Manpower = nil

Savings in disposal cost = nil

Net Benefit **= 24.73 lakhs**

Payback period **= 1.82 years [22 months]**

Waste heat recovery boiler:

Waste heat recovery boiler has been installed for the recovery of waste heat. This has resulted in substantial energy savings.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= 5.0 lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= nil

Operation Cost [Difference] in Rs.

Raw Material and handling cost	= nil
Maintenance cost	= nil
Manpower cost	= nil
Energy cost	= -1.535 lakhs/year
Water Cost	= nil
Disposal cost	= nil
Total operating cost difference	= - 1.535 lakhs

Benefits: in Rs.

Raw material and handling savings	= nil
Energy savings	= 1.535 lakhs/year
Savings in Manpower	= nil
Savings in disposal cost	= nil
Net Benefit	**= 1.535 lakhs**
Payback period	**= 3.3 years**

Based on the discussions with management, the life of the equipments is taken as 10 years and the cost of the capital 15%. The NPV has been computed accordingly:

Present Value[PV]	**= Rs.7.704 lakhs**
NPV	**= Rs. 2.704 lakhs**

B/C ratio = 1.54

Other Benefits:

In terms of other economic benefits , improved quality of air was reported as very significant. Other factors reported significant are improved health standards, improved safety standards, improved water quality and improved awareness among workers.

Nature of New Technology:

1. In the Brine plant, a chilling plant has been installed for improving solvent recovery. This is less hazardous than the earlier one as air pollution is reduced due to reduced solvent losses

2. Phenol was earlier stored in drums, now they are stored in tanks. This is less hazardous as exposure to phenol is reduced, reducing accidents and air pollution

3. And d have no influence on hazardous nature.

DRIVING FORCES AND BARRIERS

Driving Forces

The ranks assigned by the company sources have been weighted by the average of the scores given by three independent experts and the weighted ranks have been obtained.

Among the driving forces top management commitment has been assigned the top rank. This is followed by government regulations, efficiency drive and better safety and health. Other driving forces are market forces [ranked 5], quality drive [ranked 6], image [ranked 7] and risk aversion [ranked 8].

Forces	RANKING	Weights	Weighted ranks
Market forces	5	3.3	5
Image	6	3.7	7
Risk Aversion	8	4.3	8
Quality Drive	4	4,3	6
Efficiency Drive	3	4.3	3
Top management commitment	1	3.3	1
Better safety and health	7	2.0	4
Government Regulations	2	1.7	2

Barriers

There do not seem to be any barriers of significance while implementing CT as indicated by the table below.

NATURE	DESCRIPTION	INTENSITY				
		L	V.L	M	H	V.H
(a) Legislative			✔			
(b) Institutional			✔			
(c Educational			✔			
(d) Public Opinion			✔			
(e) Employees' resistance			✔			
(f) Others, specify						

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

As for the adoption of the CT itself, no problem whatsoever was faced by the company.

TRAINING:

In respect of training , it has all been undertaken in-house.

Environmental awareness courses for management	In-house
Environmental awareness courses for engineers	In-house
Environmental awareness courses for shop-floor staff	In-house
Technical training for engineers	In-house
Technical training for shop-floor staff	In-house
Training in environmental management systems	In-house
No formal training, all done on-the-job	In-house
Others, specify	In-house

Among the sources of training and information on cleaner technologies, in-house staff has been found to be very useful. Other sources such as Universities / R&D Organisations, Industry associations, external training organisations ,other companies, conference and seminars, consultants and business & environmental networks have been found to be useful.

CORPORATE CITIZENSHIP:

Responses to the parameters comprising corporate citizenship fall in the high and medium category. While shared vision/values and level of motivation towards CT seem high, the extent of improvement of employees, exposure to professional literature & other latest developments and sponsorship for short-term/long-term training programs appear in the medium category.

CASE STUDY 4: GNR FERTILIZER CORPORATION:

Description of Cleaner Technology adoption:

This is situated in coastal Gujarat. The company has implemented various CT measures in the recent years. Of them, a few prominent ones have been selected for the purpose of our analysis. A new synthesis gas generation unit [SGGU] has been installed in February 1998 to make available an independent source of syngas for methanol - 1 plant, instead of from the ammonia plant. Also, some new equipments such as Demineralised water[DMW]heater, topping & refining column, feed pumps with higher capacity, purge gas and cold shot valves with higher capacity have been installed. Consequently, there is an additional capacity of 12,000 MT of Methanol production / year.

Installation of variable speed drive in formic acid plant:

Variable speed drive has been installed for feed pump to the acid section of the formic acid plant to improve productivity and conserve energy.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= 2.50 lakhs
Land cost	= nil

Construction cost = nil

Total Investment = nil

Operation Cost [Difference] in Rs.

Raw Material and handling cost = nil

Maintenance cost = nil

Manpower cost = nil

Energy cost = - 49.50 lakhs/year

Water Cost = nil

Disposal cost = nil

Total operating cost difference = - 49.50 lakhs

Benefits: in Rs.

Raw material and handling savings = nil

Energy savings = 49.50 lakhs/year

Savings in Manpower = nil

Savings in disposal cost = nil

Net Benefit = 49.50 lakhs

Payback period = 18 days

WMI:

Not applicable

CO2 Enhancement Scheme [Ammonia Plant]:

A scheme to recover CO2 from waste CO2 stream going into the atmosphere has been implemented in November 1998. As a result, there is additional generation of 3000Nm3/hr low pressure pure CO2 which is now supplied to ammonia plant [ANP]. Also, there is improvement in the ammonia absorption efficiency in ammonium carbonate synthesis section of ANP. The perennial CO2 pollution problem of the ANP plant is also solved. Further, the scheme has also helped to increase urea production.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= 300 lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= nil

Operation Cost [Difference] in Rs.

Raw Material	= -206 lakhs
Maintenance cost	= nil
Manpower cost	= nil
Energy cost	= nil
Water Cost	= nil
Disposal cost	= nil
Total operating cost difference	= -206 lakhs

Benefits: in Rs.

Raw material and handling savings	= nil
Energy savings	= 206 lakhs/year
Savings in Manpower	= nil
Savings in disposal cost	= nil
Net Benefit	**= 206 lakhs**
Payback period	**= 1.46 years [17.5 months]**

WMI:

Could not be computed in the absence of available data.

Installation of visible light scanners in boilers:

With the installation of visible light scanners in BHEL boilers, 100% coal firing without oil support is made possible. As a result there is saving in LSHS fuel oil as a supporting fuel to the extent of 4130 KLs in the boilers annually.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= 86 lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= nil

Operation Cost [Difference] in Rs.

Raw Material	= nil
Maintenance cost	= nil
Manpower cost	= nil
Energy cost [fuel cost]	= -51 lakhs
Water Cost	= nil
Disposal cost	= nil
Total operating cost difference	= -51 lakhs

Benefits: in Rs.

Raw material and handling savings	= nil
Energy savings	= 51 lakhs/year
Savings in Manpower	= nil
Savings in disposal cost	= nil
Net Benefit	**= 51 lakhs**
Payback period	**= 1.69 years [20 months]**

WMI:

Not applicable

Hydrogen Sulphide [H2S] stripping from process condensate and recovery of Ammonia:

A new stripper has been designed and the condensate is sent to the wastewater section of the urea plant for ammonia recovery. It is expected to recover approximately 434 MT/year of ammonia. Earlier, in the ammonia plant 5m3/hr of process condensate was generated containing approximately 0.9% ammonia and

140-150 ppm of H_2S. This used to create air, liquid and solid waste pollution problems.. The new scheme commissioned in August 99 selectively strips out H_2S from the condenser. The CT exercise is expected to recover ammonia and also reduce the pollutants.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.	
Equipment cost	= 12 lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= nil

Operation Cost [Difference] in Rs.

Raw Material	= -40 lakhs
Maintenance cost	= nil
Manpower cost	= nil
Energy cost [fuel cost]	= nil
Water Cost	= nil
Disposal cost	= nil
Total operating cost difference	= -40 lakhs

Benefits: in Rs.

Raw material recovery	= 40 lakhs
Energy savings	= nil
Savings in Manpower	= nil
Savings in disposal cost	= nil
Net Benefit	**= nil**
Payback period	**= 3.6 months**

WMI:

Could not be computed

Other Benefits:

In terms of other economic benefits, there are improvements seen in health standards, safety standards, demonstration effect and awareness among the workers. No score has been assigned as to their relative significance.

Nature of New Technology:

a. *Installation of variable speed drive in formic acid plant*, this has been installed for feed pump to the acid section of the formic acid plant to improve productivity and conserve energy it does not have any influence on the hazards as such.

b. The carbondioxide enhancement scheme recovers CO2 from waste stream. This is an eco - friendly change but CO2 is not a very hazardous gas .

c. The new hydrogen stripping process condensate and recovery of Ammonia is less hazardous than the earlier one as it recovers the hazardous gas ammonia

DRIVING FORCES AND BARRIERS

Driving Forces

The ranks given by the company sources have been weighted by the average of the scores assigned by three independent experts to obtain weighted ranking.Among the driving forces top management commitment has been assigned the top rank. This is followed by better safety and health considerations, quality and efficiency drive in that order. The other factors mentioned are government regulations, image, market forces and risk aversion.

Forces	RANKING	Weights	Weighted ranks
Market forces	7	3.3	7
Image	5	3.7	6
Risk Aversion	6	4.3	8
Quality Drive	2	4,3	3
Efficiency Drive	3	4.3	4
Top management commitment	1	3.3	1
Better safety and health	4	2.0	2
Government Regulations	8	1.7	5

Barriers

There do not seem to be any barriers of significance while implementing CT as indicated by the table below.

NATURE	DESCRIPTION	INTENSITY				
		L	V.L	M	H	V.H
(a) Legislative	-					
(b) Institutional	-					
(c Educational	-					
(d) Public Opinion	-					
(e) Employees' resistance	-					
(f) Others, specify	-					

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

As for the adoption of the CT itself, no problem whatsoever was faced by the company.

TRAINING:

As far as training is concerned, a lot of importance has been given by the company. All types of training have been given from management to shop floor levels.

Environmental awareness courses for management	✔
Environmental awareness courses for engineers	✔
Environmental awareness courses for shop-floor staff	✔
Technical training for engineers	✔
Technical training for shop-floor staff	✔
Training in environmental management systems	✔
No formal training, all done on-the-job	-
Others, specify	-

Among the sources of training and information on cleaner technologies, in-house staff, Universities/R&D organisations, other companies, conferences/seminars have been placed in the very useful category. Other sources in the useful category are industry associations, suppliers of CT, consultants, business /environmental networks and journals & the media. External training organisations have not been found useful.

CORPORATE CITIZENSHIP:

The company has fared very well as most parameters are placed in the high and very high category. While very high score has been assigned to the extent of improvement of employees, level of motivation towards CT and sponsorship for short-term/long-term training programs, a high score has been given to shared vision/values and exposure to professional literature/latest developments.

CASE STUDIES IN THE SMALL SCALE SECTOR:

CASE STUDY 6: AKASH DYES AND INTERMEDIATES:

Description of Cleaner Technology adoption

This plant is located in Naroda Industrial Estate, near Ahmedabad in Gujarat. The main product is sulphotobias acid from Tobias Acid. Sulphotobias acid is a dye intermediate and is used mainly in the manufacture of reactive dyes.

Substitution of neutralising agents:

For primary treatment of effluents, both Calcium Hydroxide or hydrated lime [Ca{oH}2] and Calcium Carbonate [CaCo3] can be used. The former is more expensive since it is derived from CaCo3 and a huge amount of electricity is consumed in the conversion process. However, the quantity consumed of Ca[oH]2 is less than that of CaCo3. Quantity of Calcium hydroxide /month [30 batches] was 56 tons as against the 71 tons of calcium carbonate, for treating the same quantity of effluent before sending to the common effluent treatment plant.

Formerly, hydrated lime was put in the neutralisation tank directly whereas now, the effluent is taken in smaller quantity in another tank containing calcium carbonate to avoid the overflow of effervescence.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= 5,000
[Additional tank cost]	
Land cost	= nil
Construction cost	= nil
Total Investment	= nil

Operation Cost in Rs.

Raw Material cost**:**

Before CT amount spent on calcium hydroxide/year	= 14.76 lakhs
After CT amount spent on calcium carbonate	= 5.112 lakhs
Maintenance cost	= nil
Manpower cost after CT	
@ 30/ton for loading gypsum to trucks	= +0 .18 lakhs
Energy cost [fuel cost]	= nil
Water Cost	= nil
Disposal cost	= nil
Total operating cost difference	= -9.468 lakhs

Benefits: in Rs.

Raw material recovery	= 9.648 lakhs
Gypsum recovery 600 tons /annum	
@Rs 50/ton	= 0.3 lakhs
Energy savings	= nil
Savings in Manpower	= nil
Savings in disposal cost	= nil
Net Benefit	**= 9.768 lakhs**
Payback period	**= 2 days**

WMI Waste measurement index:

$$\text{Before CT, WMI} = \frac{0.236}{0.236 + 0 + 1} \quad 100 = 19.09$$

$$\text{After CT, WMI} = \frac{0}{0 + 0.236 + 1} \quad 100 = 0$$

The waste measurement index has come down to nil as there is total elimination of wastes.

Installation of a chilling plant :

Tobias acid is sulphonated in a reactor vessel using oleum [H2S207]. The reaction time varies from 14 hours to 18 hours at the maintained temperature of 25 degrees centigrade by circulating chilled water around the reactor vessel which has a hollow space between itself and its outer jacket. Earlier, the tank supplying chilled water was fed with ice. 3000 Kg of ice was used per batch in the chilled water tank. Now the company has installed the chilling plant to avoid the use of ice.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= 2 lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= 2 lakhs

Operation Cost in Rs.

Raw Material cost Before CT for ice	**=** 4.32 lakhs
Maintenance cost	= nil
Manpower cost after CT	= 0.24 lakhs
Energy cost after CT	= 0.9 lakhs
Water Cost	= nil
Disposal cost	= nil
Total operating cost difference	=- 3.18 lakhs

Benefits: in Rs.

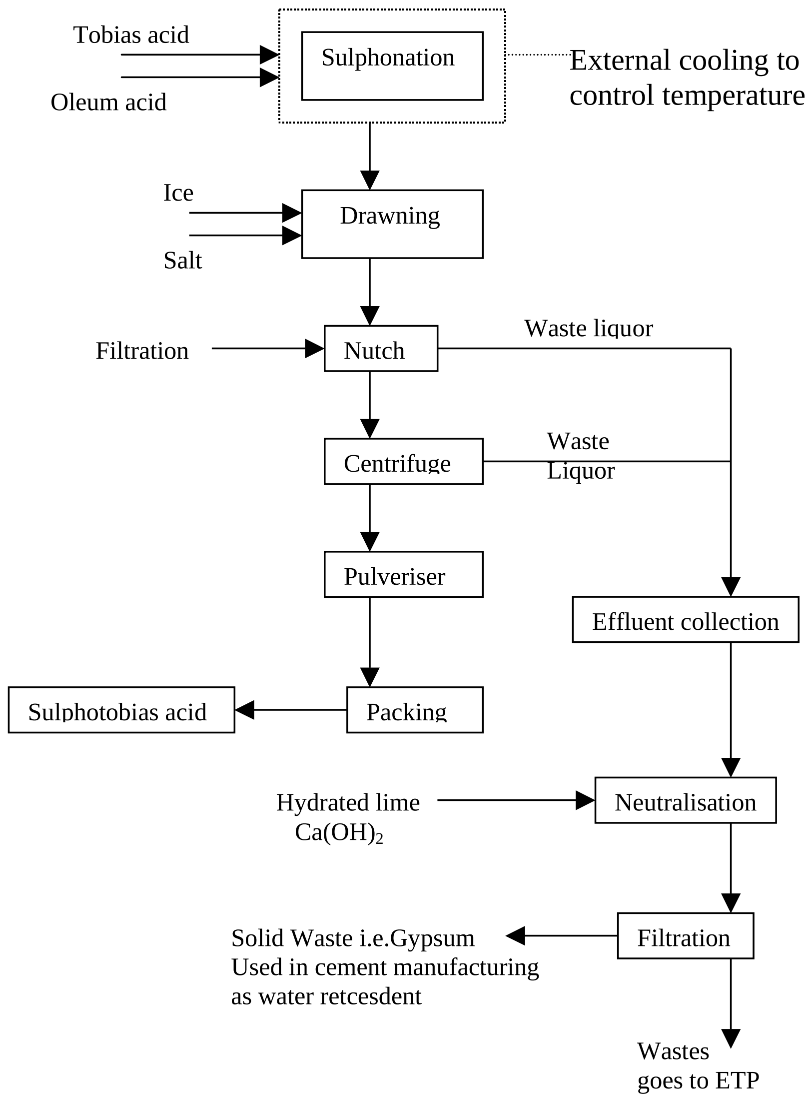
Raw material cost savings after CT = 4.32 lakhs

Energy savings	= - 0.9 lakhs
Savings in Manpower	= - 0.24 lakhs
Savings in disposal cost	= nil
Net Benefit	**= 3.18 lakhs**
Payback period	**= 7.5 months**

WMI

Waste measurement index not applicable

Flow chart:



Other Benefits:

We find only demonstration effect reported here as very significant. No other spin-off benefit has been reported.

Nature of New Technology:

The first change is only a change in the neutralising agent, this is environmentally friendly due to less energy consumption, in the same way the installation of a chilling plant also saves energy but both these changes have no great influence on the hazardous nature as such.

DRIVING FORCES AND BARRIERS

Driving Forces

The ranks assigned by the company sources have been weighted by the average of the scores given by 3 independent experts and the weighted ranks have been obtained

Market forces have been assigned the first rank in this case followed by image, energy savings for the nation and efficiency drive. No other factor has been mentioned.

Driving Forces	Ranking	Weights	Weighted ranks
Market forces	1	3.3	1
Image	2	3.7	2
Risk Aversion	-	4.3	-
Quality Drive	-	4,3	-
Efficiency Drive	4	4.3	4
Top management commitment	-	3.3	-
Better safety and health	-	2.0	-
Government Regulations	-	1.7	-
[energy savings for the nation]	3		3

Barriers
It appears, the company did not face any barriers in the implementation of CT.

NATURE	DESCRIPTION	INTENSITY				
		L	V.L	M	H	V.H
(a) Legislative		-				
(b) Institutional						
(c Educational	-					
(d) Public Opinion	-					
(e) Employees' resistance	-					
(f) Others, specify	-					

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

As for the adoption of the CT itself, lack of capital investment, long payback period amidst pressure on short term returns on investment and unproven CTs have been reported as the most important problems.

TRAINING:

In respect of training , it has all been undertaken on - the - job.

Environmental awareness courses for management	
Environmental awareness courses for engineers	
Environmental awareness courses for shop-floor staff	
Technical training for engineers	
Technical training for shop-floor staff	
Training in environmental management systems	
No formal training, all done on-the-job	✔
Others, specify	

Among the sources of training and information on cleaner technologies, Industry associations have been found very useful followed by conferences/seminars and consultants .

CORPORATE CITIZENSHIP:

Exposure to professional literature and the level of motivation towards CT, have both been assigned high scores. Shared vision and values figure in the medium category. However, the extent of improvement of employees is reported very low.

CASE STUDY 7: MILESTONE CATALYST PVT. LTD.

Description of Cleaner Technology adoption

This firm is located in Naroda Industrial Estate, Ahmedabad. It manufactures Vat dyes. Various CT measures were implemented as follow

Table of 14 changes to be inserted here

No.	Earlier Process	Implementation	Improvement
01.	Batch Sizes: not respective of reaction vessels size	Batch sizes increased to the sizes of vessels like R-31 200 Kgs to 300Kgs R-41 150 Kgs to 200Kgs R-51 200 Kgs to 300Kgs R-61 300 Kgs to 600Kgs R-71 100 Kgs to 170Kgs	Net saving of power, manpower, equipment holding time and less effluent compared to earlier batch size
02.	Simple washing of alkaline precipitated mass with water.	Neutralization of alkaline precipitated mass with acidic effluent of next sequence batch	Reduced water consumption and need not to be handled in ETP plant, thus reducing ETP treatment quantity of effluent
03.	Final product was washed with Dm water or Soft water	Storing boiler blow off separately and using in place of soft water.	Soft/Dm water is not required
04.	ETP Gypsum was being dumped at our solid waste site	Explored with Gujarat Ambuja Cement and sample was approved.	Net saving of dumping cost plus generating little revenue from ETP Gypsum
05.	Adding of fresh water for distillation	Recycling condensed water after separation	Reduction of distillation time, also reduction in add-up water.
06.	Nitrobenzene distillation condenser vapour was fed into shell side.	Vapour now been fed into tube side.	Reduction of distillation cycles nearly by 50%
07.	Recycling of hot water into condenser & filter washing	After use in filter wash, hot water is cooled in cooling tower.	Due to cold water feeding into condenser, capacity of distillation is increased
08.	3-4 sizes of drums were being used for finished good packing.	Reworked volume requirements of each customer's requirements.	Were able to reduce the drum height 1" to 3" of each customer requirement

09.	Drum label was printed with usual screen & drum no., weight etc. was hand written.	Modified label screen & included digital no. in liquid crystal form.	We are independent to paint drum no., gross wt., net wt. etc. by our manpower. Thus reduced cost, time saving and uniformity in details.
10.	Steam & water valves were maintained on staggering.	Now, valves of specific circuit are being maintained on regular interval.	Indirect saving of energy and material saving.
11.	Mixing of acidic & alkaline effluent on the generation.	Acidic & alkaline effluent is being stored separately. The acidic effluent is being neutralised with Limestone powder to bring to pH 5.5 and taking further to 7pH by adding alkaline effluent.	Limestone powder is much cheaper than hydrated lime. This alternative is proved to be of more saving & at the same time, reducing load on environment to manufacture Hydrated lime from the Limestone powder.
12.	Entire washing effluent were taken to storage tanks and then to neutralisation tank.	Filter wash 6.5 to 7.5 pH are collected and disposed of as final discharge.	Saving of pumping cost & reducing load on neutralization vessels.
13.	Acidic filtration was done in Wooden press.	Now, PP press has been installed.	Washing water quantity is reduced & washing quality is improved.
14.	Temperature of exothermic reaction was maintained by frequent cooling heating application.	Maintained equilibrium water level in the jacket and thus exothermic heat converted into steam. The final cooling water is being used in drowning vessel.	The use of steam is not planned but can be used for other application. The hot water from final cooling to drowning vessels improved product appearance & quality. Due to uniform maintenance of temperature the yield is increased significantly.

Financial Benefit: Direct

No.	Description	Saving/Batch	No. month	Monthly saving
01.	Increment in batch size: 35% thus saving in net electricity	Lump sum 35%	Monthly	Rs.17, 250.00
02.	Neutralisation of alkaline mass	Rs.500/-	10	Rs. 5,000.00
03.	Reduction of soft/DM water.	Lump sum		Rs. 1,000.00

No.	Description	Saving/Batch	No. month	Monthly saving
04.	Gypsum to cement factory.	Rs. 520/MT	60 MT	Rs. 31,200.00
05.	Recycle to condensed water	Negligible		Energy saving will be there which will not be quantified
06.	Change of vapour feeding	Rs. 900/-	5	Rs.4,500.00
07.	Recycle of hot water	Rs. 500/-	9	Rs.4,500.00
08.	Reduction of drum height	Rs.15/-	220 drums	Rs.3,300.00
09.	Modification in labeling screen	Rs.5/-	220 drums	Rs.1,100.00
10.	Preventive maintenance of valve	Lump sum		Rs.2,000.00
11.	Substitution of hydrated lime	Rs.1,400/-	40 MT	Rs.56,000.00
12.	Filter wash to direct discharge	Lump sum		Rs.1,000.00
13.	Installation of PP press	Lump sum		Rs.2,000
14.	Equilibrium water level in jacket	Rs.200/-	8 batches	Rs.1,600.00

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost = nil

Land cost = nil

Construction cost = nil

Total Investment = nil

Operation Cost difference in Rs./annum

Raw Material cost

[Hydrated lime is substituted by

limestone powder = -6.72 lakhs/annum

Maintenance cost = nil

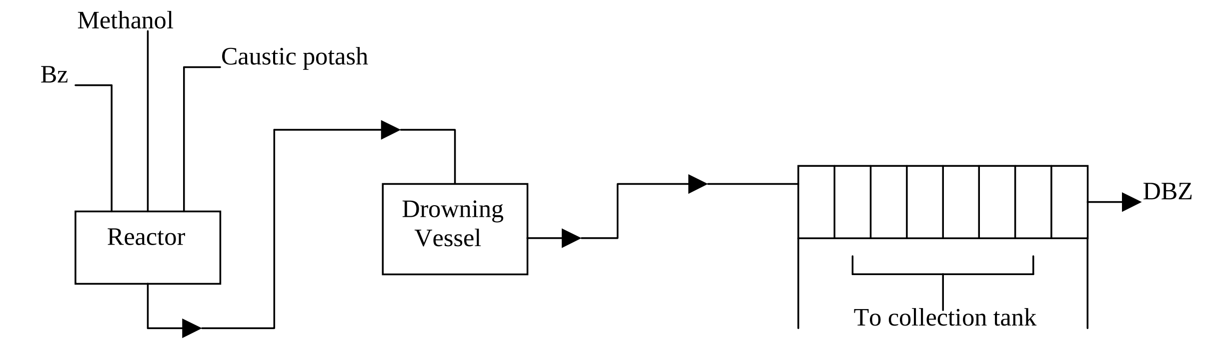
Manpower cost after CT	= nil
Energy cost after CT	= -2.61 lakhs
Water Cost	= -0.12 lakhs
Disposal cost	= -2.46 lakhs
Total operating cost difference	=-11.91lakhs

Benefits: in Rs.

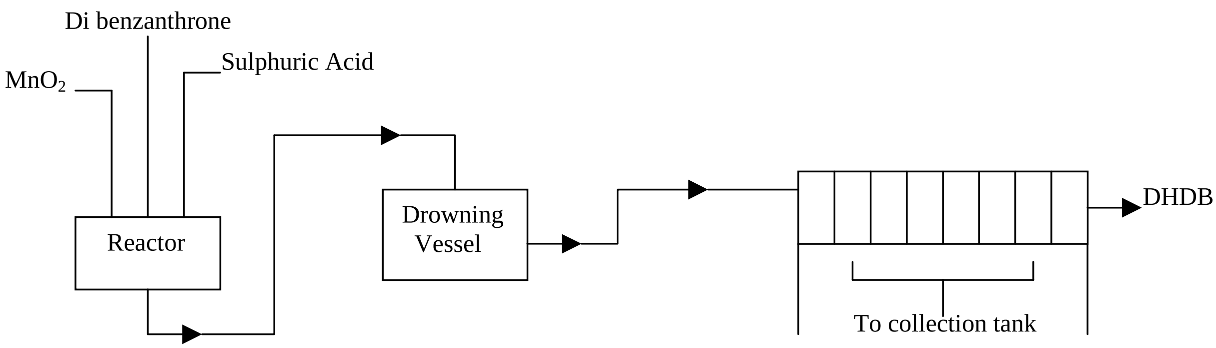
Gypsum recovery from waste	=3.74 lakhs
Raw material cost savings after CT	= 6.72 lakhs
Energy savings	= 2.16 lakhs
Savings in Manpower	= nil
Savings in disposal cost	= 2.46 lakhs
Savings in water	= 0 .12 lakhs
Net Benefit	**= 15.65 lakhs**
Payback period	**= immediate**

Flow charts

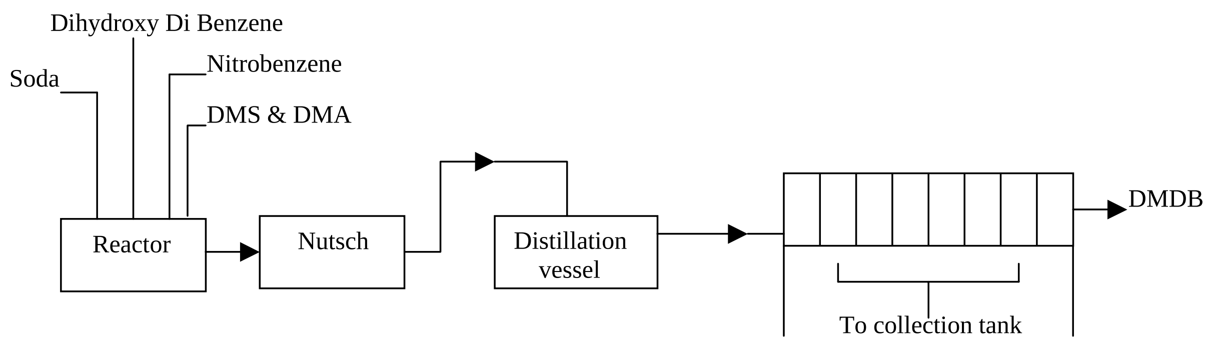
Manufacture of Vat Dyes



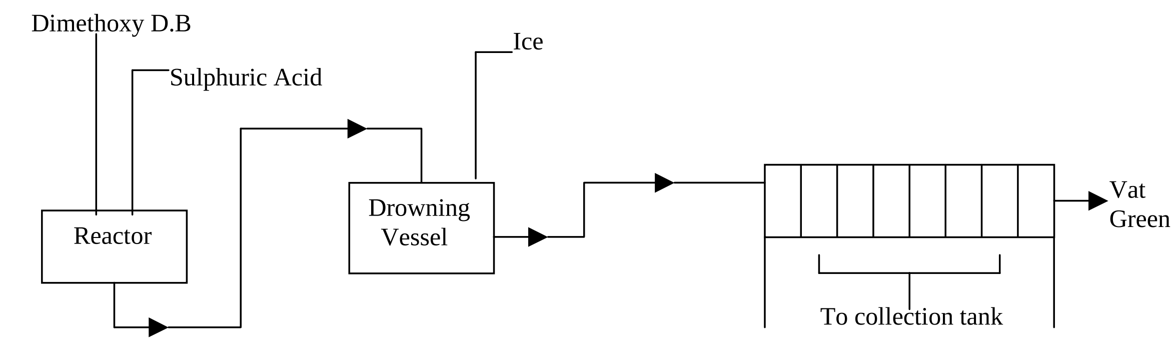
Stage 2



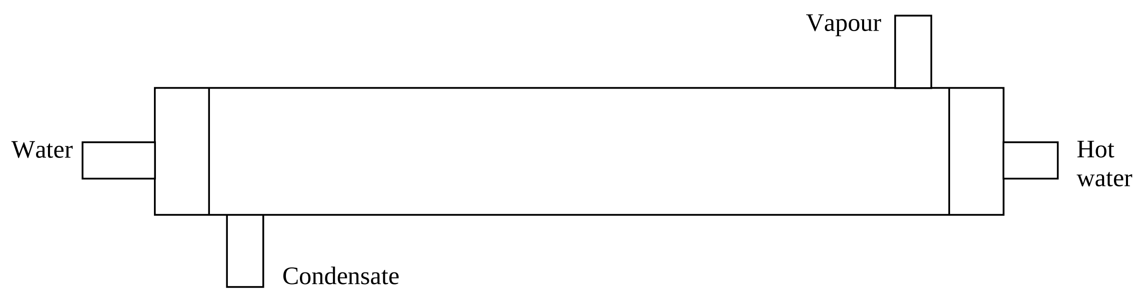
Stage 3



Stage 4



Changing of Vapour feeding line into condenser from shell side to tube side



Other Benefits:

No change has been reported in the health of the employees

Nature of New Technology:

The new changes are eco - friendly but has no implications on the hazardous nature of the processes.

DRIVING FORCES AND BARRIERS

As driving forces, only quality, efficiency drive and safety & health considerations are indicated. However, no rank has been assigned and hence weighting has not been attempted.

Driving Forces	Ranking
Market forces	-
Image	-
Risk Aversion	-
Quality Drive	✔
Efficiency Drive	✔
Top management commitment	-
Better safety and health	✔
Government Regulations	-

Barriers

It appears, the company did not face any barriers in the implementation of CT.

NATURE	DESCRIPTION	INTENSITY				
		L	V.L	M	H	V.H
(a) Legislative						
(b) Institutional						
(c Educational	-					
(d) Public Opinion	-					
(e) Employees' resistance	-					
(f) Others, specify	-					

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

As for the adoption of the CT itself, long payback period amidst pressure on short-term returns on investment seems to be the only problem going by the company's response.

TRAINING:

With regard to training environmental awareness and technical awareness courses are conducted for engineers.

Environmental awareness courses for management	-
Environmental awareness courses for engineers	✔
Environmental awareness courses for shop-floor staff	-
Technical training for engineers	✔
Technical training for shop-floor staff	-
Training in environmental management systems	-
No formal training, all done on-the-job	-
Others, specify	-

Among the sources of training and information on cleaner technologies, the ones cited as being very useful are industry associations, suppliers of CT and conferences/ seminars. The ones useful are universities/R&D organisations, external training organisations, consultants and business/environmental networks. Other companies' sources were not found useful.

CORPORATE CITIZENSHIP:

Considering that it is a small-scale unit, the sense of corporate citizenship is good. Level of motivation towards CT has been assigned very high score. The extent of improvement of employees is ranked high. Exposure to professional literature/ other latest developments is ranked in the medium category. The encouraging responses sound credible given that the Managing Director is perceived as a progressive person and a change agent in the Naroda industrial belt.

CASE STUDY 9: PRACHIN CHEMICAL

Description of Cleaner Technology adoption:

This firm is located in the Naroda Industrial area, Ahmedabad and manufactures carboxy methyl cellulose [CMC]. This is used as a raw material in pharmaceutical, food, cosmetics, ceramics, paint, welding electrodes, pencil carbon paper and ice creams.

Installation of vacuum dryer :

The spent alcohol contains soluble impurities [like sodium chloride, sodium glyconate and a little CMC]. This was being evaporated formerly to get the powder form material of low purity [20%], used in ceramics, paints and textiles.

After installing the vacuum dryer, at present the alcohol is recovered and the product, which is still wet due to the water, content is sent to the tray dryer for drying. The spent alcohol is first distilled to recover the alcohol and the residue is dried.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= 6 lakhs
Land cost	= nil
Construction cost	= nil
Total Investment	= nil

Operation Cost difference in Rs./annum

Raw Material cost	=- 15.12 lakhs
Maintenance cost	= nil
Manpower cost	= nil
Energy cost after CT	=+ 1.56lakhs
Water Cost	= nil
Disposal cost	= nil
Total operating cost difference	=-13.56

Benefits: in Rs.

Raw material cost savings after CT

[Value of alcohol recovered]	= 15.12 lakhs
Energy savings	= -1.56 lakhs
Savings in Manpower	= nil
Savings in disposal cost	=nil
Savings in water	= nil
Net Benefit	**= 13.56 lakhs**
Payback period	**= 0.44 years {5.3 months}**

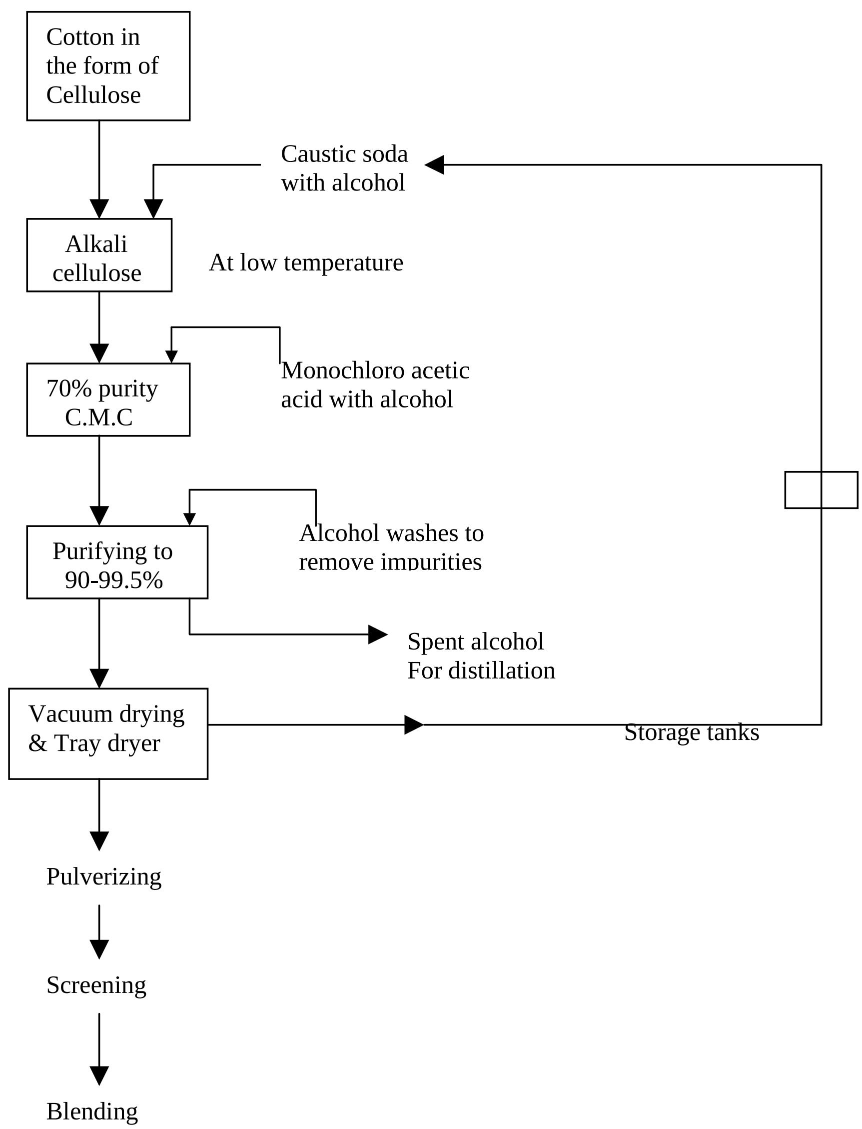
Waste Measurement Index:

$$\text{Before CT , WMI} = \frac{0.3}{0.3 + 0 + 1}\ 100 = 23.08$$

$$\text{After CT, WMI} = \frac{0}{0 + 0.3 + 1}\ 100 = 0$$

The waste measurement index has come down to nil as there is total recovery of alcohol alone.

Flow Chart



Other Benefits:

The only benefit reported is the demonstration effect and it is perceived as being very significant.

Nature of New Technology:

At present after installing the vacuum dryer, the alcohol is recovered and the product, which is still wet due to the water, content is sent to the tray dryer for drying. This is a ecofriendly modification and also less hazardous as all the alcohol [which is inflammable] is recovered.

DRIVING FORCES AND BARRIERS

The ranks assigned by the company sources have been weighed by the average of the scores given by three independent experts and the weighted ranks have been computed. As driving forces, top management commitment has been ranked first followed by market forces ,quality and efficiency drive.

Forces	Ranking	Weights	Weighted ranks
Market forces	2	3.3	2
Image	-	3.7	-
Risk Aversion	-	4.3	-
Quality Drive	3	4,3	3
Efficiency Drive	4	4.3	4
Top management commitment	1	3.3	1
Better safety and health	-	2.0	-
Government Regulations	-	1.7	-

Barriers

It appears, the company did not face any barriers in the implementation of CT.

NATURE	DESCRIPTION	INTENSITY				
		L	V.L	M	H	V.H
(a) Legislative						
(b) Institutional						
(c Educational	-					
(d) Public Opinion	-					
(e) Employees' resistance	-					
(f) Others, specify	-					

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

As for the adoption of the CT itself, lack of capital is reported to be the only problem faced by the company.

TRAINING:

No training has been conducted.

Environmental awareness courses for management	-
Environmental awareness courses for engineers	-
Environmental awareness courses for shop-floor staff	-
Technical training for engineers	-
Technical training for shop-floor staff	-
Training in environmental management systems	-
No formal training, all done on-the-job	-
Others, specify	-

Among the sources of training and information, it is mentioned that the seminar conducted by NCPC Delhi was responsible for catching with the CP concept.

CORPORATE CITIZENSHIP:

As is expected, the company does not fare well in this respect .The exposure to professional literature / latest developments is confined only to the top management . Also, sponsorship to short term and long term training programmes is very low.

CASE 10 : NUCLEOPHIL CHEMICALS:

Description of Cleaner Technology adoption:

Nucleophil Chemicals is located in GIDC industrial estate, Ankleshwar in Gujarat. The main product is 3-nitro-4-chloro - benzoic acid.

Earlier, nitration of p-chloro benzoic acid was carried out using mix acid i.e. nitric acid and sulphuric acid. Presently, nitration of P-chloro benzoic acid is done using nitric acid alone. This has led to the total elimination of sulphuric acid in the process and in the ETP.

COST BENEFIT ANALYSIS:

Initial Investment Cost in Rs.

Equipment cost	= nil
Land cost	= nil
Construction cost	= nil
Total Investment	= nil

Operation Cost difference in Rs./annum

Raw Material cost	
Before CT	=21.294 lakhs
After CT	=27 lakhs
Difference	= +5.706 lakhs
Maintenance cost	= nil
Manpower cost	= nil
Energy cost	
Before CT	=5.4 lakhs
After CT	= 0.9 lakhs
Difference	= -4.5 lakhs
Water Cost	
Before CT	= 1.8 lakhs
After CT	= nil
Difference	= -1.8 lakhs

Disposal cost	
Before CT	=0.908 lakhs
After CT	= 0.018 lakhs
Difference	= -0.89 lakhs
Total operating cost difference	= 1.484 lakhs

Benefits: in Rs.

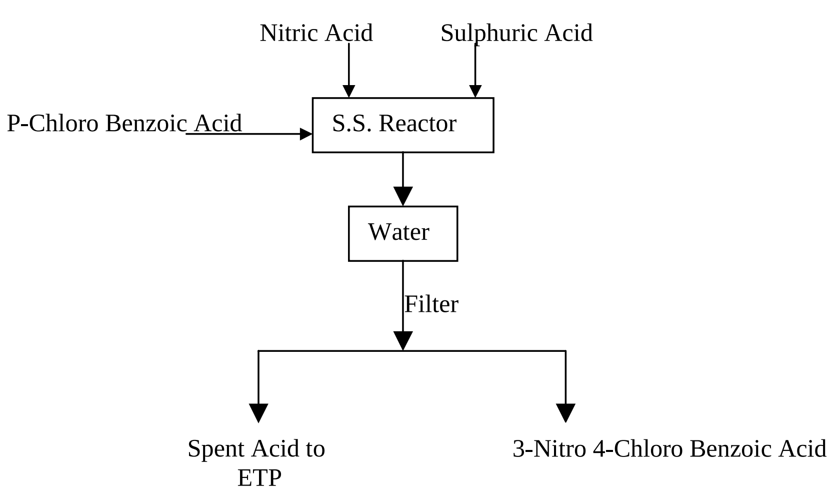
Raw material savings	= -5.706
Energy savings	= +5.4 lakhs
Savings in Manpower	= nil
Savings in disposal cost	=+ 0.89 lakhs
Savings in water	= +1.8 lakhs
Net Benefit	**= +1.484 lakhs**
Payback period	**= Immediate**

WMI

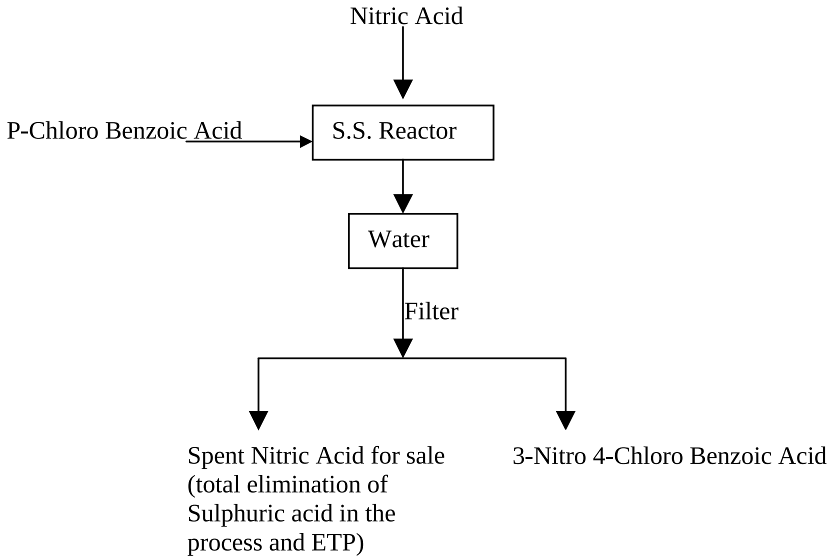
Not applicable

Flow Chart:

Old Method



New Method



Other Benefits:

Other benefits reported are improved health standards, improved safety standards and improved quality of water. While the latter is shown as very significant, the former two are listed in the significant category.

Nature of New Technology:

Earlier nitration was done with sulphuric acid and nitric acid, now only nitric acid is used. This is a modified reaction and is slightly less hazardous as sulphuric acid is no longer used.

DRIVING FORCES AND BARRIERS

As driving forces, only risk aversion, quality, efficiency drive and better safety & health have been mentioned. However, no ranks have been assigned and so weighting has not been attempted.

Driving Forces	Ranking
Market forces	-
Image	-
Risk Aversion	✔
Quality Drive	✔
Efficiency Drive	✔
Top management commitment	-
Better safety and health	✔
Government Regulations	-

Barriers

By and large, the barriers faced by the company while implementing CT appear to be minimal as is indicated by the low intensity score given to the various factors listed in the table. The only high intensity barrier experienced is that the regulatory authorities are not ready to believe that nitration is possible without sulphuric acid.

NATURE	DESCRIPTION	INTENSITY				
		L	V.L	M	H	V.H
(a) Legislative	Regulatory authorities do not believe nitration is possible without sulphuric acid					✔
(b) Institutional		✔				
(c Educational	-	✔				
(d) Public Opinion	-	✔				
(e) Employees' resistance	-	✔				
(f) Others, specify	-	-				

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

As for the adoption of the CT itself, no mention has been made as to the problems.

TRAINING:

In this particular case, training has been conducted only on the job.

Environmental awareness courses for management	-
Environmental awareness courses for engineers	-
Environmental awareness courses for shop-floor staff	-
Technical training for engineers	-
Technical training for shop-floor staff	-
Training in environmental management systems	-
No formal training, all done on-the-job	✔
Others, specify	-

Among the sources of training and information, journals and media have been found to be very useful by the company. In the useful category, Universities/R&D Organisations, conferences and seminars and business/environmental networks are indicated.

Barriers:

There do not seem to be significant barriers to the adoption of cleaner technologies. In the lower end of intensity scale, however, employee resistance and public opinion figured.

NATURE	DESCRIPTION	INTENSITY				
		L	V.L	M	H	V.H
(a) Legislative	Regulatory authorities do not believe nitration is possible without sulphuric acid					
(b) Institutional						
(c Educational	-					
(d) Public Opinion	-		✔			
(e) Employees' resistance	-	✔				
(f) Others, specify	-	-				

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

As for the adoption of the CT itself, no mention has been made as to the problems.

TRAINING:

It appears, training has received a lot of attention in the company as is revealed by the table below. Various types of training like awareness programs, technical training, training in environmental management systems and on the job training have been undertaken. Also, lead assessors training including auditors training have been given. It is gratifying to note that the training programs have covered different levels of employees ranging from shop-floor staff, engineers to management.

Environmental awareness courses for management	✔
Environmental awareness courses for engineers	✔
Environmental awareness courses for shop-floor staff	✔
Technical training for engineers	✔
Technical training for shop-floor staff	✔
Training in environmental management systems	✔
No formal training, all done on-the-job	✔
Others, specify	✔

Among the sources of training and information, journals and media have been found to be very useful by the company. In the useful category, Universities/R&D Organisations, conferences and seminars and business/environmental networks are indicated.

CORPORATE CITIZENSHIP:

The firm fares well in respect of corporate citizenship as well. Most parameters such as extent of employee improvement, level of motivation towards cleaner technologies, shared vision and values, exposure to professional literature and latest developments have been ranked either high or medium on a five-point scale. The scale ranges from very low, low, medium, high and very high.

Chapter 4: GAUGING THE 'ABILITY TO PAY' AND THE 'WILLINGNESS TO PAY' OF THE SURROUNDING AREA POPULATION:

Responses to the Contingent Valuation Method (CVM) survey

4.1. Introduction:

Using the environment for the disposal of waste products from human activities is a relevant economic issue because the environment has a limited though not necessarily fixed capacity to self degrade waste subject to the natural biological processes of decomposition (Hussen, 2000) and this has serious implications for society. *Thus as part of the Cost - Benefit Analysis, the study also seeks to examine the ability to pay and the willingness to pay in addition to gauging prevalent attitudes and awareness levels of the surrounding area population with respect to the environment, pollution, cleaner production technologies and practices.* The reason being that Cost Benefit Analysis perceives economic valuation only. Thus the total value of natural resources are undermined as in reality they do have intrinsic values that cannot be captured via market or extra market information. Since the people inhabiting the surrounding area are the ones directly and indirectly affected by industry and its production and policy options, their perceptions regarding the present status of the environment, and the need to bring about a cleaner environment in the near future become relevant. The *manner in which the roles and responsibilities of the polluting industry, the government and society are viewed by the individuals residing in the affected areas* vary greatly, as does the degree to which they hold each of the above accountable. In fact, it is in this context that the related concepts and issues like *'Ability to pay' (ATP), 'Willingness to pay' (WTP), 'whether or not the polluter should pay', Contingent Valuation techniques*, etc. assume significance. Akin to the people they are reflected by, these perceptions are not homogeneous, being influenced by a number of factors. *One's income level, educational background, age, profession, gender, access and receptiveness to appropriate information, proximity to industrial zones, personal experience and general upbringing are the factors that carry perhaps significant weightage.* Thus how this long-term economic concern of society is understood and addressed depends largely on people's perception of the relationships between the economic and the natural world (op cit. 2000). Therefore the economic value of a natural resource should include both use and non-use values and this is where Contingent Valuation Methods attain significance as they can point to the behavioural patterns of respondents while Cost Benefit Analysis by itself cannot. Now the technique designed to estimate non-use values cannot use real market information and so *the best option is to create hypothetical or artificial market conditions that elicit WTP [i.e. the standard measuring stick of benefit in economics - (op cit., 2000)] for the purpose of estimating non-use values.* This sort of direct approach to economic valuation is called Contingent Valuation and is the method employed in our survey. *In this survey, the respondents were asked as to whether they would be willing to contribute a nominal part of their income every month for a period of five years (as a sort of nominal levy/tax) if environmental damages could be pre-empted through the concerned industries' adoption of cleaner technologies in the event of their inability to afford this fully.* We have selected the *dichotomous choice approach* (i.e. by way of eliciting a yes/no response) in preference to the open-ended approach as the former is known to lead one closer to the actual WTP or at least to a closer approximation.

4.2. Administering the survey:

Thus, bearing in mind the above, a questionnaire (see Annexure II) targeting the surrounding area population was prepared and keeping the project objectives in view, a cross - section of 353 households in Navi Mumbai were interviewed with the aid of field enumerators to gauge their responses. The relative merits of the alternative methods of administering the survey such as face - to - face interviews, mail surveys, telephone surveys etc. have been discussed by Perman et al (1999). *We opted to conduct face - to -face interviews, given its potential for higher response rate and effective information provision.* It being more expensive, however, we confined the survey to the Thane - Belapur industrial belt. *In the choice of areas, the guiding principles have been proximity to this industrial belt and the inclusion of varying socio - economic groups (low, middle and upper).* To ensure randomness, a household from every tenth building on the left and right hand sides of the roads alternately was selected to be interviewed. Most of the respondents turned out to be the male earning members of the households or their sons and hence though desired, gender effects (if any) could not be asserted. Despite wanting to, given the distance and difficulties of supervision involved, we refrained from undertaking a similar survey in Gujarat.

Primarily, the analysis looks at the ‘willingness (and non willingness) to pay’ factor against the backgrounds of varying incomes and educational levels. Much as one would have liked to have chosen a larger sample, time and resource constraints prevented this or perhaps one would have also been able to attempt gender and proximity - wise comparisons of WTP as it is likely that a larger sample would have thrown more light on these relationships. Other factors like awareness levels (very high, high, medium, low, very low) have also been taken into consideration. However, it is important to note that this is really a reflection of the respondent’s own perception of his or her own awareness and hence it is likely to be biased. As a result this 'awareness' factor, which is already ambiguous and difficult to quantify, may produce an end result that is far from being accurate. Such skepticism often tends to get reinforced in the literature as well; for example, authors like Peterson (1992) have expressed the view that hypothetical questions only elicit hypothetical answers! Such aspects have also been discussed subsequently by the U.S. Department of Commerce Expert Panel (co - chaired by Arrow and Solow in 1993) and more recently by Perman et al (1999).

With this overall perspective in view, the population interviewed was classified into four different income groups, subject to their monthly earnings, i.e.:

- **(< 5,000)**: Represents the lowest income group - includes all those earning less than Rs. 5,000 per month.
- **(5,000 - 10,000)**: Represents the lower middle class - includes all those earning between Rs. 5,000 and Rs. 10,000 per month.
- **(10,000 - 20,000**): Represents the upper middle class - includes all those earning between Rs. 5,000 and Rs. 20,000 per month.
- **(> 20,000)**: Represents the highest (upper class) income group - includes all those earning more than Rs.20,000 per month.

Taking one's educational background into account, the entire population was classified into five categories, according to the level of education already completed or currently involved in, i.e.:

- **SSC** = Educated up to standard X.
- **HSC** = Educated up to standard XII or its equivalent
- **G** = Educated up to the graduation level in any area of study.
- **PG** = Educated up to the post graduation level in any area of study.
- **>PG** = Educated beyond the postgraduate level.

Age - wise, the respondents were divided into four classes, i.e.:

- < 20 yrs. = Represents all those below 20 years of age.
- 20 -30 yrs. = Represents all those between 20 and 30 years of age.
- 30 - 45 yrs. = Represents all those between 30 and 45 years of age.
- > 45 yrs. = Represents all those above 45 years of age.

In the Contingent Valuation technique used here, provisions were also made to accommodate the facts that those answering in the affirmative (with respect to WTP a certain amount 'X') might be willing to pay a little more (i.e. X+Y) and those answering in the negative might be willing to pay something less (i.e. X-Y) a la Vaughan et al (2000). The values specified in the questionnaire with their corresponding income groups are as follows:

Monthly Income Levels (Rs.)	**'X' values (Rs.)**	**'X+Y' values (Rs.)**	**'X-Y' values (Rs.)**
< 5,000	20	40	10
5,000 - 10,000	50	75	25
10,000 - 20,000	80	100	60
> 20,000	100	125	75

In the following section, the results based on the sample households interviewed are presented and discussed.

4.3. The Survey Results:

The total population of Navi Mumbai is 4,95,000 (as on May 2000) and its area - wise composition is given in Table 1:

Table 1- Population composition in Navi Mumbai

	Area	Population composition	As a proportion of total population	Sample size
1.	Vashi	1,03,000	21%	82
2.	Koper Khairne	94,000	19%	61
3.	Airoli	90,000	18%	59
4.	Turbha & Sanpada	71,000	14%	50
5.	Nerul	60,000	12%	40
6.	Ghansoli & Mahapegaon	42,000	8%	36
7.	Dighe	35,000	7%	25
	Total:	**4,95,000**	**99%** *	**353**

** The remaining 1% of the population resides in the outlying areas of the industrial belt and is hence not considered relevant for the purpose of this study.*

The above seven areas lie at varying degrees of proximity to the industrial region, ranging right from those in the heart of it, to those on the periphery. As can be discerned from Table 2, income group - wise, the lower end of the households interviewed reside primarily in the areas of Turbha, Sanpada, Ghansoli, Mahapegaon and Dighe. Incidentally, *localities like Dighe, Ghansoli, Mahapegaon, Koper Khairne and some sectors in Vashi are the worst affected areas given the fact that they are located right in the midst of the most polluted industrial zones, thus intensifying and reinforcing the problem - especially with respect to the poorer strata of society who get caught up in the vicious circle of poverty, pollution subjection and ill health.* In fact as can be observed later, in these areas the proportions exhibiting WTP are comparatively smaller. This response finds support in Davies' reaction to Arrow et al's views where he says that the immediate problems - land degradation, siltation, deforestation etc. for many of the poorest countries, primarily arise from population pressure and poverty. Of course, in the urban set - up we are concerned with, the above problems are not relevant. *However, population pressure and poverty do have several other adverse consequences on the inhabitants of the surrounding area that are more relevant to urban living in that the economic measure of the value of time, of health and of life is likely to be low for the poor.* Thus income inequalities in such cases are likely to be significant and they do tend to have a bearing on the responses and results. In Nerul, Vashi, Koper Khairne and Airoli there appears to be a middle class (upper and lower) dominance with about 92.50%, 84.16%, 62.30% and 61.02% of their total interviewed households lying in the Rs. 5,000 - Rs. 20,000 income bracket respectively. Except for Airoli, where at approximately 37.29%, the proportion falling into the Rs. 10,000 - Rs. 20,000 income group is higher than that of the Rs. 5,000 - Rs. 10,000 income group (23.73%), all the remaining areas mentioned above are inhabited primarily by the lower middle class. In Airoli, at 28.81%, the Rs. 0 - Rs. 5,000 (lower) income group also constitutes a significant proportion of its total sample size. Though in the Dighe (56%) and Turbha - Sanpada (50%) regions, there also does exist a bias towards the similar trends as the rest of the areas, these regions also house almost equally large shares of the lower stratas of society (i.e. 44% and 46% earn less than Rs. 5,000 a month respectively). Thus a strong bias towards the lower rungs of the income ladder is exhibited here (100% and 80% respectively). Koper Khairne, on the other hand, is constituted of a relatively balanced mix of the different income groups. At about 22.95%, the Rs. 0 - Rs. 5,000 (lower) income group constitutes a sizeable chunk of the total households interviewed, with the upper end of society (the greater than Rs. 20,000 income group) figuring at the tail end with 14.76% of Koper Khairne's total. The Ghansoli and Mahapegaon region accounts for largest concentration of those earning less than Rs. 5,000 per month (69.45%)

Table 2- Comparing the approximate proportions of the sample households distribution across areas, income group - wise (%)

Area ► / Income group ▼ (Rs.)	**Vashi**	**Koper Khairne**	**Airoli**	**Turbha & Sanpa--da**	**Nerul**	**Ghan--soli & Mahap--egaon**	**Dighe**
< 5,000	9.76	22.95	28.81	**46.00**	7.50	**69.45**	44.00
5,000 – 10,000	**48.79**	**32.79**	23.73	34.00	**65.00**	22.22	**56.00**
10,000 – 20,000	35.37	29.51	**37.29**	16.00	27.50	8.34	0.00
>20,000	6.10	14.76	10.17	4.00	0.00	0.00	0.00

(the highlighted figures in each area denote the existence of the highest proportion of sample households in the corresponding income groups)

Thus when one views the composition of the sample households in Navi Mumbai, one sees that the bulk of those interviewed exhibit lower income earnings capacity and this has a significant influence on their WTP. *The claim of several economists that a positive correlation exists between environmental degradation and poverty (Hussen, 2000), seems to be buttressed by our findings.*

As observed in the literature review, several studies show that some of the most important factors that the respondents think about when considering WTP, are income and financial commitments (31%), concerns about general environmental quality (17%) and doing one's fair share (13%) In our survey, the first factor seems to play a deciding role while the other two are relatively insignificant if not inconsequential.

To begin with, let us examine the Willingness (and Non willingness) to Pay component for each of the four different income groups, area - wise. The respondents' opinions with respect to whether the polluter should pay or not are also observed.

(For more data, one may refer to the detailed area - wise tables in Annexure III.)

[Note: WTP (Rs.) = Willingness To Pay (in Rupees) per month, NWTP = Non-Willingness to Pay, PSP = Polluter Should Pay, Y = Yes, N = No, no. = number]

I] Area: Vashi [Sample size = 82]

Table 3:

Income Group (Rs.)	No. of persons	Approx. proportion of sample(%)	Approx. Proportion exhibiting WTP(%)	Approx. Proportion exhibiting NWTP(%)
5,000 - 10,000	40	48.79	13.42	35.37
10,000 - 20,000	29	35.37	3.66	31.71
< 5,000	8	9.76	3.66	6.10
> 20,000	5	6.10	4.88	1.22
Total	**82**	**100**	**25.62**	**74.40**

(For more data one may refer to the detailed tables 13 - 17 in Annexure III.)

Table 3 indicates that in Vashi the largest proportion of the sample (48.79%) earns between Rs. 5,000 and Rs. 10,000 per month, followed by the 35.37% that earns between Rs. 10,000 and Rs. 20,000 per month. In spite of this, the former income group contains a proportion of 13.42% exhibiting WTP, (the largest proportion in the Vashi area) while the latter contains only 3.66% exhibiting the same. In fact from among those earning less than Rs. 5,000 per month (the lowest income group) there exists an equivalent proportion (i.e. 3.66%) exhibiting WTP. At about 4.88%, the figure representing the same in the greater than Rs. 20,000 income group, is only marginally higher. The general perception is that the higher the income (implying a higher the ability to pay), the higher will be the WTP. So ideally, more people in the higher income groups should be willing to pay in comparison to the lower income groups. Of course the amounts they are willing to pay may differ both across as well as within income groups. However from the data, we can see that this line of reasoning need not necessarily hold true. *A higher ability to pay need not necessarily imply a higher WTP at least not in this case.* Hence one cannot rely solely on income levels while analyzing WTP. The proportion exhibiting NWTP is also highest in the

Rs. 5,000 - 10,000 per month income group at 35.37%, followed closely by that in the Rs. 10,000 - 20,000 per month income group at 31.71%. Looking at the entire Vashi area, across all income groups, an overwhelming 74.40% are not willing to pay while 25.62% are. The general sentiments prevailing here were that *industry should adopt measures to reduce pollution and the cost of this should be borne by them entirely* since they create the whole problem. If they are unable to do this, *the government should handle the entire matter* since they were careless while issuing licenses and can utilize part of the taxes collected by them for this purpose of cleaner production technologies' implementation. In any case, the majority of the respondents were not ready to pay (unless payment was made compulsory) because *they did not perceive this as 'their problem'. There also existed a very strong disillusionment with respect to government policies and a staunch view that the money thus collected would not be utilized properly towards the said purpose.* Thus from tables 13 - 17 (Annexure III) and other relevant information assimilated from the questionnaire, suggest that across the different income groups, age groups, and various awareness levels, the overwhelming majority (88%) are of the opinion that *he who pollutes should pay* and hence they are not willing to contribute at all (i.e. the polluter should bear the entire cost). Only 6.10% of the households interviewed felt that instead of the polluter, the government should undertake the entire expenditure. The 25.62 % of the households in Vashi, who exhibit a WTP, are willing to contribute a monthly amount in the range of Rs. 25 - Rs. 75. Amongst these, the largest proportion at 14.63% are willing to contribute Rs. 50, followed by 6.10%, who are willing to contribute Rs. 25. The bulk of the respondents fell into the 30 - 40 years age group (43.90%), followed by the 20 - 30 years age group (34.15%). The more than 45 years age group accounted for 20.73% and the below 20 years age group for 1.22%.

II] Area: Koper Khairne [Sample size = 61]

Table 4:

Income Group (Rs.)	No. of persons	Approx. proportion of sample(%)	Approx. Proportion exhibiting WTP(%)	Approx. Proportion exhibiting NWTP(%)
5,000 - 10,000	20	32.79	18.03	14.75
10,000 - 20,000	18	29.51	8.20	21.31
< 5,000	14	22.95	8.20	14.75
> 20,000	9	14.76	8.20	6.56
Total	**61**	**100**	**42.62**	**57.38**

(For more data one may refer to the detailed tables 18 - 22 in Annexure III.)

From Table 4, it appears that the sample households in Koper Khairne are more 'evenly' distributed across the income groups. Once again, like Vashi, the largest proportion of the sample lies in the Rs. 5,000 - Rs. 10,000 per month income group (32.79%), followed by 29.51% in the Rs. 10,000 - Rs. 20,000 per month income group. 22.95% fall into the less than Rs. 5,000 per month income group and 14.76% fall into the greater than Rs. 20,000 per month income group. While the same proportion (8.20%) exhibits WTP in all the latter three income groups, it is the highest in the Rs. 5,000 - Rs. 10,000 per month income group at 18.03%. The Rs. 10,000 - Rs. 20,000 per month income group contains the highest proportion exhibiting NWTP at 21.31%. The Rs. 5,000 - Rs. 10,000 per month and the less than Rs. 5.000 per month income groups come next with proportions of 14.75% each. For Koper Khairne as a whole, the gap between those who are willing to pay (42.625%) and those who are not, (57.38%) is not as wide as in the case of Vashi. (From the Annexure III tables 18 - 22) Once again similar to Vashi, we see that across the different income, age and awareness levels in Koper Khairne, *the majority are of the view that the polluter should pay and not them.* As a result, while 57.38% exhibit NWTP irrespective of whether the polluter pays or not, 55.73% exhibit NWTP and insist that it is the polluter who must pay. A large number of these were adamant about not altering this stance irrespective of changes. A smaller proportion of 42.62% are actually willing to pay. Out of this, the largest proportion (24.59%) are willing to pay Rs. 50 from their monthly earnings, followed by 6.56% who are willing to pay Rs. 100 on a monthly basis. Most of the respondents here are more than 45 years of age (39.34%). 32.79% fall into the 30 - 40 years age bracket, 26.23% to the 20 - 30 years age group and 1.64% to the less than 20 years age group. *Though the dominant view here was that the implementation of cleaner production technologies was solely the polluter's responsibility, there also prevailed a lot more emphasis on the government's role in the matter.* Also the desire for actual implementation appeared to be a lot more apparent here. *Suggestions ranged right from getting small industries to band together and come up with appropriate solutions to arranging meetings with the local people for creating awareness about this pressing problem and stricter regulatory measures.*

III] Area: Airoli [Sample size = 59]

Table 5:

Income Group (Rs.)	No. of persons	Approx. proportion of sample(%)	Approx. Proportion exhibiting WTP(%)	Approx. Proportion exhibiting NWTP(%)
10,000 - 20,000	22	37.29	8.47	28.81
< 5,000	17	28.81	6.78	22.03
10,000 - 20,000	14	23.73	6.78	16.95
> 20,000	6	10.17	1.69	8.47
Total	**59**	**100**	**23.73**	**76.27**

(For more data one may refer to the detailed tables 23 - 27 Annexure III.)

In Airoli, the largest proportion of the sample at 37.29% lies in the Rs. 10,000 - Rs. 20,000 per month income group. It is followed first by the less than Rs. 5,000 per month income group (28.81%) and then by the Rs. 5,000 - Rs. 10,000 per month income group (23.73%). The largest proportions exhibiting WTP as well as NWTP at 8.47% and 28.81% respectively fall into the Rs. 10,000 - Rs. 20,000 per month income group. The less than Rs. 5,000 per month income group and the Rs. 5,000 - Rs. 10,000 per month income groups each have proportions of 6.78% exhibiting WTP. Considering Airoli as a whole, across all income groups, we see that here too the proportion exhibiting NWTP to pay at 76.27% is much higher than that expressing WTP at 23.73%. (From Annexure III tables 23 - 27) We see that while

49.21% of the sample households in Airoli feel that it is the polluter who should pay and that they themselves will not contribute at all, 27.06% actually feel that though they will not pay, the polluter should not pay either - it is the government who must take care of the situation. Approximately 23.73% are willing to pay, of which the largest proportions (6.78% each) seem to be willing to contribute Rs. 50 and Rs. 10 respectively. Among those interviewed, 42.37% fell into the 30 - 40 years age group, 25.42% into the 20 - 30 years category, 22.03% into the more than 45 years age group and 10.17% in the lesser than 20 years category. *Looking at the responses from Airoli, on the surface there does not seem to be any obvious correlation between higher education, higher incomes, higher awareness levels and a higher willingness to pay. In fact, most of the respondents possessing all the above attributes (high levels of education, income and awareness) are still not willing to contribute any amount at all no matter how nominal as they feel that they are already paying high taxes.* Also, this could perhaps be attributed to the fact that several respondents expressed a complete lack of faith in the actual implementation of anything of this nature. *However, simultaneously, there do exist individuals hailing from the lowest income group (i.e. less than Rs. 5,000 per month) with educational backgrounds ranging from incomplete primary school education to graduation and varying levels of awareness who are willing to contribute amounts as high as Rs. 500 per month.*

IV] Area: Turbha (inclusive of Sanpada) [Sample size = 50]

Table 6:

Income Group (Rs.)	No. of persons	Approx. proportion of sample(%)	Approx. Proportion exhibiting WTP(%)	Approx. Proportion exhibiting NWTP(%)
>5,000	23	46.00	4.00	42.00
5,000 - 10,000	17	34.00	6.00	28.00
10,000 - 20,000	8	16.00	4.00	12.00
> 20,000	2	4.00	0.00	4.00
Total	**50**	**100**	**14.00**	**86.00**

(For more data one may refer to the detailed tables 28 - 32 Annexure III.)

Table 6 shows that at 46%, the largest proportion of the sample in the Turbha - Sanpada area belongs to the lowest income group (i.e. less than Rs. 5,000 per month). The Rs. 5,000 - Rs. 10,000 per month income group follows at 34%. However the greatest proportion (6%) exhibiting WTP lies in the latter. In spite of just 16% of the total sample constituting the Rs. 10,000 - Rs. 20,000 per month income group, the proportion exhibiting WTP here is the same as that of the group with income less than Rs. 5,000 per month, i.e. 4% each. At 42%, the largest proportion exhibiting NWTP also lies in the least income group. In the Turbha – Sanpada region as well, the total proportion exhibiting WTP (14%) is a great deal lower than that exhibiting non-willingness to pay (86%). Coupling the areas of Turbha and Sanpada together, we see that 52% of the sample lies in the 20 - 30 years age group, 30% lies in the more than 45 years age group, 16%, in the 30 - 40 years age group and 2% in the lower than 20 years age group. Further (from the Annexure tables 28 - 32) we can see the following. A total proportion of 86% in this region express a NWTP - brought on by an apprehension with respect to the workability of this project as well as their financial commitments. Of this 60% of them believe that it is the polluter who must pay (as their business deals in crores of rupees, they can manage to raise the required funds on their own) whereas 26% think that instead of the polluting industry the government must ‘pay’. Out of the 14% who are willing to pay, 12% are willing to pay Rs. 20 monthly and 2 % are willing to pay Rs. 100 per month. *In this area as well we see instances which seem to indicate that there exists no direct correlation between stated levels of awareness, education, income and the amounts with respect to WTP - for example, a farmer earning less than Rs. 5,000 per month, claiming a medium level of awareness and who had been educated only up to class two was willing to pay a monthly amount of Rs. 100. The respondents here expressed outrage at the fact that though this was part of the government's duties, its pollution control bodies were not working towards any sort of concrete improvements. Several respondents also asked to be given jobs before being asked to contribute.*

V] Area: Nerul [Sample size = 40]

Table 7:

Income Group (Rs.)	No. of persons	Approx. proportion of sample(%)	Approx. Proportion exhibiting WTP(%)	Approx. Proportion exhibiting NWTP(%)
5,000 - 10,000	26	65.00	12.50	52.50
10,000 - 20,000	11	27.50	15.00	12.50
< 5,000	3	7.50	0.00	7.50
> 20,000	0	0.00	0.00	0.00
Total	**40**	**100**	**27.50**	**72.50**

(For more data one may refer to the detailed tables 33 - 36 in Annexure III.)

From the data in Table 7, we see that the largest proportion of the sample in Nerul, (65%) lies in the Rs. 5,000 - Rs. 10,000 income group. At 27.50%, the Rs. 10,000 - Rs. 20,000 income group comes in a far second. However, the proportion willing to pay a certain amount per month is higher in the latter (15%) as compared to the former (12.50%). In fact, the Rs. 5,000 - Rs.10,000 income group has the largest proportion (52.50%) exhibiting a NWTP, followed by the 10,000 - 20,000 income group at 12.50%. The trend for the whole of Nerul also follows that of the other areas, with a sizeable 72.50% expressing a NWTP and 27.50% exhibiting a willingness to contribute. Nearly half (46%) of the households interviewed, fell into the 20 - 30 years age group, 26% fell into the 30 - 40 years age group and 5% each fell into the less than 20 years and greater than 45 years age groups respectively. (Looking at Annexure III tables 33 - 36) we see that of the total proportion exhibiting NWTP (72.50%), 47.50% are of the opinion that it is the *polluters who must pay, while 25% believe that they should not and that it is the government who must claim responsibility instead.* From the 27.50% exhibiting WTP, 17.50% are willing to contribute a monthly figure of Rs. 25, while 10% are willing to contribute Rs. 50.

VI] Area: Ghansoli (inclusive of Mahapegaon) [Sample size = 36]

Table 8:

Income Group (Rs.)	No. of persons	Approx. proportion of sample(%)	Approx. Proportion exhibiting WTP(%)	Approx. Proportion exhibiting NWTP(%)
< 5,000	25	69.45	16.67	52.78
5,000 - 10,000	8	22.22	8.33	13.89
10,000 - 20,000	3	8.34	2.78	5.56
> 20,000	0	0.00	0.00	0.00
Total	**36**	**100**	**27.78**	**72.23**

(For more data one may refer to the detailed tables 37 – 40 in Annexure III.)

Clubbing the areas of Ghansoli and Mahapegaon together, in Table 8, we see that at 69.45%, the greatest proportion of the sample lies in the lowest income group (i.e. less than Rs. 5,000 per month). The largest proportions exhibiting both willingness and non-willingness to pay also lie in this income group at 16.67% and 52.78% respectively. In every income group in this region, the proportions expressing WTP are significantly lesser than those not willing to contribute anything at all. This is reflected in the overall picture of the Ghansoli - Mahapegaon region, where just 27.78% of the sample are willing to pay a certain figure on a monthly basis in comparison to 72.23% who are not. Considering the age - wise distribution of the sample in the Ghansoli - Mahapegaon area, we see that 38.89% fall into the 20 - 30 years age group, 33.33% belong to the 30 - 45 years age group, 22.22% are less than 20 years old and 5.56% are more than 45 years of age. (Looking at Annexure III tables 37 - 40) we deduce that out of the 72.23% who are not willing to pay any sum of money per month, 63.89% were of this opinion because they believe that it is the polluter who should pay and not them, while the remaining 8.34% were of the view that it is the government who should take care of all such expenses and not the polluter. *While a negligible number of respondents were actually willing to change their minds about not contributing since they were suffering the negative impacts of pollution, the majority were not. They were keener on getting the industries to provide them with employment. Concepts like a 'pollution free environment' were not regarded as issues of importance. This once again seems to point to the population -*

*poverty nexus and the low priority accorded to the environment.*16.67% of the total are willing to pay Rs. 20 per month, while 2.78% (each proportion) are willing to pay Rs. 5, Rs. 25, Rs. 50 and Rs. 75 respectively, bringing the total proportion exhibiting WTP, in the Ghansoli - Mahapegaon region, to 27.78%.

VII] Area: Dighe [Sample size = 25]

Table 9:

Income Group (Rs.)	No. of persons	Approx. proportion of sample(%)	Approx. Proportion exhibiting WTP(%)	Approx. Proportion exhibiting NWTP(%)
5,000 - 10,000	14	56.00	4.00	52.00
< 5,000	11	44.00	4.00	40.00
10,000 - 20,000	0	0.00	0.00	0.00
> 20,000	0	0.00	0.00	0.00
Total	**25**	**100**	**8.00**	**92.00**

(For more data one may refer to the detailed tables 41 - 43 in Annexure III.)

From Table 9, we see that the sample in Dighe is concentrated in the lower income group area, with 56% of the total lying in the Rs. 5,000 - Rs. 10,000 per month income group and 44% earning less than Rs. 5,000 per month. Once again, the proportion exhibiting NWTP is far greater than that exhibiting WTP in both cases as can be seen in the table. For the area as a whole, an overwhelming 92% is not willing to contribute anything while just 8% is willing. (From Annexure III tables 41 - 43) we see that Dighe is primarily a lower income group area. *As such the views expressed here are primarily concerned with and influenced by the need for survival. Several respondents did agree that they perceived a serious pollution problem, however employment from these industries was viewed as being far more important. Besides since their earnings itself are low, they feel that they cannot afford to contribute.* Looking at the age-wise distribution in this region, 64% of the households interviewed were in the 30-40 years age group and the remaining 36% were in the 20-30 years age group. Out of the 25 respondents, only two (8%) - one each from the Rs. 5,000 - Rs. 10,000 and less than Rs. 5,000 income groups - were willing to contribute; the amount being Rs. 25 per month in both cases. Once again from the majority expressing NWTP (92%), approximately 84% were of the view that the polluter must pay, while 8% felt that the government must bear all such expenses. From the sample observations in Dighe, it seems as if one's level of awareness has no influence on one's WTP, however this could be the result of the fact that Dighe constitutes one of the poorer regions in the area of study. *As such, low incomes and the limited needs these incomes are capable of satisfying, may restrict one's ability and one's willingness to contribute monetarily towards the environment, as it is not seen as being an urgent, immediate or direct need.*

From table 10 we see that the proportions expressing WTP in each area of Navi Mumbai in descending order (i.e. from the largest to the smallest proportion) are: *42.62% in Koper Khairne, 27.78% in the Ghansoli - Mahapegaon region, 27.50% in Nerul, 25.62% in Vashi, 23.73% in Airoli, 14.00% in the Turbha - Sanpada area and 8.00% in Dighe.* Obviously the proportions of those expressing NWTP in each of the areas are, from largest to smallest, (in exactly the reverse order from above): 92.00% in Dighe, 86.00% in Turbha - Sanpada, 76.27% in Airoli, 74.40% in Vashi, 72.50% in Nerul, 72.23% in Ghansoli - Mahapegaon and 57.38% in Koper Khairne. The largest proportion exhibiting WTP lies in Koper Khairne's Rs. 5,000 - Rs. 10,000 per month income group (18.03%) while the greatest proportion expressing NWTP lies in the less than Rs. 5,000 a month income group of the Ghansoli - Mahapegaon region (52.78%). *Earlier when we tackled WTP on the basis of the different income groups area - wise, we saw how within each of them there did not seem to be any real positive correlation between higher incomes and higher WTP*, i.e. WTP did not seem to rise with rising incomes, which is in keeping with the Diamond et al (1994) point of view. They put forth that there is variation in WTP across individuals and surveys - i.e. one would expect individuals with higher incomes to have larger WTP, but this does not happen. However, when we take the entire region of Navi Mumbai, we see that perhaps this is not the case across the different areas. As can be inferred from the above table, *it appears that the proportions exhibiting WTP in the financially better off (relatively speaking) areas are greater than those in the poorer regions.* So also with NWTP - the proportions exhibiting this in the predominantly lower income group areas are larger than those in the 'richer' regions. Given that the entire region is primarily inhabited by the low to upper middle classes, the variations in WTP and NWTP proportions across the areas are not widely varied. However, the differences are observable. Thus in this context we can perhaps say that as income rises, all other needs are met, the ability to pay or contribute towards projects such as the one suggested in this study also rises and eventually so does the WTP.

Table 11: Willingness To Pay across Income groups…

WTP (Rs.)	**No. of people**	**Proportion of total sample (%)**
5	2	0.57
10	5	1.42
20	13	3.68
21	1	0.28
25	17	4.82
30	2	0.57
40	1	0.28
50	**36**	**10.20**
75	4	1.13
100	6	1.70
200	2	0.57
500	1	0.28
Total:	**90**	**25.50**

From the above table we see that out of the 25.50% of the total Navi Mumbai sample households expressing WTP, the largest proportion at 10.20% is willing to pay a monthly amount of Rs. 50 for the proposed project for the specified number of years (i.e. five years).

Now, if the sample is representative of the population, the sample mean per capita (or per household) WTP can simply be attributed to everyone in the beneficiary population of size N, so total project benefits will be - N times per capita WTP. (Vaughan et al, 2000)

Sample Median WTP (per household) = Rs. 50.

Sample Mean WTP (per household) = Rs.49.62 = Rs. 50 (approximately)

Total project benefits = (No. of households in the area) x (49.62)

(In our study, the WTP was found to lie in the range of Rs. 25 - Rs. 50 a month)

Now, assuming the average household to consist of 5 family members,

We arrive at - Number of households = 99,000

Therefore, accordingly, Project Benefits = Rs. 49.124 lakhs per month.

Assuming the average household to consist of 4 family members,

We arrive at - Number of households = 1,23,750

Therefore, accordingly, Project Benefits = Rs. 61.405 lakhs per month.

Assuming the average household to consist of 4.5 family members,

We arrive at - Number of households = 1,10,000

Therefore, accordingly, Project Benefits = Rs. 54.582 lakhs per month.

Table 12: Comparison of Willingness to pay on the basis of educational background (as proportions of the total sample households)…

educa- -tion → WTP ↓ (Rs.)	**SSC %**	**HSC %**	**G %**	**PG %**	**>PG %**	**No info. %**	**Total %**
0	74.79	76.92	74.42	70.37	0.00	86.36	74.50
(NWTP) Total:	**74.79**	**76.92**	**74.42**	**70.37**	**0.00**	**86.36**	***74.50***
0-10	0.84	1.92	0.00	0.00	0.00	0.00	0.57
10-20	2.52	0.00	1.55	0.00	0.00	0.00	1.42
20-30	8.40	11.54	8.53	0.00	25.00	13.64	8.78
30-40	0.00	0.00	0.78	3.70	0.00	0.00	0.57
40-50	0.00	0.00	0.78	0.00	0.00	0.00	0.28
50-60	9.24	9.62	9.30	18.52	75.00	0.00	10.20
60-70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70-80	2.52	0.00	0.78	0.00	0.00	0.00	1.13
80-90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100-200	0.84	0.00	2.33	7.41	0.00	0.00	1.70
200-500	0.84	0.00	0.78	0.00	0.00	0.00	0.57
500 +	0.00	0.00	0.78	0.00	0.00	0.00	0.28
(WTP) *Total:*	**25.21**	**23.08**	**25.58**	**29.63**	**100.00**	**13.64**	***25.50***
<u>TOTAL</u>	**33.71**	**14.73**	**36.54**	**7.65**	**1.13**	**6.23**	***100.00***

In the area surveyed, 36.54% had either completed or were in the process of completing their graduation. The 33.71% who had completed schooling up to Standard X or less followed this. About 14.73% had finished schooling more than Standard X but less than Standard XII. Approximately 7.65% had pursued or were pursuing postgraduate studies while 1.13% had or were taking higher degrees. No information with respect to educational background was available for 6.23% of the households interviewed.

Looking at the table, we see that NWTP is highest in the HSC group and lowest in the Postgraduate group. Except in the case of the SSC and HSC educated proportions, where the latter group performs better than the former in terms of WTP (but only very marginally), in every other instance one sees that the more educated respondent groups have greater proportions expressing WTP. Thus here we can say that a positive correlation exists between education levels and WTP- i.e. the higher the education level, the more likely that an individual would be willing to pay. The amounts will vary from individual to individual. This positive correlation could exist because one assumes that as one attains higher levels of education, one's knowledge and awareness increases (hence also one's sensitivity), one has greater access to resources (people and material) both in terms of quality and quantity and one is able to enter the labour market at a higher level and thus command a higher salary. It is also likely that those who do pursue higher studies are those who are able to give higher education priority over getting a job. They can hence afford to or they choose to forgo earning for a longer while (opportunity costs involved). More often that not this implies that they do have other means of support, which allows them to be able to make this choice. That is to say that it is primarily those belonging to higher income groups and those who value education and all that it implies, who tend to pursue higher levels of education. This could be for the sake of knowledge per se or because they perceive it as an investment that results in high returns later. The implication, therefore, is that there appears to exist a positive relationship between higher incomes, higher education levels, higher ability to pay and higher WTP.

4.4 Summary:

In general, the CVM survey reveals that in the Navi Mumbai region, across the different areas, the evidence is in favour of - *'the higher the income level, the larger the proportion exhibiting WTP'* - which is in line with received economic theory as well as experiences gathered from various studies the world over. The converse (i.e. the lower the income group, the lesser the proportion exhibiting WTP) also seems to hold true in some areas - primarily in Dighe, Turbha, Ghansoli and Mahapegaon, where we see that the fraction exhibiting WTP as well as the amounts involved are very small. This is in spite of the fact that these areas fall right in the center of industrial activity and are hence directly affected by the hazards of environmental pollution. However***,*** *evidence to the contrary is also seen to coexist* when one analyses the responses pertaining to different income groups within specific areas - especially in Airoli, parts of Vashi, Koper Khairne and Nerul (i.e. the comparatively 'better - off' areas in terms of income earned), one fails to see any real positive correlation between higher incomes and higher WTP.

Findings from the survey also indicate that across the entire region, *the higher the education level, the greater the proportion expressing WTP, thus implying that a positive correlation exists between the two*. For Navi Mumbai, the average WTP was found to lie in the Rs. 25 - Rs. 50 range. The sample median WTP per household was Rs. 50 and the sample mean WTP per household was Rs. 49.62.

Another issue, which is pertinent here, is the willingness of an individual to preserve an environmental amenity because of concern for others. Therefore, if people cared about each other's utilities, they care about the costs and benefits of others (must include external costs and benefits). Given the strong majority expressing a non-willingness to pay as well as their various responses, the evidence does not bear testimony to such a behavioural pattern in our study area. In fact, most respondents were prone to turning a blind eye to the big picture. *The majority was of the staunch belief that they were 'victims', and had no responsibility, as they were not the polluters and nor were they in positions of authority which could empower them to do something about the problem.* Thus an overwhelming majority of the population interviewed in all areas (irrespective of their willingness or non - willingness to pay and especially so in the case of the latter) was primarily of the opinion that the *polluters should be the ones to pay since they are the ones causing environmental damage.* A sizeable proportion, however, also insisted that this issue was a governmental concern and should be taken care of by them. *The main arguments put forth here being that citizens pay taxes, part of which the government could very well use towards this purpose and that the government has the authority to allow or not to allow polluting industries to come up. It can determine where these industries are to be located and as such avoid their presence in residential areas. It is also the government, which can lay down the norms for pollution control. Thus the general opinion is that environmental pollution and its resolution is the responsibility of the polluter and the government.*

Another major cause of low WTP, which is of special relevance in our survey, is that the environment and its preservation or the prevention of its deterioration is not perceived as an immediate concern or threat by society. The effects of environmental degradation are only felt in the long run and thus the respondents do not feel the need to make any monetary contribution towards its as they do not view it as an issue to be tackled urgently. *Thus the problem is the inter-generational incidence of environmental costs - i.e. the fact that their effects come only in the future generations.* Intra - generational incidence is based on the incomes of those expressing their WTP. This income effect is an important factor with respect to developing countries to which India is no exception.

Thus all in all, it is felt that the whole Contingent Valuation exercise was a worthwhile one since it gives us at least some indication with respect to WTP subject to certain riders as also an insight into people's perceptions about the environment, roles of the industry and the government.

Chapter 5: CONCLUDING REMARKS AND RECOMMENDATIONS:

Summary of Findings:

It is encouraging to note that in most cases where cleaner production technologies were implemented, the *cost benefit analysis* shows that the firms have benefited by and large, both quantitatively and qualitatively. The quantitative benefits are reflected in the short pay back periods; in some cases even as short as a few days to few months. There have been no production interruptions whatsoever, in the adoption and implementation of cleaner technologies. In all the cases, firms have implemented CT exercises during shutdown periods and or adequate inventory was built up in a few cases where shut down extension was anticipated. Best efforts to obtain imputed values were made wherever found relevant for e.g. fabrication, use of land, manpower etc. In respect of *organizational citizenship*, it is heartening to note that most of the firms studied fare reasonably well. In some cases the responses have been very encouraging with high scores.

In terms of *merit goods* or qualitative benefits and spin - off / spill - over effects, there have been positive impacts on the quality of air, water, and demonstration effect and employee attitudes. In very few cases, positive health impacts has been perceived and reported. In many other cases, there may have been health benefits as a result of reduction in dust /emissions, effluents, and odor and yet the firms have not been able to link it to the CT measures or health records.

The major *driving forces* behind adoption of cleaner technologies as revealed by the study are top management commitment, better safety and health, efficiency drive and corporate image. Most companies covered in this study did not experience any significant barrier while implementing CT measures. In some cases however, the lack of funds for long term investments amidst pressure for obtaining quicker returns has been viewed as a problem while adopting CT.

The study also reveals that *training* has received due attention in most of the large scale units. Greater attention has however, seems to be on in-house training and that too on-the-job type. Among the sources of training and information in-house staff have been found very useful followed by journals /media, Universities/R&D organizations and Industry Associations.

Coming to the *'public goods'* evaluation aspect, *the CVM survey* has been confined to the surrounding area population around the Thane - Belapur Industrial belt. The evidence in general, supports the theory and experience obtained in other countries in that larger proportions of the higher income groups display willingness to pay in comparison to their 'poorer' counterparts. However, in certain specific locations [Airoli, parts of Vashi, Koper Khairne and Nerul - i.e. the comparatively 'better - off' areas in terms of income earned], evidence to the contrary is also obtained, where one does not see any real positive correlation between higher incomes and higher WTP. At the very lowest end of the income spectrum, the response is negative indicating perhaps, that the environment does not figure in their calculus of priorities at the subsistence level. Also, across the entire region, the higher the education level, the greater the proportion expressing WTP, thus implying that a positive correlation exists between the two. However, irrespective of one's income or educational qualifications the overriding view that prevails is that the "polluter should pay". A pressing need for more effective governmental intervention and control is also stressed. Thus all in all, one feels that the whole Contingent Valuation exercise was a worthwhile one since it gives one at least some indication with respect to WTP subject to certain riders as also an insight into people's perceptions about the environment, roles of the industry and the government.

Concluding Remarks and Recommendations:

While summing up, it is heartening to note that cleaner production technologies exercises are not only desirable from the environmental point of view as a pre-emptive strategy, but also make good economic sense. As has been seen in many cases, such exercises have added to the bottomline by conserving resources like energy, raw materials and manpower, improving yield and reducing treatment/disposal costs. The study should go a long way in promoting widespread adoption/implementation of Cleaner production technologies in other industries so that tangible progress is made in the direction of sustainable development. It is also observed that there are significant gains accruing from the merit goods viewpoint as well.

By way of *policy implications*, we may add that best efforts should be made to promote cleaner technologies through suitable incentives, setting up state- wise information clearing houses on CT. This is especially important given that many firms have indicated lack of funds for long term investment, and lack of information on tested technologies. In the present legal framework on environmental protection, there are no laws encouraging waste minimisation, recovery and recycling. The Government of India can make cleaner production a major focus area by amending the existing Environment Protection Act - 1986.

Also, efforts at the level of the *Industry Associations* need far more strengthening and the emphasis needs to be shifted more towards facilitating CTs and Green Rating rather than mere abatement to meet regulatory requirements. As of now, green rating seems to be confined to NGOs like the Centre for Science and Environment (CSE). Moreover, they should develop networking with their counterparts elsewhere, government agencies and others like the Global Reporting Initiatives need to be undertaken in order to move closer to the creation and development of a clearing house for speedier exchange of information on CT and accelerate the demonstration effect. The present state of affairs at the disposable points, whether individual ETPs or common ETPs, leaves much to be desired. Arguments such as, 'disposal is safe through long pipelines to the Gulf of Cambay because there are no micro-organisms there', may not be tenable for long. Worse still, in some places people privately admit that ETPs are viewed only as a cost item and are functional only when pollution control authorities are likely to visit the plant, remaining shut the rest of the time. As for incinerators, cases are not infrequent where one is told they do not work.

It is all the more imperative, therefore, to make sincere and serious efforts towards CT alternatives such as exploring opportunities for using biotechnology, reed-bed technologies etc., in a big way as attempted in other parts of the world. Surely, prevention is better than cure!

Limitations of the Study:

While concluding it is important to note that no generalization can be attempted as the study is not based on statistical representation of the sectors/industries covered but confined to case studies. First and foremost, there are only a few firms within industries like fertilizers and agro-chemicals i.e., they have an oligopoly- type market structure. Secondly, within this limited number of players itself, the firms which have implemented CT are still fewer. Thirdly, even in cases where CT implementation has taken place there is strong resistance to part with data and relevant information. The reason often cited is that it is a company. policy not to reveal details of technology, process flow charts and input structure. Some of the firms, which have participated in this study, have requested for confidentiality and anonymity. However, despite giving such assurances as to confidentiality and anonymity, some firms have given only net savings and not pre-CT and post-CT input requirements.

In the CVM survey, the differing pattern based on *relative proximity* to polluting industries and *gender* could not be ascertained. Here too, there was a lot of resistance to spare time for the face to face interview with the enumerators.

Scope for Future Work:

The study could be extended to other major energy/resource intensive industries like power, refineries and iron & steel and also to other states. Further, efforts can be made to obtain time series data wherever possible so that IRR and ERR could be estimated. Besides, recourse may be made to normative costs if available in cases where actual data is not forthcoming.

Lastly, to supplement surrounding area population survey, repertory grid analysis can be attempted with the help of community workshops . This can give us better picture of relative importance assigned to environmental quality by different social strata of people at different locations.

ANNEXURE I

NITIE, Mumbai 400 087

WORLD BANK-AIDED RESEARCH PROJECT

ON

"COST-BENEFIT ANALYSIS OF CLEANER PRODUCTION TECHNOLOGIES IN INDIA"

QUESTIONNAIRE FOR SURVEY*

(RESPONDENTS: ENTERPRISES)

Objectives of the Study:

a) To carry out a cost-benefit analysis of cleaner production technologies in terms of financial, economic environmental & other societal spill-over/spin-over effects.

b) To evaluate the impact of cleaner production technologies in some of the most polluting Indian Industries.

c) To examine the background and driving forces for the development and use of cleaner production technologies as well as the barriers to them.

d) To infer implications of this study for corporate (and also new industries) and macro policies including the local economy.

Name of the Firm :

Address :

Contact Person :

I. Products manufactured and Technology adopted:

Products and byproducts	*Technology (a)/(b)/(c)/(d) (Briefly describe the technology	Process ** Batch/ continuous	Present Capacity	Date of installation

* (a) Old technology improved with cleaner production methods (b) Old technology with some retrofitting or upgradation (c) Old technology but new plant/machinery (d) Clean (new) technology that minimises waste, reduces pollution, protects human life and environment.

** Please attach the flow charts of the old and new (or modified) processes.

II. Details regarding the products manufactured by you.

Products	Nature of usage (Raw material/ intermediate good/ capital good/ final consumption good)	Major consumers of the product	Market where sold (Domestic/Export)

III. Details of production and raw material consumption (per annum or per day)

Products	Present Production per annum/day (Quantity)	Raw Material Consumption			Byproducts generated	
		Name	Quantity used	Wastage (%)	Name	Quantity

IV. a. Present system of pollution control methods

End of Pipe/Clean Technology/Recycling

IV. b. Designation of the person responsible for environmental management

IV. c. Which of the following systems for environmental management have been implemented or are planned in the next 3 years? Tick appropriate column.

	Implemented	Planned	No plans
Impact assessment for new plant			
Environmental audits			
Audits for production processes			
Life cycle analysis for products (Supply chain & Disposal chain)			
Environmental reviews of suppliers			
Annual environmental report			
Others, please specify			

V. Details regarding improvements/modifications made in the recent past or currently being envisaged like procurement, raw material substitution, process modification, equipment modification, pollution preventive/control measures, etc.

Plant/ Product line	* Source & Cause of Waste Generation	Quantity of pollutants (per ton of output) (Effluents, gases or solid wastes)		Details of process modifications or improvements at different stages	Date of Impleme nt ation	Costs Involved			
		Before CT	After CT			Equip-ment (Rs.)	Land (Rs.)	Constr u-ction (Rs)	Dispos -al costs (Rs)

* (Raw Material handling, procuring, processing, Transport, Storage, Waste treatment, energy mgmt. Systems, product redesigning)

VI. Costs of CT implementation (initial capital costs, maintenance, operational and manpower costs before and after the implementation of the above changes).

Product Line	Initial Capital Cost including of equipment, its installation, land & Construction (Rs.)	Maintenance costs (Rs.)		Operational Costs (Rs.)		Manpower Costs (Rs.)		Disposal Costs (Rs)	
		Before	After	Before	After	Before	After	Before	After

VII. Costs of energy (fuel, electricity, steam, etc.) water and raw material per unit of output before and after the implementation of the above changes.

Product	Energy Costs (Rs.)		Water Costs (Rs.)		Raw material Costs (Rs.)		Others (Rs.)
	Before	After	Before	After	Before	After	

VIII. COST OF MANOWER TRAINING FOR THE SWITCH-OVER

Nature and duration of training	Employee Level	Training cost (Rs.)

IX. IMPACT ON HEALTH OF EMPLOYEES

Variations observed in Health records		No. of visits to Doctor/Clinic		No. of employees on medical leave or loss of manpower	
Before CT	After CT	Before CT	After CT	Before CT	After CT

X. COSTS OF ABATEMENT

COSTS OF ABATEMENT	BEFORE CT (Rs.)	AFTER CT (Rs.)
Air Pollution Control		
ETP		
Solid Waste Treatment		
Monitoring/Recording/Documentation System		

XI. DRIVING FORCES:

If cleaner technologies have been implemented, the reasons/driving forces for implementation

NATURE	Rank them in order of preference
1. Market forces	
2. Image	
3. Risk aversion	
4. Quality	
5. Efficiency driven	
6. Top Management Commitment	
7. Better Safety & Health	
8. Government Regulations	
9. Others (Specify)	

Driving forces for implementing cleaner technologies:

a) Governmental regulations, pressure from local bodies, NGOs, etc.

b) Self-control to escape from public denunciation

c) Enlightened management open to new ideas

d) Need to lower the cost of production in view of stiff competition from others.

e) Mounting costs of raw materials, energy, water, waste minimisation measures.

f) Possibility of space economisation

g) Demand from supervisory staff and workers for better environment around the factory premises.

h) Desire to project better corporate image of being environmentally friendly.

i) Preference in the international market for environmentally friendly products.

j) Inspiration derived from other units/demonstration effect.

k) Availability of soft loans for pollution control measures.

l) Tax incentives

m) Depreciation benefits

n) Market/competition driven

o) Quality/Efficiency driven

p) Better safety concern

q) Top management commitment

r) Other factors (Please specify)

XII. a. BARRIERS

The Main Barriers faced while implementation of Cleaner Technology such as:

NATURE	DESCRIPTION	INTENSITY				
(a) Legislative		L	V.L	M	H	V.H
(b) Institutional						
(c Educational						
(d) Public Opinion						
(e) Employees' resistance						
(f) Others, specify						

L = Low, V.L = Very Low, M = Moderate, H = High, VH = Very High

XII. b. What do you see as the most important problems associated with adopting CT? Please tick.

Lack of capital for investment due to recession	
Long pay back period/pressure for short term returns on investment	
High cost compared to EOP	
Many CT are not proven yet	
Poor service or lack of integrated systems from suppliers	
Uncertainty about regulatory framework	
Lack of commitment from top management to strategic approach to environmental issues	
Lack of commitment from middle management	
Others, specify	

XIIII. a. What training has been carried out in relation to adoption of CT? Please tick.

Environmental awareness courses for management	
Environmental awareness courses for engineers	
Environmental awareness courses for shop-floor staff	
Technical training for engineers	
Technical training for shop-floor staff	
Training in environmental management systems	
No formal training, all done on-the-job	
Others, specify	

XIII. b. Organisation Learning

	Low	Very low	Medium	High	Very high
The extent of improvement of employees					
Level of motivation towards CT					
Shared Vision / Values					
Exposure to professional / literature and other latest developments					
Sponsorship for short-term / long-term training programs					
Others					

XIII. c. Which of these sources of training and information on CT have been most useful to you? Please tick.

	Very Useful	Useful	Not at all useful	Not practiced
In-house staff				
Universities/R&D Organisations				
Industry Associations				
External training organisations				
Suppliers of CT				
Other Companies				
Conferences & Seminars				
Consultants				
Business.Envt. networks				
Journals/Press				
Others, Specify				

XIV. Benefits of CT Implementation

Increase in production capacity and output after the implementation of the above changes. (t_1…………………..t_n)

Product	Rise in Production Capacity (TPD)				Rise in Output (TPD) of Products and byproducts			
	From		To		From		To	
	Qty.	Value (Rs.)	Qty.	Value (Rs.)	Qty.	Value (Rs.)	Qty.	Value (Rs.)

XV. Overall benefits (in Rupees) derived due to the implementation of changes and pay back period. (t_1…………t_n)

Benefits on accounts of	Amount benefited per product line where changes were carried out/are contemplated to be carried out (Rs.)		
Capacity improvement Raw material Saving Energy Saving Water Saving Improved recovery from waste Reduction in abatement costs			
Improved Productivity			
Net Savings Pay back period			

XVI. Other Economic Benefits (t_1………………t_n)

	Yes/No	If yes, to what extent		
		V.Significant	Significant	Somewhat
Improved Health Standards				
Improved Safety Standards				
Improved Quality of Air				
Improved Water Quality				
Reduction in Noise				
Demonstration Effect				
Improved Awareness among Workers				
Preempting People's resistance to Industrialisation				
Any other spill-over/spin off effects				

Date: **Name & Designation:**

Place: **Signature:**

ANNEXURE II

QUESTIONNAIRE
(RESPONDENTS: SURROUNDING AREA POPULATION)

1. Name & Address:

2. Age:

3. Educational background (of the respondent):

4. Profession & type of work:

5. Family size:

6. Monthly Income of the household:
- Less than Rs. 5,000 per month
- Rs. 5,000 - Rs. 10,000 per month
- Rs. 10,000 - Rs. 20,000 per month
- More than Rs. 20,000 per month

7. (a) Are you aware of the Type of industries operating in your area?
    - Yes
    - No

   (b) If 'Yes', specify the Type/Types:

8. Proximity to industrial zone/ factory (approximate kilometers)
- Very close (1/2 km.)
- Close (1 km.)
- Medium distance (1 – 2 kms.)
- Far (beyond 2 kms.)

9. How would you rate your own awareness about pollution/ environmental issues/ environmental damage etc.?
- Very low
- Low
- Medium
- High
- Very high

10. Perception about the industrial units (in existence and or coming up in the nearby area):
    (a) Benefits accrued/ perceived (such as income, employment, proximity to local services like transport, market, etc.):

    (b) Negative aspects: (like polluted air, water, noise, impact on health etc.):

11. To your knowledge has there been any perceptible improvement in environmental quality in the last few years as a result of better environmental management?

- Yes
- No

12. Are you aware about any technological changes in the nearby industries?

- Yes
- No

13. If 'Yes', your source of information:

- Newspapers/ Magazines
- Authorities
- Others (please specify):

14. In your view, the environmental damages caused by the industries in terms of the following are:

(a) Air
(b) Water (ground/ stream/ potable/ other):
(c) Noise
(d) Solid Wastes:
(e) Land Mass:
(f) Crops (their yield/ quality etc.):
(g) Wild Life:
(h) Flora & Fauna:
(i) Rivers/ streams/ Seas:
(j) Fish Catch/ Other means of livelihood:
(k) Others:

15. In relation to the environment, how do you see yourself?

- Very concerned
- Concerned
- Indifferent
- Not concerned at all

16. Do you believe that a polluter should install and pay for cleaner technology?

- Yes
- No
- Any other response:

17. If the damages (cited in Question 14) could be pre-empted through the adoption of cleaner technologies, and if the industry could not afford it fully, in order to reduce such damages, would you be willing to contribute a nominal part of your income every month for a specified period of '5' years (as a sort of nominal levy/ tax)?

- Yes
- No

18. If ‘No’,
(a) Your reasons? (Tick the appropriate ones)

- You do not see the environment and its damage as you responsibility.
- You expect the polluters (industry) to deal with it themselves exclusively.
- You believe that the Government should handle the matter.
- You do not think that the money thus collected will reach the said purpose/ project.
- Your income is better spent on matters more directly pertinent to daily life than the environment.
- Any other reason:

(b) Under what circumstances would you change your mind?

- Increase in income.
- A very visible worsening in the environment (air/ water pollution for e.g.)
- Perceived threat to the health of your family and yourself (due to illnesses related to pollution etc.)
- If you were to find out that a long - term exposure (to air/ water pollution etc.) could affect your future generations (in terms of disease, disabilities, disorders etc.)
- If you were assured that the money would reach its destined purpose.
- Any other:
- You would no change your mind under any circumstances.

19. If ‘Yes’ (to Question 17), would you pay a monthly figure of Rs. ‘X’ (for e.g. Rs. 50)?

- Yes
- No

20. (a) If ‘Yes’ (to Question 19), would you pay Rs. [X+Y] (for e.g. Rs. 75)?

- Yes
- No

(b) If ‘No’ (to Question 19), would you be willing to pay a lesser amount of Rs. [X-Y] (for e.g. Rs. 25)?

- Yes
- No

21. If you are willing to pay Rs. [X+Y] (for e.g. Rs. 75),
(a) would you be willing contribute still more?

- Yes
- No

(b) If ‘Yes’, how much more?

22. If you are willing to pay Rs. [X-Y] (for e.g. Rs. 25),
(a) would you be willing contribute a figure greater than Rs. [X-Y] (for e.g. Rs. 25), but less than Rs. ‘X’ (for e.g. Rs. 50)

- Yes
- No

(b) If ‘Yes’, what is the amount?

23. Reasons why you are willing to contribute:
(a) (Without prompting):

(b) (With prompting - tick in the appropriate cells):

Concern about the:	Not/least Concerne d:	Somewhat Concerne d:	Concerne d:	Very Concerne d:
a) general environment				
b) quality of drinking water				
c) quality of air you breathe				
d) public health				
e) seas/lakes/rivers/streams				
f) forests				
g) wild life & endangered species				
h) crops, fish-catch & other means of livelihood				
i) employment				
j) recreation				
k) natural beauty & its continued existence				
l) leaving a better world for future generations				

24. Any other suggestions/ comments (regarding policies):

Place:
Date:
Signature:

Notes:
1. Depending on the income groups, there is an option of putting forth 4 different choices of Rs. ‘X’.
2. For instance we could have the following ‘x’ values corresponding to the monthly income levels:

Monthly Income Level:	**Rs. ‘X’ Values:**
Less than Rs. 5,000	Rs. 20
Rs. 5,000 - Rs. 10,000	Rs. 50
Rs. 10,000 - Rs. 20,000	Rs. 80
More than Rs. 20,000	Rs. 100

3. In which case, we could have the following scenario:

Monthly Income Level:	**Rs.‘X’ Values:**	**Rs.[X+Y] Values:**	**Rs. [X-Y] Values:**
Less than Rs. 5,000	Rs. 20	Rs. 40	Rs. 10
Rs. 5,000 - Rs. 10,000	Rs. 50	Rs. 75	Rs. 25
Rs. 10,000 - Rs. 20,000	Rs. 80	Rs. 100	Rs. 60
More than Rs. 20,000	Rs. 100	Rs. 125	Rs. 75

ANNEXURE III

AREA - WISE TABLES

I] Area: Vashi [Sample size = 82]

1. Income Group: Rs. 5,000 - Rs. 10,000 (sample size = 40)
Table 13:

WTP (Rs.)	PSP	No. of persons	%
0	Y	28	34.15
0	N	1	1.22
Total	Y,N	**29**	**35.37**
0-25	Y	2	2.44
25-50	Y	1	1.22
50-75	Y	7	8.54
50-75	N	1	1.22
Total	Y	10	12.20
Total	N	1	1.22
Total	Y,N	**11**	**13.42**

2. Income Group: Rs. 10,000 - Rs. 20,000 (sample size = 29)
Table 14:

WTP (Rs.)	PSP	No. of persons	%
0	Y	24	29.27
0	N	2	2.44
Total	Y,N	**26**	**31.71**
0-60	Y	2	2.44
65-80	Y	1	1.22
Total	Y	3	3.66
Total	N	0	0.00
Total	Y,N	**3**	**3.66**

3. Income Group: < Rs. 5,000 (sample size = 8)

Table 15:

WTP (Rs.)	PSP	No. of persons	%
0	Y	5	6.10
0	N	0	0.00
Total	Y	**5**	**6.10**
20-40	N	1	1.22
>40	Y	2	2.44
Total	Y	2	2.44
Total	N	1	1.22
Total	Y,N	**3**	**3.66**

4. Income Group: > Rs. 20,000 (sample size = 5)

Table 16:

WTP (Rs.)	PSP	No. of persons	%
0	Y	1	1.22
0	N	0	0.00
Total	Y,N	**1**	**1.22**
0-75	Y	4	4.88
Total	Y	4	4.88
Total	N	0	0.00
Total	Y,N	**4**	**4.88**

5. Vashi - WTP across all Income Groups

Table 17:

WTP (Rs.)	No. of Persons	%
25	5	6.10
40	1	1.22
50	12	14.63
75	3	3.66
Total:	**21**	**25.62**

II] Area: Koper Khairne [Sample size = 61]

1. Income Group: Rs. 5,000 - Rs. 10,000 (sample size = 20)

Table 18:

WTP (Rs.)	PSP	No. of persons	%
0	Y	9	14.75
0	N	0	0.00
Total	Y,N	**9**	**14.75**
0-25	Y	1	1.64
25-50	Y	7	11.48
25-50	N	2	3.28
50-75	Y	1	1.64
Total	Y	9	14.75
Total	N	2	3.28
Total	Y,N	**11**	**18.03**

2. Income Group: Rs. 10,000 - Rs. 20,000 (sample size =18)

Table 19:

WTP (Rs.)	PSP	No. of persons	%
0	Y	12	19.67
0	N	1	1.64
Total	Y,N	**13**	**21.31**
0-60	Y	3	4.92
80-100	Y	2	3.28
Total	Y	5	8.20
Total	N	0	0.00
Total	Y,N	**5**	**8.20**

3. Income Group: < Rs. 5,000 (sample size =14)

Table 20:

WTP (Rs.)	**PSP**	**No. of persons**	**%**
0	Y	9	14.75
0	N	0	0.00
Total	Y,N	**9**	**14.75**
0-10	Y	1	1.64
>40	Y	3	4.92
>40	N	1	1.64
Total	Y	4	6.56
Total	N	1	1.64
Total	Y,N	**5**	**8.20**

4. Income Group: > Rs. 20,000 (sample size = 9)

Table 21:

WTP (Rs.)	**PSP**	**No. of persons**	**%**
0	Y	4	6.56
0	N	0	0.00
Total	Y,N	**4**	**6.56**
0-75	Y	1	1.64
75-100	N	1	1.64
100-125	Y	1	1.64
>125	Y	2	3.28
Total	Y	4	6.56
Total	N	1	1.64
Total	Y,N	**5**	**8.20**

5. Koper Khairne - WTP across all Income Groups

Table 22:

WTP (Rs.)	**No. of Persons**	**%**
10	1	1.64
21	1	1.64
25	2	3.28
30	1	1.64
50	15	24.59
100	4	6.56
200	2	3.28
Total:	**26**	**42.62**

III] Area: Airoli [Sample size = 59]

1. Income Group: Rs. 10,000 - Rs. 20,000 (sample size = 22)

Table 23:

WTP (Rs.)	PSP	No. of persons	%
0	Y	12	20.34
0	N	5	8.47
Total	Y,N	**17**	**28.81**
0-60	Y	3	5.08
0-60	N	1	1.69
80-100	Y	1	1.69
Total	Y	4	6.78
Total	N	1	1.69
Total	Y,N	**5**	**8.47**

2. Income Group: < Rs. 5,000 (sample size =17)

Table 24:

WTP (Rs.)	PSP	No. of persons	%
0	Y	10	16.95
0	N	3	5.08
Total	Y,N	**13**	**22.03**
0-10	N	1	1.69
10-20	N	1	1.69
20-40	Y	1	1.69
>40	Y	1	1.69
Total	Y	2	3.39
Total	N	2	3.39
Total	Y,N	**4**	**6.78**

3. Income Group: Rs. 5,000-Rs. 10,000 (sample size = 14)

Table 25:

WTP (Rs.)	PSP	No. of persons	%
0	Y	4	6.78
0	N	6	10.17
Total	Y,N	**10**	**16.95**
0-25	Y	2	3.39
50-75	N	2	3.39
Total	Y	2	3.39
Total	N	2	3.39
Total	Y,N	**4**	**6.78**

4. Income Group: > Rs. 20,000 (sample size = 6)

Table 26:

WTP (Rs.)	PSP	No. of persons	%
0	Y	3	5.08
0	N	2	3.34
Total	Y,N	**5**	**8.47**
0-75	N	1	1.69
Total	Y	0	0.00
Total	N	1	1.69
Total	Y,N	**1**	**1.69**

5. Airoli- WTP across all Income Groups

Table 27:

WTP (Rs.)	No. of persons	%
5	1	1.69
10	4	6.78
20	2	3.39
30	1	1.69
50	4	6.78
100	1	1.69
500	1	1.69
Total:	**14**	**23.72**

IV] Area: Turbha (inclusive of Sanpada) [Sample size = 50]

1. Income Group: < Rs. 5,000 (sample size = 23)

Table 28:

WTP (Rs.)	**PSP**	**No. of persons**	**%**
0	Y	13	26.00
0	N	8	16.00
Total	Y,N	**21**	**42.00**
10-20	Y	1	2.00
>40	Y	1	2.00
Total	Y	2	4.00
Total	N	0	0.00
Total	Y,N	**2**	**4.00**

2. Income Group: Rs. 5,000-Rs. 10,000 (sample size = 17)

Table 29:

WTP (Rs.)	**PSP**	**No. of persons**	**%**
0	Y	12	24.00
0	N	2	4.00
Total	Y,N	**14**	**28.00**
0-25	Y	1	2.00
0-25	N	2	4.00
Total	Y	1	2.00
Total	N	2	4.00
Total	Y,N	**3**	**6.00**

3. Income Group: Rs. 10,000-Rs. 20,000 (sample size = 8)

Table 30:

WTP (Rs.)	**PSP**	**No. of persons**	**%**
0	Y	3	6.00
0	N	3	6.00
Total	Y,N	**6**	**12.00**
0-60	Y	2	4.00
Total	Y	2	4.00
Total	N	0	0.00
Total	Y,N	**2**	**4.00**

4. Income Group: > Rs. 20,000 (sample size = 2)

Table 31:

WTP (Rs.)	PSP	No. of persons	%
0	Y	2	4.00
0	N	0	0.00
Total	Y,N	**2**	**4.00**

5. Turbha (inclusive of Sanpada) - WTP across all Income Groups

Table 32:

WTP (Rs.)	No. of persons	%
20	6	12.00
100	1	2.00
Total:	**7**	**14.00**

V] Area: Nerul [Sample size = 40]

1. Income Group: Rs. 5,000 - Rs. 10,000 (ample size = 26)

Table 33:

WTP (Rs.)	PSP	No. of persons	%
0	Y	15	37.50
0	N	6	15.00
Total	Y,N	**21**	**52.50**
25-50	Y	3	7.50
50-75	Y	2	5.00
Total	Y	5	12.50
Total	N	0	0.00
Total	Y,N	**5**	**12.50**

2. Income Group: Rs. 10,000 - Rs. 20,000 (sample size = 11)

Table 34:

WTP (Rs.)	PSP	No. of persons	%
0	Y	3	7.50
0	N	2	5.00
Total	Y,N	**5**	**12.50**
0-60	Y	6	15.00
Total	Y	6	15.00
Total	N	0	0.00
Total	Y,N	**6**	**15.00**

3. Income Group: < Rs. 5,000 (sample size = 3)

Table 35:

WTP (Rs.)	PSP	No. of persons	%
0	Y	1	2.50
0	N	2	5.00
Total	Y,N	**3**	**7.50**

4. Nerul - WTP across all Income Groups

Table 36:

WTP (Rs.)	No. of Persons	%
25	7	17.50
50	4	10.00
Total:	**11**	**27.50**

VI] Area: Ghansoli (inclusive of Mahapegaon) [Sample size = 36]

1. Income Group: < Rs. 5,000 (sample size = 25)

Table 37:

WTP (Rs.)	**PSP**	**No. of persons**	**%**
0	Y	18	50.00
0	N	1	2.78
Total	Y,N	**19**	**52.78**
10-20	Y	2	5.56
10-20	N	2	5.56
20-40	Y	1	2.78
>40	Y	1	2.78
Total	Y	4	11.11
Total	N	2	5.56
Total	Y,N	**6**	**16.67**

1. Income Group: Rs. 5,000 - Rs. 10,000 (sample size = 8)

Table 38:

WTP (Rs.)	**PSP**	**No. of persons**	**%**
0	Y	4	11.11
0	N	1	2.78
Total	Y,N	**5**	**13.89**
0-25	Y	2	5.56
50-75	N	1	2.78
Total	Y	2	5.56
Total	N	1	2.78
Total	Y,N	**3**	**8.33**

2. Income Group: Rs. 10,000 - Rs. 20,000 (sample size = 3)

Table 39:

WTP (Rs.)	PSP	No. of persons	%
0	Y	1	2.78
0	N	1	2.78
Total	Y,N	**2**	**5.56**
0-60	Y	1	2.78
Total	Y	1	2.78
Total	N	0	0.00
Total	Y,N	**1**	**2.78**

3. Ghansoli (inclusive of Mahapegaon) - WTP across all Income Groups

Table 40:

WTP (Rs.)	No. of Persons	%
5	1	2.78
20	6	16.67
25	1	2.78
50	1	2.78
75	1	2.78
Total:	**10**	**27.78**

VII] Area: Dighe [Sample size = 25]

1. Income Group: Rs. 5,000 - Rs. 10,000 (sample size = 14)

Table 41:

WTP (Rs.)	PSP	No. of persons	%
0	Y	12	48.00
0	N	1	4.00
Total	Y,N	**13**	**52.00**
0-25	Y	1	4.00
Total	Y	1	4.00
Total	N	0	0.00
Total	Y,N	**1**	**4.00**

2. Income Group: < Rs. 5,000 (sample size = 11)

Table 42:

WTP (Rs.)	**PSP**	**No. of persons**	**%**
0	Y	7	28.00
0	N	3	12.00
Total	Y,N	**10**	**40.00**
20-40	Y	1	4.00
Total	Y	1	4.00
Total	N	0	0.00
Total	Y,N	**1**	**4.00**

3. Dighe - WTP across all Income Groups

Table 43:

WTP (Rs.)	**No. of Persons**	**%**
25	2	8.00
Total:	**2**	**8.00**

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