EERC

ENVIRONMENTAL ECONOMICS RESEARCH COMMITTEE

Theme: National and International Policy Issues
EERC Working Paper Series: NIP-3

Delineation and Dissemination of Corporate Green Accounting Procedures: With Case Studies in Medium sized Textile, Pharmaceutical and Chemical Industries

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Delineation and Dissemination of Corporate Green Accounting Procedures with Case Studies in medium sized Textile, Pharmaceutical and Chemical Industries

Sponsor:

Indira Gandhi Institute of Development Research, **Mumbai – 400 065**

World Bank aided TA Project, India: Environment Management Capacity Building
Theme 3 : Economics of Green Initiatives

SIES – Indian Institute of Environment Management
Navi Mumbai: 400 706

September 2001

Acknowledgements

The Institute is grateful for the help and cooperation extended by the Management and Staff of **M/s. Indian Oil Blending Ltd, M/s. Paithon Silk Mills Ltd, M/s. Kedia Chemicals Ltd** and **M/s. Eskay Fine chemicals Ltd**, to conduct this study on their premises.

We are grateful to **Dr. Jyoti Parikh**, National Project Coordinator, Capacity 21 Project, UNDP & Chairperson, Environmental Economics Research Committee, EMCaB Project, World Bank and **Dr. Kirit Parikh**, distinguished Economics Expert of Inida, for their valuable suggestions.

1. Introduction

Economics and accounting are the key components of business activity. Economy drives a business, some of the key players being the government, resources, markets, and customers. Businesses and organizations are no longer seen as hierarchical systems. Rather, they are living organisms with a web of stakeholder relationships, product cycles, and value-based genetic coding. Organizing elegance of natural systems, the success secrets that have accumulated over 3.5 billion years, is adopted as the key-driving paradigm in business of the new millennium. This changing perspective of the business widens its focus from **cash flow** to **life flows,** and from **accountability to shareholders** to **accountability to stakeholders**. In this enlarged mode, the economy is aligned with natural laws, and operates within its limitations.

The relationship between the business, the society and the environment is changing worldwide. **Figure 1a, 1b, 1c** illustrates how these relationships have been changing overtime and why business ecology is a framework for sustainable enterprise in the twenty-first century. In the first model **(Figure 1a),** resources are mechanistically flushed through, reaping disproportionate profits for industry, and damage to environment and communities. In the second **(Figure 1b),** regulations are imposed to help bring balance to these inequalities. In the third **(Figure 1c)**, closed loop thinking, ie. recycle and reuse, resource efficiency and pollution prevention begin to emerge, saving money for business and society, and reducing the need for costly regulations.

Economy is the environment for the business organism. It determines the rules of the game–how, what and where products, services and resources are bought, sold and exchanged. This widened perspective of today's business demands a shift from the traditional industrial economic principles to ecological economy. **The ecological economy is the environment of sustainable business.**

It helps us reconnect to the life sustaining natural capitals that support us, our business, communities, and the entire web of life. While the industrial economy is object-oriented, and profit- and consumption- driven; the **ecological economy is**

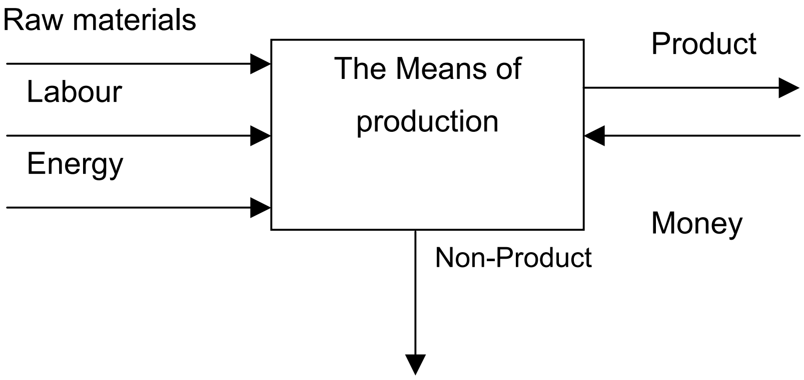

Figure 1a. Resource flushed through Industry

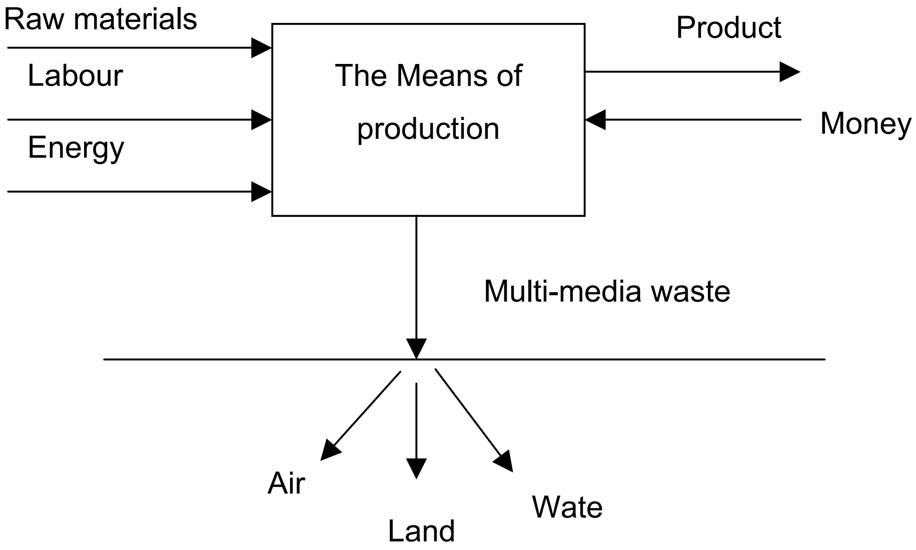

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Figure 1b. Responding with Polluter Pays, Costly Laws & Regulations

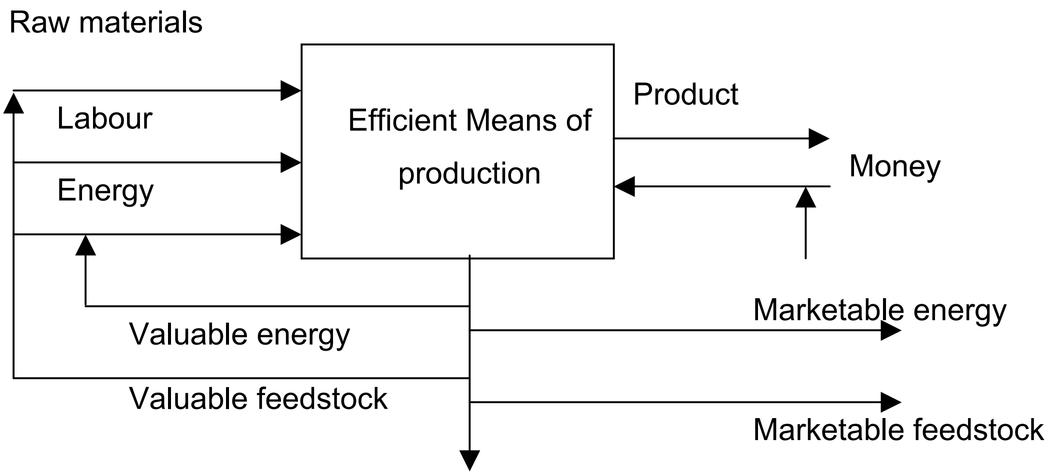


Figure 1c. Pollution Prevention Paradigm

relationship oriented, and values- and quality- driven. In a closed loop economy, customers pay for the value, or quality-of-life improvements, delivered by products and services that are produced through increasingly efficient use of life-sustaining-flows. **Corporate Environmental Accounting** or **Green Accounting** is a method for improving business decision-making in recognition of the increasing environmental challenges and opportunities posed to business today. It does this by identifying misallocated internal and external environmental resources and allocating them to particular products or processes. Environmental accounting provides firms with truer costs of their products and processes, thus leading to better business decisions and sustained profitability, over the entire life-cycle of the product/services.

In order to ensure that Indian industry is geared to face the current competition from multinational corporations, and to meet customers' soaring expectations; Indian corporations need to internalize environmental issues in their decision-making. Corporate environmental accounting serves as a tool in the hands of management in that direction. Due to lack of any structured framework for the inclusion of environmental costs in Corporate accounts, the current study has been undertaken to help delineate a framework for explicit inclusion of environmental costs and benefits in the accounting practices, and its validation through case studies in the medium sized industries.

Four medium sized industries#, viz. Indian Oil Blending Ltd (Petrochemical), Paithan Silk Mills Ltd (Textile), Kedia Chemicals Ltd (Chemical), and Eskay Fine Chemicals Ltd (Pharmaceutical) have been identified for case studies to validate the proposed framework for Corporate Environmental Accounting.

[#] The industries identified for case studies were so chosen that they all meet the emission norms stipulated in EPA 1986. This approach was adopted as the detailed estimation of the cost-of-pollution to the society in respect of health, economic, and aesthetics is a long-term and expensive exercise not affordable in the context of the current project. The emission norms in India are established through a wet study in each industry sector through the Central Pollution Control Board that ascertains the Annual Burden on Pollution Control *vis-a vis* annual turnover of the industry under consideration. Such analyses with the economic impact of pollution on the polluter and the society are then presented to the industry committee for each industrial sector. The consensus leads to the stipulation of emission norms. Thus the emission stipulations are technocrats' judgment in respect of industrial development with minimal cost of pollution to the society.

2. Organization of the report

Sections 3 and 4 delineate the objectives and work elements in the study

Section 5 details the methodology adopted in the study

Section 6 details the framework of Green Corporate Accounting procedures

Section 7 details the validation of the framework of Green Corporate Accounting through case studies

3. Objectives

- Delineation of a Corporate Green Accounting framework appropriate for accounting practices in India incorporating environmental costs and benefits of production process in vogue
- Validation and dissemination of the framework for usage in medium sized chemical, textile and pharmaceutical industrial units
- Monetization and demonstration of cost-effectiveness of pollution prevention and waste minimization practices with recourse to corporate green accounting framework in three industrial units.

4. Work Elements

Phase I: Delineation of framework for Corporate Green Accounting

- Review of existing corporate accounting practices
- Setting a definition of environmental costs
- Setting a survey and evaluation team
- Delineation of environment related activities and environmental costs in the material and energy usage, emissions, effluents, noise and residues (**Box 1**)
- Identification of relevant entries in accounting practices
- Environmental and economic evaluation of avoidance and defensive options
- Delineation of a framework for integration of environmental costs and proceeds into corporate accounting system

Phase II: Validation and Dissemination of Corporate Accounting Framework

- Identification of three units each in textile, pharmaceutical, and chemical sectors for validation and dissemination of green accounting framework
- Organization of workshops with senior and middle level management to discuss relevance and acceptability of proposed accounting framework in the identified industrial units
- Analysis of feedback and tailoring of the accounting framework to specific sectors, scale and ownership variances
- Identification of participants from amongst middle level management in pilot exercises

Phase III: Demonstration of utility of Green Accounting Framework

- Constitution of environmental costing team
- Setting up of Green Accounting Framework

- Evaluation of environmental costs and proceeds, and integrating them with existing accounting systems

- Conduct of environmental audits to identify pollution prevention and waste minimization programmes

- Evaluation of marginal corporate environmental costs and proceeds after implementation of identified pollution prevention and waste minimization programmes

- Monetization and demonstration of cost-effectivity of pollution prevention and waste minimization programmes

Phase IV: Documentation and Dissemination

- Organization of work shops to discuss experiences gained out of pilot implementation of green accounting framework

- Analysis of feedback, and modification in green accounting framework if necessary

- Dissemination of Green Accounting Framework amongst Corporate Sector

Box 1

Categorization of Environmental Costs

- Material and monetized value of corporate wastes and emissions
- Treatment and disposal costs
- Economic and health damage costs due to residual pollution
- Avoidance costs through cleaner technology
- Tax exemptions[#] on pollution control and avoidance equipment
- Operation and maintenance costs
- Depreciation costs
- Costs of environmental investigation

[#] Tax exemptions on pollution control and avoidance equipment are given in **Annexure 1.**

5. Methodology

Preceding the commencement of fieldwork, three discussions sessions were conducted with senior and middle level management from engineering, production, maintenance and finance at **IOBL** (in June 2000), **PSML** (between December 2000 and February 2001), **KCL** (between December 2000 and February 2001) and **ESKAY** (December 2000 to February 2001) to decide upon the steps to be taken to meet the objectives of the study. Following categories of environmental costs were identified for inclusion in Corporate Environmental Accounts:

Tier 0: Direct costs associated with capital expenditures, operation and maintenance costs of pollution control equipment etc.

Tier 1: Hidden costs from activities such as environmental monitoring, and reporting etc.

Tier 2: Savings incurred through pollution prevention and waste minimization programmes.

5.1 Scope of Corporate Green accounting

- Establish evaluation team comprising of representatives from production, engineering, accounts, stores, and R&D divisions
- Study manufacturing process, and material and energy balance in the industry
- Identify waste generating (Environmental Cost) centers
- Identify process emissions and effluents, their location, quantification and categorization
- Identify pollution prevention and waste minimization opportunities
- Evaluate economics of pollution prevention programmes
- Evaluate social costs
- Study accounting practices in the organization
- List out environment related activities after discussion with the evaluation team

- Identify entries in the account books for the following:
  - Capital expenditure for procuring and installing pollution prevention equipment
  - Depreciation for above equipment
  - Operating and maintenance cost (labour, power, consumables, and spares)
  - Monitoring and Pollution Control (compliance costs)
    - ♦ Pollution Control Board fees
    - ♦ Cost towards emissions and effluents monitoring
    - ♦ Penalties and fines paid, if any
    - ♦ Training of employees for ISO 14000
    - ♦ Record keeping for characteristics of emissions and effluents
  - Cost towards ISO 14000 implementation and any other environmental management systems
  - Green belt development and maintenance cost
- Collect information regarding benefits from pollution prevention activities
  - Quantify operational and maintenance requirements, material and power consumption
  - Quantify emissions and effluents reduced/recycled
  - Monetization of benefits
- Identify accounting codes / heads
- Discuss how and who will maintain the identified accounting heads
- Generate data for quarter/annum, and review.

6. Delineation of Green Corporate Accounting Framework

6.1 Conventional Accounting system

Historically, the environmental effects of doing business have been excluded from financial information systems unless they directly affect the entity's profitability or future, for example fines or accidents. Environmental effects, which are not regulated or scrutinized by the government, are often ignored because they may be considered to be:

- Unimportant (for example, there appear to be unlimited resources)
- Not pertinent to the core business function or the bottom line
- Part of the price of progress
- Difficult to estimate and to assign financial values.

Conventionally, financial accounts (**Table 1**), such as balance sheets, income statements and cash flow statements are used to keep track of business incomes and outflows. These financial reports are for use by persons outside the firm - for example, lenders or investors. These are relevant to the enterprise as a whole and are subject to strict government rules.

Management or cost accounting systems, part of an enterprise's information system, refer to the internal tracking and allocation systems towards costs and expenditures (Table 2). These are internal rather than external accounting systems. There are no fixed rules governing how an entity should keep track of cash flows internally, although there are many formal methods available to the business. Capital budgeting is basically a form of predictive cost accounting over a set timeframe, which is used to analyze the costs of alternative projects or expenditures over the specified period of time. The main objectives of such managerial/cost accounting are (Hilton, 1988):

- Providing managers with information for decision making and planning.
- Assisting managers in directing and controlling operations.

- Motivating managers towards the organization's goals.
- Measuring the performance of managers and sub-units within the organization.

Thus, it acts as drivers in day-to-day business decision-making affecting every aspect of the firm's activities. Good cost accounting is vital to understanding the profitability of current activities and to predicting the profitability of future activities. The principal types of financial accounting statements are presented hereunder in Table 1, while Table 2 delineates the cost categories.

Table 1. Principal Financial Accounting Statements

Statements	Description
Balance Sheet	Balance Sheets present a snapshot of the investing and financing activities of a firm at a particular moment in time (usually the last day of the firm's fiscal year). The balance sheet presents a summary of the firm's assets, liabilities and shareholder's equity. In a balance sheet the sum of the assets must equal the sum of the liabilities and shareholder's equity. There are strict guidelines governing the estimation of assets and liabilities.
Income Statement	The Income Statement presents the results of the operating activities of a company for a specific period of time - usually the fiscal year. The statement summarized the revenues and expenses and reveals the net income or earnings of the firm during the period of time covered.
Cash Flow Statement	The Cash Flow Statement shows the net cash flows related to operating, investing, and financing activities for a specific period of time - usually the firm's fiscal year.

Table 2. General Cost classifications

Cost elements	Description
Variable Costs	Variable costs change in total in proportion to the level of activity. For example if a carmakers production increases by 5%, its tire costs will increase by about 5%.
Fixed Costs	A fixed cost remains unchanged in total as the level of activity varies. For example, the property tax on a rental apartment is the same regardless of the number of building occupants.
Direct Costs	A direct cost is the cost of direct labor and material used in making the product or delivering the service.
Indirect Costs/Overhead Costs	Indirect costs are costs of an activity, which are not easily associated with the production of specific goods or services.
Opportunity Costs	The benefit that is sacrificed when the choice of one action precludes an alternative course of action.
Sunk Costs	Costs that have been incurred in the past and cannot be changed by current actions.

Note: These classifications are not exclusive, for example a cost may be fixed and indirect, or variable and direct.

6.2 Shortcomings of conventional accounting systems

The current Indian corporate sector managerial accounting systems do not track total costs closely. Easily identifiable costs, such as labor or raw materials, are often finely tracked and allocated to particular product or process lines, but many costs - such as administration costs and environment, health, and safety costs, are considered to be indirect or overhead costs, and are allocated broadly across product and process lines. Placing a cost in an overhead account allows it to be shared across activities, but generally removes cost responsibility from any one particular product line or manager. If no one is responsible for a cost, it is likely to be ignored, or in the worst case, may increase as a result of efforts to reduce other costs.

Corporate financial statements also exclude estimates of social costs beyond those directly impacting the bottom line. However, there are guidelines on the reporting of environmental liabilities - these pertain to likely remediation and liability issues, rather than long-term social issues. These liabilities are often reported in the statement footnotes since their magnitude is not monetized.

Because of the shortcomings of conventional accounting information systems, managers often develop a distorted picture of environmental costs. Consider the hypothetical manufacturing cost sheet presented in Table 3. Familiar to managers in many industries, this product-oriented format itemizes the main elements of costs, both fixed and variable, to show the relative contributions of labor, capital, and material inputs. But a quick search of the sheet for “environmental costs” turns up only a single item, wastewater treatment.

Consider a firm that uses a particular chemical in production. The accounting system tracks the purchase of the material. But the costs of storing the chemical may be higher due to environmental considerations. The company may incur larger costs for treating contaminated rinse water using that chemical, or managing the resulting sludge. Securing the necessary permits, monitoring compliance, and subsequent reporting also represent real costs. Depending on the nature of the facility, use of this material might also force the company to pay for additional worker training.

Thus, the decisions as common as choosing a process chemical can give rise to various environmental costs that are difficult to recognize or quantify. In any case, the managers must look beyond their traditional sources of cost information to develop a true picture of environmental costs. Examination of costs through an environmental lens yields new insights, as environmental costs are hidden in many of the conventional cost categories.

Table 3. A Typical Manufacturing Cost Statement

Product				
Product Manufacturing Cost Statements				
Production Volume				
A – Variable Cost				
Item	**Factors**	**Usage**	**Cost**	**Unit Cost**
Raw Material				
Intermediates				
Additives				
Utilities				
Direct labor				
Packaging				
Wastewater Treatment				
Total Variable cost				
B – Fixed Cost				
Item	**Cost**			
Supervisor				
Fixed labor				
Depreciation				
Divisional overhead				
General services & Admin.				
Total Fixed Cost				
Cost Summary				
Total Variable Cost (A)				
Total Fixed Cost (B)				
Total Manufacturing Cost				
Unit Manufacturing Cost				

In this typical cost statement “labour” or “material” costs are influenced by the environmental objectives. These hidden costs imposed on the firm towards environment liability are good economic signals. Consumer preferences for greener product and shareholders preference for corporations that harness environment liabilities as opportunities are increasingly becoming evident. Firms that fail to respond to these signals will be loose in competition.

The wiser course of action is to truly internalize environmental costs-not merely to bear them, but to anticipate and manage them. This means identifying the activities that gives rise to them. Firms must be able to generate, evaluate, and implement alternatives to the status quo. They must be able to motivate executives, managers, and employees towards this common goal of alignment of the whole business corporate. In this endeavor, the most effective tool is the accounting procedures that currently improve economic, environmental social performance.

6.3 Frameworking the “Green Corporate accounting” system

Environmental cost should be accounted in the same manner as in case of other costs, as it also affects the bottom line considerably. Green accounting describes how goods and services should be priced to reflect their true costs (including environmental and social costs). In green corporate accounting, the natural resources are redefined as assets in company ledgers, and the environmental costs are built into a product’s cost.

It is still being debated whether, within the corporate accounting system, the term green corporate accounting should be used to refer to either the full private (or bottom line) costs estimation to an enterprise of an activity, or to the full social costs to society of the activity including externalities (such as health impacts resulting from air pollution). Externalities are costs not borne by the responsible entity. For example, the ecological impacts of climate change resulting from automobile emissions are not included in the price consumers’ pay for petroleum. In its correct formulation, green accounting should refer to all costs on cradle-to-grave cradle-to-cradle basis.

However, this is considered difficult in practice and many attempts at green accounting (particularly in managerial accounting efforts) have stopped at the level of incorporation of environmental costs in enterprise bottom-line costing. The difference between current accounting systems, ie. full "private" accounting systems, and full "Green" accounting systems is depicted in Figure 2.

When firms incur environmental costs that they do not link to processes and products, managers are deprived of a clear picture of where and how costs are generated. Even in modest-sized manufacturing firms with two or three production lines; the costs of licensing, monitoring, waste storage, emissions controls, environmental staff time, off-site disposal, insurance, future regulatory compliance, and even liability are not driven equally by each production line. Some process lines may be more hazardous materials-intensive, generate more emissions per unit output, require more frequent and intensive inspection and monitoring, and generate greater quantities of waste requiring off-site disposal. Similarly, particular processes, or products may cause a disproportionate share of costs associated with training and reporting to government agencies, or give rise to risks which may result in higher insurance costs or risks of future personal or property damages. In short, when it comes to environmental costs, not all processes and products are created equal.

The term environmental costs can be used to describe **private** environmental costs – the costs that directly impact a firm's bottom line, and **public or social** environmental costs – the costs to society as a whole (**Annexure 2**). Aforementioned discussion has been made with inherent aim towards the explicit entry of environmental costs in conventional costing system. A standard framework in this mode is presented in **Table 4a-b**. This framework has been delineated with special reference to Indian corporate sectors. It is fluctuating in nature and could be easily used in different industrial sectors whether they are large or medium scale. For its validation and its effective dissemination to Indian corporate, four sample industries each from different sectors viz. Chemical, Textile and Pharmaceutical have been identified as case study. The experiences gained are presented in **Section 7** of this report.

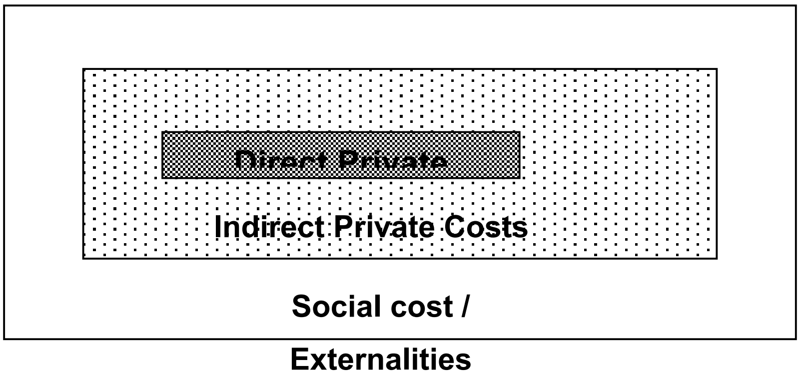


Figure 2. **Typical accounting framework**: dark shaded area shows direct private costs allocated to products or activities, light shaded area shows indirect private costs (including some environmental costs) allocated to overhead accounts. Unshaded area shows social costs resulting from corporate activities but not charged to the company.

Modified full cost accounting framework: All direct and Indirect costs private costs are allocated to products or activities. Social costs resulting from corporate activities are not charged to the company.

Green accounting framework: All direct, Indirect and Social cost are allocated to products or activities.

Table 4a. Green Accounting Framework

Cost elements			**Units of measure**	**Consumption**	**Unit cost (Rs.)**	**Total cost (Rs.)**
Fixed Cost	Depreciation on pollution control equipments					
	Expenditure for implementing ISO 14000 / EMS					
	Expenditure saved due to installation of equipments and/or through technology upgradation for Cleaner Technology					
	Other Tax exemptions and Benefits					
	Sub total					
Waste Management	Solid waste	Handling				
		Treatment				
		Recycle / Reuse / Sold as scrap				
		Disposal				
		Sub total				
	Liquid waste	Handling				
		Treatment				
		Recycle / Reuse / Sold in market				
		Disposal				
		Sub total				
	Air Emissions	Handling cost				
		Treatment cost				
		Recycle / Reuse / Sold in market				
		Disposal cost				
		Sub total				
	Compliance / Surveillance Audit					
	Env. Monitoring & Reporting					

Environmental services	Environmental facility O&M	Water				
		Chemicals				
		Energy				
		Labour				
	Sub total					
Social costs	Damage caused by Air Pollutants to Health and Vegetation					
	Damage caused by Wastewater Pollution to Health and Vegetation					
	Damage caused by Dumping of Solid waste to Health and Vegetation					
Safety Aspects	First Aid Facility					
	Safety Measure’s Expenses					
	Medical Compensation					
	Routine Diagnostics					
	Sub total					
Grand Total						

Table 4b. Green Corporate Accounting Framework integrated with General Accounting

Cost elements				Units of measure	Consumption	Unit cost (Rs.)	Total cost (Rs.)
Raw Materials		A					
		B					
		Sub total					
Utilities	**Energy**	Electrical					
		Thermal	Furnace Oil				
			LDO				
			Diesel				
	Water	Process use					
		Others					
		Sub total					
Fixed Costs		Packaging					
		General services & Admin.					
		Labour	Direct				
			Fixed				
		Divisional overhead					
		Depreciation					
		Sub total					
Waste Management		Solid waste	Handling				
			Treatment				
			Disposal				
			Sub total				
		Liquid waste	Handling				
			Treatment				
			Disposal				
			Sub total				
		Air Emissions	Handling				
			Treatment				
			Disposal				
			Sub total				
Packaging material inventory		Sold as scrap					
		Reuse					
		Disposal					

	Sub total				
Environmental services	Compliance /Surveillance Audit				
	Environmental Monitoring & Reporting				
	Environmental facility O & M				
	Sub total				
Social costs	Total Damage caused by Air Pollutants to Health and Vegetation				
	Total Damage caused by Wastewater Pollution to Health and Vegetation				
	Damage caused by Dumping of Solid waste to Health and Vegetation				
Safety Aspects	First Aid Facility				
	Safety Measure's Expenses				
	Medical Compensation				
	Routine Diagnostics				
	Sub total				
Grand Total					

7. Case Studies

7.1 Case Study – I: Indian Oil Blending Ltd.

Indian Oil Blending Ltd (IOBL) is a subsidiary of Indian Oil Corporation (IOCL) and is in the business of manufacturing grease. The plant is located at Kulshet in Thane-Belapur industrial estate, Navi Mumbai. IOBL is a relatively new establishment, and is the first public undertaking with the state-of-art technology and process automation through Distributed Control System (DCS). It has an annual turnover of Rs. 6.4 Crores. IOBL profile is shown in **Annexure 3**.

Identification of stakeholders at IOBL and their expectations are summarised in **Table 5**.

7.1.1 Grease Production Process

Grease is a mixture of a fluid lubricant (usually petroleum oil) and a thickener (usually soap) dispersed in oil. ASTM (American Society for Testing Material) defines grease as a solid- to- semi fluid product of dispersion of a thickening agent in a liquid lubricant. Other ingredients imparting special properties may be included. It is used for extended lubrication where oil would not be retained. Thickener plays an important role in lubrication. Soap thickeners are formed by reacting metallic hydroxide, or alkali, with a fat, fatty acid or ester. This process is called saponification.

Depending on the desired properties of grease different types of soap is used in grease manufacturing. Details about grease and its properties are given in **Annexure 4**.

Table 5. Stakeholder analysis of IOBL

Stakeholders	Expectations from IOBL
Indian Oil Corporation Ltd.	▪ Excellent quality grease production ▪ Maximization of contribution towards profit while keeping the expenditure to minimum
Customers	▪ Excellent quality grease ▪ On time delivery ▪ Minimal prices
Suppliers	▪ Continual demand for raw materials ▪ Timely payments
Employees	▪ Job satisfaction and security ▪ Satisfactory wages
Pollution Control Board	▪ Industry abiding by the Pollution Control board standards for emission and effluent discharge at all times
Neighbouring industries	▪ Healthy relations ▪ No nuisance causing actions
Society	▪ Non-polluting industry ▪ Generation of jobs ▪ Improvement of the infrastructure of the surrounding areas
Environment (Air, Water, and Land)	▪ Zero emission or discharges to the environment ▪ Minimal use of water and electricity ▪ Development of green belt in the surrounding areas
Maharashtra Industrial Development Corporation	▪ Continual purchase of water
Maharashtra State Electricity Board	▪ Continual purchase of electricity
Packaging materials suppliers and disposers	▪ Continually increasing demand
Shareholders	▪ Increase in share value
Government	▪ Payment of taxes

Grease manufacture comprises following steps, in sequential order:

- Charging
- Cooking
- Blow down to kettle
- Homogenizing
- Filling

The contactor/reactor is charged with alkali, fat and base oil. Cooking of the raw materials follows charging. The process is called SAPONIFICATOIN. The temperature here is maintained to about 200-250°C using hot oil circulation. Due to ensuing reaction the pressure in the contactor begins to build up and is maintained at 7-7.5 Kg by venting out the excess vapour through the pressure vent Following cooking, the contactor contents are vented down to any of the 6 kettles 3Kg/cm^2. (K101-K106). Following venting the reactor is washed with base oil (160-180°C) and the contents are blown down to the kettle. The kettle temperature is cooled to 130-140°C using cold oil/cooling water and the soap and base oil are mixed thoroughly with the help of the agitator. Simultaneously the homogenisation process is also started (pr 2000 - 4000 PSI) to get particle size of 20-30 microns. The temperature is brought down to 100°C for the addition of additives, which impart specific properties to the grease. At this stage cut back oil is added to the kettle to adjust the penetration of the grease. Following mixing, a sample is taken from the homogenisation to kettle line and penetration of the grease is checked using the penetrometer. If the penetration value is OK, filling is started. If the penetration is not correct, cut back oil is added to adjust the penetration.

Charging is carried out twice daily, once at the beginning of every shift. At a time only one of the contactors (R101/R102) is operated. Kettles K101 & K102 has a cooling water system. The advantage beings that lower temperatures can be achieved faster.

Kettles K103-K106 are cooled by cold oil systems, which takes longer time to cool. Kettle K105 is used mostly for small tin filling. Contactor wash consumes about 3KL of base oil, where as kettle wash consumes about 300-400Kg of base oil. This wash oil is recycled back storage tanks and is reused for future wash.

7.1.2 Material Audit

Material audit is a basis for development of raw material balance for a given unit operation or unit process during which reuse and by product recovery can be considered. Material balance helps in determining the quantities of material required and products produced under a given set of condition. Material balance also serves as useful tool to study plant operations and to check performance against design and locate sources of material loss, which form the basis for drawing conservation. The **Figure 3** depicts the flow of materials at IOBL. The material input and the raw material input-output statistics for 1999-2000 are given in **Table 6** and **7.**

The general mass conservation equation for any process is:

Rate of accumulation of reactant within system boundary = Rate of flow of reactant into system boundary – Rate of flow of reactant out + Rate of generation within the system boundary

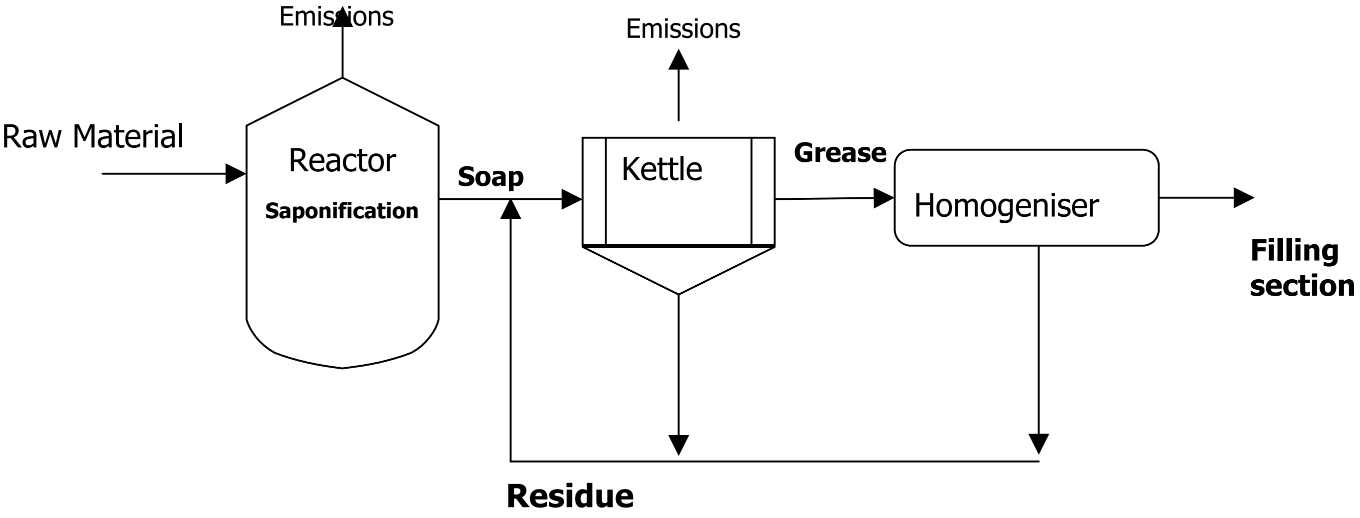


Figure 3. Material Flow in IOBL

Table 6. Material Input for 1625 Batches of grease in 1999-2000

Description	Quantity (Kgs)	Average per batch (Kgs)
Base Oil	118,13,190	7,269.655
Additives (drums)	8,62,194	530.58
Additives (others)	16,44,352	1,011.91
MF and slop usage	4,030	2.48
Rectification usage	49,194	30.27
Total inputs	143,72,960	8,844.895

Table 7. Raw material input-output statistics for 1999-2000

Total Raw material input (Kg)	143,72,960
Production (Kg)	140,51,000
Total loss of material (Kg)	3,21,960
Percentage loss of material	2.29%
Loss per batch (Kg)	198.13

Notes:

- Average number of batches per day: 5
- Loss as Water Vapour 1% of base Oil/Batch: 72.7 Kgs
- Loss of materials other than base oil: 125.43 Kg/Batch
- Total loss of material per day: 657.15 Kgs

7.1.3 Water Consumption Details

IOBL receives its water supply from the Maharashtra Industrial Development Corporation. The supply is about 3000 KL/month. The major water consumption areas at IOBL are:

- Boiler water
- Process
- Cooling tower
- Fire fighting
- Domestic (Staff canteen and washroom)
- Green belt development

The effluent generated at IOBL is discharged to the Navi Mumbai municipality sewerage system.

7.1.4 Energy Audit

Energy audit conducted at IOBL aims at balancing the total energy inputs with its use and served to identify all the energy streams at IOBL. Analysis of data collected at IOBL revealed that the energy bill of IOBL is Rs. 89.21 lakhs for year 1999-2000 (**Table 8**). About 46% of total energy is accounted as thermal energy, and remaining 54% as electrical energy.

Table 8. Energy Utilization Status at IOBL (1999-2000)

Type of energy	**Quantity**	**Unit Rate (Rs)**	**Cost (Rs. Lakhs)**
Thermal energy			
LDO (KL)	294.021	13849.9	40.71
Electrical Energy			
MSEB (KW)	1325570	3.50	46.39
Self generation* (KW)	15100	0.29	2.11
Total			**89.21**

*DG-Set used on Friday which is a regular electricity - holiday in Thane-Belapur belt

7.1.5 Environmental Issues

Manufacturing of grease generates solid wastes and fugitive emissions. Given below are the locations, and characteristics of the **Environmental Cost Centres** and wastes generated at IOBL (**Table 9**). **Figure 4** shows the emission, solid waste and wastewater generation sources.

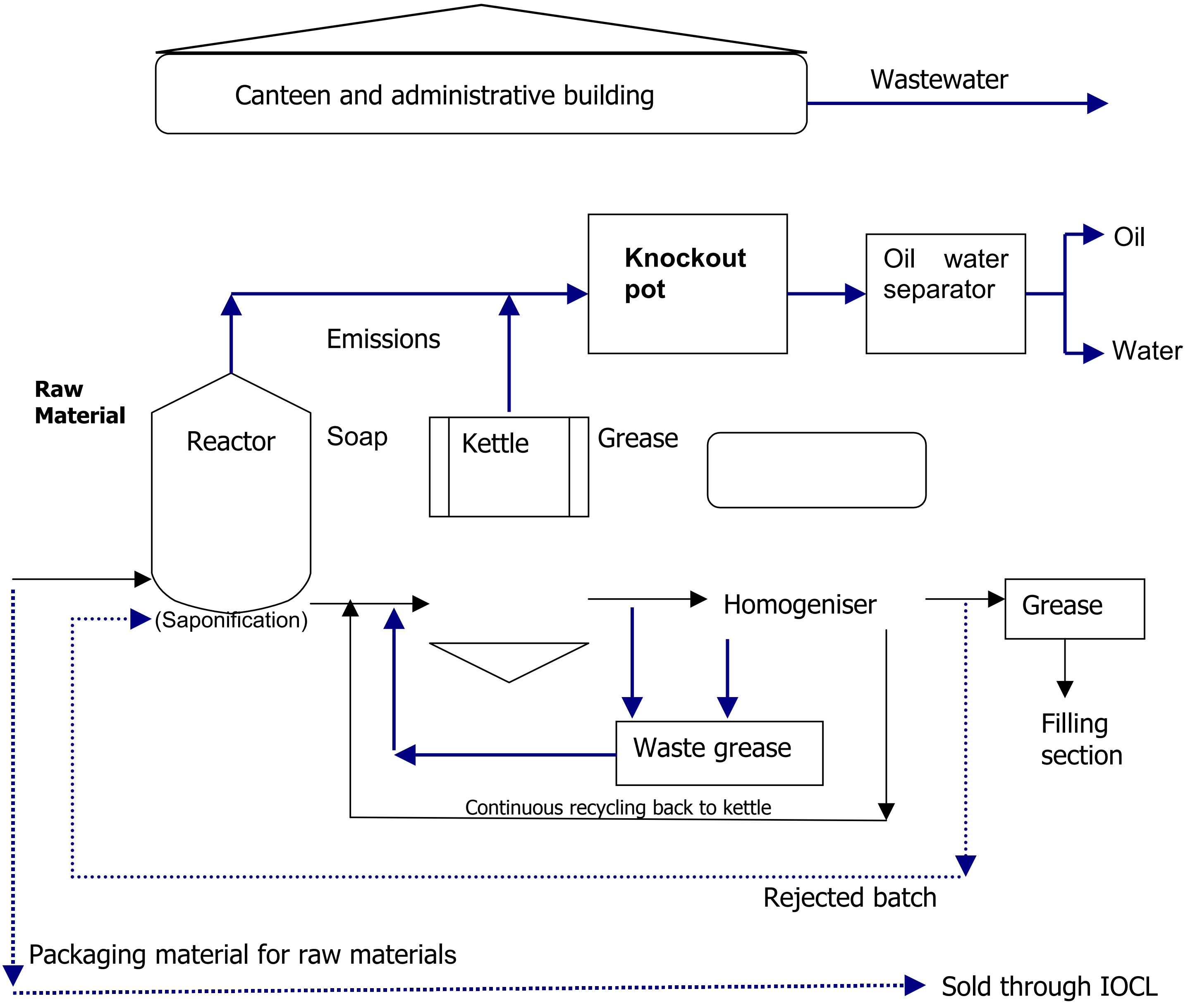


Figure 4. Waste generation sources

Table 9. Details of Environmental Cost Centres and Wastes generated at IOBL

Solid wastes		
Environmental Cost Centre	**Characteristics of solid waste**	**Remark**
Kettle	Grease	Recycled back to kettle
Homogeniser	Grease	Recycled back to kettle
Packaging for raw material	Cardboard drums, polythene and jute bags	Sold through IOCL
Air Emissions		
Environmental Cost Centre	**Characteristics of air emissions**	**Remark**
Blow down from Reactor to Kettle	Water vapour 98.5% Oil 0.5% Soap 1.0%	The vapour during blow down is condensed in the knockout pot and passed to the oil-water separator
Boiler	SPM 103 µg/m^3 SO_2 37.5 µg /m^3	Within acceptable limits (ie. SPM: < 500 µg/ m3 SO_2 : < 80 µg/ m3 As per MPCB emission standards)
Furnace (2 nos) (Ottley Burner, max fuel consumption 180 L/hr)	SPM 82 µg/m^3 SO_2 65.2 µg/m^3	Burner management system (Automatic regulation of fuel/air ratio with safety interlocks)
Wastewater		
Environmental Cost Centre	**Characteristics of wastewater**	**Remark**
Process and domestic waste water	pH 5.1 - 7.5 SS 46 - 78 mg/l DO 1 - 4.6 mg/l COD 198 - 216 mg/l BOD 21 – 28 mg/l	The source of process wastewater is the condensate from the Knockout pot, which is not generated on regular basis. The process water along with the domestic water is drained in to the septic tank

7.1.6 Waste generated in 1999-2000

IOBL recycles solid wastes generated, including rejected batches. The waste quantified includes material not recycled and the waste can be minimized by good operational practices like regular monitoring on shop floor and to recycling of rejected batches and grease used for sampling. **Table 10** details the additional profit due to waste recovery for the year 1999-2000.

Table 10. Monetization of recoverable waste for 1999-2000

Description	Quantity / Value
Total Raw material Inputs	143,72,960 Kgs
Total Production	140,51,000 Kgs
Material Loss	3,21,960 Kgs
Loss due to moisture not recoverable (1% of Base oil)	11,813.9 Kgs
Recoverable Material	3,10,146.1 Kgs
Assuming 80% of recovered material is processed, additional Grease production that can be achieved	2,50,000 Kgs.
Manufacturing Fees IOBL can collect @ Rs. 4250 per MT	Rs. 10,62,500
Marginal expenses to manufacture 250 MT of recovered material (including recovery cost) @ Rs. 3937 per MT*.	Rs. 9,84,250
Additional contribution to Profit	**Rs. 78,250**
Increase in profitability over profit of Rs. 17.52 lakhs	**4.45%**

*Assuming total expenses of Rs. 628.23 lakhs in 1999-2000 and Rs. 628.73 lakhs in 1998-1999, to manufacture 14051 & 14178 MT, respectively. This consists of fixed and variable costs, variable cost works out to be Rs. 3937/MT.

7.1.7 Fume extraction system

IOBL has commissioned a Fume Extraction unit, which consists of following units:

- Knockout pot
- Vapour condenser
- Scrubber
- Activated Carbon chamber

Presently IOBL is not utilizing this unit. Based on design parameters the waste, that can be recovered from the Fume Extraction unit is presented in **Table11.**

Table 11. Waste Recovery from Fume Extraction System

Scrubber	15 Kgs of grease/Batch
Activated carbon chamber	1.5 Kgs of grease/Batch
Total grease recovered	16.5 Kgs/Batch
Number of batches in 1999-2000	1625
Total material expected to be recovered*	26,812.5 Kgs
Cost of manufacturing recovered material	Rs. 1,10,500
Less cost of recovery **	Rs. 36,000
Power ***	
Consumables (Water, steam for regeneration activated carbon)	
Profit for 1999-2000	**Rs. 74,500**

* 10.72% of total loss of material (total loss of material as per **Table 11** for year 1999-2000 is 3,21,960 Kgs)

** Water expenditure for the fume extraction system is assumed to be Rs.3,000 per month

*** Blowers used for Fume extraction unit are the same as those being used currently to release vapour to atmosphere

7.1.8 Observation on grease manufacturing practices at IOBL

- During production, vapour is vented after blowdown of soap from reactor to kettle that is condensed in the knockout pot. The water and oil not recycled and is allowed to overflow in the drain during the rainy season

- During cooking in kettle (the duration of which varies from 2 – 6 hrs) vapour containing oil and soap is released to atmosphere

- The fume extraction system, installed and commissioned in April 1999, is currently not in operation

- Due to the lack of maintenance of oil-water separator (American Petroleum Institute's- standard model), water overflows from this during the rainy season which mixes with domestic water, and thus increases the COD values

7.1.9 Accounting system at IOBL

IOBL does not have a dedicated environmental accounting system. Cost information was obtained from financial ledgers, and profit and loss statements. The accounting heads at IOBL are:

1. **Capital expenditure**
2. **Wages & salaries**
3. **Repairs & maintenance**
4. **Energy bills**
5. **Water bills**
6. **Taxes and duties**

7.1.10 Environmental related activities

- Capital expenditure towards Fume extraction unit
- Depreciation for above
- Operation and maintenance cost (labour, power, consumables, and spares)
- Monitoring and Control of Pollution (compliance costs)
  - Pollution Control Board fees
  - Cost towards environmental monitoring
  - Training of employees for ISO 14000
  - Record keeping for characteristics of effluent and emission generated

7.1.11 Environmental Accounting for 1997-2000

Environmental accounting is the process of economically recognizing the benefits derived by corporate houses from immediate environment and initiating remedial measures, which abate any possibility of environmental degradation through its business activities. It is an attempt to identify and bring to light the resources utilized and costs imposed on ecosystem by corporate houses.

Accounting heads for environmental costs at IOBL have been identified and engineering departments can maintain these accounts as satellite accounts. The expenditure on the environmental related activities at IOBL is summarized in **Table 12**.

7.1.12 Pollution prevention activities at IOBL

Pollution prevention and control is best practiced through effective management, maintenance and housekeeping of process that incorporates transforming the linear production process loops into cyclic ones, process water conservation and recycling, energy conservation, and disposal of solid wastes as by products. Pollution prevention can profitably reduce energy consumption, resource use, cost for operation and maintenance, and can avoid costly regulatory structures and its negative penalties. The problem areas due to pollution at IOBL are presented in **Table 13**.

Table 12. Environmental costs for 1997-2000

Description	1999-2000	1998-99	1997-98
Production (MT)	14051	14178	12643.9
Expenditure (Rs. Lakhs)	628.23	628.73	518.31
Income (Rs. Lakhs)	645.75	636.94	564.31
Profit (Rs. Lakhs)	17.52	8.21	46.00
Capital investment for pollution prevention system (Fume Extraction System) (Rs. Lakhs)	16.99	--	--
Environmental Costs			
Depreciation	3.55	3.55	3.55
Environmental Monitoring & Reporting (MPCB)	0.53	0.96	0.17
Environmental consultant fees	0.20	0.19	0.21
Environmental services (MIDC)	0.16	--	--
Green belt development and maintenance	1.08	0.93	1.21
ISO 14000	2.25	--	--
Social costs*	--	--	--
Total Environmental costs (EC) (Rs. Lakhs).	**6.69**	**5.63**	**5.14**
EC as % of expenses	1.0649	0.8955	0.9917
EC per MT of production	**Rs 47.61**	**Rs 39.71**	**Rs 40.65**

*The industry is complying with the MPCB's mandatory emissions limit

Table 13. Environment related- Problem areas at IOBL

Area	Problem	Approach adopted by IOBL
Intermediate Products	Contribute towards process waste	Material recycled in the process
Pressure	Seal leakages	Follow Preventive maintenance programmes
Equipment cleaning	Waste generated by cleaning of equipment	Material is recycled
Venting from reactor	Fumes containing soap, oil, alkali and water vapour	- Regenerative treatment units used (activated carbon adsorption) - Return recovered samples to process
Combustion	Air emissions	Burner Management Systems (Automatic regulation of fuel/air ratio with safety interlocks)
Packaging	Solid wastes	Disposed for reuse through authorised agency

7.1.13 Waste minimization options

There are ample scopes for waste minimization at IOBL. Some important waste minimization options are listed for IOBL in **Table 14.** Implementation of these suggestions would result in increased profit for the industry in terms of material and energy savings, reduced environmental residues, and improved social performance.

Table 14. Waste minimization options suggested for IOBL

Area	Recommendation	Remarks
Process	▪ Hot oil after heating reactor can be used to heat Kettles prior to blow-down ▪ Vented heat from the rector can be used for pre heating the kettle	This will reduce the amount of fuels and emissions
Filling	▪ Small containers increase chances for material spillage and waste generation	Use bulk supply and repack at regional depots of IOC
General	▪ Prevent the process water from mixing with domestic waste water ▪ Treat wastewater from the process ▪ Solar water heaters for preheating water before feeding Boiler ▪ Photovoltaic cells for oil heating and lighting	Monitor domestic wastewater discharge IOBL can shift to these cost effective options

7.1.14 Recommendations

- The agitator in reactor / kettle, and homogeniser are driven by two speed 75/100 HP AC motors. To reduce the energy consumption and provide precise agitator speeds required for various grades of grease variable speed drive (VSD) motors should be used

- Operating the reactor at its full capacity will significantly reduce the time for production thus reducing the costs of production. The designed capacity of the reactor is 5 MT but is operated at 4 – 4.5 MT of reactor capacity

- Hot oil used for heating of reactor can be circulated to heat kettles during blow-down operation

- The steam generated during the dehydration and blow down process can be used for preheating of kettle

- Replacing the existing homogeniser by colloidal mill will result in saving the power consumption by one-fourth (25 hp). **The power saved is about 75 hp per hour and cost saving expected is Rs 14,17,500/- per annum**, considering 300 working days. The cost of the colloidal mill is about one-third of the homogeniser (cost of homogeniser is Rs 60 Lakhs)

- Monitor regularly flows of boiler blowdown and wastewater to ensure the same does not mix with domestic wastewater

- Regular maintenance of oil-water separator to ensure that there is no mixing of process and domestic wastewater

- Domestic wastewater should be utilized for green belt development after treatment

- Solar water heater can be used to preheat water before feeding boiler, which will reduce LDO consumption, thereby reduce cost of energy. The installation operation can take place in the factory without disrupting the production schedule

- Looking at the current oil price hike IOBL should develop grease manufacturing techniques using renewable raw materials viz. biodegradable grease using vegetable oil (**Annexure 5**)

7.1.15 Conclusion

Having identified Environmental Costs, and Environmental Cost centres, IOBL needs to truly internalize these costs, and not merely bear them. The Management should design a Corporate Environmental Plan with targets to reduce environmental costs by:

- Setting targets for Production department for restarting Fume Extraction within a month, and reduce material loss by 50% within six months
- Monitoring movement of waste material and ensure that the same is transferred to production facility regularly
- Utilizing the unused area in the premises for additional activities to justify environmental charges paid to MIDC as environmental charges at Rs. 809.70 per acre per month. As the plant is spread over 10 acres, the charges work out to be about Rs. 97,166 per annum
- Constituting a team of managers from production, maintenance, and finance departments to monitor the current environmental costs and anticipate future costs, so that remedial steps can be initiated well in advance
- Discussions should be held with R&D facility of IOC at Faridabad to identify grades of grease which consume lower energy for cooking and homogenisation
- Endeavour towards formulating a mix for lithium, calcium and aluminium based biodegradable grease (**Annexure 5**)
- Conducting seminars and conferences with IOC marketing team, dealers and major consumers to promote the identified less-energy and material-intensive products.

This study will not only help the organization to identify areas where environmental costs arise, but has also drawn attention to everyday operations which have critical impact on current and future environmental costs. By adequately motivating the employees at IOBL, material losses will be minimized, facilitating achievements of ISO 14000 targets **(Annexure 6).** Adopting these positive values would not only strengthen stakeholder relationships but also align the organization goals to that of sustainability.

7.2 Case Study – II: Paithon Silk Mills Ltd.

Paithan Silk Mills Ltd (PSML) is a small-scale textile-processing unit located in the Trans Thane Creek industrial belt. The annual turn over is usually around Rs.500 lakhs. At present, the major types of fabric processed at Paithan industries are pure cotton, polyester - cotton, bright polyester, nylon etc. Paithan mills has a built-up capacity for processing 5,00,000 m of cloth per month, but were operating at 50% of its installed capacity during the study period. Production details for the years 1998-1999 and 1999-2000 are presented in **Annexure 7**.

The stakeholders at PSML, and their expectations, are summarised in **Table 15**.

7.2.1 Production Process

Paithan silk mills basically a textile-processing unit, mainly carrying out dyeing and finishing of gray cloth. Before dying, fabrics need pre-treatment to remove natural impurities as processing chemicals that interfere with dying and finishing or processing chemicals that interfere with dying and finishing or processing chemicals. Pre-treatment consists of a series of various chemical treatment and rinsing steps critical to obtaining good results in subsequent textile finishing processes. Typical preparation treatments followed at Paithan are desizing, scouring, mercerizing and bleaching (Figure 5 exhibits the process flow sheet at Paithan mills).

Table 15. Stakeholder analysis of PSML

Stakeholders	Expectations from PSML
Paithan Silk Mill Ltd.	▪ Excellent quality product ▪ Maximization of contribution towards profit while keeping the expenditure to minimum.
Customers	▪ Excellent quality product ▪ On time delivery ▪ Minimal prices
Suppliers	▪ Continual demand for raw materials ▪ Timely payments
Employees	▪ Job satisfaction and security ▪ Satisfactory wages
Pollution Control Board	▪ Industry abiding by the Pollution Control board standards for emission and effluent discharge at all times
Neighbouring industries	▪ Healthy relations ▪ No nuisance causing actions
Society	▪ Non-polluting industry ▪ Generation of jobs ▪ Improvement of the infrastructure of the surrounding areas
Environment (Air, Water, and Land)	▪ Zero emission or discharges to the environment ▪ Optimum use of water and electricity ▪ Development of green belt in the surrounding areas
Maharashtra Industrial Development Corporation	▪ Continual purchase of water
Maharashtra State Electricity Board	▪ Continual purchase of electricity
Packaging materials suppliers and disposers	▪ Continually increasing demand
Shareholders	▪ Increase in share value
Government	▪ Payment of taxes

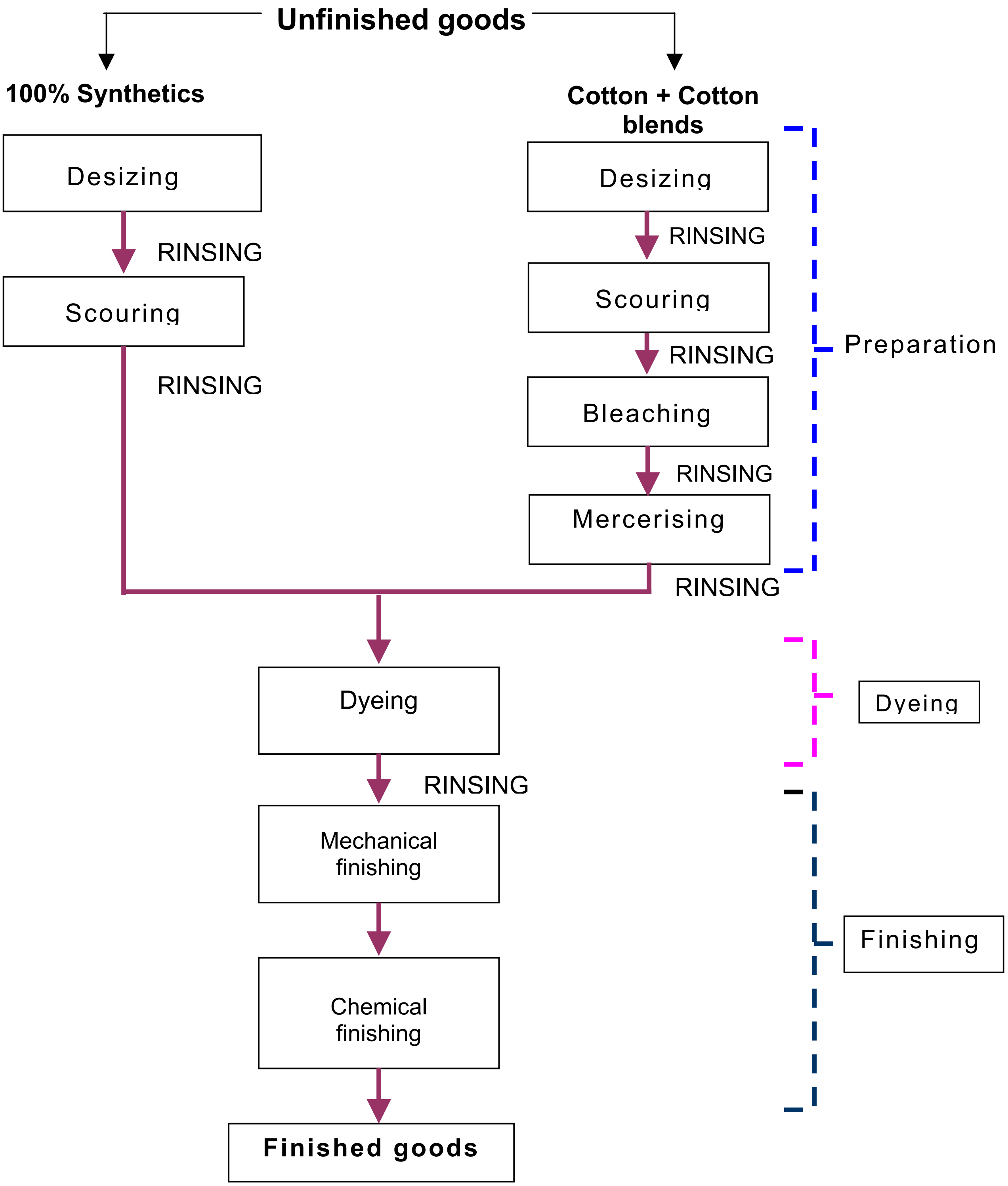


Figure 5. Process flow sheet at Paithan Silk mills

Desizing and Scouring

Desizing is an important preparation step used to remove size materials applied prior to weaving**.** Water-soluble sizing agents are used at Paithan mills and this step is combined with scouring.

Scouring is a cleaning process that removes impurities from fibers, yarns, or cloth through washing. At Paithan mills alkali, typically sodium hydroxide is used, to break down natural oils and surfactants and to emulsify and suspend remaining impurities in the scouring bath. The specific scouring procedures, chemicals, temperature, and time vary with the type of fiber, yarn, and cloth construction. Impurities may include lubricants, dirt and other natural materials, water-soluble sizes, antistatic agents, and residual tints used for yarn identification. Scouring wastes contribute a large portion of biological oxygen demand (BOD) and Chemical oxygen demands (COD) loads from preparation processes

Bleaching

Bleaching is a chemical process that eliminates unwanted colored matter from fibers, yarns, or cloth. Bleaching decolorizes colored impurities that are not removed by scouring and prepares the cloth for further finishing processes such as dyeing. The bleaching agents used at Paithan mills are hydrogen peroxide and sodium hypochlorite. Hydrogen peroxide mostly used for cotton and cotton blends with caustic solutions. Peroxide bleaching contributes wastewater with high pH levels. The bleaching process involves several steps:

- The cloth is saturated with the bleaching agent, activator, stabilizer, and other necessary chemicals
- The temperature is raised to the recommended level depending on particular fiber or blend and held for the amount of time needed to complete the bleaching action
- The cloth is thoroughly washed and dried.

Mercerising

Mercerization is a continuous chemical process used for cotton and cotton/polyester goods to increase dyeability, luster, and appearance. This process, which is carried out at room temperature, causes the flat, twisted ribbon-like cotton fiber to swell into a round shape and to contract in length. This causes the fiber to become more lustrous than the original fiber, increase in strength by as much as 20 percent, and increase its affinity for dyes. The mercerising process at Paithan mills is carried out in the mercerising unit, where the fabric is passed through a cold 40 to 52 percent solution of caustic soda and then is subjected to hot-water sprays for removal of caustic solution. After treatment, the caustic is removed by several washes under tension. Remaining caustic is squeezed through an squeezer and than neutralized with a cold acid treatment followed by several more rinses to remove the acid. The caustic solution from the squeezing section is recycled back and stored and maintained at 40-52% concentration. Wastewater from mercerising can contain substantial amounts of high pH alkali, accounting for about 20 percent of the weight of goods.

Dyeing

Dyeing operations are used at various stages of production to add color and intricacy to textiles and increase product value. Textiles are dyed using a wide range of dyestuffs, techniques, and equipment. The most frequently used dyes at Paithan mills are sulphur dyes, vat dyes and reactive dyes.

Methods of Dyeing

Paithan silk mills Dyeing is performed in batches using jiggers and jet dyeing machines. There are eight jigger machine, two of 150 kg capacity and the rest of 100 kgs, one JT jumbo jigger of capacity 8000 kg, one U-jet dyeing machine of capacity 15000 kg and two beam jet machine of 1000 kgs. As per the capacity, the cloth is loaded into a dyeing machine and brought to equilibrium, or near equilibrium, with a solution containing the dye. Depending on the type of cloth being dyed and the type of dye used the fabric is kept in contact with the dye solution in the dye bath. Auxiliary chemicals and controlled dye bath conditions (mainly temperature) accelerate and optimize the action. The dye is fixed in the fiber using heat and/or chemicals, and the tinted textile substrate is washed to remove unfixed dyes and chemicals **Figure 6** Illustrates the jig, and jet methods for dyeing.

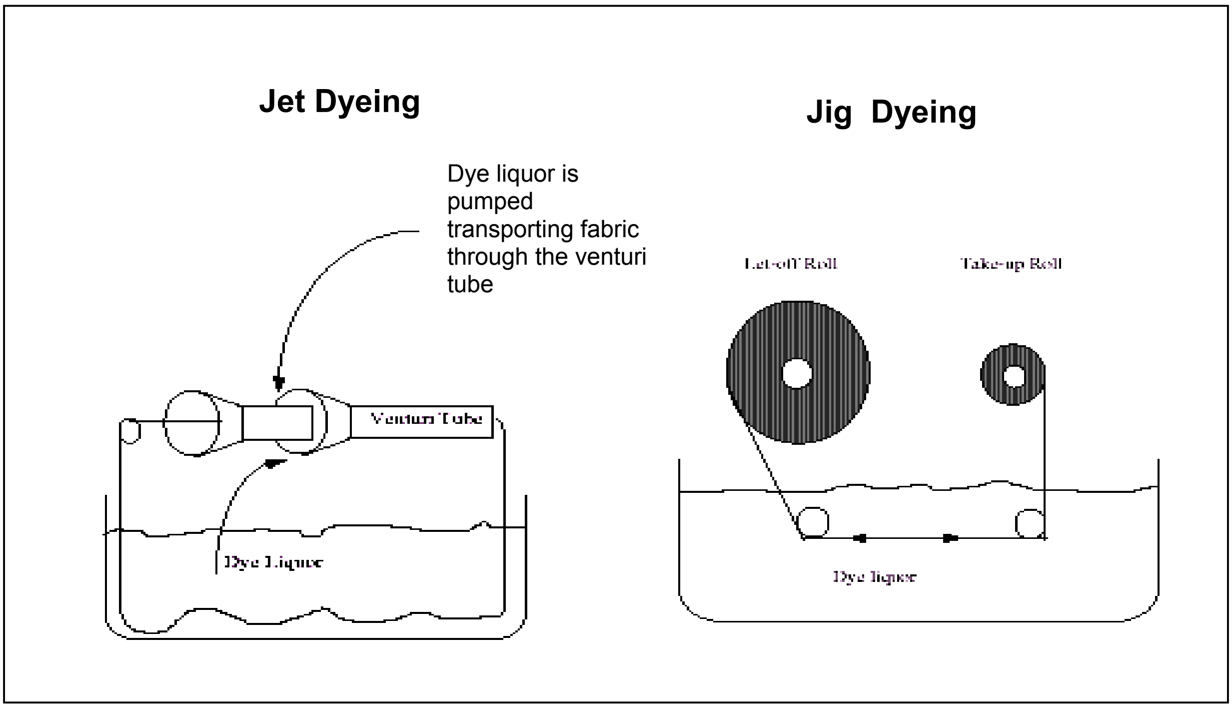


Figure 6. Jig and Jet Dyeing Process

Finishing

The cloth after dyeing process is finished using 0-0 machine and deca drying of fabric to improve appearance, texture, or performance. The cloth maintains its shape and size in finishing operation and is stabilized in the form in which it is held during heat setting (e.g., smooth, creased, uneven). Textural surface effects such as pleating, creasing, puckering, and embossing etc are taken care of in these operations. The cloth may be chemically set depending on the expected characteristics of the finished product like stain resistance, soil release, softening and abrasion-resistant finishes etc. Drying, curing, and cooling steps usually follow chemical finishes. Chemical finishes is often done in conjunction with mechanical finishing steps.

7.2.2 Material audit

The raw materials used at Paithan Silk Mills for processing of fabric are chemicals and water. Chemicals are used in the scouring, mercerizing dyeing and finishing processes are presented in **Tables 16** to **18**.

Table 16. Chemicals used in various processes

Process	Chemicals used
Scouring	Sodium hydroxide, Hydrogen peroxide Scouring agent Sodium carbonate, Sodium silicate, Soap
Mercerising	Caustic lye, Acetic acid
Bleaching	Hydrogen peroxide, Soda ash Soap
Dyeing	Dye*, Dye fixing agent, Soda ash, Acetic acid, Common salt, Sodium sulphide, Sodium acetate, Hydrogen peroxide
Finishing	Finishing agent, Acetic acid

* Dyes used at Paithan mills are sulphur dyes, vat dyes and reactive dyes

Table 17. Raw Material Input during 1999 – 2000

Raw Materials	Average Monthly consumption (kgs)
Acetic acid	300
Soda ash	750
Caustic soda	500
Hydrogen peroxide	500
Oxalic acid	200
Bleaching powder	150
Sodium hydrosulphite	250
Cationic softener	50
Sulphuric acid	4,000
Caustic lye	2,500
Vat dye	40
Sulphur dye	25
Reactive dye	20
Total Consumption	**9,285**

Table 18. Raw Material Input-output statistics during 1999 – 2000

Parameter	Amount (Kgs)
Total Raw Material input	2,57,725
Material used in processing	51,545
Total Material Loss	2,06,180

7.2.3 Water Consumption Details

Large quantity of fresh water is a prerequisite for any textile industry. The type of processing and the number of sequences of treatment given to the materials determine the quantity of water required.

After the processing, steam generation also consumes large quantities of water. Practically every step in the textile processing consumes steam for hot wash, heating etc. Besides, significant amount of water is consumed as drinking water and also for maintaining personal hygiene of the workers. The quantity of water required for various sections depend on the quantity of material, nature of processing involved and the sequence of processing. In general shorter the process sequence, lower will be the consumption of water. The water consumption at different stages in a typical textile processing industry is presented in **Table 19.**

Table 19. Water consumption at different stages in Textile Industry

Machine/ Process	Water consumption (L/kg)
Open width scouring/ peroxide range	15 / range
Mercerizing units	20
Jigger scouring/ Bleaching	30 / operation
Jumbo jiggers	30
Ordinary jiggers	25 - 35
Jet dyeing (including washing)	10
Conventional	20
Rapid	15
Beam dyeing	25
Carbonizing	30
Caustic peroxide saturator	1

The water consumption at Paithan Silk Mills is in the range of 1200-1300 cum/ month. 75% of the total water supply is used in the process while the remaining is used for domestic purpose. The water consumption details for the year 1999-2000 are given in **Table 20**.

Table 20. Water Consumption Details (1999 - 2000)

Month	Consumption **(m^3)**
April	853
May	1,131
June	1,380
July	1,180
August	1,200
September	1,578
October	1,721
November	1,697
December	1,625
January	1,085
February	1,174
March	1,012

The average water consumption per month =1168 m^3.
Considering 15 days operation/month; the daily usage of water is 80 m^3
Daily consumption of process water (75 % of total water consumption) is 60 m^3.

7.2.4 Energy Details

PSML obtains electric supply from the Maharashtra State Electricity Board. It also generates in house power using DG sets. Thermic Fluid Heater and boilers, which run on furnace oil, are used for generation of steam for heating purposes. The detail electricity consumption for year 1999 -2000 is presented in **Table 21**. The details of oil consuming equipments and the overall energy consumption scenario at PSML are presented in **Table 22** and **23**, respectively.

Table 21. Electricity consumption (March - December 2000)

Month	Unit (Kwh)	Rate (Rs/kWh)	Total* (Rs)
April	58424	3.35	267185
May	44346	3.35	208884
June	67471	3.35	302721
July	60334	3.35	267036
August	40876	3.35	196762
September	36403	3.35	176797
October	37071	3.35	178963
November	53871	3.35	235736
December	41123	3.35	195075

*The demand charges are included in the total charge

Table 22. Details of oil consuming equipment

Name of the equipment	Nos	Capacity (Ltrs)
Thermic Fluid Heater	1	1000
Boiler	2	1000 & 600

Table 23. Overall energy consumption scenario

Type of energy & units	Quantity (units)	Unit rate	Cost (Rs. Lakhs)
Thermal energy			
Furnace oil (Ltrs)	5,17,805	10.97-16.57	56.30
Electrical Energy			
MSEB (kWh)	5,35,598	3.25	21.61
Diesel (self generation) (Ltrs)	95,600	6.65 -12.25	9.44
Total			87.35

7.2.5 Thermal Energy Audit

Thermal energy audit was conducted for Thermic Fluid Heater, Boiler and related equipments and processes. Analyses of the operation of various equipments were conducted at the following strategic points:

- Fuel Storage and Handling System
- Thermic Fluid Heater
- Boiler
- Steam traps
- Recoverable Heat loss centres (Stenter, condensate).

The Flue gas analysis of Thermic Fluid Heater, and Boiler are presented in **Table 24** and **Table 25**, respectively.

Table 24. Flue gas analysis of the Thermic Fluid Heater

Parameters	**Values**
Oxygen	5%
Carbon monoxide	0.0062%
Carbon dioxide	11.7%
Excess air	37%
Stack temperature	260^{o}C
Ambient temperature	36^{o}C
Efficiency	82.4%

Table 25. Flue gas analysis of the Boiler

Parameter	**Values**
Oxygen	7%
Carbon monoxide	0.053%
Carbon dioxide	18.7%
Excess air	47%
Stack temperature	$340\pm10\ ^{0}$C
Ambient temperature	36^{0}C
Steam pressure	5kg/cm^{2}
Efficiency	78.7%

Savings anticipated by reducing stack temperature in Boiler and Thermic Fluid Heater (TFH)

Three areas particularly relevant to efficient system operation are: proper stack temperature, cleanliness of the heating surface, and burner adjustment. The stack temperature to prevent gas condensation is expected by the following relationship:

49°C + boiler water temp (°C) + [1/2 x stack ht (m)] = stack temp (°C)

At present the stack temperature in the boiler is 340 ± 10°C while the ideal stack temperature should be 234°C. If the stack temperature is brought down to 234°C, it would result in 5% savings on fuel (according to empirical rules, for every reduction in stack temperature by 20°C, the fuel saving will be 1%) as shown in **Table 26**.

Table 26. Fuel Savings by reduction in stack temperature

Items	Values
Oil consumption by boilers	1,12,320 litres per annum
Fuel cost per annum	Rs. 12,35,520
5 % fuel savings	5,616 litres per annum
Annual monetary savings on fuel cost (fuel cost @ Rs. 11 / litre)	Rs. 61,776

The boiler unit is supplied with two outlets to the chimney; one of which is a regular outlet and the second outlet was constructed later for directing the carbon exhaust during backfiring of the burner through the chimney. This causes the flue gas to escape through the second outlet without passing through the economizer. Hence, the feed water temperature is almost at the ambient temperature. If the second outlet is closed, the flue gas would pass through the economizer and this will increase the efficiency of the boiler by bringing down the stack temperature. The steam condensate from the steam traps is currently let out in drain. Instead, it can be collected and reused as boiler feed water. If this steam condensate is fed to the boiler at 75°C (ie. 50°C higher than the water temperature of 25°C), the total fuel savings expected is 8% (according to empirical rule, for every increase in 6°C of boiler feed water temperature there will be 1% fuel saving) as shown in **Table 27**.

Table 27. Fuel savings by recycling steam condensate

Item	Values
Oil consumption by boiler	1,12,320 litres per annum
Fuel cost per annum	Rs. 12,35,520
8 % fuel savings	8,985.6 litres per annum
Annual monetary savings on fuel cost (fuel cost @ Rs. 11 / litre)	Rs. 98,841

The CO levels in the flue gas are significantly high (0.09%) than the normal concentration (0.002 - 0.003%). When incomplete combustion occurs - and this can be the case when a system is pushed too close to the 100% peak efficiency level without careful maintenance - one of the obnoxious by-products is carbon monoxide (CO). Even when CO is at levels well below toxicity, each 1% CO in the flue gases decreases boiler efficiency by 4%. It has a cooling effect on the flame temperature, which adversely affects thermal efficiency of the boiler. Furthermore, excess air must be kept to a minimum so that energy is not wasted.

Savings anticipated by insulation of valves

There are 44 valves installed in the thermic fluid and steam pipes. All these valves are not insulated. Hence there is substantial heat loss to the environment from the valves. The heat loss from a valve is equated to the heat loss from a 0.5 m length of uninsulated pipe of similar diameter. Insulating the valves would result in 2% savings on total fuel cost as presented in **Table 28**.

The hot air from Stenter is being let out into the atmosphere. The recycling of hot air to the Stetner would result in significant savings on fuel costs. The hot air could be recycled through a moist trap. The heating of the air could be restricted to the maintenance of air temperature, rather than to heating fresh air as is currently the case.

Table 28. Fuel savings by insulation of valves

Items	Values
Total oil consumption	3,49,000 litres per annum
Fuel cost per annum	Rs. 38,39,000
2.21 % fuel savings	7,712.9 litres per annum
Annual monetary savings on fuel cost (fuel cost @ Rs. 11 / litre)	Rs. 84,842

In sum, the overall potential savings through appropriate precautions/changes are presented in **Table 29**.

Table 29. Cost- Benefit Analysis of implementing remedial measures in Thermal Energy sector

Items		Values
Total oil consumption		3,49,000 litres per annum
Fuel cost per annum		Rs. 38,39,000
Total annual monetary savings on fuel cost		Rs. 2,45,495
Through reduction in stack temperature of the boiler	Rs. 61,776	
Through recycling of steam condensate	Rs. 98,841	
Through insulation of valves	Rs. 84,842	
Cost of implementing the necessary modifications		Rs. 2,62,000
Tilting of fuel storage tanks, relocation of the drain valve	Rs. 5,000	
Insulation of valves	Rs.1,32,000	
Piping for redirection of steam condensate	Rs.1,00,000	
Miscellaneous expenses	Rs. 25,000	
Investment Payback Period		13 months

7.2.6 Environmental issues

The textile processing at PSML uses large quantity of water for scouring, mercerizing, bleaching, dyeing and finishing process where in chemicals are added to fresh water and the fabric is treated with it. The process water with chemicals present is discharged as effluent. The chemicals retained on the cloth are further washed off using hot and cold water. About 90% of the total waste generated from PSML is wastewater. However, steam released from the drying and heating process also forms the next important form of waste.

Textile processing consumes large volumes of water and consequently discharge large quantities of effluent that exhibit-polluting characteristic. The details of Environmental Cost Centres and characteristics of wastesare presented in **Tables 30** and **31**.

Table 30. Details of wastewater generated and Environmental Cost Centres at PSML

Environmental Cost Centre	Operation / process	Composition
a. Nylon parachute processing		
Stenter	Water Wash	Suspended solids
Scouring Jigger I	Water Wash	Suspended solids
Jigger II	De-rusting	Oxalic acid
Jigger II	Peroxide treatment	Sodium carbonate
Wash trough	Cold & Hot wash	Suspended solids
Wash trough	Acidification	Acetic acid
Stenter trough	Silicone treatment	Silicone
b. Bright polyester goods processing		
Jet scouring machine	Water wash	
Scouring machine	Sc. Agent treatment	NaOH, Scouring agent
Jigger	De-rusting	Oxalic acid, HCl
Wash trough	Cold & Hot wash	Suspended solids
Jet machine	Peroxide treatment	Sodium carbonate
Wash trough	Cold & Hot wash	Suspended solids
Squeezing machine	Squeezing	Suspended solids

Table 30 contd…

c. Polyester- Cotton Fabric Processing		
Desizing jigger	Desizing	Wastewater
Wash trough	Cold & Hot wash	Wastewater
Wash trough	Hac wash	Acetic acid
Jet dyeing machine	Polyester dyeing	Acetic acid
Jet dyeing machine	Cotton dyeing	NaOH, Dye
Bleaching	Peroxide transfer	Wastewater
Wash trough	Soap wash	Soap
d. Steam generation and Thermic fluid heating		
Boiler	Steam generation	Flue gas
Thermic Fluid Heater	Heating thermic fluid	Flue gas

Effluent quantity

The quantity of effluent discharge varies with the type of chemical treatment and the quantity of cloth processed. On an average the daily effluent generation from process is about 60 m^3/day and the domestic water is about 10 m^3/day.

Table 31. Combined Raw Effluent characteristics

Parameters	Concentration
Flow	60 m^3
PH	9.0 –12.0
TDS	1200 – 1700 mg/l
BOD	300 – 500 mg/l
COD	1000 – 1400 mg/l
TSS	400 – 600 mg/l
Colour	Dark Coloured

Wastewater Recycling

Wastewater generated from the process can recycle back to the system after appropriate treatment.

Treatability studies: The process water after neutralization (pH 7) using HCl was treated with $FeSO_4$ (500 mg/l) and Lime (300 mg/l) for coagulation and flocculation of suspended solids, and removal of colour from the effluent. The supernatant was passed through activated charcoal filter (retention time 15 minutes). The flow sheet of effluent treatment is given in **Figure 7**. The characteristics of treated effluent are presented in **Table 32**. Treated sample is tested for dye affinity and was found suitable for reuse. The reuse of the treated water would result in the saving of 60 m^3 of water per day. The monetization of treating the combined raw effluent for reuse in the production process is given in **Table 33 (a, b, c)**.

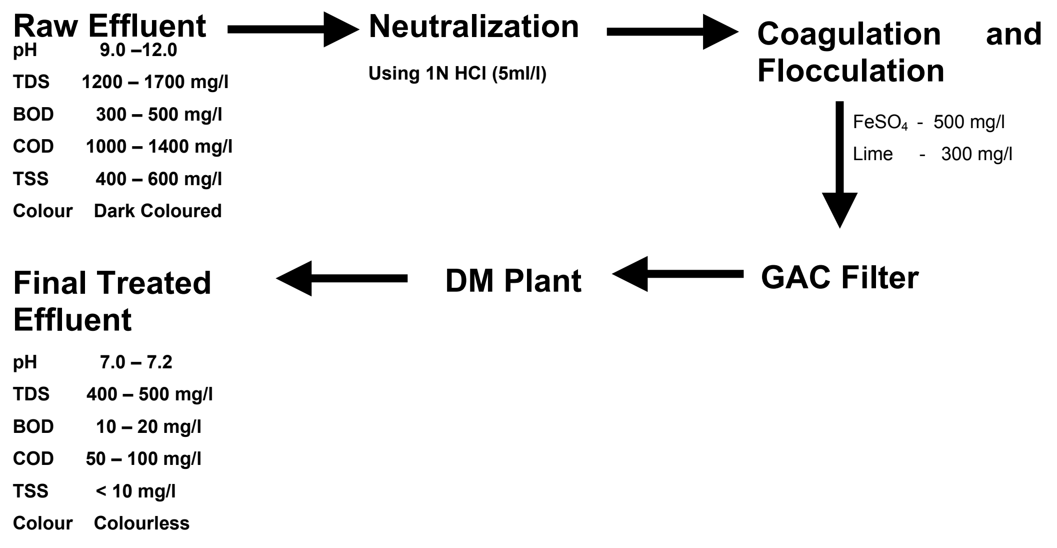


Figure 7. Flow sheet of Effluent Treatment

Table 32. Final Treated Effluent characteristics

Parameters	Concentration
PH	7.0 – 7.2
TDS	400 – 500 mg/l
BOD	10 – 20 mg/l
COD	50 – 100 mg/l
TSS	5 – 10 mg/l
Colour	Colourless

Table 33a. Approximate Cost of Chemicals for suggested Treatment

Chemicals	**Total consumption / day / m^3**	**Rate/kg (Rs)**	**Cost/Day (Rs)**
HCl (35%)	60 lts	4.50	270
$FeSO_4$	30 kg	4.50	135
Lime	18 kg	4.50	81
Caustic Soda	20 kg	10.0	200
Total			**686**

Table 33b. Power Requirement and approximate cost for suggested Treatment

Machinery	**Nos**	**Capacity** (H.P.)	**Total Operating Hours**	**Total Power consumption** (kwh)	**Rate** (Rs/kwh)	**Cost** (Rs)
Pump	3	1.5	12	13.5	3.5	47.25
Motor	1	0.5	10	3.75	3.5	13.13
Total						**60.38**

Table 33c. Monetization of suggested treatment plan

Capital investment for suggested treatment plant	**Rs. 3,50,000**
• Machineries	Rs. 3,00,000
• Construction	Rs. 50,000
Operating Cost (per annum)	**Rs. 2,66,915**
• Chemicals (@Rs. 686/day)	Rs. 2,16,090
• Power (@ Rs. 61/day)	Rs. 19,215
• Labour (315 Man days, @ Rs.60/d)	Rs. 18,900
• Miscellaneous (@ 10% O&M cost)	Rs. 12,710
Savings	
• Present expenditure on water supply and disposal (60 cum/ per day)	Rs. 1200 / day
• Total O&M cost for suggested treatment	Rs. 847/ day
• The savings by reuse of treated water:	
▪ Daily Savings (1200 – 847)	**Rs. 353 per day**
▪ Yearly savings	**Rs. 1,11,195**
Capital Expenses Pay Back period	**38 months**

7.2.7 Accounting system at Paithan Silk Mills Ltd.

Cost information at Paithan silk Mills is maintained in the form of financial ledgers, and profit-loss statements. The accounting heads at PSML are:

- Capital expenditure
- Wages and salaries
- Repairs and maintenance
- Energy bills
- Water bills
- Taxes and duties

7.2.8 Environmental related activities

- Operation and maintenance cost (labour, power, consumables, and spares)
- Monitoring and Control of Pollution (compliance costs)
  - Pollution Control Board fees

- Effluent Treatment cost
- CETP cost

7.2.9 Environmental Accounting for 1997-2000

Accounting heads for environmental costs at PSML have been identified and engineering departments can maintain these accounts as satellite accounts. The expenditure on the environmental related activities at PSML is summarized in **Table 34**.

The loss accruing in the production process can be recovered by the reuse and recycling of the industrial effluent and thereby reducing the environmental stressors or local, regional and global level. Besides, the maintenance of satellite accounts at departmental level would help in locating the major cost centers and facilitate easier control to keep the costs under check.

Table 34. Environmental Costs for 1997-2000

Description	1999-2000	1998-99	1997-98
Production (m)	2,50,000	2,66,000	2,48,000
	1,38,75000	1,46,83,200	1,36,64,800
	1,03,75000	1,05,33,200	1,02,86,800
PROFIT (Rs. Lakhs)	-35.00	- 41.50	-33.78
Capital investment for pollution prevention system (Rs. Lakhs)	16.83	19.80	23.30
Environmental cost (Rs. Lakhs)			
Depreciation*	2.52	2.97	3.45
Environmental Monitoring & Reporting (MPCB)	0.05	0.05	0.04
Effluent treatment cost	0.84	0.84	0.79
CETP costs	0.10	0.10	0.09
Environmental services (MIDC)	0.25	0.25	0.20
Green belt development and maintenance	0.96	0.75	0.60
Total Environmental costs (EC) (Rs. Lakhs).	4.72	4.96	5.17
EC per meter of product (Rs)	**1.89**	**1.86**	**2.08**

* WDV method has been used for depreciation

7.2.10 Pollution prevention activities at PSML

Pollution prevention and control is practiced through effective management, maintenance and housekeeping process. Waste minimization options suggested for PSML are presented in **Table 35.**

Table 35. Waste minimization options suggested for PSML

Area	Recommendation	Remarks
Process	Steam condensate from steam traps and spent steam can be redirected to Boiler as boiler feed water	This will reduce amount of fuel consumed and thereby emissions
	The hot air from the Stetner can be recycled introducing a moisture trap in between.	
	Raw effluent can be treated and recycled	This will reduce fresh water supply consumption and result in considerable savings

7.2.11 Recommendations

- The inlet pipe to the fuel storage tanks needs to be provided with coarse filter (10 mesh) to retain any dirt and floating matter that may be present in the oil.
- The storage tank need to be tilted in the ratio 1:50 towards the back side of the tank, and the drain valve relocated to the back side of the tank. This would result in settling of the sludge and water towards the backside of the tank from where it could be drained off.
- Regular cleaning of on-line filters and burner nozzle would improve the firing, and aid in complete combustion of the fuel.

7.2.12 Conclusion

Having identified Environmental Costs, and Environmental Cost centres, PSML needs to truly internalize these costs, and not merely bear them. The Management should design a Corporate Environmental Plan with targets to reduce environmental costs by treating and recycling the effluent.

This study will not only help the organization to identify areas where environmental costs arise, but has also drawn attention to everyday operations which have critical impact on future environmental costs.

Adopting these positive values would not only strengthen stakeholder relationships but also align the organization goals to that of sustainability.

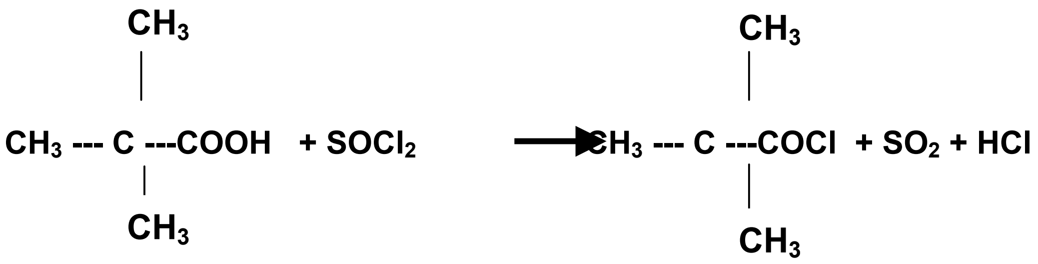
7.3 Case Study – III: Kedia Chemical Ltd.

M/s Kedia chemical Ltd., being a medium-scale chemical unit of Kedia Group, is currently producing Pivaloyl Chloride, which is used as intermediate for antibiotics like Ampicillin and Amoxycillin and also in synthesis of Cephalosporins. It is also used during synthesis of Pharmaceuticals and Pesticides, using Pivallic Acid crude as a raw material. With assets of Rs 15.16 Crores, it achieved an annual turnover of Rs. 2.45 Crores during FY 2000. KCL's financial profile is given in **Annexure 8**.

Identification of stakeholders of KCL and their expectations is summarised in **Table 36.**

7.3.1 Process Description

The basic chemical reaction involved in the Pivallic Chloride production process is given as under



$$CH_3\text{---}\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{C}}\text{---}COOH + SOCl_2 \longrightarrow CH_3\text{---}\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{C}}\text{---}COCl + SO_2 + HCl$$

Pivallic acid + Thionyl Chloride → Pivaloyl Chloride + Hydrochloric acid

The process involves two major steps

1. Recovery of Pivallic acid (PA) from crude
2. Chlorination of PA with Thionyl Chloride to Pivaloyl Chloride

Table 36. Stakeholder analysis of KCL

Stakeholders	**Expectations from KCL**
Kedia Chemical Ltd.	▪ Excellent pharmaceutical quality production ▪ Maximization of contribution towards profit while keeping the expenditure low and turning into profit making unit.
Customers	▪ Excellent pharmaceutical production ▪ On time delivery ▪ Minimal prices
Suppliers	▪ Continual demand for raw materials ▪ Timely payments
Employees	▪ Job satisfaction and security ▪ Satisfactory wages
Pollution Control Board	▪ Industry abiding by the Pollution Control board standards for emission and effluent discharge at all times
Neighbouring industries	▪ Healthy relations ▪ No nuisance causing actions
Society	▪ Non-polluting industry ▪ Generation of jobs ▪ Improvement of the infrastructure of the surrounding areas
Environment (Air, Water, and Land)	▪ Zero emission or discharges to the environment ▪ Minimal use of water and electricity ▪ Development of green belt in the surrounding areas
Maharashtra Industrial Development Corporation	▪ Continual, optimal usage of water
Maharashtra State Electricity Board	▪ Continual purchase of electricity with least losses
Packaging materials suppliers and disposers	▪ Continually increasing demand
Shareholders	▪ Increase in share value and assets
Government	▪ Payment of taxes in time

Recovery of Pivallic acid (PA) from crude

Hydrolysis (Hydrolysis of esters to liberate alcohols)

During the first phase, crude is pumped into the agitated vessel. Concentrated sulphuric acid and water are sucked in to the vessel by vacuum. The charge is heated under agitation when hydrolysis reaction takes place. Low boiling compounds such as Methanol, Ethanol, Isopropyl alcohol, Acetone, water etc gets distilled out. Some PA is also lost along with the low boiling chemicals. The reaction is then cooled to a temperature of 60^{o}C and allowed to settle down for phase separation.

The aqueous phase of spent acid containing many organic chemicals, including small percentage of PA is drained out to waste. The organic phase (Crude PA) is washed with water two times to remove the mineral acid and is transferred to an intermediate storage tank. These washings containing some PA, water-soluble organic chemicals, along with water are drained to waste.

Distillation of Crude PA (Eliminate high boiling and non-volatile impurities)

This phase consists charging of crude PA (2 litre) and heating under atmospheric pressure. As distillation of PA continues, the level of material in kettle falls, and thereby, more crude is sucked periodically into it. The residue containing some PA and high boiling impurities is transferred into an intermediate storage tank so that more space would be available for changing more crude. This operating procedure is continued till a total volume of about 135 KL is processed.

After charging the total volume of crude, the distillation process is continued and as level of liquid in kettles falls, a semi-processed residue is collected in the intermediate storage tank, which is later sucked for the recovery of PA from it. After distillation, most of PA, residues (containing a high percentage of PA) is drained to waste and washed out. On cooling, residues solidify to the consistency of tar. Attempts are being made to recover the PA lost in the residue and to make suitable use of residue. The distillate contains 50-60% PA.

Fractional distillation of PA of 50- 60% purity (To Achieve 90-95% PA)

Here distilled PA of 50-60% purity is charged into the kettle, mixed for 10 minutes and allowed to settle. The aqueous phase separated at the bottom is drained to waste. The kettle is heated and distillation is carried out at atmospheric pressure till the liquid temperature increased to 150^{o}C . The distillate which contain 10-20% PA is collected for recycle. The mass is cooled to a temperature of 100^{o}C before the vacuum is applied for continuing the distillation. Low boiler removal is continued till the concentration of PA in the liquid in the kettle rises to 90-95%. PA of 90-95% purity is suitable for chlorination.

Chlorination

In this phase, the crude reaction is transferred from R6/R7/R10 to R2/R4 by vacuum. Distillation at atmospheric pressure is carried out, without reflux, till the temperature of the vapor rises to 90^{o}C. The distillate consists mainly of low boiling impurities. Distillation is continued at high rate of reflux {60/40}. Low boilers are distilled out till the temperature of the vapor rises to 104^{o}C. This cut contains some of the product and it may be recycled. The main fraction collected in the boiling range of 104-106^{o}C. Residue contains some part of product and hence recycled.

7.3.2 Material audit

The production of the Pivaloyl Chloride has started in June 2000, and therefore, the results has been presented herein are of 7 month periods.

The basic raw materials used are:

- Pivallic acid crude
- Thionyl Chloride
- Sulfuric Acid

The secondary data generated by analysing the primary data, collected from industry and on site verification, is presented hereunder through **Figures 8** and **9**, and **Tables 37** to **39**.

Table 37. Pivallic Acid Crude Consumption Scenario (June – Dec 2000)

Months	Crude PA[1] (Kgs)	Assumed PA (%)	Assumed PA (Kgs)	Actual PA Yield (Kgs)	Loss		
					PA (Kgs)	Others[2] (Kgs)	Total (Kgs)
DECEMBER	47,158	83.72	39,480	35,055	4,425	7,678	12,103
NOVEMBER	48,991	50.266	24,606	16,519	8,087	24,385	32,472
OCTOBER	31,220	70.33	21,957	13,930	8,087	9,263	17,290
SEPTEMBER	80,452	48.25	38,818	27,398	11,420	41,634	53,054
AUGUST	72,700	42.84	31,148	19,385	11,763	29,789	41,552
JULY	51,422	42.84	22,029	16,300	5,729	29,393	35,122
JUNE	37,701	62.91	23,721	20,085	3,636	13,980.5	17,617
Total	**3,69,644**		**2,01,759**	**1,48,672**	**53,147**	**1,56,122.5**	**2,09,209.5**

[1]Pivalic Acid ,[2] Lowers & high Boilers

Table 38. P A to PC production Scenario (June – Dec 2000)

MONTHS	Pivallic Acid Consumption (Kgs)		Pivaloyl Chloride production (Kgs)		Pivallic Acid Loss (Kgs)
	PA Consumption	Actual PA Requirement	Assumed	Actual	
DECEMBER	35,055	22,575	41,365	26,684	12,481
NOVEMBER	16,523	10,382	19,497	12,272	6,141
OCTOBER	11,645	8,108	13,741	9,584	3,537
SEPTEMBER	19,304	13,769	22,779	16,275	5,355
AUGUST	19,385	13,466	22,874	15,917	5,919
JULY	22,368	15,863	26,394	18,751	6,505
JUNE	17,888	15,133	21,108	15,175	2,754
Total	**1,42,168**	**99,296**	**1,67,758**	**1,14,658**	**42,692**

Table 39. Raw Material loss scenario (June - Dec. 2000)

MONTHS	PA Loss (Kgs)			PC Can be produced (Kgs)	Extra $SOCl_2$ Needed (Kgs)
	Crude to PA	PA to PC	Total		
DECEMBER	4,425	12,481	16,906	19,966	10,438
NOVEMBER	8,087	6,141	14,228	16,803	12,442
OCTOBER	8,087	3,537	31,134	13,728	6,944
SEPTEMBER	11,420	5,355	16,775	19,812	12,926
AUGUST	11,763	5,919	17,682	20,883	13,574
JULY	5,729	6,505	34,457	14,448	7,541
JUNE	3,636	2,754	6,390	7,547	1,260
TOTAL	**53,147**	**42,692**	**95,839**	**1,13,187**	**65,125**

7.3.3 Water consumption Details

Large quantity of fresh water is required for pharmaceutical industry. Practically in every step of pharmaceutical industry consumes water. Besides, a large amount of water is consumed as potable water and also for maintaining personal hygiene of workers. The water consumption at KCL is presented in **Table 40.**

Table 40. Water Consumption Scenario (June - Dec 2000)

Month	CONSUMPTION OF WATER	
	TOTAL (m^3)	Per Kg of PC
DECEMBER	831	0.03
NOVEMBER	783	0.06
OCTOBER	823	0.01
SEPTEMBER	887	0.05
AUGUST	1067	0.07
JULY	471	0.03
JUNE	763	0.05

7.3.4 Energy Details

KCL obtains electric supply from the Maharashtra State Electricity Board. It also generates in house power using DG sets. The detail electricity consumption for year June-Dec. 2000 is presented in **Table 41**.

Table 41. Energy Consumption Scenario (June - Dec 2000)

Month	**Electrical Energy** (kWh)	**Thermal Energy** (L)		
		Furnace oil	**LDO**	**Diesel**
DECEMBER	33908	23130	300	180
NOVEMBER	29373	10964	5700	375
OCTOBER	26400	14040	------	2000
SEPTEMBER	30572	20567	------	566
AUGUST	31068	18015	------	685
JULY	29867	21175	------	1335
JUNE	27884	18081	1200	900
TOTAL	**209072**	**125972**	**7200**	**6041**

7.3.5 Environmental Issues

Manufacturing of pivaloyl chloride generates fugitive emissions and liquid waste. The air pollution caused by vent losses is the major environmental problem besides the wastewater, which contains residual crude in significant quantities. Approximate quantities of the liquid organic waste streams and the volatile organic carbon (VOC) gaseous emissions calculated are given in **Table 42**.

Table 42: Environmental Cost Centres and vent losses at KCL

Waste Stream code	Equipment code	Environmental Cost Centres (Operation/ Process)	Composition (Quantity in Kg/MT of PC)		
			PA	PC	Others
W/G/1	R-5	Hydrolysis	107	7	
W/G/1	R-1	Distillation	66	6.5	
W/G/3	R-3	Frac. Distillation	314	142	
W/G/4	R2/R4/R11	Distl of PC	122	40	
W/G/5	R6/R7/SC	Chlorination	15		18

7.3.6 Environmental related activities

- Operation and maintenance cost (labour, power, consumables, and spares)
- Monitoring and Control of Pollution (compliance costs)
  - Pollution Control Board fees
  - Air pollution control
  - Cost for treatment of effluent at CETP

7.3.7 Environmental Accounting for June-Dec 2000

Environmental accounting is the process of economically recognizing the benefits derived by corporate houses from immediate environment and initiating remedial measures, which abate any possibility of environmental degradation through its business activities. It is an attempt to identify and bring to light the resources utilized and costs imposed on ecosystem by corporate houses.

Accounting heads for environmental costs at KCL have been identified and engineering departments can maintain these accounts as satellite accounts. The expenditure on the environmental related activities at KCL is summarized in **Table 43**.

Table 43. Environmental Cost (June – December 2000)

Description	Jun – Dec 2000
Production (MT)	245
Expenditure (Rs. Lakhs)	190.5
Income (Rs. Lakhs)	133.5
PROFIT (Rs. Lakhs)	-57
Capital investment for pollution prevention system (VOC Extraction System) (Rs. Lakhs)	23
Environmental Costs	
Depreciation (Rs. Lakhs)	4.5
Environmental Monitoring & Reporting (MPCB) (Rs.Lakhs)	0.53
Environmental consultant fees (Rs. Lakhs)	0.20
Environmental services (MIDC) (Rs. Lakhs)	0.16
Green belt development and maintenance (Rs. Lakhs)	1.08
Social Costs	--
Total Environmental costs (EC) (Rs. Lakhs).	6.47
EC as % of expenses	**3.396 %**
EC per MT of production	**Rs 2,641/ton**

7.3.8 Pollution prevention activities at KCL

During the process of acid hydrolysis and subsequent operations of distillation/fractionation several streams of light and intermediate cuts are produced. Even though these fractions contain valuable chemicals such as PA, Alcohols, Esters etc these mixtures of unknown composition do not have any commercial value.

As a result of the study the company has evolved a method of blending the liquid VOC with the fuel oil used in boiler for generation of steam there-by disposing off the waste hygienically while realizing the calorific value of the chemical waste. Pollution of water effluent by the liquid VOC is thus avoided.

7.3.9 Residue minimization and reuse practice at KCL

- During the process of converting PA to PC through reaction with $SOCl_2$, HCl and SO_2 fumes are generated. These fumes are scrubbed and recovered. HCl is reused in the process in the hydrolysis step and the Na_2So_3 formed while scrubbing SO_2 with caustic lye is sold in the market
- This low boiler collected in the organic phase is used as fuel along with LDO, furnace oil and Diesel. About 40% of the fuel requirement is compensated by the low boilers
- The high boilers are incinerated and the waste heat is recovered to preheat the feed water to the boilers
- Process steam condensate is collected in condensate recovery tank and reused as boiler feed water leading to savings in fuel and water consumption

7.3.10 Residue minimization options suggested

By improving the efficiency of mass transfer during distillation and efficiency of heat transfer during condensation, production of liquid VOC and vent loss (of VOC) could be minimized. Moreover, the recovery of PA would be maximized. It might be possible to recover other useful chemicals from the mixed VOC, which is disposed off as a fuel.

7.3.11 Recommendations

- When the equipment is operated under sub-atmospheric pressure, air leaks into the system and leaves through the vent. Depending on gas temperature of condenser outlet and vapour pressure of VOC, air becomes saturated with VOC and gets diffused in the atmosphere, causes pollution. Minimizing the air leak could reduce the loss of VOC

- Adequacy of condensers should be confirmed. If the condensation is incomplete, the size (ie. area) of condenser should be increased or the driving force available for heat transfer should be augmented

- The condensers have to be lifted two meters above the top of column to enable feeding of reflux by gravity

- Part of the VOC condenses in the condenser, and is refluxed back in to the reactor. Remaining part is carried by the non-condensable gas to the absorption system and is lost to the environment causing pollution of air and water. The quantity of the VOC lost depends on the dew point of the VOC at the temperature at which the gases leave the condenser. This can be avoided by operating the condenser with refrigerated coolant it is possible to reduce the temperature of the gases leaving the condenser and to reduce the loss of VOC to the absorber and hence reduce pollution

- The efficiency of separation could be improved without compromising on capacity by increasing the packed height of distillation columns

- Reflux ratio could be increased to improve separation efficiency

- Pressure drop across the packing should be monitored while the reflux ratio is increased (caution should be taken to prevent flooding of the column)

- Avoid spillage of VOCs by using vacuum for transfer of liquid materials

- While charging a vessel, top nozzle opposite to the vapour outlet should only be used as liquid inlet to avoid entrainment

- The distillation still has to be raised to enable safe collection of the residue in barrels

- When HCl gas is absorbed in water, the partial pressure of VOC increases and condensation takes place in the absorber. PC is likely to undergo hydrolysis to form PA; TC is likely to decompose. It may be possible to recover this PA.

7.3.12 Conclusion

Having identified Environmental Costs, and Environmental Cost centres, KCL needs to truly internalize these costs, and not merely bear them. The Management should design a Corporate Environmental Plan with targets to reduce environmental costs by treating and recycling the effluent.

This study has not only helped the organization to identify areas where environmental costs arise, but has also drawn attention to everyday operations which have critical impact on future environmental costs.

Adopting these positive values would not only strengthen stakeholder relationships but also align the organization goals to that of sustainability.

7.4 Case Study – IV: Eskay Fine Chemicals Ltd.

Eskay Fine Chemicals is a medium scale unit in the business of producing pharmaceutical intermediates. The company has the annual turnover of Rs. 900 Lakhs. The product file of Eskay fine is presented in **Annexure 9**.

Identification of stakeholders of EFCL and their expectations are summarised in **Table 44.**

Table 44. Stakeholder analysis of EFCL

Stakeholders	Expectations from EFCL
ESKAY Fine Chemicals Ltd.	▪ Excellent Chemical production ▪ Maximization of profit while keeping the expenditure to minimum.
Customers	▪ Excellent chemical products ▪ On time delivery ▪ Minimal prices
Suppliers	▪ Continual demand for quality raw materials ▪ Timely payments
Employees	▪ Job satisfaction and security ▪ Satisfactory wages/perks
Pollution Control Board	▪ Industry abiding by the Pollution Control board standards for emission and effluent discharge at all times
Neighbouring industries	▪ Healthy relations/ interactions ▪ No nuisance causing actions
Society	▪ Non-polluting, eco-friendly industry/ ▪ Generation of jobs/facilities ▪ Improvement of the infrastructure of the surrounding areas for development
Environment (Air, Water, and Land)	▪ Zero emission or discharges to the environment ▪ Minimal use of water and electricity ▪ Development of green belt in the surrounding areas
Maharashtra Industrial Development Corporation	▪ Continual purchase of water with minimal wastage
Maharashtra State Electricity Board	▪ Continual purchase of electricity with least losses and improved P.F.
Packaging materials suppliers and disposers	▪ Continually increasing demand & eco-friendly disposal
Shareholders	▪ Increase in share value & assets generation
Government	▪ Payment of taxes

7.4.1 Process Description

Ammonium Bromide

Reaction: $8NH_3 + 3\ Br_2 \rightarrow 6NH_4\ Br_2 + N_2$

For a single batch of (250 kg) 70 litres of mother liquor along with 75 litre of fresh water is charged into 1000 litre capacity HDPE drum. 450 kg of ice is broken into small pieces and charged into the reactor. 60 kg of ammonia gas is passed into the water when NH_4OH is formed. To the solution of ammonium hydroxide 210 kg of bromine is added. Ammonium bromide is formed and remains in solution.

Purification of Ammonium Bromide

Filtration

The ammonium bromide solution is passed through an activated carbon filter. The clear solution is collected in an intermediate tank. The spent cake is washed with water and the washing is collected along with product solution.

Crystallization

The ammonium bromide solution is charges into open pan evaporator jacketed for steam. Water is evaporated off to the atmosphere and the product is crystallized and the allowed to cool

Centrifuging

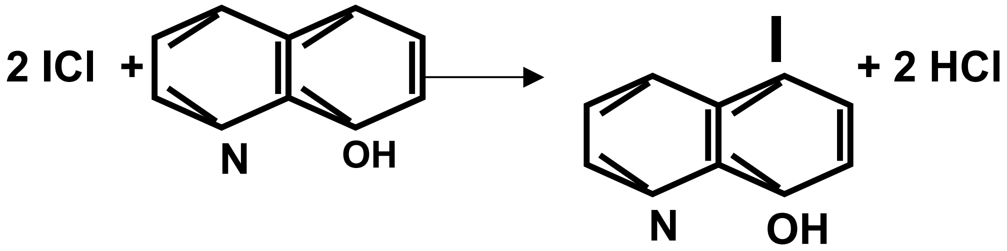
The ammonium bromide slurry is charged into the centrifuge and the wet solid ammonium bromide is unloads into trays and the mother liquor is collected for recycling.

Drying and pulverization

Wet ammonium bromide is dried in dryer by passing dry air and pulverized before being packed. Substantial amount of ammonium bromide dust is lost during the operation and is washed off by a jet of water to the drain.

Diiodohydroxyquinoline USP

Reaction : $I_2 + Cl_2 \rightarrow 2\ ICl$



Preparation of Iodine Monochloride solution

In a 50 L flask fitted with water bath 25 kg Iodine is taken and 7 kg of chlorine gas is passed in to it slowly. The reaction proceeds to form Iodine Monochloride which being in a liquid state at operating temperature helps the dissolution of Iodine and chlorine. Chlorination is continued till iodine is converted to iodine Monochloride to which Hydrochloric acid is added to make the total volume of 50 Lit. The mixture is siphoned out in to a 400 Lit drum.

Preparation of 8-HydroxyQuinoline solution

14.7 kg of 8-hydroxyquinoline is dissolved in hydrochloric acid. The solution is siphoned into 400 Lit. HDPE drums where it is stirred with iodine Monochloride solution.

The stirring is continued for 45 minutes and water is added to make up the volume to 400 Lit. the slurry is transferred to the upper tank and further agitated for 30 minutes. The mixture is diluted with 2500 Lit of water.

Centrifuging

The slurry is centrifuged and the mother liquor is drained into ETP. The cake is washed with 1500L water and the washings also is drained in to ETP. The wet cake is unloaded in to trays.

Drying and pulverizing

The wet cake of Diiodohydroxyquinoline is dried at 80^0C in a dryer through which hot air is passed and the moisture is vented to the atmosphere. The dry cake is pulverized and packed.

Barium Sulphate

Reaction: $BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl$

Process description

Preparation of barium Chloride solution

In a 1100 Lt. Capacity HDPE drum 700 Lt. Water is charged along with $#) Kg of Barium chloride crystals. Dissolve the crystals completely in water. Add 4-6 kg of Hydrogen peroxide to oxidize any barium sulphide that may be present to barium sulphate. This solution is kept overnight at ambient temperature.

The Barium chloride solution is pumped in to the reactor. 185 Kg of concentrated sulphuric acid is charged slowly under agitation. Slight excess of sulphuric acid is added to ensure complete conversion of the chloride into sulphate. Barium sulphate is precipitated and settled down. The supernatant liquid is tested for excess of sulphuric acid.

Washing and Purification

The acidic supernatant solution is siphoned out to the ETP. Equal volume of fresh water is added in to the reactor, agitated and settled. The supernatant liquid is again siphoned out to the ETP

Filtration

The thick slurry, water is added to make the slurry amenable to pumping. The slurry is transferred in to vacuum nutsche. Mother liquor is drained to waste. The cake is washed in the filter to remove all the residual acid. The filtrate is tested for acid till it becomes neutral.

Drying and Pulverising

The wet Barium sulphate is dried at 80^0C and then is packed after pulverisation.

Potassium Iodide

Reaction: $2\ KOH + I_2 + HCOOH \rightarrow 2KI + CO_2 + 2H_2O$

Process

Mother liquor from the previous batch is charged in to a 1000-liter HDPE drum. 2 blocks of ice is added in to it. 52 Kg of formic acid is charged in to it. 120 kg of caustic potash is charged slowly in to it when potassium formate is formed. Inspite of the reaction being exothermic the temperature remains low due to absorption of the latent heat of melting of ice. 240 Kg of Iodine is added under stirring when potassium Iodide is formed in solution. The reaction mass is heated about 60^0 C by injection of live steam in to the reaction mass. Now the reaction mass is kept overnight for completed reaction. During the reaction carbon dioxide gas is evolved and it is vented out to the atmosphere.

Purification of Potassium Iodide

The reaction mass is heated by passing steam through the jacket of open pan evaporator. pH is adjusted to 8 by adding minimum quantity of potassium hydroxide or formic acid.

Filtration and Decolourization

2 Kg of activated carbon is put in a bucket of water and the slurry is charged in to the vacuum nutsche to form a filtered on filter cloth. The crude potassium Iodide solution is charged in to the nutsche when any suspended particles and colouring matter that may be present I the solution is absorbed/adsorbed by carbon bed and clear and colourless Potassium Iodide solution is retained in the carbon bed is washed down by adding 14.5 litre of water and washing also is collected with the product solution.

Evaporation/ Crystallization

Potassium iodide solution is charged in to the jacketed open pan. Steam at 30 psi is passed in to the jacket to heat up the solution to boil when water vapour escapes in too the atmosphere. Evaporation is continued till crystals are formed. Potassium iodide is cooled to 350C by passing water through the jacket of the evaporation pan.

Centrifuging

The slurry of potassium iodide from the evaporation pan is charged in to the centrifuge when crystals are seperated and the mother liquor is collected in a tank for recycling. The crystals of potassium Iodide is unloaded from the centrifuge in to the trays.

Drying and Pulverizing

The wet crystals in the tray are loaded in to the dryer where it is contacted with hot air to evaporate the moisture present in the crystals. Dry cake with less than 1% moisture is cooled and taken out of the dryer. Air with water vapour is vented out to the atmosphere. The dry cake of potassium iodide is pulverized to fine powder. The dry powder of 98-99% purity is packed.

7.4.2 Material Details

6.4.2.1 Water Consumption Details

Eskay fine chemicals receives water from Maharashtra Industrial Development Corporation. The average monthly consumption is in the order of 1180 cum, 75% of which is utilized for the manufacturing process. The remaining water is utilized for gardening and domestic usage. The monthly consumption of water for year 1999-2000 is presented in **Table 45**.

7.4.3 Energy Details

Eskay Fine Chemicals obtain their electric supply from the Maharashtra State Electricity Board. It also generates in house power using DG sets. Boilers, which run on LDO are used for generation of steam for heating purposes. The electricity consumption detail for year 1999-2000 is presented in **Table 46**. The detail of oil consuming equipments is presented and overall energy consumption scenario in **Table 47** and **48**, respectively.

Table 45. Monthly water consumption (1999 - 2000)

Month	Consumption Cum	Rate per Cum (Rs)	CETP charges (Rs)	Total (Rs)*
April	772	10.25	1100	21215
May	3259	10.25	1100	8950
June	1171	10.25	1100	31179
July	1217	10.25	1100	13614
August	2063	10.25	2200	12415
September	1513	10.25	1100	22772
October	1563	10.25	1100	17124
November	1036	10.25	1100	17831
December	1803	10.25	1100	17914
January	1804	10.25	1100	20107
February	1497	10.25	1100	20117
March	1821	10.25	1100	18419

*The total cost is inclusive of fire cess and CETP charges

The wastewater generated is discharged to the CETP after initial treatment with lime for pH adjustment.

Table 46. Electricity consumption (April 1999- March 2000)

Month	Consumption (kWh)	Rate per m^3 (Rs)	Total (Rs)*
April	772	3.35	112484
May	3259	3.35	11037
June	1171	3.35	146902
July	1217	3.35	79403
August	2063	3.35	68412
September	1513	3.35	149729
October	1563	3.35	153086
November	1036	3.35	105959
December	1803	3.35	114348
January	1804	3.35	108904
February	1497	3.35	124891
March	1821	3.35	119715

*The demand charges are included in the total charge

Table 47. Details of Oil consuming equipment

Name of the equipment	**NOS.**	**Capacity (ltrs)**
Thermopack	One	9,800
Boiler	Two	20,200

Table 48. Overall Energy Consumption Scenario

Type of energy	**Quantity**	**Rate per unit**	**Energy bill** (Rs. Lakhs)
Thermal energy **LDO**	30,000 L	Rs. 11.0	3.30
Electrical Energy MSEB (KW)	15,25,198 kWh	Rs. 3.35	51.09
Total			**54.39**

7.4.4 Environmental Issues

The manufacturing process at EFCL is of two to three step processes. Waste is generated in washing and purification stages.

Wastes generation Details

During last one year, Eskay Fines has produced Barium sulphate, Dihydrooxyquinoline, Potassium iodide and Ammonium bromide. Raw materials, power and water consumption for these products have been collected, analysed and presented hereunder. The Environmental Cost Centres and waste generated are detailedin **Table 49**.

Table 49. Environmental Cost Centres and Wastes generated at EFCL

Barium Sulphate Plant			
	Process	**Chemicals**	**Quantity**
Solid	Filling (spillage)	Barium sulphate	6.5 Kg/d
	Pulverising	Barium sulphate (Dust)	0.5 Kg/d
Liquid	Reaction and washing	Hydrochloric acid Water	96 L/d 2500 L/d
	Filtration	**Mother Liquor:** Water Hydrochloric acid	 1869 L/d 32 L/d
Gas	Drying	Water vapour	400.5 L/d
Potassium Iodide Plant			
Solid	Filtration (handling loss)	KI	4.5 Kg/d
	Centrifuging (handling loss)	KI	1.7 Kg/d
	Pulverising(Dust loss)	KI	1.3 Kg/d
Liquid	PH adjustment	Water	4.5 L/d
Gas	Reaction	Carbon dioxide	41.6 L/d
		Water vapour	34 L/d
	Evaporation	Water vapour	500 L/d

	Drying	Water vapour	40 L/d
Ammonium Bromide Plant			
Solid	Centrifuging (handling loss)	Ammonium bromide	3 Kg/d
	Pulverising (Dust loss)	Ammonium bromide	2 Kg/d
Liquid	Filtration	Ammonium bromide solution: Ammonium bromide Water	2 L/d 4 L/d
Gas	Reaction	Nitrogen	12.3 L/d
	Evaporation	Water vapour	510 L/d
		Ammonia	Traces
	Drying	Water vapour	25 L/d
DIIODO plant			
Solid	Pulverising (Dust loss)	DIIODO	0.3 Kg/d
Liquid	Centrifuging	**Mother liquor:** Water Hydrochloric acid DIIODO	1400 L/d 42 L/d 0.7 L/d
	Washing	Water	1563 L/d
Gas	Drying	Water vapour	37 L/d
Boiler			
Liquid	Boiler blowdown	TDS	100 L/d
Gas	Boiler stack	Flue gas	5 m^3/d

7.4.5 Accounting System at EFCL

EFCL does not have a dedicated environmental accounting system. Cost information was obtained from financial ledgers, and profit and loss statements. The accounting heads at EFCL are:

- Capital expenditure
- Wages and salaries
- Repairs and maintenance
- Energy bills

- Water bills
- Taxes and duties

7.4.6 Environmental related activities

- Capital expenditure towards Effluent Treatment
- Depreciation for above
- Operation and maintenance cost (labour, power, consumables, and spares)
- Monitoring and Control of Pollution (compliance costs)
  - Pollution Control Board fees
  - Cost towards environmental monitoring
  - Training of employees for ISO 14000
  - Record keeping for characteristics of effluent and emission generated

7.4.7 Environmental Accounting for June - Dec. 2000

Environmental accounting is the process of economically recognizing the benefits derived by corporate houses from immediate environment and initiating remedial measures, which abate any possibility of environmental degradation through its business activities. It is an attempt to identify and bring to light the resources utilized and costs imposed on ecosystem by corporate houses.

Accounting heads for environmental costs at EFCL have been identified and engineering departments can maintain these accounts as satellite accounts. The expenditure on the environmental related activities at EFCL is summarized in the **Table 50.**

7.4.8 Pollution prevention activities at EFCL

Pollution prevention and control is best practiced through effective management, maintenance and housekeeping of process that incorporates transforming the linear production process loops into cyclic ones, process water conservation and recycling, energy conservation, and disposal of solid wastes as by products. Pollution prevention can profitably reduce energy consumption, resource use, cost for operation and maintenance, and can avoid costly regulatory structures and its negative penalties.

7.4.9 Recommendations

- The loss of raw materials due to spillage during drying and pulverising stage is in the range of 2-3% . This loss can by reduced by following good house keeping practices.

- The faulty steam traps should be immediately repaired. A periodic steam trap check-up and repair should be performed.

Table 50. Environmental costs (January – December 2000)

Cost elements		Units of measure	Consumption	Unit cost (Rs.)	Total cost (Rs. Lakh)
Raw materials					**811.26**
Barium chloride		Kgs	1,75,587		
Sulphuric acid		Kgs	62,126		
Iodine		Kgs	31,905		
HCl		Kgs	63,445		
Formic acid		Kgs	2,398		
Potassium hydroxide		Kgs	5,481		
Bromine		Kgs	5,365		
Ammonia gas		Kgs	1,629		
Chlorine		Kgs	6,183.70		
Energy					**51.39**
Electrical		KWh	15,25,198	3.35	
Thermal	LDO	L	30,000	11.00	
Water		m^3	21347	10.25	**2.19**
Total Expenditure		Rs			**895.30**
Environmental Costs					
Effluent Treatment Cost					**0.58**
Chemicals		Cost per annum		35,000	
Labour				23,000	
Waste disposal					**0.23**
Incineration		Cost per annum		10,000	
CETP				12,000	
Packaging material disposal				1,000	
Environmental services (MIDC)		Cost per annum		1100	**0.01**
Environmental Monitoring and Reporting (MPCB)	Effluent sample testing charges			855	**0.34**
Environmental consultancy charges					**0.30**
Total Environmental Cost					**1.23**

7.4.10 Conclusion

Having identified Environmental Costs, and Environmental Cost centres, EFCL needs to truly internalize these costs, and not merely bear them. The Management should design a Corporate Environmental Plan with targets to reduce environmental costs by treating and recycling the effluent.

This study has not only helped the organization to identify areas where environmental costs arise, but has also drawn attention to everyday operations which have critical impact on future environmental costs. Adopting these positive values would not only strengthen stakeholder relationships but also align the organization goals to that of sustainability.

8. Dissemination of Green Accounting Framework

8.1 Dissemination Efforts

Green Accounting Framework was first disseminated to the industries that were selected for case study. As the first step, the representatives of the industries were explained the relevance and importance of identifying and accounting Environmental and Social Costs separately in pricing their product(s) reflecting the true cost. As the second step, survey and evaluation team was set up for each industry, identified as case study for collecting secondary and primary data, and to identify relevant entries in accounting practices of the industry.

During the data collection process there was lot of interaction with the industry representative, and they were also involved in most of the exercises. The compiled data, the recompiled environmental cost data and waste minimization measures suggested were described to the industry representatives through seminars conducted in the Institute and in the industry premises.

The Green Accounting Framework was also disseminated to the members of the Thane-Belapur Industries Association through seminars conducted in the Institute and in TBIA premises. TBIA is considering to include the Green Accounting Framework in their website for wider dissemination. The Institute has also included Green Accounting Framework in its website “**sies-iiem.org**”.

8.2 Outcome of Project

Green Accounting concept was widely acknowledged by the industries in Thane-Belapur Industrial Estate (TBIE), one of the largest Industrial Estates in the world. As an outcome of the dissemination effort, some of the industries in TBIE and elsewhere have approached the Institute to evaluate their societal environmental costs, as also to identify the environmental cost centres so that they could minimize waste, enroute to implementing Cleaner Production processes. The TBIA has since formulated a work plan through its SHE Committe to pursue the matter on industrial estate-wide basis.

Annexure - 1

Monetary Benefits of pollution control

In order to encourage users to adopt effective pollution control measures, the Government of India (GOI) offers various fiscal incentives for pollution control / monitoring activities. These incentives include:

- Excise Duty exemptions
- Customs Duty concession
- Depreciation

Excise Duty Exemptions

This measure provides exemption of excise duty in excess of 5% ad-valorem of manufactured pollution control devices and specified pollution-monitoring facilities. This exemption extends to the whole system including accessories.

Customs Duty Concession

Under sub-section (1) of sec. 25 of the Customs Act, 1962 (52 of 1962), the Central Government, has exempted the goods, when imported into India for the purposes of environment pollution control.

a. The portion of the duty of customs liveable thereon which is specified in the First Schedule to the Customs Tariff Act, 1975 (51 of 1975) as is in excess of the amount calculated at the rate of **40 percent** ad valorem; and

b. The whole of the additional duty leviable thereon under sec. 3 of the said Customs Tariff Act. The equipments and allied accessaries having tax exemption are listed below:

List of Equipments / Accessaries

Sr No	Item
1.	Monitoring Instruments of various ranges suitable for ambient air and stack monitoring for toxic/ hazardous chemicals.
2.	Gas detectors/ alarms for measuring concentration of toxic/ hazardous gases.
3.	Personal samplers with re-chargeable battery units.
4.	Toxic gas monitoring kits containing personal samplers, sampler with filter head, filter holders, membrane filter of different pore sizes, small cyclone for repairable dust monitoring and activated carbon tubes for collection of specified chemical pollutants.
5.	Direct reading calorimetric indicator tubes with accessories for monitoring toxic gases/vapour.
6.	Long-term direct reading detector tubes with peristaltic pump, for monitoring toxic gases/chemicals.
7.	Direct reading instrument for monitoring and evaluation of air borne particles.
8.	Direct reading instruments for air borne gasses and vapours incorporating the principles of ultra violet or infrared absorption, chromatography with flame ionisation or photo-ionisation detector or micro-processor control solid state circuity
9.	Platinum based catalyst and systems to incinerate formaldehyde in gaseous emissions.
10.	Special incineration system for various toxic gases/ solids.
11.	Condensing heat exchangers for reducing thermal pollution through stack gases.
12.	Self –contained and compressed air/blower based breathing apparatus.
13.	Full Body protection suit for dealing with emergencies created due to leakage/ spillage of highly toxic chemicals.
14.	Hypalon suits for emergencies for hydrofluoric acid.
15.	Ultrasonic or irradiation type thickness testers
16.	Instruments for liquid effluent control, namely: a) Ion chromatograph for anions; b) Atomic absorption spectroscope for metal analysis; c) Differential pulse polarograph for metal analysis.
17.	Plate type compact classifiers.
18	Sulzer or equivalent high efficiency packing for distillation columns for pollution control.
19.	Special plastic media for fixed film technology used in Anaerobic treatment of high strength organic waste effluents.

20.	Analysers for carbon monoxide and hydrocarbon.
21.	Auto analyser for phosphate and nitrogen.
22.	Thermohydrograph.
23.	Air sampling bags
24.	Resistively measuring kits to analyse characteristics of flyash at different elevated temperatures.

Source : Notification No. 68/89 Cms, dated 1-3-1989 as amended by Notification No. 130/90- Cms. dated 20-3-1990; No. 104/91-Cms, dated 25-7-1991; No. 84/93 – Cms, dated 28-2-1993

Depreciation

One hundred percent* depreciation is allowed to the user for installing pollution control equipments (see list above) to control air and water pollution and for installing solid waste recycling and recovery systems. The following depreciations are applicable:

Assets	Depreciation
Pollution Control Equipment*	100%
Energy Saving Devices	10-20%

*** Proposed depreciation is 150% for budget 2001**

Annexure – 2

Determination of Cost of Pollution to Society

To determine Cost of Pollution to Society due to the manufacture of a particular product, the environmental stressors are identified for the type of industry and the manufacturing process in vogue. Then dispersion and transformation models are employed to estimate the possible environmental changes that could be caused by different stressors. Finally, assessment and quantification of possible physical impacts and damages that could result during the manufacture of the product, and their representation in terms of monetary values.

Step 1: Determination of pollutants and emissions, and identify the type and size of associated environmental impact

In this step, the pollution sources and emission intensities are determined based on information about the fuel used and production process. Then on the basis of previous research, the environmental impacts are then identified. After bringing together this information, the potential stressors and impacts that are quantitatively assessed.

Step 2: Identifying and assessing the changes in environmental quality

Based on literature review as well as pollution dispersion and transformation models, the incremental changes of each pollutant in the environment is simulated and calculated. Once the atmospheric dispersion and transformation models are established, the spatial distribution of the pollutants emitted by the point source is calculated. Typically, receptor cells are defined for the effected regions. The concentration at the central point of each receptor cell is calculated using the model and this central point value will serve as a proxy for the concentration of the whole receptor cell.

Step 3: Calculation of physical damages caused by pollutants by establishing dose-response relationships

Using a dose-response relation and concentration changes (**ΔC_i**) of pollutants, the physical damages caused by each pollutant is calculated. Each pollutant will affect several receptors within a receptor cell. The degree of damage (**D_{ijk}**), in each receptor cell is the function of ΔC_i and the number of receptors. Although most of the D_{ijk} functions are non-linear, to simplify calculation, a linear function can be used for simulating the real D_{ijk} at certain levels of concentration.

A linear dose-response function is given below:

$$D_{ij} = D(\Delta C_i)$$

$$D_{ijk} = B_{ij} \times \Delta C_{ik} \times T_{ijk} \qquad C_{ik} \geq C_{i0}$$

$$D_{ijk} = 0 \qquad C_{ik} < C_{i0}$$

In which,

D_{ij} – physical damage ^{j} caused by pollutant ^{I}
D_{ijk} – physical damage ^{j} in receptor cell ^{k} caused by pollutant ^{i}
ΔC_{ik} – concentration changes of pollutant ^{i} in receptor cell ^{k}
C_{i0} – threshold for damage caused by pollutant ^{i}
B_{ij} – coefficient of dose-response of pollutant ^{i} and impact ^{j}
T_{ijk} – number of receptors in cell ^{k} for impact ^{j} caused by pollutant ^{I}

Step 4: Valuation of physical damage in receptor cells identified above

The valuation methodology for the various types of physical damage will vary depending on the characteristics of the damage. One of the techniques that is used commonly is the "**benefit transfer technology**" technique. In this technique, the following formula is used to calculate the monetary value of the physical damages:

$$E_{ijk} = P_{ij} \times D_{ijk}$$

In which,

E_{ijk} – monetary value of the impact ^{j} in receptor cell ^{k} produced by pollutant ^{i}

P_{ij} – monetary value of impact ^{j} in one year produced by pollutant ^{i}

D_{ijk} – physical damage ^{j} in receptor cell ^{k} caused by pollutant ^{i}

Step 5: Summary and analysis of the computational results

The following formula summarizes the computation of damage effects:

$$\mathbf{E} = \Sigma_i \Sigma_j \Sigma_k [P_{ij} \times (A_{ik} \times Q_i) \times B_{ij} \times T_{ijk}]$$

In which,

E – represents the annual value of total environmental damages

A_{ik} – is a parameter determined by the atmospheric dispersion models. Its value is dependent on the type of pollutant ^{i} as well as the location, topographic features, and meteorological conditions of receptor cell ^{k}

Q_i – intensity of pollutant ^{i}

B_{ij} – coefficient of dose-response of pollutant ^{i} and impact ^{j}

T_{ijk} – number of receptors in cell ^{k} for impact ^{j} caused by pollutant ^{i}

As the production processes for a particular product generally do not vary much, coefficients of pollution emission and the environmental damage functions from other models can be used. This allows for the use of computer programs to calculate the damages and determine the monetary value the damages.

Identification and classification of pollution damages

Industries emit various pollutants that when released into the environment impact the health and well being of humans and other forms of life. The major impacts can be summarized as follows:

- Impacts on Human Health
- Impacts on Human Welfare

- Impacts on Aesthetics
- Impacts on Environmental Resources
- Impacts on Global Climate

Potential Stressors and Impacts

The potential Stressors and Impacts are identified for the manufacturing process of a product as given below:

Identification of Stressors and their Potential impacts for the manufacturing process of a product

Stressors	Potential Impacts
Emission / Burden on air: Hazardous chemicals	
Inorganic	Human health
Metals	Human health
Organic	Human health
Emission / Burden on air: Gases	
CO	Human health
SO_2	Human health, Human welfare, Environmental resources
Nox	Human health, Human welfare, Environmental resources
Oxidants	Human health, Human welfare
GHG	Global climate
Aerosols/particulate (PM-10)	Human health, Human welfare
Particulate (> PM-10)	Human health, Environmental Resources
Electro Magnetic Radiation	Human health, Environmental Resources
Noise	Human health, Aesthetics
Potential Emission / Burden to Water: Hazardous chemicals	

Inorganic (non metals)	Human health
Metals	Human health, Environmental resources
Organic	Human health, Environmental resources
BOD / COD	Environmental resources
Exotics	Human welfare, Environmental resources
Acids / Bases	Environmental resources
Waste products	Environmental resources
Acid deposition	Environmental resources
Suspended solids	Environmental resources
Water diversion / withdraw	Environmental resources
Thermal alteration	Environmental resources

Potential Emission / Burden to Land: Hazardous chemicals	
Inorganic (non metals)	Human health
Metals	Human health, Environmental resources
Organic	Human health, Environmental resources
Waste products	Environmental resources
Acid deposition	Environmental resources
Soil erosion	Environmental resources
Land use	Human welfare

The identified potential Stressors and Impacts are then screened and categorized in to four categories for estimating the cost of pollution to society:

- The impact that could be mitigated – **(C1)**
- The impact that is relatively low – **(C2)**
- There is not enough scientific information available for a quantitative assessment of the impact – **(C3)**
- A quantitative assessment of the impact can be completed – **(C4)**

Based on the screening classifications (C1-C4), the impacts of category C4 are assigned full or partial economic valuation; category C3 impacts are qualitatively assessed and analysed separately; C2 impacts are deleted from further analysis; and the costs associated with mitigation of C1 impacts are included in calculations of pollution prevention cost.

Estimation of Dose-Response function and Monetary Valuation Parameter for Pollutants

1. Estimation of Damages by Air Pollutants

a. Human Health Effects of Air Pollutants

Human Health Effects of PM-10

With regards to human health effects, particulates that cause the greatest damage are those under 10 microns in aerodynamic diameter (PM-10) as they are small enough to enter into the airways of the lungs. PM-10 comes from the smoke and soot directly emitted, or indirectly as the secondary pollutants of SO_2 and NOx. Therefore, smoke and soot pollution is still a major source of pollution damages on human life and health. Thus, PM-10 parameter is more accurate to indicate the dose for damages.

The human health effects of PM-10 include mortality and respiratory disease. Studies show that the health problems and impacts related to PM-10 includes: chronic bronchitis (CB), respiratory hospital admissions (RHA), asthma (AA), restricted activities days (RAD), acute respiratory symptoms (ARS), emergency room visits (ERV), and asthma for children. Formula given below is used to calculate the dose-response of health effects of PM-10.

$$\Delta D_a = R \text{ x } \Delta PM10 \text{ x } POP \text{ x } N$$

In which,

ΔD_a – annual incremental cases of disease due to PM-10
R – dose-response coefficient (case/(day·µg/m^3)
ΔPM10 – annual concentration change of PM-10
POP – affected population

N – days of PM-10 exceeding standards in one year

The dose-response coefficient estimation is therefore the key issue for estimating health effects.

Damage functions of health effects of PM-10

Effects	**Unit**	**Damage function**					
		L	*P*	**C**	**P**	**H**	**P**
Mortality>=65	case/day*person* 1µg/m^3	10.1*10^{-8}	*33*	16.9*10^{-8}	*34*	25.4*10^{-8}	*33*
Mortality <65	case/day*person* 1µg/m^3	0.14*10^{-8}	*33*	0.23*10^{-8}	*34*	0.35*10^{-8}	*33*
CB (>=25)	case/year* 1µg/m^3	3.0*10^{-5}	*25*	6.1*10^{-5}	*50*	9.3*10^{-5}	*25*
RHA $^{\#}$	case/day* 1µg/m^3	1.8*10^{-8}	*25*	3.3*10^{-8}	*50*	4.8*10^{-8}	*25*
ERV	case/day*1µg/m^3	3.2*10^{-7}	*25*	6.5*10^{-7}	*50*	9.7*10^{-7}	*25*
AA	day/day*1µg/m^3	0.9*10^{-4}	*33*	1.6*10^{-4}	*50*	5.4*10^{-4}	*17*
RAD (>=18)	day/day* 1µg/m^3	0.8*10^{-4}	*33*	1.6*10^{-4}	*34*	2.5*10^{-4}	*33*
ARS	day/day*1µg/m^3	2.2*10^{-4}	*25*	4.6*10^{-4}	*50*	7.0*10^{-4}	*25*
Asthma for children (<18)	case/year* 1µg/m^3	0.8*10^{-3}	*25*	1.6*10^{-3}	*50*	2.4*10^{-3}	*25*

\# - The average days for staying in hospital for a RHA case varies from country to country and region to region

Note: L refers to low value; C refers to central value; H refers high value; P refers to probability (%).

Source: A.D. Rowe, 1995; Schwardz, 1992.

Human Health Effects of Ozone

Ozone has some obvious impacts on human health, including morbidity, respiratory hospital admissions (RHA), asthma (AA), minimum restricted activities days (MRAD), and acute respiratory symptoms (ARS). Formula given below is used to calculate the human health effects of ozone:

$$\Delta D_a = R \text{ x } \Delta O_3 \text{ x } POP \text{ x } N$$

In which,

ΔD_a – annual incremental cases of disease due to ozone

R – dose-response coefficient (case/(day·µg/m^3))
□O_3 – annual average of daily changes in high-hour ozone
POP – affected population
N – days of ozone exceeding standards in one year

Dose-response functions of human health effects of O_3

Effects	**Unit**	**Dosage – Response**					
		L	***P***	**C**	***P***	**H**	***P***
Mobility	Case/day*1ppm	0.0	*33*	$3.3*10^{-6}$	*34*	$6.6*10^{-6}$	*33*
RHA	Case/day*1ppm	$8.4*10^{-6}$	*33*	$13.7*10^{-6}$	*34*	$19.0*10^{-6}$	*33*
AA	Case/day*1ppm	$1.06*10^{-1}$	*33*	$1.88*10^{-1}$	*50*	$5.20*10^{-1}$	*17*
MRAD	Day/day*1ppm	$1.93*10^{-2}$	*25*	$4.67*10^{-2}$	*50*	$7.40*10^{-2}$	*25*
ARS	Day/day*1ppm	$0.73*10^{-2}$	*25*	$1.37*10^{-2}$	*50*	$2.04*10^{-2}$	*25*

Note: L refers to low value; C refers to central value; H refers high value; P refers to possibility (%).
Source: A.D. Rowe, 1995; Schwardz, 1992.

Human Health Effects of Lead and Mercury

Lead and mercury are emitted into the air with soot produced during coal combustion. Exposure can occur through breathing and ingestion (foods and liquids). Epidemiological studies have found that Pb levels can lead to higher rates of hypertension, nonfatal heart attacks, nonfatal strokes and risks of premature death for adult men. In children age 1-7, potential effects include reduced stature, impaired hearing, behavioral changes, interference with nervous system development, metabolic effect, impaired heme synthesis, anemia, and possible cancer. Mercury is a common heavy metal found in coal and is very volatile. Uptake of mercury at elevated levels may cause paraesthesia of the extremities, psychomotor retardation in prenatal exposed infants, neuro-response in young children and other adverse health effects. Effects of mercury exposure are quite complex and difficult to quantify. As a result, the damage value per unit of pollutant is usually calculated after adjusting for per capita GDP values, to directly calculate the damages. Formulae used to calculate the human health effects of lead and mercury are given below:

$$E_{il} = R_{il} \text{ x } POP \text{ x } C_{il}$$

In which,

E_{il} – damages due to health effects of lead
POP – population exposed to lead
C_{il} – incremental lead level produced by electricity plant
R_{il} – damage function of lead

$$E_{ik} = R_{jk} \text{ x } C_{ik}$$

!

in which,

E_{ik} – damages due to health effects of mercury
C_{ik} – incremental mercury level produced by electricity plant
R_{jk} – damage function of mercury

Damage functions for human health effects of lead and mercury

Effects	**Units**	**Damage Function**					
		L	**P**	**C**	**P**	**H**	**P**
Health effects of lead	$/(person*□g/dl)	0.53	*33*	1.61	*34*	8.6	*33*
Health effects of mercury	$/Kg	0.35	*25*	6.95	*50*	41.0	*25*

Note: 1) L refers to low value; C refers to central value; H refers high value; P refers to probability (%).

2) The value here is subjected to adjust by GNP ratio

Source: Rowe et al., 1995; Schwardz; 1992.

Human Health Effects of Radiation

Radiation can cause various health effects. The dose received by an individual can be used as an indicator of the damage caused by radiation. Formula used to estimate the health effects of radiation is as follows:

$$E_R = R \times r \times POP/1000$$

In which,

E_R – value of damages caused by radiation

R – value of damages per unit radiation

r – radiation exposure/person/year due to 1000MW electricity plant

POP – affected population

Human Health Impacts of Air Toxics

Air toxics included here are the suspected carcinogenic air emissions such as As, Be, Cd, Cr, Nickel, and POMs. Uptake of these pollutants can happen through breathing and ingestion (food and liquids). According to the US EPA's Integrated Risk Information System (IRIS), the dose response functions of air toxics are:

$$\Delta D_i = POPi \times \Delta C_i \times \mathbf{RF_i / 70}$$

In which,

ΔD_i – incremental case of cancer by pollutant ^{I}

ΔC_i – incremental concentration of pollutant ^{i}

RF_i – cancer risk factor for inhalation for chemical *i* (which refers to 1 incremental concentration exposure in one's life time, 70 years) – annual average of daily changes in high-hour ozone

POP – affected population

N – days of ozone exceeding standards in one year

The example of value used for RF_i is shown in below:

Damage functions of selected toxic chemicals

Pollutants	Damages	Rfi (□g/m^3)
As	Respiratory	0.004
Cd	Respiratory	0.002
Cr	Lung	0.012
Ni	Respiratory	0.001
Bap	Respiratory	0.017

Source: USEPA 1992.

Valuation for Human Health Effects

There are several different ways to estimate the economic costs of human health effects. The Willingness to Pay (WTP), Cost of Illness (COI) and Human Capital Approaches (HCA) are three common methods.

Damage to crops by SO_2 and acid deposition

Given that there is a direct relationship between SO_2 emissions and acid deposition, the following formula is used to calculate the damages to various crops.

$\square Qi = \square Ri\cdot\square C_{SO2j}\cdot Qij$

$$\square Vi = \square Qi\cdot Pi = Pi\cdot \square Ri\cdot\square C_{SO2j}\cdot Qij = \square Ri\cdot\square C_{SO2j}\cdot Vi$$

In which,

□ Vi – losses to crop i

□ Qi – production loss of crop i

Pi – market price of crop i

Ri – damage functions for crop i

□ C_{SO2j} – incremental value of SO_2 at region j

Qij – total production of crop i at region j

Vij – total output value of region j

Material damages by acid deposition

The relevant damage functions for materials can be estimated. The following formula can be used to estimate the cost of materials damages caused by acid deposition.

$$E = \Sigma \times R \times \square CSO_{2}i \times HH_{i}$$

In which,

E - material damages cost due to SO_2 and acid deposition

R - damage function

□$CSO_{2}i$ - as incremental concentration of SO_2 at receptor cell k

HH_i - number of households at receptor cell k

For covering materials: $R = 5.61 + 2.84SO_2 + 0.74 \times 10^4[H^+]$

For marble: $R = 14.53 + 23.81SO_2 + 3.8 \times 10^4[H^+]$

For galvanized steel: $R = 0.43 + 4.47SO_2 + 0.95 \times 10^4[H^+]$

For steel: $R = 39.28 + 81.41SO_2 + 21.2 \times 10^4[H^+]$

In which, R refers to the speed of the corrosion (μm/year); SO_2 refers to the concentration of the SO_2; $[H^+]$ refers to the concentration of $[H^+]$ of rainfall (mol/L).

Estimation of Damages by Waste Water Pollution

The cost for water treatment (outside of the plant) is used to estimate the environmental cost of wastewater pollution. Specifically, the secondary treatment cost for urban wastewater is used to calculate the losses.

Estimation of Damages produced by each major pollutant

By breaking down the external costs in terms of pollutant type, the environmental costs imposed by each major pollutant can be compared and the key pollutants and environmental impacts can be identified. The annual average externalities produced by major pollutants are presented (example) below as Tables. From the tables, one will find that air pollutants are the major sources of environmental externalities. They account for maximum total damages, while SO_2, NO_x, and particulates

Annexure - 3

IOBL Profile

Production Capacity Installed (MT per annum)	
Conventional plant	12,000
Titanium / Aluminium Complex	3,000
Synthetic grease	1,200
Total	**16,200**

Production of Conventional Plant

Year	Installed Capacity (MT pa)	Production (MT pa)
1999-2000	12,000	14,051
1998-99	12,000	14,178
1997-98	12,000	12,643.9
1996-97	12,000	12,724.2
1995-96	12,000	11,485
1994-95	12,000	9,711

Product Profile Product Mix

Description	**Special characteristics**	**Production share in 1999-2000**
Lithium base		56.91%
Sodium base	Heat Resistant Water sensitive	11.53%
Calcium base		8.19%
Aluminum complex	Introduced in 1952 Outstanding water resistant	-
Lithium Complex	Introduced in 1962 Added heat resistant	2.9%
Calcium Complex	High load carrying capacity	1.07%
Specialties		-
Non Soap		2.89%
Titanium Complex	Introduced in 1995 Shear reversibility Improved heat resistance	-
Others		16.51%

Annexure – 4

Grease

Grease is a mixture of a fluid lubricant (usually a petroleum oil) and a thickener (usually a soap) dispersed in the oil. Because greases do not flow readily, they are used where extended lubrication is required and where oil would not be retained. The thickener may play as important a role as the oil in lubrication. Soap thickeners are formed by reacting (saponifying) a metallic hydroxide, or alkali, with a fat, fatty acid, or ester. The type of soap used depends on the grease properties desired. Calcium (lime) soap greases are highly resistant to water, but unstable at high temperatures. Sodium soap greases are stable at high temperatures, but wash out in moist conditions. Lithium soap greases resist both heat and moisture. A mixed-base soap is a combination of soaps, offering some of the advantages of each type. A complex soap is formed by the reaction of an alkali with a high molecular-weight fat or fatty acid to form a soap, and the simultaneous reaction of the alkali with a short-chain organic or inorganic acid to form a metallic salt (the complexing agent). Complexing agents usually increase the dropping point of grease. Lithium, calcium, and aluminium greases are common alkalis in complex-soap greases. Non-soap thickeners, such as clays, silica gels, carbon black, and various synthetic organic materials are also used in grease manufacture.

Properties of various grades of grease

Properties	Sodium	Calcium	Calcium (Anhydrous)	Lithium	Aluminium Complex	Calcium Complex	Lithium Complex	Polyurea	Organo-Clay
Dropping point (°F)	325-350	205-220	275-290	350-400	500+	500+	500+	470	500+
Dropping point (°C)	163-177	96-104	135-143	177-204	260+	260+	260+	243	260+
Max usable temperature (°F)	250	200	230	275	350	350	350	350	350
Max usable temperature (°C)	121	93	110	135	177	177	177	177	177
Water resistance	P-F	G-E	E	G	G-E	F-E	G-E	G-E	F-E
Work stability	F	F-G	G-E	G-E	G-E	F-G	G-E	P-G	F-G
Oxidation stability	P-G	P-E	F-E	F-E	F-E	P-G	F-E	G-E	G
Rust protection	G-E	P-E	P-E	P-E	G-E	F-E	F-E	F-E	P-E
Pumpability in centralized systems	P-F	G-E	F-E	F-E	F-G	P-F	G-E	G-E	G
Oil separation	F-G	P-G	G	G-E	G-E	G-E	G-E	G-E	G-E
Appearance	Smooth to fibrous	Smooth, buttery	Smooth, buttery	Smooth, buttery	Smooth, buttery	Smooth, buttery	Smooth, buttery	Smooth, buttery	Smooth, buttery

E: Excellent; G: good; F: fair; P: poor

Some of the key issues necessary for satisfactory lubricant performances are:

- Low volatility under operating conditions: Volatility characteristics are essentially inherent in the choice of base oil for a particular type of service and cannot be improved by the use of additive materials.

- Satisfactory flow characteristics in the temperature range of use: Flow characteristics largely depend on the choice of base oil; however, they can be improved through the use of pour point depressants and viscosity modifiers. The former improves low-temperature flow properties, while the latter enhance high-temperature viscosity characteristics.

- Superior stability or ability to maintain desirable characteristics for a reasonable period of use: While these characteristics depend to some extent on the base oil, they are primarily associated with additive materials, which enhance base fluid properties in this area. The environment in which it operates affects lubricant stability. Factors such as temperature, oxidation potential and contamination with water, unburned fuel fragments, and corrosive acids limit the useful life of a lubricant. This is the area where additives have made a major contribution in improving the performance characteristics and extending the useful life of lubricants.

- Compatibility with other materials in the system: Compatibility of lubricants with seals, bearings, clutch plates, etc., may also be partially associated with the base oil. However, additive chemistry can have a major influence on such characteristics.

Grease is preferred as a lubricant over liquid-oil in the following cases:

- Situations where oil does not remain in place due to high load, low speed, intermittent operation, sudden jerks etc.
- Bearings and gears that work at high temperature
- Situations where bearing needs to be sealed against entry of dust, dirt, grit or moisture

Situations where dripping or spurting of oil is undesirable, because unlike oils grease if used does not splash or drip over articles being prepared by machines. For example in machines preparing paper, textile, etc.

Annexure - 5

Shift towards Biodegradable grease

India is projected to become one of the seven largest consumers of energy within a decade, and its indigenous oil reserves are not expected to last beyond 2014 at current levels of consumption. Currently, India produces less than 33 million tonnes of oil compared to demand for around 96 million tonnes, calling for imports to the tune of around 64 million tonnes. India's oil import dependency has gone up from around 37 per cent in 1989-90 to around 68 per cent in 1999-2000, and its import dependency is expected to go up to around 90 percent by 2010-18.

World oil prices were as low as $10 a barrel (157.5 litres) as recently as the beginning of last year, and have shot up close to $30 a barrel.

In these adverse conditions to sustain profitably, IOBL should shift the focus towards alternatives using renewable raw materials viz. Biodegradable grease.

Biodegradable grease

Enhancing the ability of grease components to degrade, as a result of natural biological processes is a major area of research within the grease industry. Biodegradable greases are composed of essentially the same chemicals as non-biodegradable products. The primary component affecting biodegradability is the type of base oil used in the formulation. Vegetable oils or synthetic oils must be used because mineral oils are not readily biodegradable.

The challenge in using vegetable oils is their high-temperature limitation and synthetic oils are expensive. If high performance is needed, the additization of these products is also a challenge. For instance, in the manufacture of the grease most often used for multipurpose applications — based on lithium 12 hydroxystearate or lithium complex soap chemistry — the oil and thickener are heated to 400°F. At this temperature, vegetable oils will oxidize. Therefore, biodegradable greases are made from calcium soaps, which have a lower cooking temperature. Biodegradable greases have also been made from clay, polyurea, and aluminium complex soaps, but all have performance/cost limitations. R&D department at IOBL should be focussed to formulate a mix that economically overcomes these challenges.

Components of Biodegradable Grease

Base Fluid 75 to 95%	Thickeners 5 to 20%	Additives 1 to 8%
Vegetable oils Synthetic oils	Conventional soaps	Oxidation inhibitors Corrosion inhibitors Antiwear agents Polymers

The specifications for standardized test methods for biodegradable grease is an area under development. The Grease and the Environment working group within the European Lubricating Grease Institute (ELGI) is developing a test specification (using the CEC test modified for use with greases) for measuring grease biodegradability. This test is referred to as CEC L-33-A-94.

EnviroLogic™ 802 Li-Complex, Biodegradable, NLGI #2 Grease

EnviroLogic™ 802 is a multi-purpose, Li complex, biodegradable NLGI #2 grease. It demonstrates excellent dropping point, water resistance, and structure stability over an extremely wide range of temperatures. EnviroLogic 802 also is formulated to possess excellent oxidation stability, corrosion protection, and EP/antiwear protection. This package of performance allows for a wide range of industrial and equipment applications.

EnviroLogic 802 was specially designed for high performance in applications where incidental environmental exposure due to lubricant might be cause for concern.

Summary of Performance

Test	Result
NLGI Grade	#2
Worked penetration at 77^0 F, ASTM D217	265-295
Dropping Point, ^{o} F, ASTM D 2265	550+
Four Ball Wear, ASTM D 266	0.40 mm Typical
Weld Load	400 Kg
Oil separation	<3.0%
Bomb Oxidation, ASTM D942 at 100 hrs at 500 hrs	0 Psi Typical -2 Psi Typical
Wheel Bearing Leakage, ASTM D1263	<2 gm
Time OK load	60 Typical
Colour	Green
Appearance	Smooth, slight tack
Water washout, ASTM D1264	4.0%
USS Mobility (LT 37)	
0^0 F	0.06 gm/sec
20^0 F	0.39 gm/sec
40^0 F	1.03 gm/sec
60^0 F	3.27 gm/sec
77^0 F	7.21 gm/sec

Annexure - 6

ISO 14000 Objectives and Targets at IOBL

Environmental Objectives

- All applicable MPCB norms shall be compiled with
- Reduction of expulsion of soap and recycling of the same
- Treating of fumes from kettle to prevent environmental pollution
- Handling of material with less spillage
- Preservation of natural greenery in and around IOBL premises

Environmental Targets

- Ensure 100% compliance to all MPCB norms at all times
- Start monitoring flue gases and effluents on monthly basis
- Reduce expulsion of soap by 15% by December 2000
- Ensure treatment of blowdown fumes from kettle by December 2000
- Reduction of additive usage in production process by 50%. Increase oil catch in oil catch pit by 40%
- Reduce consumption of paper by 30% by December 2000

Annexure - 7

Production Details of M/s. Paithon Silk Mill Ltd.

Items	1998 –1999	1999 – 2000
Man Made Fibers	32,08,360 lakh meters	33,91,916 lakh meters
Cotton	47,451 lakh meters	32,08,360 lakh meters

Annexure – 8

M/s. KCL's Profile

Items	1999-2000	1998-99	1997-98	1996-97	1995-96
SOURCES OF FUNDS					
Share Capital +	5.47	5.47	5.47	5.47	5.47
Reserves & Surplus +	2.67	4.33	5.29	5.89	8.47
Total Shareholders Funds	8.14	9.8	10.76	11.36	13.94
Secured Loans +	7.32	7.45	7.27	7.34	6.96
Unsecured Loans +	0	0.01	0.01	0.01	0.52
Total Debt	7.32	7.46	7.28	7.35	7.48
Total Liabilities	15.46	17.26	18.04	18.71	21.42
APPLICATION OF FUNDS :					
Gross Block +	14.16	14.51	14.19	14.09	13.78
Less: Accum. Depreciation	2.26	2.37	1.78	1.19	0.66
Net Block	11.9	12.14	12.41	12.9	13.12
Capital Work in Progress	0.88	0.88	0.88	0	0.89
Investments +	0	0	0	0	0
Current Assets, Loans & Advances					
Inventories +	0.33	0.33	0.01	0.01	0.1
Sundry Debtors +	1.07	0.64	1.65	5.02	6.49
Cash and Bank Balance	0.01	0.11	0.32	0.07	0.07
Loans and Advances +	1.98	3.1	3.22	0.93	2.02
Less: Current Liab. & Prov.					
Current Liabilities	1.1	0.33	0.91	0.77	1.92
Provisions	0	0.02	0.02	0	0.02
Net Current Assets	2.29	3.83	4.27	5.26	6.74
Miscellaneous Expenses	0.39	0.41	0.48	0.55	0.67
Total Assets	15.46	17.26	18.04	18.71	21.42

Annexure 7 continued…

INCOME :					
Sales Turnover +	2.45	2.85	2.56	2.68	13.19
Other Income +	0.27	0.28	0.41	0.48	0.8
Stock Adjustments +	-0.05	0.05	0	0	-1.43
Total Income	2.67	3.18	2.97	3.16	12.56
EXPENDITURE :					
Raw Materials +	1.04	1.11	0.27	1.22	11.19
Excise Duty	0.32	0.92	1.29	1.01	0.09
Power & Fuel Cost	0.38	0.41	0.27	0.34	0.27
Other Manufacturing Expenses +	0.53	0.32	0.33	0.24	0.1
Employee Cost +	0.32	0.38	0.39	0.43	0.33
Selling Administration Expenses +	0.07	0.04	0.05	0.19	0.2
Miscellaneous Expenses +	1.15	0.23	0.15	0.19	0.11
Less: Preopert. Expnd. Capitalized	0	0	0	0	0
Operating Profit	-1.14	-0.23	0.22	-0.46	0.27
Interest & Financial Charges +	0.01	0.15	0.17	0.73	0.46
Gross Profit	-1.15	-0.38	0.05	-1.19	-0.19
Depreciation	0.44	0.52	0.59	0.58	0.13
Profit Before Tax	-1.59	-0.9	-0.54	-1.77	-0.32
Tax	0	0	0	0	0
Net Profit	-1.59	-0.9	-0.54	-1.77	-0.32
Adjustment below Net Profit +	0	0.01	-0.05	-0.81	0
P & L Balance brought forward	-1.89	-1.37	-0.78	1.8	2.12
Appropriations +	0	-0.37	0	0	0
P & L Bal. carried down	-3.48	-1.89	-1.37	-0.78	1.8
Equity Dividend	0	0	0	0	0
Preference Dividend	0	0	0	0	0

Corporate Dividend Tax	0	0	0	0	0
Equity Dividend (%)	0	0	0	0	0
Earning Per Share (Rs.)	0	0	0.99	0	0
Book Value(Unit Curr.)	11.32	14.22	19.67	16.29	25.48
Extraordinary Items +	-0.87	0	0	-0.03	0.74

Annexure – 9

M/s. EFCL's Products Profile

Sr. No	Product	Capacity		
		Kg/Batch	Kg/Day	Kg/Annum
1	Barium Sulphate	400	800	1,60,000
2	Potassium Iodide	250	250	22,500
3	Sodium Iodide	250	250	22,500
4	Ammonium Bromide	250	250	22,500
5	Di-Ido-hydroxy Quinoline	225	225	45,000
6	8-Hydroxy Quinoline	37.5	37.5	7,500
7	Barium sulphate formula			60,000

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