TECHNICAL EIA GUIDANCE MANUAL

FOR

PETROCHEMICAL COMPLEXES

Prepared for

The Ministry of Environment and Forests
Government of India

by

IL&FS Ecosmart Limited
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ACRONYMS

AAQ	Ambient Air Quality
API	American Petroleum Institute
AVO	Audio, Visual and Olfactory Leak Detection
B/C	Benefits Cost Ratio
BAT	Best Available Technology
BOD	Biochemical Oxygen Demand
BOQ	Bill of Quantities
BOT	Build Operate Transfer
CCA	Conventional Cost Accounting
CEMS	Continuous Emission Monitoring Systems
CER	Corporate Environmental Reports
CEAA	Canadian Environmental Assessment Agency
CFE	Consent for Establishment
CPCB	Central Pollution Control Board
CREP	Corporate Responsibility for Environmental Protection
CRZ	Coastal Regulatory Zone
DfE	Design for Environment
DMP	Disaster Management Plan
DSG	Dilution Steam Generation
EAC	Expert Appraisal Committee
ECI	Environmental Condition Indicators
EcE	Economic-cum-Environmental
EIA	Environmental Impact Assessment
EIS	Environmental Information System
EMA	Environmental Management Accounting
EMP	Environmental Management Plan
EMS	Environmental Management System
EPI	Environmental Performance Indicators
ES	Environmental Statements
FCA	Full Cost Assessment
FGR	Flue Gas Recirculation
FID	Flame Ionization Detector
HAZOP	Hazard and Operability Studies
HTL	High Tide Level
IL&FS	Infrastructure Leasing & Financial Services Limited

IPCL	Indian Petrochemical Corporation Limited
ISBL	Inside Battery Limits
ISO	International Standard Organization
IVI	Importance Value Index
LCA	Life Cycle Assessment
LDAR	Leak Detection and Repair
LTL	Low Tide Level
MCA	Maximum Credible Accident
MoEF	Ministry of Environment & Forests
NAQM	National Air Quality Monitoring
NGO	Non-Government Organizations
OECD	Organization for Economic Co-operation and Development
O&M	Operation and Maintenance
OVA	Organic Vapour Analyser
PEMS	Predictive Emission Monitoring Systems
PID	Photo Ionization Detector
PM	Particulate Matter
PPA	Participatory Poverty Assessment
PTA	Purified Terephthalic Acid
PRA	Participatory Rural Appraisal
QA/QC	Quality Assurance/Quality Control
QRA	Quantitative Risk Assessment
SCR	Selective Catalytic Reduction
SNCR	Selective Non-Catalytic Reduction
SEA	Strategic Environmental Assessment
SEAC	State Level Expert Appraisal Committee
SEIAA	State Level Environment Impact Assessment Authority
SEZ	Special Economic Zone
SIA	Social Impact Assessment
SPCB	State Pollution Control Board
SPM	Suspended Particulate Matter
TA	Technology Assessment
TCA	Total Cost Assessment
TCLP	Toxicity Characteristic Leachate Procedure
TEQM	Total Environmental Quality Movement
TGM	Technical EIA Guidance Manual
TVP	True Vapour Pressure
ToR	Terms of Reference
UT	Union Territory

UTEIAA	Union Territory Level Environment Impact Assessment Authority
UTPCC	Union Territory Pollution Control Committee

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Acknowledgement

The Notification issued on the prior environmental clearance process by the Ministry of Environment and Forests (MoEF) on September 14, 2006 delegated substantial powers to the State Level Environment Impact Assessment Authorities (SEIAA) to grant environmental clearance for certain categories of developmental activities/projects. It was felt that proper guidance to the stakeholders would enhance appreciation of environmental impacts of proposed projects and possible mitigation measures. Further, such a guidance would also help ensure that decision making authorities across different States and Union Territories could adopt similar considerations and norms with due weightage for site-specific considerations.

We feel privileged to be part of the interventions being spearheaded by Sh. Jairam Ramesh, Hon'ble Minister, MoEF, Government of India, to mainstream environmental considerations in the decision making process. IL&FS Ecosmart as part of this important initiative, prepared Technical EIA Guidance Manuals for 27 identified development activities. In view of the diversity of 27 developmental activities entrusted to IL&FS Ecosmart Ltd., in consultation with the MoEF, an expert Peer and Core Committee was constituted to review and finalize each of the draft Manuals. The Manuals prepared by IL&FS were technically reviewed and up-dated by the respective sector-specific expert resource persons.

The Manuals designed by the Expert Committee have benefitted from the advise and feedback received from MoEF. The Manuals are designed to provide readers with an in-depth understanding of the environmental clearance mechanism, developmental activity specific environmental impacts with possible mitigation measures, environmentally compliant manufacturing/ production processes and pollution control technologies, etc.

IL&FS Ecosmart hopes that these Manuals are a step forward to realize the MoEF's desired objective of enhancing functional efficiency and effectiveness in the environmental clearance process. We hope the stakeholders will find the Manuals useful.

We take this opportunity to convey our appreciation to the MoEF team under the leadership of Mr. J.M. Mauskar, Additional Secretary, for the technical inputs, guidance and support extended throughout the project period for successful completion of the project. The technical guidance and support extended by the Expert Peer and Core Committee under the Chairmanship of Dr. V. Rajagopalan, former Chairman, Central Pollution Control Board and inputs of the sector-specific resource persons are gratefully acknowledged.

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FOREWORD

The Ministry of Environment & Forests (MOEF) introduced the Environmental Impact Assessment (EIA) Notification 2006 on 14th September 2006, which not only reengineered the entire environment clearance (EC) process specified under the EIA Notification 1994, but also introduced a number of new developmental sectors which would require prior environmental clearance. The EIA Notification 2006 has notified a list of 39 developmental sectors which have been further categorised as A or B based on their capacity and likely environmental impacts. Category B projects have been further categorised as B1 and B2. The EIA Notification 2006 has further introduced a system of screening, scoping and appraisal and for the setting up of Environment Impact Assessment Authority (EIAA) at the Central level and State Level Environment Impact Assessment Authorities (SEIAAs) to grant environmental clearances at the Central and State level respectively. The Ministry of Environment & Forests is the Environment Impact Assessment Authority at the Central level and 25 State Level Environment Impact Assessment Authorities (SEIAAS) have been set up in the various States/UTs. The EIA Notification 2006 also stipulates the constitution of a multi-disciplinary Expert Appraisal Committee (EAC) at the Centre and State level Expert Appraisal Committees (SEACs) at State/UT Level for appraisal of Category A or B projects respectively and to recommend grant/rejection of environmental clearance to each project/activities falling under the various sectors to the EIAA/SEIAAs respectively.

Although the process of obtaining environmental clearance consisting of Screening, Scoping and Appraisal and for undertaking public consultation including the process of conduct of Public Hearing has been elaborated under the EIA Notification 2006, the Notification itself provides for bringing out guidelines from time to time on the EIA Notification 2006 and the EC process with a view to bringing clarity on the EC process for expediting environmental clearance. This need was further reinforced after the constitution of SEIAAs and SEACs in various States, who were assigned the task for the first time and with a need for addressing the concerns of standardization of the quality of appraisal and in reducing inconsistencies between SEACs/SEIAAs in granting ECs for similar projects in different States.

The Technical Guidance Manual of **"Petrochemical Complexes"** sector describes types of EIA, process and pollution control technologies, operational aspects of EIA with model TOR of that Sector, technological options with cleaner production and waste minimization techniques, monitoring of environmental quality, post clearance monitoring protocol,

related regulations, and procedure of obtaining EC if linked to other clearances for e.g., CRZ, etc.

'Petrochemical Complexes' are involved in manufacturing aromatic hydrocarbons such as Benzene, Toluene, Xylene, Ethylene Benzene, Napthalene which find application in manufacture of synthetic fibre, explosives, pesticides, dye and dye intermediates, detergents, resins, polymethane, etc. Gas & oil cracker units are also covered. Emissions with mercaptans, hydrocarbons, VOCs, sulphides, phenolic compounds, cyanides, heavy oil, spent caustic, BOD, COD, SS, and Benzene, Toluene, Xylene, Cadmium etc. have to be effectively controlled.

Atmospheric contamination by hazardous chemicals from the petrochemical industry can be complex, particularly when substances or processes combine. Their combined effects are often far more toxic and dangerous. Many of these chemicals can produce oxygen deficient, toxic, or explosive atmospheres. These hazards are multiplied on a refinery site because of the complex collection of tanks, reactors, vessels, and ducts combined with a wide variety of hazardous chemicals and emissions, often within enclosed areas. Clean Technologies should be used instead of 'end-of- pipe treatment' technology. Due importance should be given to recycle/reuse of liquid effluents, solid/hazardous waste management, risk assessment and for the preparation of on-site/off-site emergency plans and disaster management plan. Knowledge of general confined space procedures and specific in-plant requirements are critical in refinery work.

India's industrial competitiveness and environmental future depends on Industries such as Petrochemical Complexes adopting energy and resource efficient technologies. Recycling and reuse of materials is critical. To keep pace with changing technologies and needs of sustainable development, the manual would require regular updating in the future. The manual will be available on the MoEF website and we would appreciate receiving responses from stakeholders for further improvements.

I congratulate the entire team of IL&FS Ecosmart Ltd., experts from the sector who were involved in the preparation of the Manuals, Chairman and members of the Core and Peer Committees of various sectors and various Resource Persons whose inputs were indeed valuable in the preparation and finalization of the Manuals.

Jairam Ramesh

(Jairam Ramesh)

1. INTRODUCTION TO THE TECHNICAL EIA GUIDANCE MANUALS PROJECT

Environmental Impact Assessment (EIA) is a process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made. These studies integrate the environmental concerns of developmental activities into the process of decision-making.

EIA has emerged as one of the successful policy innovations of the 20th Century in the process of ensuring sustained development. Today, EIA is formalized as a regulatory tool in more than 100 countries for effective integration of environmental concerns in the economic development process. The EIA process in India was made mandatory and was also given a legislative status through a Notification issued by the Ministry of Environment and Forests (MoEF) in January 1994. The Notification, however, covered only a few selected industrial developmental activities. While there are subsequent amendments, the Notification issued on September 14, 2006 supersedes all the earlier Notifications, and has brought out structural changes in the clearance mechanism.

The basic tenets of this EIA Notification could be summarized into the following:

- Pollution potential as the basis for prior environmental clearance instead of investment criteria; and
- Decentralization of clearing powers to the State/Union Territory (UT) level Authorities for certain developmental activities to make the prior environmental clearance process quicker, transparent and effective.

Devolution of the power to grant clearances at the state level for certain category of the developmental activities / projects is a step forward to fulfill the basic tenets of the re-engineering *i.e.*, quicker, transparent and effective process but many issues impede/hinder its functional efficiency. These issues could be in technical and operational domains as listed below:

Technical issues

- Ensuring level playing ground to avoid arbitrariness in the decision-making process
- Classification of projects which do not require public hearing and detailed EIA (Category B2)
- Variations in drawing Terms of Reference (ToR) of EIA studies for a given developmental activity across the States/UTs
- Varying developmental-activity-specific expertise requirement for conducting EIA studies and their appraisal
- Availability of adequate sectoral experts and variations in competency levels
- Inadequate data verification, cross checking tools and supporting institutional framework

- Meeting time targets without compromising with the quality of assessments/ reviews
- Varying knowledge and skill levels of regulators, consultants and experts
- Newly added developmental activities for prior environmental clearance, *etc*.

Operational issues

- State level /UT level EIA Authorities (SEIAA/UTEIAA) are formulated for the first time and many are functioning
- Varying roles and responsibilities of involved organizations
- Varying supporting institutional strengths across the States/UTs
- Varying manpower availability, *etc*.

1.1 Purpose

The purpose of developing the sector-specific technical EIA guidance manuals (TGM) is to provide clear and concise information on EIA to all the stakeholders *i.e*., the project proponent, the consultant, the reviewer, and the public. The TGMs are organized to cover following:

Chapter 1 (Introduction): This chapter provides a brief introduction on the EIA, basic tenets of EIA Notification, technical & operational issues in the process of clearance, purpose of the TGMs, project implementation process and additional information.

Chapter 2 (Conceptual facets of an EIA): Provides an overall understanding to the conceptual aspects of control of pollution and EIA for the developmental projects. This basic understanding would set the readers at same level of understanding for proper interpretations and boundaries for identifying the environmental interactions of the developmental projects and their significance for taking measures of mitigation. This chapter covers the discussion on environment in EIA context *i.e.,* sustainable development, pollution control strategies, preventive environmental management tools, Objectives of EIA, types and basic principles of EIA, project cycle for petro-chemical industry, understanding on type of environmental impacts and the criteria for the significance analysis.

Chapter 3 (About Petrochemical Complexes including Process and Pollution Control Technologies): The purpose of this chapter is to provide the reader precise information on all the relevant aspects of the industry, which is essential to realize the likely interaction of such developmental activities on the receiving environment. Besides, this Chapter gives a holistic understanding on the sources of pollution and the opportunities of the source control.

The specific coverage which provides precise information on the industry include (i) Introduction - Petrochemical capacities, Feedstock processed, Status of technology, Scope of coverage of chemicals under the petrochemical industry, Production patterns, (ii) Feedstock Processing - Lower olefins production- steam cracking, Aromatics, (iii) Water and Wastewater Management - Sources of wastewater generation, Control & treatment technology, (iv) Air Pollution - Control technologies for air emissions, VOC emissions, Monitoring & reporting of air emissions, (v) Energy and Fuel Management - Environmental considerations, (vi) Non-routine conditions - Unplanned events, (vii) Waste management - Solid/hazardous waste generation from ethylene cracker, Solid/hazardous waste generation from aromatics plants, Composition of petrochemical

industry waste streams, Technology for waste treatment, Waste storage, Recycle and reuse, Waste pre-treatment- sludge reduction processes, Waste disposal methods and (viii) Summary of Applicable National Regulations for this developmental activity - General description of major statutes, General standards for discharge of environmental pollutants, Industry-specific requirements, Pending and proposed regulatory requirements.

Chapter 4 (Operational aspects): The purpose of this chapter is to facilitate the stakeholders to extend clear guidance on coverage of legislative requirements, sequence of procedures for obtaining the EIA clearance and each step-wise provisions and considerations.

The coverage of the Chapter include provisions in the EIA Notification regarding the petro-chemical complexes, siting guidelines, scoping (pre-feasibility report, guidance for filling form 1, identification of valued environmental components, identification of impacts, *etc*.), arriving at terms of reference for EIA studies, impact assessment studies (EIA team, assessment of baseline quality of environment, impact prediction tools, significance of impacts), social impact assessment, risk assessment considerations, typical mitigation measures, designing considerations for environmental management plan, structure of EIA report for incorporation of study findings, process of public consultation, project appraisal, decision making process and post-clearance monitoring protocol.

Chapter 5 (Roles and responsibilities of various organizations involved in the process of prior environmental clearance): The purpose of this Chapter is to brief the stakeholders on the institutional mechanism and roles & responsibilities of the stakeholders involved in the process of prior environmental clearance. The Coverage of the Chapter include (i) roles and responsibilities of the stakeholders, (ii) organization specific functions, (iii) constitution, composition and decision making process EAC and (iv) other conditions which may be considered.

For any given industry, each topic listed above could alone be the subject of a lengthy volume. However, in order to produce a manageable document, this project focuses on providing summary information for each topic. This format provides the reader with a synopsis of each issue. Text within each section was researched from many sources, and was condensed from more detailed sources pertaining to specific topics.

The contents of the document are designed with a view to facilitate addressing of the relevant technical and operational issues as mentioned in the earlier section. Besides, facilitates various stakeholders involved in the EIA clearance process *i.e,*

- Project proponents will be fully aware of the procedures, common ToR for EIA studies, timelines, monitoring needs, *etc*., in order to plan the projects/studies appropriately.
- Consultants across India will gain similar understanding about a given sector, and also the procedure for EIA studies, so that the quality of the EIA reports gets improved and streamlined
- Reviewers across the States/UTs will have the same understanding about an industry sector and would able to draw a benchmark in establishing the significant impacts for the purpose of prescribing the ToR for EIA studies and also in the process of review and appraisal.
- Public who are concerned about new or expansion projects, can use this manual to a basic idea about the manufacturing/production details, rejects/wastes from the

operations, choice of cleaner/control technologies, regulatory requirements, likely environmental and social concerns, mitigation measures, *etc*., in order to seek clarifications appropriately in the process of public consultation. The procedural clarity in the document will further strengthen them to understand the stages involved in clearance and roles and responsibilities of various organizations.

- In addition, these manuals would substantially ease the pressure on reviewers at the scoping stage and would bring in functional efficiency at the central and state levels.

1.2 Project Implementation

The Ministry of Environment & Forests (MoEF), Government of India took up the task of developing sector-specific TGMs for all the developmental activities listed in the re-engineered EIA Notification. The Infrastructure Leasing and Financial Services Ecosmart Limited (IL&FS Ecosmart), has been entrusted with the task of developing these manuals for 27 industrial and related sectors. Petro-chemical complex is one of these sectors, for which this manual is prepared.

The ability to design comprehensive EIA studies for specific industries depends on the knowledge of several interrelated topics. Therefore, it requires expert inputs from multiple dimensions *i.e.*, administrative, project management, technical, scientific, social, economic, risk *etc*., in order to comprehensively analyze the issues of concern and to draw logical interpretations. Thus, Ecosmart has designed a well-composed implementation framework to factor inputs of the experts and stakeholders in the process of finalization of these manuals.

The process of manual preparation involved collection & collation of the secondary available information, technical review by sectoral resource persons and critical review & finalization by a competent Expert Committee composed of core and sectoral peer members.

The MoEF appreciates the efforts of Ecosmart, Expert Core and Peer Committee, resource persons and all those who have directly and indirectly contributed to this Manual. .

1.3 Additional Information

This TGM is brought out by the MoEF to provide clarity to all the stakeholders involved in the 'Prior Environmental Clearance' process. As such, the contents and clarifications given in this document do not withstand in case of a conflict with the statutory provisions of the Notifications and Executive Orders issued by the MoEF from time-to-time.

TGMs are not regulatory documents. Instead, these are the tools designed to assist in successful completion of an EIA. For the purpose of this project, the key elements considered under TGMs are: conceptual aspects of EIA; developmental activity-specific information; operational aspects; and roles and responsibilities of involved stakeholders.

This manual is prepared considering the Notification issued on 14th September, 2006 and latest amendment as on 1st December 2009. For recent updates, if any, may please refer the website of the MoEF, Government of India *i.e.,* http://moef.nic.in/index.php.

2. CONCEPTUAL FACETS OF EIA

It is an imperative requirement to understand the basic concepts concerned to the pollution control and the environmental impact assessment in an overall objective of the sustainable development. This Chapter highlights the pollution control strategies and their tools besides the objectives, types & principles of EIA, type of impacts their significance analysis, in order to provide consistent understanding to the reader before assessing the development of activity-specific environmental concerns in Chapter 3 and identification & prediction of significant impacts in order to design mitigation measures as detailed in Chapter 4.

2.1 Environment in EIA Context

"Environment" in EIA context mainly focuses, but is not limited to physical, chemical, biological, geological, social, economical, and aesthetic dimensions along with their complex interactions, which affect individuals, communities and ultimately determines their forms, character, relationship, and survival. In EIA context, 'effect' and 'impact' can often be used interchangeably. However, 'impact' is considered as a value judgment of the significance of an effect.

Sustainable development is built on three basic premises *i.e.*, economic growth, ecological balance and social progress. Economic growth achieved in a way that does not consider the environmental concerns, will not be sustainable in the long run. Therefore, sustainable development needs careful integration of environmental, economic, and social needs in order to achieve both an increased standard of living in short term, and a net gain or equilibrium among human, natural, and economic resources to support future generations in the long term.

It is necessary to understand the links between environment and development in order to make choices for development that will be economically efficient, socially equitable and responsible, as well as environmentally sound.

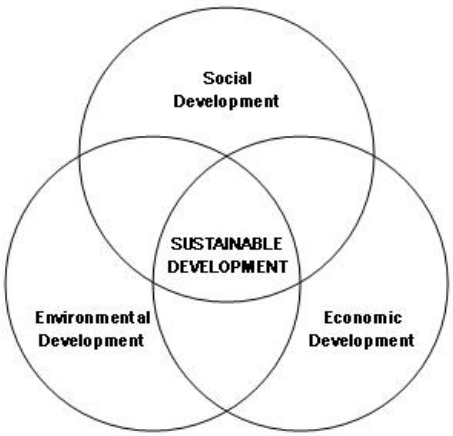

Figure 2-1: Inclusive Components of Sustainable Development

2.2 Pollution Control Strategies

Pollution control strategies can be broadly categorized in to preventive and reactive. The reactive strategy refers to the steps that may be applied once the wastes are generated or contamination of the receiving environment takes place. The control technology or a combination of technologies to minimize the impact due to the process rejects/wastes varies with quantity and characteristics, desired control efficiency and economics.

Many combinations of techniques could be adopted for treatment of a specific waste or the contaminated receiving environment, but are often judged based on techno-economic feasibility. Therefore, the best alternative is to take all possible steps to avoid pollution it self. This preventive approach refers to a hierarchy that involves i) prevention & reduction; ii) recycling and re-use; iii) treatment; and iv) disposal, respectively.

Therefore, there is a need to shift the emphasis from the reactive to preventive strategy *i.e.,* to promote preventive environmental management. Preventive environmental management tools may be grouped into management based tools, process based tools and product based tools, which are given below:

Management Based Tools	Process Based Tools	Product Based Tools
Environmental Management System (EMS)	Environmental Technology Assessment	Industrial Ecology
Environmental Performance Evaluation	Toxic Use Reduction	Extended Producers Responsibility
Environmental Audits	Best Operating Practices	Eco-labeling
Environmental Reporting and Communication	Environmentally Best Practice	Design for Environment
Total Cost Accounting	Best Available Technology (BAT)	Life Cycle Assessment (LCA)
Law and Policy	Waste Minimization	
Trade and Environment	Pollution Prevention	
Environmental Economics	Cleaner Production	
	4-R Concept	
	Cleaner Technology	
	Eco-efficiency	

2.3 Tools for Preventive Environmental Management

The tools for preventive environmental management can be broadly classified into following three groups.

- Tools for assessment and analysis - risk assessment, life cycle assessment, total cost assessment, environmental audit / statement, environmental benchmarking, environmental indicators
- Tools for action - environmental policy, market based economic instruments, innovative funding mechanism, EMS and ISO certification, total environmental quality movement, eco-labeling, cleaner production, eco-efficiency, industrial ecosystem or metabolism, voluntary agreements
- Tools for communication - state of environment, corporate environmental reporting

Specific tools under each group are discussed precisely in next sections.

2.3.1 Tools for assessment and analysis

2.3.1.1 Risk assessment

Risk is associated with the frequency of failure and consequence effect. Predicting such situations and evaluation of risk is essential to take appropriate preventive measures. The major concern of the assessment is to identify the activities falling in a matrix of high & low frequencies at which the failures occur and the degree of its impact. The high frequency, low impact activities can be managed by regular maintenance *i.e*, Leak detection and repair (LDAR) programmes. Whereas, the low frequency, high impact activities are of major concern (accidents) in terms of risk assessment. As the frequency is low, often the required precautions are not realized or maintained. However, risk assessment identifies the areas of major concerns which require additional preventive measures; likely consequence distances considering domino effects, which will give the possible casualties and ecological loss in case of accidents. These magnitudes demand the attention for preventive and disaster management plans (DMP). Thus is an essential tool to ensure safety of operations.

2.3.1.2 Life cycle assessment

A broader approach followed to deal with environmental impacts during manufacturing is called LCA. This approach recognizes that environmental concerns are associated with every step of the processing w.r.t. manufacturing of products and also examines environmental impacts of the product at all stages of project life cycle. LCA includes product design, development, manufacturing, packaging, distribution, usage and disposal. LCA is concerned with reducing environmental impacts at all the stages and considering the total picture rather than just one stage of the production process.

Industries/firms may apply this concept to minimize costs incurred on the environmental conservation throughout the project life cycle.

2.3.1.3 Total cost assessment

Total Cost Assessment (TCA) is an enhanced financial analysis tool that is used to assess the profitability of alternative courses of action *e.g.*, raw material substitution to reduce the costs of managing the wastes generated by process; an energy retrofit to reduce the costs of energy consumption. This is particularly relevant for pollution prevention options. These options, because of their nature, often produce financial savings that are overlooked in conventional financial analysis, either because they are misallocated, uncertain, hard to quantify, or occur more than three to five years after the initial investment. TCA includes all the relevant costs and savings associated with an option so that it can compete for scarce capital resources fairly, on a level playing field. The assessments are often beneficial w.r.t the following:

- Identification of costly resource inefficiencies
- Financial analysis of environmental activities/projects such as investment in cleaner technologies
- Prioritization of environmental activities/projects
- Evaluation of product mix and product pricing
- Benchmarking against the performance of other processes or against the competitors

A comparison of cost assessments is given below:

- Conventional cost accounting (CCA): Direct and indirect financial costs+ Recognized contingent costs
- Total Cost Assessment (TCA): A broader range of direct, indirect, contingent and less quantifiable costs
- Full Cost assessment (FCA): TCA + External social costs borne by society

2.3.1.4 Environmental audit/statement

Key objectives of an environmental audit includes compliance verification, problem identification, environmental impact measurement, environmental performance measurement, conforming effectiveness of EMS, providing a database for corrective actions and future actions, developing company's environmental strategy, communication and formulating environmental policy.

The MoEF, Government of India issued Notification on '*Environmental Statements*' (ES) in April, 1992 and further amended in April 1993 – As per the Notification, the industries are required to submit environmental statements to the respective State Pollution Control Board (SPCB). ES is a proactive tool for self-examination of the industry to reduce/ minimize pollution by adopting process modifications, recycling and reusing of the resources. The regular submission of ES will indicate the systematic improvement in environmental pollution control being achieved by the industry. In other way, specific points in ES may be used as environmental performance indicators for relative comparison, implementation and to promote better practices.

2.3.1.5 Environmental benchmarking

Environmental performance and operational indicators could be used to navigate, manage and communicate the significant aspects and give enough evidence of good environmental house keeping. Besides the existing prescribed standards, an insight to identify the performance indicators and prescribing schedule for systematic improvement in performance of these indicators will yield better results.

Relative indicators may be identified for different industrial sectors and be integrated in companies and organizations to monitor and manage the different environmental aspects of the company, to benchmark and compare two or more companies from the same sector. These could cover water consumption, wastewater generation, energy consumption, solid/hazardous waste generation, chemical consumption *etc*., per tonne of final product. Once these benchmarks are developed, the industries which are below them may be guided and enforced to reach them while those which are better than the benchmark may be encouraged further by giving incentives *etc*.

2.3.1.6 Environmental indicators

Indicators can be classified in to environmental performance indicators (EPI) and environmental condition indicators (ECI). The EPIs can be further divided into two categories *i.e.,* operational performance indicators and management performance indicators.

The operational performance indicators are related to the process and other operational activities of the organization. These would typically address the issue of raw material consumption, energy consumption, water consumption in the organization, the quantities of wastewater generated, other solid wastes & emissions generated from the organization *etc*.

Management performance indicators are related to the management efforts to influence the environmental performance of the organizational operations.

The environmental condition indicators provide information about the environment. These indicators provide information about the local, regional, national or global condition of the environment. This information helps an organization to understand the environmental impacts of its activities and thus helps in taking decisions to improve the environmental performance.

Indicators basically used to evaluate environmental performance against the set standards and thus indicate the direction in which to proceed. Selection of type of indicators for a firm or project depends upon its relevance, clarity and realistic cost of collection and its development.

2.3.2 Tools for action

2.3.2.1 Environmental policy

An environmental policy is a statement of an organization's overall aim and principles of action w.r.t the environment, including compliance with all relevant regulatory requirements. It is a key tool in communicating environmental priorities of the organization to all its employees. To ensure organization's commitment towards a formulated environmental policy, it is essential for the top management to be involved in the process of formulating the policy and setting priorities. Therefore, the first step is to get the commitment from the higher levels of management. The organization should then conduct an initial environmental review and draft an environmental policy. This draft should be discussed and approved by the board of directors. The approved environmental policy statement should then be communicated internally among all its employees and must also be made available to the public.

2.3.2.2 Market-based economic instruments

Market based instruments are regulations that encourage behavior through market signals rather than through explicit directives regarding pollution control levels. These policy instruments such as tradable permits, pollution charge are often described as harnessing market forces. Market based instruments can be categorized into the following four major categories which are discussed below.

- **Pollution charge:** Charge system will assess a fee or tax on the amount of pollution a firm or source generates. It is worthwhile for the firm to reduce emissions to the point, where its marginal abatement costs is equal to the tax rate. Thus firms control pollution to different degrees *i.e.,* High cost controllers – less; Low-cost controllers-more. The charge system encourages the industries to further reduce the pollutants. The collected charges can form a fund for restoration of the environment. Another form of pollution charge is a deposit refund system, where, consumers pay a surcharge when purchasing a potentially polluting product, and receive a refund on return of the product after useful life span at appropriate centers. The concept of extended producers' responsibility brought in to avoid accumulation of dangerous products in the environment.
- **Tradable permits:** Under this system, firms that achieve the emission levels below their allotted level may sell the surplus permits. Similarly, the firms, which are

required to spend more to attain the required degree of treatment/allotted levels, can purchase permits from others at lower costs and may be benefited.

- **Market barrier reductions:** Three known market barrier reduction types are as follows:
  - Market creation: Measures that facilitate the voluntary exchange of water rights and thus promote more efficient allocation of scarce water supplies
  - Liability concerns: Encourage firms to consider potential environmental damages of their decisions
  - Information programmes: Eco-labeling and energy efficiency product labeling requirements
- **Government subsidy reduction:** Subsidies are the mirror images of taxes and, in theory, can provide incentive to address environmental problems. However, it has been reported that the subsidies encourage economically inefficient and environmentally unsound practices, and often leads to market distortions due to differences in the area. However, these are important to sustain the expansion of production, in the national interests. In such cases, the subsidy may be comparable to the net social benefit.

2.3.2.3 Innovative funding mechanism

There are many forums under which the fund is made available for the issues which are of global/regional concern *i.e.,* climate change, basal convention and further fund sources are being explored for the Persistent Organic Pollutants Convention. Besides the global funding mechanism, there needs to be localized alternative mechanisms for boosting the investment in environmental pollution control. For example, in India the Government has established mechanism to fund the common effluent treatment plants, which are specifically serving the small and medium scale enterprises *i.e.,* 25% share by the State Government, matching grants from the Central Government and surety for 25% soft loan. It means that the industries need to invest only 25% initially, thus encouraging voluntary compliance.

There are some more options *i.e.,* if the pollution tax/charge is imposed on the residual pollution being caused by the industries, municipalities *etc*., fund will automatically be generated, which in turn, can be utilized for funding the environmental improvement programmes. The emerging concept of build-operate-transfer (BOT) is an encouraging development, where there is a possibility to generate revenue by application of advanced technologies. There are many opportunities which can be explored. However, what is required is the paradigm shift and focused efforts.

2.3.2.4 EMS and ISO certification

EMS is that part of the overall management system, which includes the organizational structure, responsibilities, practices, procedures, process and resources for determining and implementing the forms of overall aims, principles of action w.r.t the environment. It encompasses the totality of organizational, administrative and policy provisions to be taken by a firm to control its environmental influences. Common elements of an EMS are the identification of the environmental impacts and legal obligations, the development of a plan for management & improvement, the assignment of the responsibilities and monitoring of the performance.

2.3.2.5 Total environmental quality movement

Quality is regarded as

- A product attribute that had to be set at an acceptable level and balanced against the cost
- Something delivered by technical systems engineered by experts rather than the organization as a whole
- Assured primarily through the findings and correction of mistakes at the end of the production process

One expression of the total environment quality movement (TEQM) is a system of control called Kaizen. The principles of Kaizen are:

- Goal must be continuous improvement of quality instead of acceptable quality
- Responsibility of the quality shall be shared by all members of an organization
- Efforts should be focused on improving the whole process and design of the products

With some modifications, TEQM approach can be applied in the improvement of corporate environmental performance in both process and product areas.

2.3.2.6 Eco-labeling

Eco-labeling is the practice of supplying information on the environmental characteristics of a product or service to the general public. These labeling schemes can be grouped into three types:

- Type I: Multiple criteria base; third party (Govt. or non-commercial private organizations) programme claims overall environmental preferability.
- Type II: Specific attribute of a product; often issued by a company/industrial association
- Type III: Agreed set of indices; provide quantified information; self declaration

Among the above, Type I are more reliable because they are established by a third party and considers the environmental impacts of a product from cradle to grave. However, the labeling program will only be effective if linked with complementary program of consumer education and up on restriction of umbrella claims by the producers.

2.3.2.7 Cleaner production

Cleaner production is one of the tools, which has lot of bearing on environmental pollution control. It is also seen that the approach is changing with time *i.e.,* dumping-to-control-to-recycle-to-prevention. Promotion of cleaner production principles involves an insight into the production processes not only to get desired yield but also to optimize on raw material consumption *i.e.,* resource conservation and implications of the waste treatment and disposal.

2.3.2.8 4-R concept

The concept endorses utilization of wastes as a by-product to the extent possible *i.e.,* Re-cycle, Recover, Reuse, Recharge. Recycling refers to using wastes/by-products in the

process again as a raw material to maximize production. Recovery refers to engineering means such as solvent extraction, distillation, precipitation *etc*. to separate the useful constituents of wastes, so that these recovered materials can be used. Re-use refers to the utilization of waste from one process as a raw material to other. Recharging is an option in which the natural systems are used for renovation of waste for further use.

2.3.2.9 Eco-efficiency

The World Business Council on sustainable development (WBCSD) defines eco-efficiency as "the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with earth's carrying capacity". The business implements the eco-efficiency on four levels *i.e.,* optimized processes, recycling of wastes, eco-innovation and new services. Fussler (1995) defined six dimensions of eco efficiency, which are given below to understand/examine the system.

- **Mass:** There is an opportunity to significantly reduce mass burdens (raw materials, fuels, utilities consumed during the life cycle)
- **Reduce energy use:** The opportunity is to redesign the product or its use to provide significant energy savings
- **Reduce environmental toxins:** This is concern to the environmental quality and human health. The opportunity here is to significantly control the dispersion of toxic elements
- **Recycle when practical:** Designing for recyclibility is important
- **Working with mother nature:** Materials are borrowed and returned to the nature without negatively affecting the balance of the ecosystem
- **Make it Last Longer:** It relates to useful life and functions of products. Increasing the functionality of products also increase their eco efficiency

The competitiveness among the companies and long-term survival will continue and the successful implementation of eco efficiency will contribute to their success. There is a need to shift towards responsible consumerism equal to the efficiency gains made by corporations – doing more with less.

2.3.2.10 Industrial ecosystem or metabolism

Eco-industrial development is a new paradigm for achieving excellence in business and environmental performance. It opens up innovative new avenues for managing business and conducting economic development by creating linkages among local 'resources', including businesses, non-profit groups, governments, unions, educational institutions, and communities. They can creatively foster the dynamic and responsible growth. Antiquated business strategies based on isolated enterprises are no longer responsive enough to market, environmental and community requirements.

Sustainable eco-industrial development looks systematically at development, business and environment, attempting to stretch the boundaries of current practice - on one level. It is as directly practical as making the right connections between the wastes and resources needed for production and at the other level, it is a whole new way of thinking about doing business and interacting with communities. At a most basic level, it is each

organization seeking higher performance within it self. However, most eco-industrial activity is moving to a new level by increasing the inter connections between the companies.

Strategic partnership, networked manufacturing and performed supplier arrangements are all the examples of ways used by the businesses to ensure growth, contain costs and to reach out for new opportunities.

For most businesses, the two essentials for success are the responsive markets and access to cost-effective, quality resources for production or delivering services. In absence of these two factors, virtually, every other incentive becomes a minor consideration.

Transportation issues are important at two levels, the ability to get goods to market in an expeditious way is essential to success in this day of just in time inventories. The use of least impact transportation with due consideration of speed and cost supports business success and addresses the concerned in community.

Eco-industrial development works because it consciously mixes a range of targeted strategies shaped to the contours of the local community. Most importantly, it works because the communities want nothing less than the best possible in or near their neighborhoods. For companies, it provides a path towards significantly higher operating results and positive market presence. For our environment, it provides great hope that the waste will be transformed into valued product and that the stewardship will be a joint pledge of both businesses and communities.

2.3.2.11 Voluntary agreements

Voluntary environmental agreements among the industries, government, public representatives, NGOs and other concerned towards attaining certain future demands of the environment are reported to be successful. Such agreements may be used as a tool where Government would like to make the standards stringent in future (phase-wise-stringent). These may be used when conditions are temporary and require timely replacement. Also these may be used as supplementary/complimentary in implementation of the regulation. The agreements may include:

- Target objectives (emission limit values/standards)
- Performance objectives (operating procedures)
- R&D activities – Government and industry may have agreement to establish better control technologies.
- Monitoring & reporting of the agreement conditions by other agents (NGOs, public participants, civil authority *etc*.)

In India, the MoEF has organized such programme, popularly known as the corporate responsibility for environment protection (CREP) considering identified 17 categories of high pollution potential industrial sectors. Publication in this regard, is available with Central Pollution Control Board (CPCB).

2.3.3 Tools for communication

2.3.3.1 State of environment

The Government of India has brought out the state of environment report for entire country and similar reports available for many of the states. These reports are published at regular intervals to record trends and to identify the required interventions at various levels. These reports consider the internationally accepted DPSIR framework for the presentation of the information. DPSIR refers to

- D – Driving forces – causes of concern *i.e.* industries, transportation *etc*.
- P – Pressures – pollutants emanating from driving forces *i.e.* emission
- S – State – quality of environment *i.e*. air, water & soil quality
- I – Impact – Impact on health, eco-system, materials, biodiversity, economic damage *etc*.
- R – Responses – action for cleaner production, policies (including standards/ guidelines), targets *etc*.

Environment reports including the above elements gives a comprehensive picture of specific target area in order to take appropriate measures for improvement. Such reports capture the concerns, which could be considered in EIAs.

2.3.3.2 Corporate environmental reporting

Corporate environmental reports (CERs) are only one form of environmental reporting defined as publicly available, stand alone reports, issued voluntarily by the industries on their environmental activities. CER is just a means of environmental improvement and greater accountability, not an end in itself.

Three categories of environmental disclosure are:

- Involuntary disclosure: Without its permission and against its will (env. Campaign, press *etc*.)
- Mandatory disclosure: As required by law
- Voluntary disclosure: The disclosure of information on a voluntary basis

2.4 Objectives of EIA

Objectives of EIA include the following:

- To ensure environmental considerations are explicitly addressed and incorporated into the development decision-making process
- To anticipate and avoid, minimize or offset the adverse significant biophysical, social and other relevant effects of development proposals;
- To protect the productivity and capacity of natural systems and the ecological processes which maintain their functions; and
- To promote development that is sustainable and optimizes resource use as well as management opportunities

2.5 Types of EIA

Environmental assessments could be classified into four types *i.e.* strategic environmental assessment (SEA), regional EIA, sectoral EIA and project level EIA. These are precisely discussed below:

Strategic environmental assessment

SEA refers to systematic analysis of the environmental effects of development policies, plans, programmes and other proposed strategic actions. SEA represents a proactive approach to integrate environmental considerations into the higher levels of decision-making – beyond the project level, when major alternatives are still open.

Regional EIA

EIA in the context of regional planning integrates environmental concerns into development planning for a geographic region, normally at the sub-country level. Such an approach is referred to as the economic-cum-environmental (EcE) development planning. This approach facilitates adequate integration of economic development with management of renewable natural resources within the carrying capacity limitation to achieve sustainable development. It fulfils the need for macro-level environmental integration, which the project-oriented EIA is unable to address effectively. Regional EIA addresses the environmental impacts of regional development plans and thus, the context for project-level EIA of the subsequent projects, within the region. In addition, if environmental effects are considered at regional level, then cumulative environmental effects of all the projects within the region can be accounted.

Sectoral EIA

Instead of project-level-EIA, an EIA should take place in the context of regional and sectoral level planning. Once sectoral level development plans have the integrated sectoral environmental concerns addressed, the scope of project-level EIA will be quite minimal. Sectoral EIA will help in addressing specific environmental problems that may be encountered in planning and implementing sectoral development projects.

Project level EIA

Project level EIA refers to the developmental activity in isolation and the impacts that it exerts on the receiving environment. Thus, it may not effectively integrate the cumulative effects of the development in a region.

From the above discussion, it is clear that EIA shall be integrated at all the levels *i.e.* strategic, regional, sectoral and the project level. Whereas, the strategic EIA is a structural change in the way the things are evaluated for decision-making, the regional EIA refers to substantial information processing and drawing complex inferences. The project-level EIA is relatively simple and reaches to meaningful conclusions. Therefore in India, project-level EIA studies are take place on a large scale and are being considered. However, in the re-engineered Notification, provisions have been incorporated for giving a single clearance for the entire industrial estate for *e.g.*, Leather parks, pharma cities *etc*., which is a step towards the regional approach.

As we progress and the resource planning concepts emerge in our decision-making process, the integration of overall regional issues will become part of the impact assessment studies.

2.6 Basic EIA Principles

By integrating the environmental impacts of the development activities and their mitigation early in the project planning cycle, the benefits of EIA could be realized in all stages of a project, from exploration and planning, through construction, operations, decommissioning, and beyond site closure.

A properly-conducted-EIA also lessens conflicts by promoting community participation, informing decision makers, and also helps in laying the base for environmentally sound projects. An EIA should meet at least three core values:

- Integrity: The EIA process should be fair, objective, unbiased and balanced
- Utility: The EIA process should provide balanced, credible information for decision-making
- Sustainability: The EIA process should result in environmental safeguards

Ideally an EIA process should be:

- Purposive - should inform decision makers and result in appropriate levels of environmental protection and community well-being.
- Rigorous - should apply 'best practicable' science, employing methodologies and techniques appropriate to address the problems being investigated.
- Practical - should result in providing information and acceptable and implementable solutions for problems faced by proponents.
- Relevant - should provide sufficient, reliable and usable information for development planning and decision making.
- Cost-effective - should impose minimum cost burdens in terms of time and finance on proponents and participants consistent with meeting accepted requirements and objectives of EIA.
- Efficient - should achieve the objectives of EIA within the limits of available information, time, resources and methodology.
- Focused - should concentrate on significant environmental effects and key issues; *i.e.,* the matters that need to be taken into account in making decisions.
- Adaptive - should be adjusted to the realities, issues and circumstances of the proposals under review without compromising the integrity of the process, and be iterative, incorporating lessons learned throughout the project life cycle.
- Participative - should provide appropriate opportunities to inform and involve the interested and affected publics, and their inputs and concerns should be addressed explicitly in the documentation and decision making.
- Inter-disciplinary - should ensure that appropriate techniques and experts in the relevant bio-physical and socio-economic disciplines are employed, including use of traditional knowledge as relevant.
- Credible - should be carried out with professionalism, rigor, fairness, objectivity, impartiality and balance, and be subject to independent checks and verification.

- Integrated - should address the interrelationships of social, economic and biophysical aspects.
- Transparent - should have clear, easily understood requirements for EIA content; ensure public access to information; identify the factors that are to be taken into account in decision making; and acknowledge limitations and difficulties.
- Systematic - should result in full consideration of all relevant information on the affected environment, of proposed alternatives and their impacts, and of the measures necessary to monitor and investigate residual effects.

2.7 Project Cycle

The generic project cycle including that of the petro-chemical industry has six main stages:

1. Project concept
2. Pre-feasibility
3. Feasibility
4. Design and engineering
5. Implementation
6. Monitoring and evaluation

It is important to consider the environmental factors on an equal basis with technical and economic factors throughout the project planning, assessment and implementation phases. Environmental considerations should be introduced at the earliest in the project cycle and must be an integral part of the project pre-feasibility and feasibility stage. If the environmental considerations are given due respect in site selection process by the project proponent, the subsequent stages of the environmental clearance process would get simplified and would also facilitate easy compliance to the mitigation measures throughout the project life cycle.

A project's feasibility study should include a detailed assessment of significant impacts and the EIA include a detailed prediction and quantification of impacts and delineation of Environmental Management Plan (EMP). Findings of the EIA study should preferably be incorporated in the project design stage so that the project as well as the site alternatives is studied and necessary changes, if required, are incorporated in the project design stage. This practice will also help the management in assessing the negative impacts and in designing cost-effective remedial measures. In general, EIA enhances the project quality and improves the project planning process.

2.8 Environmental Impacts

Environmental impacts resulting from proposed actions can be grouped into following categories:

- Beneficial or detrimental
- Naturally reversible or irreversible
- Repairable via management practices or irreparable
- Short term or long term
- Temporary or continuous
- Occurring during construction phase or operational phase

- Local, regional, national or global
- Accidental or planned (recognized before hand)
- Direct (primary) or Indirect (secondary)
- Cumulative or single

The category of impact as stated above, and the significance will facilitate the Expert Appraisal Committee (EAC) to take a look at the ToR for EIA studies, as well as, in decision making process about the developmental activity.

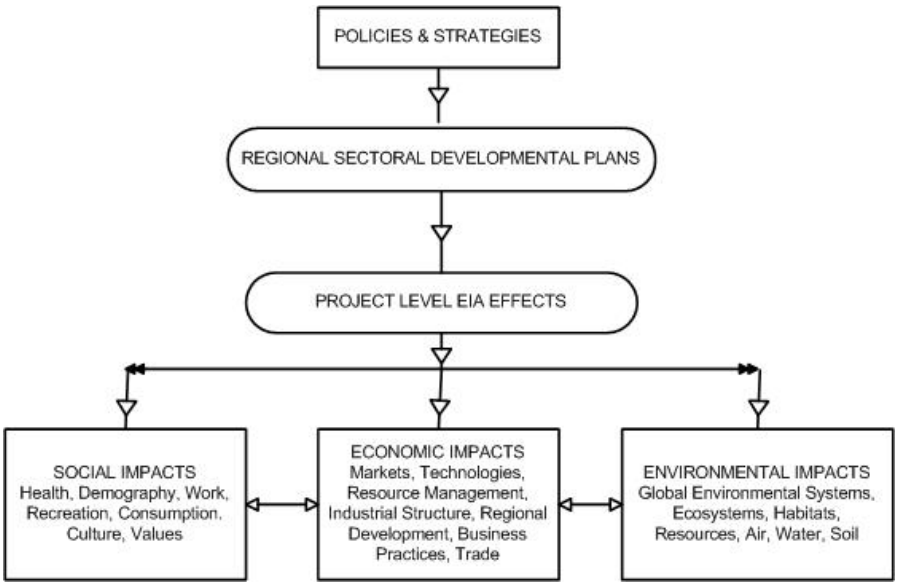

Figure 2-2: Types of Impacts

The nature of impacts could fall within three broad classifications *i.e.*, direct, indirect and cumulative, based on the characteristics of impacts. The assessment of direct, indirect and cumulative impacts should not be considered in isolation or considered as separate stages in the EIA. Ideally, the assessment of such impacts should form an integral part of all stages of the EIA. The TGM does not recommend a single method to assess the types of impacts, but suggests a practical framework/approach that can be adapted and combined to suit a particular project and the nature of impacts.

2.8.1 Direct impacts

Direct impacts occur through direct interaction of an activity with an environmental, social, or economic component. For example, discharges from petro-chemical industry or effluent from the Effluent Treatment Plant (ETP) may pollute nearby water bodies.

2.8.2 Indirect impacts

Indirect impacts on the environment are those which are not a direct result of the project, often produced away from or as a result of a complex impact pathway. The indirect impacts are also known as secondary or even tertiary level impacts. For example, ambient air SO_2 rise due to stack emissions may deposit on land as SO_4 and cause acidic soils. Another example of indirect impact, is the decline in water quality due to rise in temperature of water bodies receiving cooling water discharge from the nearby industry. This, in turn, may lead to a secondary indirect impact on aquatic flora in that water body and may further cause reduction in fish population. Reduction in fishing harvests,

affecting the incomes of fishermen is a third level impact. Such impacts are characterized as socio-economic (third level) impacts. The indirect impacts may also include growth-inducing impacts and other effects related to induced changes to the pattern of land use or additional road network, population density or growth rate. In the process, air, water and other natural systems including the ecosystem may also be affected.

2.8.3 Cumulative impacts

Cumulative impact consists of an impact that is created as a result of the combination of the project evaluated in the EIA together with other projects in the same vicinity, causing related impacts. These impacts occur when the incremental impact of the project is combined with the cumulative effects of other past, present and reasonably foreseeable future projects. Figure 2-3 depicts the same. Respective EAC may exercise their discretion on a case-by-case basis for considering the cumulative impacts.

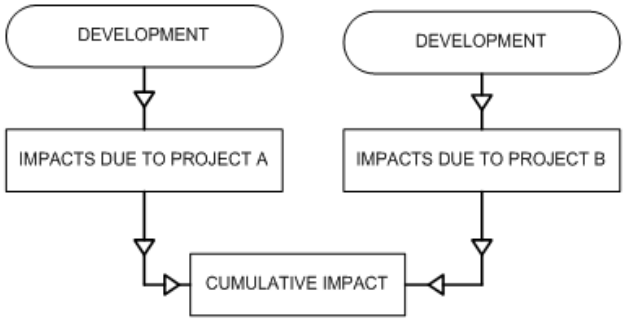

Figure 2-3: Cumulative Impact

2.8.4 Induced impacts

The cumulative impacts can be due to induced actions of projects and activities that may occur if the action under assessment is implemented such as growth-inducing impacts and other effects related to induced changes to the pattern of future land use or additional road network, population density or growth rate (*e.g.*, excess growth may be induced in the zone of influence around a project area, and in the process causing additional effects on air, water and other natural ecosystems). Induced actions may not be officially announced or be part of any official announcement/plan. Increase in workforce and nearby communities contributes to this effect.

They usually have no direct relationship with the action under assessment, and represent the growth-inducing potential of an action. New roads leading from those constructed for a project, increased recreational activities (*e.g.*, hunting, fishing), and construction of new service facilities are examples of induced actions.

However, the cumulative impacts due to induced development or third level or even secondary indirect impacts are difficult to be quantified. Because of higher levels of uncertainties, these impacts cannot normally be assessed over a long time horizon. An EIA practitioner usually can only guess as to what such induced impacts may be and the possible extent of their implications on the environmental factors. Respective EAC may exercise their discretion on a case-by-case basis for considering the induced impacts.

2.9 Significance of Impacts

This TGM establishes the significance of impacts first and proceeds to delineate the associated mitigation measures. So the significance here reflects the "worst-case scenario" before mitigation is applied, and therefore provides an understanding of what may happen if mitigation fails or is not as effective as predicted. For establishing significance of different impacts, understanding the responses and interaction of the environmental system is essential. Hence, the impact interactions and pathways are to be understood and established first. Such an understanding will help in the assessment process to quantify the impact as accurately as possible. Complex interactions, particularly in the case of certain indirect or cumulative impacts, may give rise to non-linear responses, which are often difficult to understand and therefore their significance is difficult to assess. It is hence understood that indirect or cumulative impacts are more complex than the direct impacts. Currently the impact assessments are limited to direct impacts. In case mitigation measures are delineated before determining significance of the effect, the significance represents the residual effects.

However, the ultimate objective of an EIA is to achieve sustainable development. The development process shall invariably cause some residual impacts even after implementing an EMP effectively. Environmentalists today are faced with a vital, not-easy-to-answer question—"What is the tolerable level of environmental impact within the sustainable development framework?" As such, it has been recognized that every ecosystem has a threshold for absorbing deterioration and a certain capacity for self-regeneration. These thresholds based on concept of carrying capacity are as follows:

- Waste emissions from a project should be within the assimilative capacity of the local environment to absorb without unacceptable degradation of its future waste absorptive capacity or other important services.
- Harvest rates of renewable resource inputs should be within the regenerative capacity of the natural system that generates them; depletion rates of non-renewable inputs should be equal to the rate at which renewable substitutes are developed by human invention and investment.

The aim of this model is to curb over-consumption and unacceptable environmental degradation. But because of limitation in available scientific basis, this definition provides only general guidelines for determining the sustainable use of inputs and outputs. To establish the level of significance for each identified impact, a three-stage analysis may be referred:

- First, an impact is qualified as being either negative or positive.
- Second, the nature of impacts such as direct, indirect, or cumulative is determined using the impact network
- Third, a scale is used to determine the severity of the effect; for example, an impact is of low, medium, or high significance.

It is not sufficient to simply state the significance of the effect. This determination must be justified, coherent and documented, notably by a determination methodology, which must be described in the methodology section of the report. There are many recognized methodologies to determine the significance of effects.

2.9.1 Criteria/methodology to determine the significance of the identified impacts

The criteria can be determined by answering some questions regarding the factors affecting the significance. This will help the EIA stake-holders, the practitioner in particular, to determine the significance of the identified impacts eventually. Typical examples of such factors include the following:

- **Exceeding threshold Limit:** Significance may increase if a threshold is exceeded. *e.g.*, particulate matter emissions exceed the permissible threshold.
- **Effectiveness of mitigation:** Significance may increase as the effectiveness of mitigation measures decreases. *e.g.*, control technologies, which may not assure consistent compliance to the requirements.
- **Size of study area:** Significance may increase as the zone of effects increases.
- **Incremental contribution of effects from action under review:** Significance may increase as the relative contribution of an action increases.
- **Relative contribution of effects of other actions:** Significance may decrease as the significance of nearby larger actions increase.
- **Relative rarity of species:** Significance may increase as species becomes increasingly rare or threatened.
- **Significance of local effects:** Significance may increase as the significance of local effects is high.
- **Magnitude of change relative to natural background variability:** Significance may decrease if effects are within natural assimilative capacity or variability.
- **Creation of induced actions:** Significance may increase as induced activities also highly significant.
- **Degree of existing disturbance:** Significance may increase if the surrounding environment is pristine.

For determining significance of impacts, it is important to remember that secondary and higher order effects can also occur as a result of a primary interaction between a project activity and the local environment. Wherever a primary effect is identified, the practitioner should always think if secondary or tertiary effects on other aspects of the environment could also arise.

The EIA should also consider the effects that could arise from the project due to induced developments, which take place as a consequence of the project. Ex. Population density and associated infrastructure and jobs for people attracted to the area by the project. It also requires consideration of cumulative effects that could arise from a combination of the effects due to other projects with those of other existing or planned developments in the surrounding area. So the necessity to formulate a qualitative checklist is suggested to test significance, in general.

3. ABOUT PETROCHEMICAL COMPLEXES INCLUDING PROCESS AND POLLUTION CONTROL TECHNOLOGIES

3.1 Introduction

Petrochemical complexes from the context of EIA Notification are defined as the complexes that are involved in either cracker and/or reformation unit to get basic petrochemicals *i.e.* ethylene; propylene, butadiene and/or benzene, toluene and xylene.

The petrochemical industry in India had its modest beginning in late 1960s when a 20,000 tonnes per annum (TPA) Naphtha cracker was set up by Union Carbide in Mumbai-based on naphtha. The startup of Indian Petrochemical Corporation Limited (IPCL) complex at Baroda in the 1980s, commissioning of first gas-based plant IPCL's Nagothane complex followed by Gandhar complex, Reliance Industries cracker complex at Hazira, GAIL's complex at Auraiya and HPL's Haldia complex have been significant milestones in the Indian petrochemical industry. Since then it has made phenomenal growth and is one of the fastest growing core sectors of the economy. As a result, many petrochemical plants of different sizes and technologies co-exist at the present time. The petrochemical industry is highly technological and capital-intensive. Technologies for petrochemical industries have been developing very fast. Tremendous resources and efforts are being continuously spent on increasing size and yield of plants through continuous upgrade of catalyst, reducing energy consumption and cost reduction through novel process rate, new chemistries or scale up approaches.

Aromatic hydrocarbons - benzene, toluene, xylenes, ethyl benzene, naphthalenes are important petrochemicals and find application in the manufacture of large number of intermediates and are the basic building blocks for large number of products – synthetic fibers, elastomers, explosives, pesticides, dyes, detergent, phenolic resins, epoxy resins, polyurethane, *etc*.

This TGM is focused on the process and environmental concerns of the petrochemical complexes. While efforts have been made to cover all the relevant aspects, suggest the readers to refer other TGMs also for further details such as TGM on Oil and gas transportation pipelines, TGM on Isolated storages, TGM on CETPs, TGM on Industrial Estates, *etc*.

3.1.1 Petrochemical capacities

At present, there are eight cracker complexes in operation with combined ethylene capacity of about 2.4 million TPA. In addition, there are four aromatic complexes namely, Bongaigaon Refinery and Petrochemicals Ltd., IPCL and RIL (two complexes) in operation with a combined Xylene capacity of about 1.8 million tonnes.

Table 3-1 furnishes the installed capacities and the names of production units for major petrochemical products.

Table 3-1: Major Petrochemical Product Capacities & Production Units

Product	Installed Capacity (TPA)	Production Unit
Ethylene	2,497,000	▪ IPCL (RIL) Baroda, MGCC, Gandhar ▪ RIL Hazira ▪ GAIL, Auraiya ▪ HPL, Haldia
Propylene	15,59,600	▪ IPCL (RIL) Baroda, MGCC, Gandhar ▪ RIL Hazira ▪ GAIL, Auraiya ▪ HPL, Haldia ▪ RPL, Jamnagar ▪ MRL ▪ HOC, Cochin
Butadiene	3,32,000	▪ IPCL (RIL) Baroda ▪ RIL, Hazira ▪ HPL, Haldia
Benzene	8,36,220	▪ IPCL (RIL) Baroda ▪ RIL, Hazira ▪ HPL, Haldia ▪ BPCL, Mumbai ▪ CRL, Cochin ▪ RPL, Jamnagar ▪ IOC, Koyali ▪ SAIL (Bhilai, Bokaro Durgapur, Rourkela)
Toluene	1,76,355	▪ RIL, Hazira ▪ BPCL, Mumbai ▪ CRL, Cochin, ▪ IOC, Koyali ▪ SAIL (Bhilai, Bokaro, Durgapur, Rourkela)

3.1.2 Feedstock processed

Liquid feedstock from refineries namely; naphtha, kerosene, and cracked LPG have been traditionally used as feedstock in India. In Indian context, the main choice of feedstock is limited between C_2/C_3 and naphtha as LPG is invariably earmarked as domestic fuel and gas oil being heavier fraction is not preferred due to the complex processing involved for olefins manufacture. Table 3-2 summarizes the feedstock being utilized at various cracker complexes in India.

Table 3-2: Feedstock for Major Petrochemical Complexes

Complex	Ethylene Capacity (TPA)	Feedstock
IPCL (RIL) Baroda	1,30,000	Naphtha
IPCL- MGCC, Nagothane	4,00,000	Gas (C_2/C_3) ethane, propane fraction
IPCL (RIL) GPC, Gandhar	3,00,000	Gas (C_2/C_3) ethane/ propane

Complex	Ethylene Capacity (TPA)	Feedstock
		fraction, propane/ butane fraction
RIL, Hazira	7,50,000	Naphtha, natural gas Liquid
HPL, Haldia	4,20,000	Naphtha
GAIL, Auraiya	4,00,000	Gas (C_2/C_3)

Feedstock used has a direct impact on environmental performance of the petrochemical processes. As an example of this impact, a comparison has been made between gas and naphtha cracker operations for specific energy consumption per kilogram (kg) of ethylene, per kg of total olefins after taking into account the energy requirement for feedstock. This is summarized in Table 3-3.

The complexity of steam cracking and production of olefins depends on the feedstock. Olefin plants are complex and costly with both complexity and cost increasing with heaviness of feedstock. Heavier feedstock produces wider variety of olefins requiring more complex separation and recovery process.

Gas cracker plants have two additional units - gas sweetening for the removal of CO_2 & H_2S; and gas fractionation unit for separation of methane from C_2/C_3 fraction. However, the basic steam cracking technology remains same for naphtha, gas oil and natural gas.

Table 3-3: Comparison of Feedstock – Energy consumption

Feedstock	Specific Energy Consumption	
	Kcal/ Kg of Ethylene	Kcal/ Kg of olefins
Ethane	3100	3050
Propane	4100	3050
Ethane/Propane (60/40)	3600	3300
Naphtha	5000	3650

Almost 60% of ethylene production in India uses naphtha as feedstock. Naphtha is also used for production of aromatics. For maximizing olefin production, it is essential to use high paraffinic naphtha with low aromatic content in cracker. Naphtha production from imported crude, which has high paraffinic content, is ideal for olefin production. Regarding the production of aromatics, higher yields are derived from the feedstock, which consist higher percentages of aromatics precursor content.

The steam cracking section comprises hot and cold sections. The cracking of hydrocarbons and separation of cracked light gases from heavier fraction pyrolysis gasoline (pygas) takes place in the hot section while the separation of light cracked gases ethylene, propylene, butadiene and other fractions takes place in cold section which operates below 0 ^{0}C.

3.1.3 Status of technology

Technology is an important consideration in environmental performance of petrochemical plants. In India, many plants of different sizes and technologies co-exist at present.

Various technological developments for steam crackers have been incorporated with basic objective to have:

- Lower energy consumption per tonne of ethylene
- Improved overall yield of ethylene by shorter residence time, higher severity
- Total feedstock flexibility
- Higher furnace availability
- Increased furnace tube life
- Reduced maintenance cost

The older plants have been modernized from time-to-time to keep pace with the developments, to the extent that existing plants coupled with new plants bring state-of-the-art technology. Worldwide, the crackers have dramatically increased in capacity over the past 40 years. New crackers today are being built at giant capacities of 5,00,000 to 6,00,000 TPA, about 20 times the size of early crackers built in 1950s. Broadly, there has been a doubling in size in the economic capacity levels every decade.

Relatively new gas crackers in India have world size pyrolysis furnaces, highly energy integrated separator trains and digital control system with provision of advanced control features. These are comparable to any latest cracker plants in the world, both in size and technical sophistication. The older crackers had older generation pyrolysis coils with lower selectivity. IPCL (RIL) Baroda also revamped its facility to increase capacity and reduce energy consumption.

In aromatic plants, the earlier units were based on technology employing semi-regenerative processes and monometallic catalyst. Later on, many of these units were revamped using bimetallic catalyst. The operating reformer unit of RIL is based on the CCR process.

In general, for most of the petrochemical processes, a succession of catalyst improvements has resulted in better yield, stability and simplified operation. Engineering design tools particularly in the area of fractionation, heat integration and reactor design have become much sophisticated resulting in more efficient and optimized design. Equipment has improved particularly heat exchangers, instrumentation and high performance packing for fractionators, resulting in further gains in efficiency and less expensive plant design. The experience gained in operation and maintenance of aromatic complexes has resulted in designs that have more process integration, higher heat recovery, less intermediate storage and higher efficiency.

Modifications to equipment can also prevent pollution – opportunities are given in **Annexure I**.

3.1.4 Scope of coverage of chemicals under the petrochemical complexes

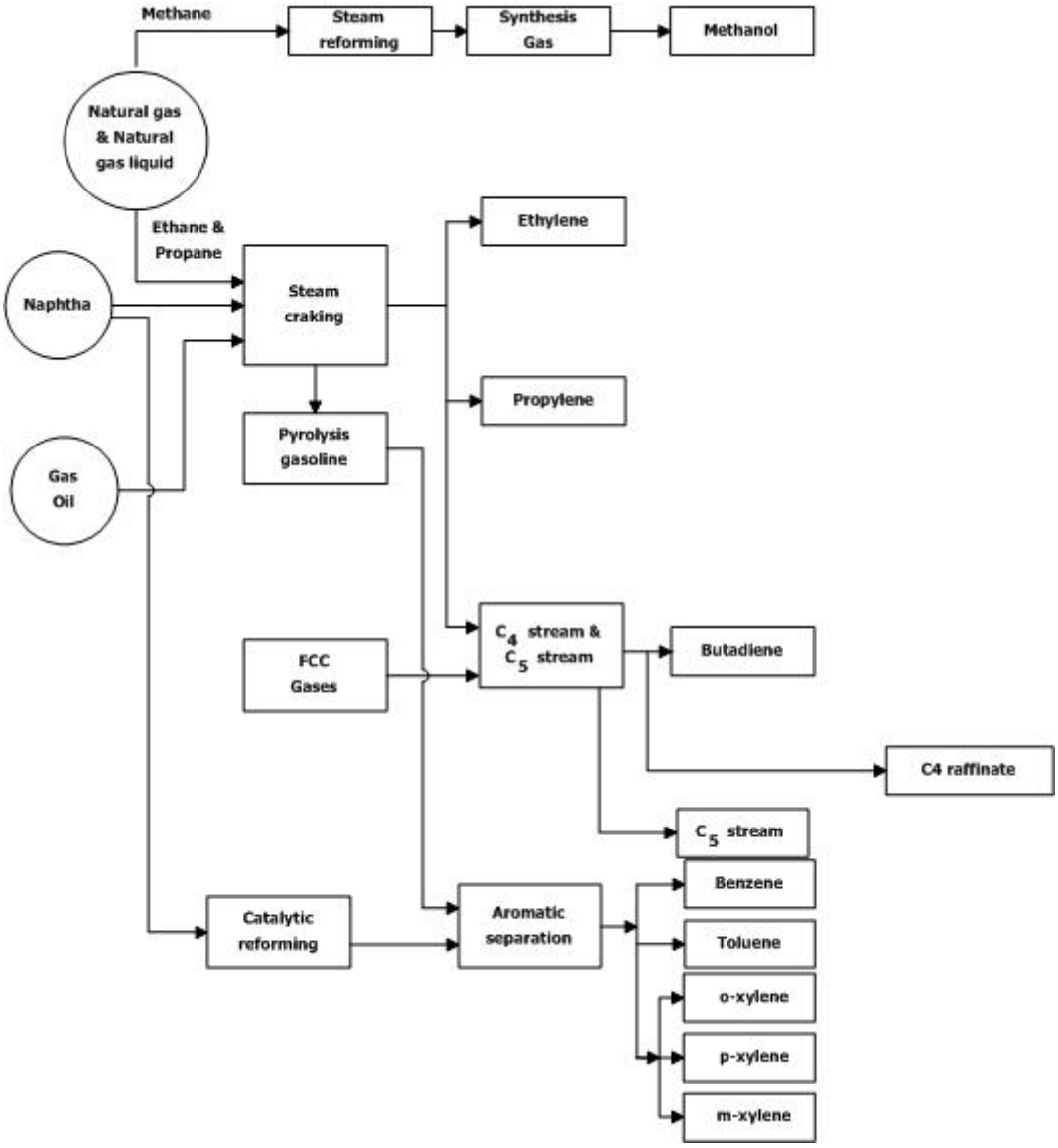

Figure 3-1: Coverage of Chemicals under Petrochemical Complexes Industry

3.1.5 Production patterns

Olefins (ethylene, propylene & butadiene) are made by cracking of natural gas, C_2/C_3 fraction of natural gas and naphtha. Currently, 59% of the country's ethylene capacity is based on gas and 40% on naphtha.

Natural gas results in higher yields of ethylene compared to other olefins. On the other hand, naphtha gives a wider range of output products (including propylene, butadiene derivatives). Use of alcohol from molasses as feedstock for ethylene manufacture is rapidly declining.

Aromatics (Benzene, Toluene & Xylene) are produced by number of processes, predominantly by naphtha reforming, as recovery products from coke oven gas and as refinery by-products. Refineries account for 47 %, whereas reformer accounts for 42 %

of total Benzene production. There has been a rapid increase in p-xylene production capacity for production of purified terephthalic acid (PTA) due to enhancement in production capacities of synthetic fibers.

3.2 Feedstock Processing

This section discusses in brief, the process description, feedstock considerations and factors affecting environmental performance. For process flow diagrams of olefins and aromatics, may please refer **Annexure II**.

3.2.1 Lower olefins production- steam cracking

The most important petrochemical process is aimed to maximize ethylene production (and associated butadiene and propylene) from the steam cracking of naphtha or ethane. The world-wide demand for lower olefins (ethylene, propylene, butenes and butadienes) is higher than any other chemical, but due to their high reactivity they are only found in very low concentrations in crude oil. It is therefore necessary to 'crack' saturated hydrocarbons into unsaturated hydrocarbons using the large-scale cracking processes.

Ethylene is a very important building block for the organic chemical industry.

Cracking is the process by which saturated hydrocarbons are converted into more sought after unsaturated species. This is a dehydrogenation reaction. In this process, suitable hydrocarbons are heated to very high temperatures, in the presence of steam, to split or 'crack' the molecules into the desired lower olefin products.

Unlike majority of the chemical industry, only a small number of international technology contractor's employ licensed equipment for crackers. These specialist contractors utilize similar generic designs, but with modifications that optimize the plant performance to local conditions (especially with respect to integrated energy efficiency). Most proprietary designs concern the furnace, but there may also be variations in the pressure and temperature of the fractionation columns; refrigeration systems (open versus closed loop); and the use of turbo expanders. Regardless of contractor or feedstock, the processes in the cracker can be broken down into three separate sections: pyrolysis; primary fractionation / compression; and product fractionation.

3.2.1.1 Feedstock considerations

The ideal feedstock for the production of ethylene by steam cracking are straight-chain normal paraffins (CnH_2n+2), where n is typically in the range 2 to 12. Apart from ethane (C_2) and propane (C_3), it is unusual to find pure component feeds. The butanes (C_4) are more often found as a mixture of normal and iso-butane isomers, whilst for C_5 and above the number of isomers increases significantly. Most producers are therefore obliged to crack mixtures of feedstock that are either gaseous (ethane, propane, and sometimes butane) or liquid (light, medium, heavy, full range naphtha, natural gas condensates).

Different feedstock produces different ethylene yields and ranges of products. Generally, as the molecular weight of a feedstock increases, the yield of ethylene decreases and other products (*e.g.,* propylene, butadiene and benzene) are produced in recoverable quantities (although the separation and purification of these co-products adds complexity and cost to the process).

Heavier petroleum fractions are also subject to more side reactions that produce tarry products and contain coke precursors. Even for a set feedstock, there is some flexibility within the cracking process to adjust the relative yields of the products by changing the cracking 'severity.

While the steam cracking process is broadly similar, each plant has a different economic optimum configuration for the producer. No feedstock can therefore be described as optimal for the production of olefins since supply-demand economics drive the relative cost of the feeds, and the value of co-products. Different types of feedstock necessitate subtle differences in equipment and operating regime to the cracking Unit Process, and these are outlined below.

Table 3-4: Feedstock based Differences in Cracking Unit Processes

Feed / Product	Gas Ethane	Gas Propane	Gas Butane / LPG	Naphtha	Gas Oil
Ethylene	79-84	42-45	30-40	23-38	23-26
Propylene	1-3	14-18	16-20	13-18	13-14
Butadiene	2	2	2.5-3	4-5	4.5-5
Butane / Butene	1	1	6.5-6.8	4-5	4.5-5.3
Aromatics	0.4	3.5	3.4	7-14	10-13

Gas feedstock

Lower olefins are often produced from gaseous feeds of ethane or propane, or, to a much lesser extent, n-butane. The cracking of ethane produces ethylene and only small quantities of products that are heavier than C_3. Ethane gives the best ethylene yield (one tonne of ethylene is produced from 1.25 tonnes of ethane) and by contrast, 2.17 tonnes of propane or 2.3 tonnes of butane are required to produce one tonne of ethylene. Field butane (a mixture of n-butane and iso-butane) can also be used as gas cracker feedstock and the iso-butane has an excellent propylene yield.

Ethane crackers are frequently operated without a de-butaniser and heavier products are used as fuel or in gasoline. The equipment for separation of heavy ends depends on the concentration of propane and/or butane in the cracker feedstock. For gas feed plants, the pygas yield is generally too low to justify the expense of a first-stage hydro-treater within the plant to make gasoline-pool product. Plants designed to crack ethane are therefore generally simpler in design than those designed to crack heavier feeds.

Naphtha feedstock

Naphtha (also known as Light Distillate Fraction or crude gasoline) describes the C_6-C_{10} hydrocarbons that boil in the gasoline boiling range of 50 - 200°C. Naphtha cracking produces a broad range of co-products (from propylene to fuel oil) and typically 3.17 tonnes of naphtha are needed to produce one tonne of ethylene. 'Light virgin naphtha' (independent of crude source) gives a high yield of ethylene at high cracking severity. In contrast, 'full-range' and 'heavy' naphthas give higher yields of aromatics, iso-paraffins, and naphthenes, and lower yields of butadiene and ethylene.

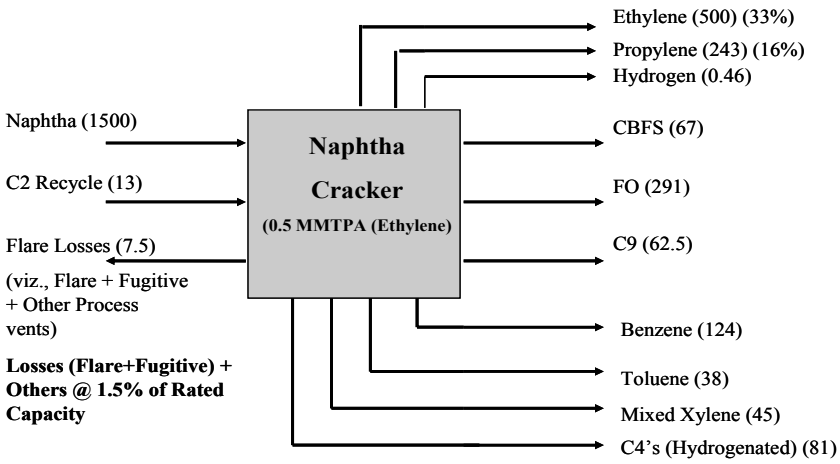

Figure 3-2: Naphtha Cracking

A typical naphtha cracking process follows the same general processing sequence as gas, but requires a higher steam/hydrocarbon weight ratio (about 0.5) to achieve proper hydrocarbon partial pressure in the cracking furnace.

Since naphtha produces large quantities of pygas and fuel oil, the cooling of cracked gas requires an additional tower to remove fuel oil constituents before the cracked gas enters water quench tower. This allows gasoline to be separated from the condensed dilution steam and hence re-vaporization of the dilution steam is practicable.

The quantity of cracked gasoline product (with 25 - 40 %w/w benzene and 10 - 15 %w/w toluene) usually justifies a hydrogenation unit to remove di-olefins as feedstock for aromatic extraction units. Alternatively, pygas may be fractionated to recover C_5 molecules for specialist applications, or heat soaked to produce a stable stream that can be blended into motor gasoline.

3.2.1.2 Process 'severity'

Several proprietary cracking technologies are available, which focus mostly on the design of cracking furnaces. Ethylene is usually the most valued product, but there will also be co-products (propylene, acetylene, a C_4 stream, aromatics in the form of pygas and byproducts (methane-rich gas, hydrogen-rich gas, C_5 compounds, pyrolysis oil, C_3 compounds, light hydrocarbons). The downstream demand for other products will influence the design selection.

'Severity' is the most significant operating variable in adjusting the yields from hydrocarbon cracking and is a function of residence time, temperature, partial pressure and feedstock. High severity (low residence time and high temperature) maximizes the yield of primary olefins and reduces the secondary reactions that promote coking. The maximum attainable severity is restricted by the physical limitations of the furnace.

At low and medium severities, primary cracking and dehydrogenation reactions predominate. They cause a sharp increase in the yield of methane, ethylene, propylene and C_4 hydrocarbons, reduction in C_5. However, at very high severity, methane and ethylene yield levels off while those of propylene and C_4 cut reach a peak and then decline. Ratio of ethylene and propylene yields increases with the severity, which hence favors the formation of ethylene.

3.2.1.3 Auxiliary chemicals & utilities

A number of auxiliary chemicals and utilities are used to support the steam cracking process and these may include:

- Dilution steam is used to reduce the partial pressure of hydrocarbons in the cracking furnaces and to reduce coke formation. It may be generated by the vaporization of primary fractionation spent water
- Sodium hydroxide, sometimes in combination with amines, is used to remove acidity from the compressed process gas
- Methanol to dry the cold circuits before start-up, or to dissolve the solid hydrocarbon hydrates
- Antifouling agents in the units for pyrolysis, compression, butadiene extraction, depropaniser and debutaniser
- Antioxidants to stabilize the butadiene
- Hydrogen to stabilize the crude gasoline, and hydrogenate the acetylenics in C_2, C_3, C_4 cuts
- Hydrogenation catalysts (generally precious metal on inert support)
- Gas drying agents (generally molecular sieves)
- A furnace for the regeneration of drying agents
- Extraction agent for butadiene recovery
- Flare systems provide safe relief in the event of plant upsets and start-up. Fuel gas is required for the flare pilot flames. Controls are needed to ensure smokeless operation
- Nitrogen for permanent or intermittent (maintenance) inerting
- Air and air plus steam for the decoking of the cracking furnaces
- Plants typically have three large compressors (one each serving the charge gas, ethylene refrigeration and propylene refrigeration) and these frequently use steam driven turbines. Steam turbine drivers may also be used for boiler feed water pumps, circulating oil pumps (naphtha and gas oil feedstock, only), circulating quench water pumps, and cooling water pumps
- Pyrolysis flue gas analyzers and other sampling systems (closed loop or to flare).

3.2.1.4 Factors affecting environmental performance

There are some specific factors that are relevant to understanding resource consumption and emission data from lower olefin processes.

Plant boundary definition and the degree of integration: A number of operations are directly associated with olefins production, including feed pretreatment, butadiene recovery or hydrogenation, gasoline heat soaking or hydro-treatment, benzene concentration or extraction and tar (residue from heavy gas oil feeds) handling. Fully integrated olefins plants using naphtha feedstock may include some or all of these associated processes within the cracker ISBL (inside battery limits), but these operations may be undertaken in separate facilities that also process streams from other plants.

Feedstock issues: Emission levels can be reported on a 'per tonne ethylene' basis. However, this can introduce problems in comparison to plant performances since the

actual emissions relate not only to ethylene production, but also to the production of other olefins, and to the feedstock selected. On a per tonne ethylene basis, emissions will tend to be lower for those plants using gas feedstock than those using naphtha and gas-oil. As a general rule, the percentage conversion of hydrocarbon to lower olefins reduces as the molecular weight of feedstock increases. For illustration, approximately 80% of ethane is converted to ethylene in the cracking process, whereas ethylene yield from naphtha is typically 30 - 35%. However, virtually no propylene (the next most important olefin) is produced from ethane cracking, whereas propylene production from naphtha can be as high as 70% of ethylene. Even when cracking identical feedstock, there is some flexibility to change the proportion of high value products by adjustment of cracking severity, according to the specific needs of the producer. Cracking severity and feedstock type can also affect operations such as furnace run length (length of time between steam/air decokes) or acetylene converter run length (time between regenerations) which can have a secondary effect on specific emissions. Industry performance benchmarking often considers other ratios such as: usage per tonne of ethylene product; usage per tonne olefins (ethylene plus propylene); and usage per tonne high value chemicals (ethylene, propylene, recovered hydrogen, butadiene and benzene).

Scale of operation: Unit capacity (measured in tonnes of ethylene production) can have an impact on specific emissions, particularly to air. The technique used to estimate non-channelled (fugitive) emissions makes no allowance for throughput or the size of the source. Since most olefin units have a similar number of unit operations and point sources, plants with a low capacity and lower ethylene yielding feedstock will tend to show a disproportionately high specific emission to atmosphere.

Plant age: Older plants tend to suffer technology disadvantages. Furnace conversion, selectivity, rotating equipment specification and overall energy efficiency are usually lower when compared to a modern plant. Older plants may have more direct emission routes for non-routine or emergency situations, *e.g.* atmospheric (as opposed to closed system) safety valve discharges. Older units may also have less well-developed energy recovery systems, compression train efficiency, control systems and high-integrity equipment to avoid fugitive emissions. Older plants can therefore have higher specific emissions than modern units. However, nearly all plants undergo some modification since their initial construction often involving improvements that directly or indirectly impact the emissions. The major refurbishment of older plants is often restricted by plant congestion and the close proximity to other plants on established complexes.

3.2.2 Aromatics

The term ‘aromatics’ is used to describe benzene, toluene, mixed xylenes, ortho-xylene, paraxylene, meta-xylene (commonly known as BTX). BTX aromatics are produced from two main feedstock: refinery reformates and steam cracker pygas. The processes that produce feedstock for aromatic plants are not selective and produce a mix of aromatics that have to be separated and purified. However, the routes to produce aromatics often have some scope for upgrading of products according to the market need (*e.g.* benzene and/or xylene from toluene, p-xylene from mixed xylenes). Aromatic production units may be physically located in either refinery or petrochemical complexes as there are close links to both activities.

Main processing schemes in aromatic production are:

- Catalytic reforming of naphtha or steam cracking of naphtha for production of pygas

- Solvent extraction for separation of non-aromatics from aromatics
- Pre-treatment of pygas, which includes two stage selective hydrogenation.
- Separation of benzene, toluene, and C_8 fractions
- Further separation of C_8 hydrocarbons – xylenes and ethyl benzene which includes separation of ethyl benzene by superfractionation and separation of p-xylene by either crystallisation or by selective adsorption.

Major units in aromatic complex are:

- Catalytic reforming
- Benzene-toluene extraction and separation
- Xylene fractionation
- Isomerization
- Para Xylene recovery using adsorption or crystallisation
- Trans-alkylation and Disproportionation

There are a large variety of plant configurations for the production of aromatics and these range from simple systems for the sole production of benzene, to complicated plants producing the whole range of aromatics. Except in some particular cases, benzene production units also co-produce toluene and xylene (which may be separated for sale as pure products or upgraded to benzene). The choice of production process is a strategic decision that depends on the feedstock availability and cost, and the demand for aromatic products. The composition of pygas and reformate feedstocks can be influenced to some extent by adjusting the operating conditions and feedstock quality of the steam crackers and reformer, but aromatics always remain secondary products of the processes to produce olefins and gasoline. Pygas and reformate are never supplied as pure cuts but, once aromatics have been extracted, the remainder of the feedstock (*i.e.,* the C_5 cut and C_6-C_8 non-aromatic cut 'Raffinate') can realize value in the car gasoline pool of refineries or can be recycled as feedstock to steam cracking plants.

Such are the variations of feedstock and desired products that each aromatic plant has an almost unique configuration. However, aromatics production from a petrochemical feedstock will utilize some, or all, of a set of closely connected and integrated unit processes that allow the separation of aromatics (from non-aromatics), the isolation of pure products, and the chemical conversion to more beneficial products.

Isolation of pure benzene from its feedstock is complex as it forms azeotropes with many C_6, C_7 and C_8 alkanes. The azeotropes can be broken using sophisticated physical separation processes. The most widely applied methods are solvent extraction followed by distillation. Many different solvents and mixtures are used in commercial liquid-liquid extraction processes. The liquid-liquid and the extractive distillation processes use selective solvents, which dissolve aromatics fraction better than the non-aromatics fraction. Solvent residuals in the raffinate (non-aromatics fraction) have to be separated and recycled. Separation of the C_8 fraction (mainly consisting of o-, m-, p-xylene and ethylbenzene) is very difficult and may use techniques such as crystallization or adsorption on solids.

The initial product streams can be converted into more beneficial products by using such techniques as:

- Toluene to benzene by hydrodealkylation (THD or HDA)
- Toluene to benzene and xylene by toluene disproportionation (TDP)
- Xylene and/or m-xylene to p-xylene by isomerization

Most of the aromatic processes are built and designed by technology providers which are typically internationally based and have been developed using the current best available techniques. The process designs do not normally incorporate venting to atmosphere. Another important aspect of most of these processes is that they are typically designed and integrated with adjacent operating units and processes.

3.2.2.1 Aromatic plant feedstock and configuration

Many different configurations and integration with adjacent facilities are possible. In order to simplify this situation, three typical aromatic plant configurations can be considered:

- Integrated olefins complex with BT (Benzene/Toluene) or BTX (Benzene/ Toluene/ Xylene)
- Integrated refinery complex with BT (Benzene/Toluene) or BTX (Benzene/ Toluene/ Xylene)
- Polyester complex based on p-xylene

An excellent source of BTX-aromatics is the pygas that is produced, in addition to ethylene, by the high-temperature, short-residence time cracking of paraffin gases and naphthas in cracker plant. According to the cracking severity, pygas typically contains 20–40 % benzene, 16–20 % toluene, 10-13 % higher aromatics (*e.g.,* ethyl benzene, styrene, xylenes), with a balance of non-aromatic hydrocarbons (mainly olefins and diolefins).

Reformate is produced in refineries by the hydrotreatment of naphtha (to remove sulphur and nitrogen) followed by catalytic reforming (to optimize aromatics generation). The resulting reformate is separated by distillation into three aromatic cuts (C_7, C_8 and $C_9/_{10}$) for use as feedstock in aromatics plant. Various catalytic reformers available are: semi-regenerative fixed bed reactors, cyclic fixed bed reformers and continuous reformers

The C_6-C_7 cut is treated by liquid-liquid extraction or extractive distillation to produce pure benzene and toluene cuts. The raffinate is recycled to the refinery or to a steam cracking plant. The C_8 cut is used as the source of para-xylene. Xylene isomers have similar boiling points (138 - 144°C) and so it is not possible to separate para-xylene by distillation. Separation is therefore affected by adsorption (often in a continuous circulating bed) or crystallization (taking advantage of the different melting points of para-xylene and the other xylene isomers). Once depleted of para-xylene, the mixed isomer stream may undergo isomerization to convert the ortho and meta isomers into additional para-xylene. The C_9/C_{10} cut is mixed with the toluene cut and undergoes a transalkylation to yield mixed xylenes (for recycle to the para-xylene separation step) and benzene (for purification in the distillation unit).

This standard process configuration can be modified to meet particular market needs, for example:

- Toluene (and the depleted xylenes cut) can undergo hydro-dealkylation to generate additional benzene (by subsequent distillation)
- Toluene may undergo disproportionation to produce more valuable benzene and xylenes
- Pure o-xylene may be distilled and sold as marketable product

- The xylenes cut can be sold or shipped as feedstock for o-m-p xylene production plants
- Pure m-xylene may be extracted and sold as a marketable product.

3.2.2.2 Auxiliary chemicals

A number of auxiliary chemicals are used in the processes of producing aromatics:.

- Hydrogen to prepare the feedstock (olefins and di-olefins conversion), to convert higher aromatics into benzene by HDA, and to convert benzene into cyclohexane
- Hydrogenation catalyst (for liquid or gas phase reactions)
- Other catalysts (for disproportionation, isomerization)
- Adsorbents (for xylene separation)
- Clay (for olefins removal)
- Solvents (for benzene extraction and para-xylene extraction)
- Fuel gas (consumed and produced)
- Nitrogen (for inerting, blanketing)
- Process water (to improve the benzene extraction solvent performances)
- Steam (flare, ejectors)
- Process chemicals (*e.g.,* inhibitors, stabilizers)

3.2.2.3 Factors affecting environmental performance

Demand for aromatic products varies and the resulting differences in process configuration make it difficult to describe the consumption and emission levels from aromatics plants.

Two significant factors for aromatics plants are the definition of plant boundaries and the degree of integration with upstream and downstream processes. Plants are usually described in terms of equipment and process units inside battery limits (ISBL) and outside battery limits (OSBL). But aromatics plants are complicated because they involve several different processing steps (each with their own boundaries) that may be located in different parts of a chemical or refinery complex.

Systems such as wastewater treatment and flares are typically optimized over a complete chemical complex. Integration with other process units may allow the waste streams to be recovered more efficiently or utilized by other processes within the chemical or refinery complex in the most profitable manner. Vent streams, sometimes containing large concentrations of hydrogen or other valuable components, are typically recovered and re-used within the adjacent refinery or chemical plant.

Emissions from various processes differ based on the process conditions, equipment and control systems. The complexity and different products produced in an aromatics complex affect energy consumption. In addition to the local factors described earlier, the energy consumption will depend on the aromatics content of the feedstock, the extent of heat integration and the technology.

The petrochemical industry is a complex and is an integrated industry that includes a large variety of processes and products. Because of a large number of processes, use of wide variety of raw materials, catalysts, additives, chemicals, presence of explosives and hazardous materials, the problem of environmental pollution from petrochemical industries is also quite complex. A wide variety of pollutants is discharged into water stream and emitted into the environment. Emissions from petrochemical complex can be

classified into four major categories: emissions from storage and handling units, process emissions, fugitive emissions, and secondary emissions.

Table 3-5: Pollutants into Water and Air Environment from Various Processes in Petrochemical Complex Production

Units in Petrochemical Industry	Pollutants
Cracker plant	Inorganic sulphides, mercaptans, soluble hydrocarbons, polymerised product, phenolic compounds, sulphide, cyanide, heavy oils, coke, spent caustic, SO_x, NO_x, hydrocarbons, particulates, water borne waste containing BOD, COD, Suspended solid, oil.
Aromatic plant	Dissolved organics, volatile organic compounds, heavy metals, hydrocarbons, particulates, H_2S, SO_x, NO_x, CO, water borne waste containing BOD, COD, suspended solid, oil & grease, toluene, benzene, xylenes, HCl, chlorine, cadmium.

3.3 Water and Wastewater Management

The quantity and characteristics of wastewater generated from a petrochemical complex is strongly dependent on individual process plants operating at the complex. Wastewater generated from ethylene cracker and aromatic plants are discussed in subsequent Sections.

3.3.1 Sources of wastewater generation

3.3.1.1 Ethylene crackers

There are three effluent streams that are specific to the steam cracking process, namely: process water, spent caustic and decoke drum spray water (where installed). In addition, cooling or boiler water blowdown, surface or maintenance water may also be generated. The main potential pollutants include: hydrocarbons; dissolved inorganic solids and particulates; materials that may exert a chemical or biological demand for oxygen; and trace quantities of metal cations. Major water and air pollutants are inorganic sulphides, mercaptans, soluble hydrocarbons, polymerised product, phenolic compounds, sulphide, cyanide, heavy oils, coke, spent caustic, SOx, NOx, hydrocarbons, particulates, water borne waste containing BOD, COD, suspended solids, and oil. Oily water is the main source of liquid effluent from cracker plant. Liquid effluents like pygas, pyrolysis fuel oil quench water, process water stripper bottoms give peculiar odour.

Process Water: In the steam cracking process, hydrocarbons are cracked in the presence of dilution steam to improve reaction selectivity to the desired olefin products. This steam is then condensed, and has to be removed from the furnace products before they can be further processed and separated. Process water refers to the bleed of condensed dilution steam. The process water may contain phenol and other dissolved or suspended hydrocarbons. Most of the crackers utilize some form of Dilution Steam Generation (DSG) to enable up to 90 % of the process water flow to be recovered and recycled to the furnaces. The emission factor of crackers including a DSG is within 0.03 to 2 cubic metres per tonne (m^3/T) of ethylene, while the range is 0.03 to 7 m^3/T ethylene for the whole population of crackers.

Spent caustic: Acid gases (carbon dioxide, mercaptans, hydrogen sulphide) are scrubbed from the process stream (cracked gas compression system) using sodium hydroxide (caustic). Spent caustic is purged from the base of the caustic wash tower. The exact volume and composition of spent caustic are directly linked to sulphur content in the feedstock but also depends on the cracking severity and operation of the caustic tower. Spent caustic contains sulphides, phenols, BOD, COD, oil, *etc*. The COD before treatment is typically in the range of 20–50 grams per litre (g/l) and other components are:

- Sodium hydroxide (0.5 - 5.0 % wt)
- Sodium sulphide (0.5 - 5.0 % wt)
- Sodium carbonate (0.5 - 10.0 % wt)
- Dissolved hydrocarbons (0.1 - 0.3 % wt) including up to few hundred ppm of benzene
- Liquid phase hydrocarbons may be present (including phenols and cresols if naphtha cracker)
- Carbonyls, mercaptans, cyanides and dienes in smaller quantities.

The hydrocarbon contaminants in the spent caustic include carcinogenic benzene and diolefins, which make it hazardous. Presence of carbonyls and diolefins may cause spent caustic to be a solution with foul smell. The sulphide content of this aqueous stream is typically 10 g sulphide/te ethylene. The total salt content is reported as 0.12 to 1.10 kg/te ethylene where air oxidation is used and 1.3 to 6.0 kg/te ethylene where acidification is used. Plants using air oxidation for treatment of the spent caustic stream will tend to have a higher total salt loading than those employing acid neutralization.

Typical dilution steam/hydrocarbon feed ratios are 0.5/0.6 to 1 in the furnace feed for liquids and 0.3/0.5 for gas crackers. On per tonne of ethylene basis, the range is therefore between 1 T/T and 4 T/T. With no dilution steam generation, the contribution of process water stream to the total wastewater flow from the plant is therefore also between 1 and 4 m^3/T ethylene. Dilution steam generation systems are typically designed to recycle around 90 % of the process water (*i.e.,* a 10 % purge rate), which would therefore reduce the contribution to aqueous effluent from this source to 0.1 to 0.4 m^3/t ethylene.

3.3.1.2 Aromatics plants

Water may be used in the process to recover small amounts of solvent remaining in the raffinate streams, and stripping steam is used in stripping columns to separate heavy aromatics from the solvent. Process water within aromatics plants is generally operated in closed-loops. Water input, as either steam or water, is sometimes required to account for losses to raffinate and product streams.

In aromatics processes there is generally little or no continuous wastewater stream, but the exact quantity depends on the plant configuration. The main wastewater source is process water recovered from condensates of the steam jet vacuum pumps and overhead accumulators of certain distillation towers (due to the water content of the feedstock or water added to improve extraction efficiency). These streams contain small quantities of dissolved hydrocarbons and are generally drained to a central treatment facility. Wastewater containing sulphide and COD may also arise from any caustic scrubbers. The only other sources are unintentional spillages, purge of cooling water, rainwater, equipment wash-water, which may contain extraction solvents and aromatics. Water generated by tank drainage and process upsets may contain aromatics. Wastewater

containing hydrocarbons may be collected separately, settled and steam stripped prior to biological treatment.

Dissolved organics, VOCs, heavy metals, hydrocarbons, particulates, H_2S, SOx, NOx, CO, water-borne waste containing BOD, COD, suspended solids, oil & grease, toluene, benzene, xylenes, HCl, chlorine, cadmium.

3.3.1.3 Other specific common wastewater streams

Pump and compressor cooling: Some amount of water-cooling will be used for hot pump pedestals, glands as well as compressor jackets. Additionally, some water and/or oil may be use in pump and compressor seals. The drips and drains from these systems constitute another source of 'oily drain water' and will normally have low solids content.

Paved utility area drains: These waters will usually be non-oily and from sources within the boiler plant, water treating units, air compression units, *etc*. Thus, these waters will normally be defined as 'high solids clean water'. Should the utility area include oil handling equipment such as fuel oil pumps, then these waters should be defined as 'high solids oily drain water'.

Boiler blowdown and water treating rinses: These waters will be non-oily and high in dissolved solids. Hence, these waters are 'high solids clean water'.

Cooling water: A process plant may employ once-through cooling water or circulating cooling water systems (or perhaps both may be used in large plants). If the tubes in the water-cooled heat exchangers develop leaks, then these waters are liable to contamination with the process fluids. If the process fluids are volatile enough to vaporize readily (pentanes or lighter), then the risk of oil contamination in the cooling water is quite negligible.

If the cooling water is once through, then the cooling water discharge is low in dissolved solids. However, if the cooling water is circulated in a closed system with a cooling tower, the blowdown from the system will be high in dissolved solids.

Categories of cooling water are:

- Once through cooling water (light ends) – this will be 'clean cooling water' and will be non-oily.
- Once through cooling water (oil) – this will be 'oily cooling water' to acknowledge the possibility of exchanger tube leaks of non-volatile oil.
- Circulating cooling water blowdown (light ends) – this will be 'high solids clean cooling water' and will be non-oily.
- Circulating cooling water blowdown (oil) – this will be 'high solids oily cooling water' to acknowledge the possibility of exchanger tube leaks of non-volatile oils.

3.3.2 Control & treatment technology

The control technology is to be based upon the most exemplary combination of in-process and end-of-process treatment & control technologies. This level of technology is primarily based upon significant reductions in the COD, as well as the BOD.

End-of-pipe treatment in this case will be biological plus additional activated carbon treatment. The techniques that can be applied to new plants and to existing facilities will differ. In existing plants, the choice of control techniques is usually restricted to process-integrated (in-plant) control measures, in-plant treatment of segregated individual streams and end-of-pipe treatment. New plants provide better opportunities to improve environmental performance through the use of alternative technologies to prevent wastewater generation.

An appropriate control strategy for wastewater from the Petrochemical industry can be summarized as:

- Organic wastewater streams not containing heavy metals or toxic or non-biodegradable organic compounds are potentially fit for combined biological wastewater treatment (subject to an evaluation of biodegradability, inhibitory effects, sludge deterioration effects, volatility and residual pollutant levels in the effluent)
- Wastewater streams containing heavy metals or toxic or non-biodegradable organic compounds (*e.g.* indicated by high AOX /EOX or high COD/BOD ratios) are preferably treated or recovered separately. Individual waste streams containing toxic or inhibitory organic compounds or having low bio-degradability are treated separately *e.g.* by (chemical) oxidation, adsorption, filtration, extraction, (steam) stripping, hydrolysis (to improve biodegradability) or anaerobic pre-treatment.

General prevention techniques

Before considering wastewater treatment techniques, it is first necessary to fully exploit all the opportunities for preventing, minimizing and reusing wastewater. However, water use, effluent generation and effluent treatment are all intrinsically linked and should be considered in combination. A typical exercise in preventing wastewater may include the following steps:

Step 1: Identify wastewaters - The first step is to identify all wastewater sources from a process and to characterize their quality, quantity and variability. Pareto analysis is useful to identify those sources that use most water and contribute most wastewater. Further clarification is provided by the preparation of plans that show all drain networks, points of arising, isolation valves, manholes and points of discharge.

Step 2: Minimize water flows - The overall aim is to minimize the use of water in the process in order to obviate effluent production or, if that is not possible, to produce more concentrated effluents. It will be necessary to identify minimum quantity of water that is needed (or produced) by each step of the production process and then to ensure that these requirements are implemented by such practices as:

- Use of water-free techniques for vacuum generation (*e.g.*, use the product as a sealing liquid in vacuum pumps, use dry pumps)
- Employ closed loop cooling water cycles
- Use management tools such as water-use targets and more transparent costing of water
- Install water meters within the process to identify areas of high use

Step 3: Minimize contamination - Wastewaters are created by contamination of process water with raw material, product or wastes; either as part of process operation, or unintentionally. The following techniques can prevent this contamination:

Process operation:

- Use indirect cooling systems to condense or cool steam phases (not direct injection systems)
- Use purer raw materials and auxiliary reagents (*i.e.*, without contaminants)
- Use non-toxic or lower toxicity cooling water additives (*e.g.,* chromium based additives).

From spills:

- Fit secondary containment to vessels and pipe-work that pose a high risk of leaks
- Provide spill clean-up material (adsorbents, booms, drain plugs, *etc.*) at strategic points around the installation and prepare spill contingency plans
- Use separate collection systems for process effluent, sewage and rainwater (although there may be cases where the blending of effluent streams offers treatment advantages)

Step 4: Maximize wastewater reuse - Even when wastewaters are created they do not necessarily have to be sent to a treatment plant. To identify options for re-use it is first necessary to define the lowest water quality that can be used for each activity in the process.

Wastewater reuse may be achieved by refining and reusing (rather than disposing of) mother liquors; reusing wastewater in the process (*e.g.*, for raw material make-up) and reusing wastewater for other purposes (*e.g.,* equipment cleaning).

Abatement techniques

The selection of appropriate treatment technologies requires detailed consideration of physical and chemical nature of all the wastewaters. The chosen treatment technique may involve a combination of physical, chemical and biological methods. The following paragraphs give brief, generic descriptions of typical wastewater streams that originate from petrochemical processes and the possible treatment techniques.

Acid/alkaline effluents: A suitable neutralizing agent can be added to adjust pH. Wherever possible, other wastes (and not virgin raw materials) should be used for neutralization. In some cases the acid dosing of effluents may release toxic gases.

Mixtures of oil/organics and water: The two phases can be separated using such techniques as tilted plate separators, American Petroleum Institute (API) separators, air flotation, coalescing agents or hydrocyclones.

Biodegradable organics: Biodegradable material (as measured by BOD) may be biologically degraded, normally using aerobic microbial activity (but anaerobic activity has applications as a pre-treatment technique). The treatability of effluent will depend on the presence of inhibitory materials, the absence of necessary nutrients, the pollutant concentration and pollutant variability. The steam or air stripping of volatile components may be required in preparation for biological treatment.

High organic load: Conventional aerobic or anaerobic biological treatment may not be applicable to effluents with high organic concentrations if they are toxic or difficult to

degrade. It may be necessary to use various forms of extreme oxidation such as incineration or wet oxidation. All techniques have significant capital and operating costs.

Recalcitrant organics: Recalcitrant organics are organics that are not efficiently removed by biodegradation but may be removed efficiently by appropriate pre-treatment or incineration. This refers to single substances and to tributary effluents with BOD:COD <4. Some long chain aliphatics, aromatics and highly chlorinated compounds are difficult to biodegrade and may need to be treated by activated carbon adsorption, other adsorption techniques, hydrolysis, filtration or advanced oxidation techniques. The amenability to biological treatment can be improved by steam or air stripping to remove the volatile components. Where the volatiles are chlorinated species the off-gases are passed to an incinerator.

Suspended solids: Solids may need to be removed as a precursor to further treatment or as a polishing step prior to discharge. The techniques include settlement, flotation, precipitation and filtration. The solids produced by these techniques will need to be dewatered and dried prior to disposal. Removal efficiencies can be improved by the use of coagulants and flocculants.

Metals: Metals may occur in effluents, for example, through the use of catalysts. Metals generally need to be removed by separate treatment, because they cannot be removed efficiently in biological treatment plants. The impact of heavy metals on a biological treatment facility must be evaluated with regard to inhibitory effects, sludge deterioration effects and residual pollutant levels in the effluent. Whenever unacceptable effects are expected, the individual wastewater stream needs separate treatment or central (combined) special treatment, using such treatment methods as chemical precipitation (creating a sludge that may allow metal recovery), ion exchange, electrolytic recovery or reverse osmosis. Metals also make the re-use of biosludge (*e.g.* in agriculture) more difficult.

Control and treatment technologies used in petrochemical industries can be divided into two broad classes:

- In plant source control
- End of pipe treatment

In-plant source control affords two major benefits:

- The overall reduction of pollutant load that must be treated by an end-of-pipe system
- The reduction or elimination of a particular pollutant parameter before dilution in the main wastewater stream

Highly contaminated spent caustic waste generated in the petrochemical industries requires specific treatment before mixing with the end-of the pipe treatment.

In-plant processes

All in-plant treatment options require segregation of the process waste streams under consideration. If there are multiple sources of particular pollutant or pollutants, they all require segregation and also require combining them into few manageable groups for respective treatment before routing to the end-of-pipe-treatment facility.

In-plant practices are the sole determinant of the amount of wastewater to be treated. There are two types of in-plant practices that reduce flow to the treatment plant. First,

there are reuse practices involving the use of water from one process in another process. Second, there are recycle systems that use water more than once for the same purpose. Some of the In-plant measures are:

- Dilution Steam Generator (DSG) and associated facility in cracker units
- Elimination of once-through barometric condenser water
- Sewer segregation to separate uncontaminated storm water runoff and once through cooling waters
- Elimination of contaminated once-through cooling water, either by replacement of the once-through cooling system with an air-cooled/ cooling tower recycle system or by careful monitoring of the once-through cooling system and tightening of the system to reduce losses of hydrocarbons to the cooling water
- Replacement of water-cooled equipment with air-cooled equipment wherever practical
- Use of treated process wastewater as cooling water, scrubber water, and influent to the water treatment plant
- Use of closed cooling water systems on compressors and pumps
- Reuse of boiler condensate as boiler feed water

In-plant practices have not been documented for the Indian petrochemical industries. MINAS development does take into account the in-plant practices prevailing at that time. However, the environmental statements also do not report these practices. It is recommended that all these practices also be covered in the environmental statements and format suggested incorporates these aspects.

End-of-pipe treatment

Effluent treatment facility after having required individual stream-specific treatment, in general include a scheme comprising:

- Primary treatment including equalization, oil removal
- Biological treatment

To further improve quality of effluent, processes grouped under tertiary category are to be used for removal of critical pollutants, in view of receiving environment considerations.

Tertiary processes generally considered for petrochemical wastewater are membrane separation processes, and activated carbon.

Further, the control technology can be utilized to achieve following objectives:

- Reduction in effluent flow
- Reduction in concentration of pollutants

Levels of treatment technologies, for petro-chemical industries may include following:

- Level I : Primary Treatment
- Level II : Secondary Treatment
- Level III : Advanced Secondary treatment

- Level IV : Tertiary treatment
- Level V : Advanced Tertiary Treatment
- Level VI : Zero Discharge

Wastewater reduction and reuse

Reduction in water usage sometimes may be more cost effective in reducing the quantity of wastewater discharged than water reuse or recycle. Good housekeeping is one inexpensive method of wastewater reduction. Instead of repeating the well-known good practices followed for wastewater reduction the emphasis in this report is on improving reporting norms so as to enable benchmarking and provide an impetus to the efforts of reducing water consumption through spread of best practices.

Many wastewater streams are suitable for reuse within the plant. However, reuse of wastewater requires investigation on a plant-by-plant basis to determine the technical and economic feasibility.

Wastewaters emanating from end-of-pipe treatment facilities, particularly those having tertiary treatment are generally of such quality that reuse can be quite attractive. In general following are the major reuse options:

- Properly treated wastewater can be recycled as make-up to the cooling-tower system. There are various factors determining the least costly system including
  - Cost of fresh water
  - Level of contaminants in treated effluents and acceptable level in the cooling tower
  - Cycle of concentration with and without recycle of effluent
  - Chemical treatment program required for recycling (particularly for plants which have already minimized cooling tower blowdown)
- Recovery and reuse of condensate streams
- Reuse for fire water systems

Spent caustic management

Spent caustic is generated when hydrocarbons are scrubbed in Caustic Wash Tower to remove acid gases. The acid gas components include CO_2, Hydrogen Sulfide (H_2S), and mercaptans. The spent caustic effluent generated from petrochemical plants mainly contains sulfides, carbonates, naphthenates and other similar organic and inorganic compounds.

Spent caustic has a strong impact on the environment. These compounds are possible causes of water pollution from standpoint of toxicity, BOD, taste, odor, pH and appearance. The strength of spent caustic in terms of COD is usually quite high.

Processes available for treatment of spent caustic are:

- Stripping after acidification.
- Oxidation

  - Wet air oxidation, which can be performed in different conditions of temperature and pressure, generally confined to the S_2O_{32}- state and less often reaching the SO_{42}- state
  - Oxidation using Hydrogen Peroxide
  - Oxidation using Ozone/Permanganate/Chlorine
- Precipitation using Chlorinated Copperas
- Incineration

Theoretically, the first process requires re-neutralizing the acid effluent after it has been stripped and is more expensive in reagents. Meanwhile, the oxidation process is supposed to allow some recycling of the oxidized spent caustic which is still highly alkaline. In practice however, the first process requires less investment and also performs partial phenol removal from the phenolic spent caustic.

The oxidation process using hydrogen peroxide, as such has no drawbacks and is quite efficient but is high in costs. Oxidation using Chlorinated Copperas has been widely used but has a serious drawback of sludge formation requiring elaborate handling.

Oxidation using Chlorine/Permanganate/Ozone is not popular due to hazardous emissions and/or costs involved.

Many petrochemical complexes utilize Wet Air Oxidation.

Ultimate disposal methods

The ultimate mode of disposal depends on several factors *i.e.,* achievable level of the treated wastewaters, receiving media and its assimilative capacity, compatibility with equipment usage, *etc*.

3.4 Air Pollution

Atmospheric emissions from petrochemical processes can be broadly categorized into channelised (Ducted) and fugitive emissions. Only ducted emissions can be routed to the control devices for treatment. As far as diffuse and fugitive emissions are concerned, the objective of control is their prevention and/or minimization (*e.g.*, improved process equipment with least fugitive emissions; and by capturing them in a ducted system).

- Channalised emissions include:
  - Process emissions released through a vent pipe by the process equipment and inherent to running of the plant
  - Flue gases from energy-providing units such as process furnaces, steam boilers, combined heat and power units, gas turbines, gas engines
  - Waste gases from emission control equipment, such as incinerators or adsorbers, likely to contain unabated pollutants or pollutants generated in the abatement system
  - Tail gases from reaction vessels and condensers
  - Waste gases from catalyst regeneration
  - Waste gases from solvent regeneration

  - Waste gases from vents from storage and handling (transfers, loading and unloading) of products, raw materials and intermediates
  - Waste gases from purge vents or pre-heating equipment, which are used only on start-up or shutdown operations
  - Discharges from safety relief devices *(e.g.* safety vents, safety valves)
  - Exhaust from vents from captured diffuse and/or fugitive sources*, e.g.* diffuse sources installed within an enclosure or building.
- Diffuse emissions, arising from point, linear, surface or volume sources under normal operating circumstances include:
  - Emissions from the process equipment and inherent to running of the plant, released from a large surface or through openings, *etc.*
  - Non-ducted emissions (*e.g.* working losses and breathing losses, when not captured and ducted) from storage equipment and during handling operations (*e.g.* filling of drums, trucks or containers)
  - Non-routine emissions, resulting from operations other than routine processing of the facility, including emissions during start-up or shutdown, and during maintenance
  - Emissions from flares
  - Secondary emissions, resulting from handling or disposal of waste (*e.g.,* volatile material from sewers, wastewater handling facilities or cooling water).
- Fugitive emissions such as:
  - Equipment leaks from pump and compressor seals, valves, flanges, connectors and other piping items, or other equipment items, such as drain or vent plugs or seals.

The main air pollutants from petrochemical processes and energy supply are:

- Sulphur oxides (SO_2, SO_3) and other sulphur compounds (H_2S, CS_2, COS)
- Nitrogen oxides (NOx, N_2O) and other nitrogen compounds (NH_3, HCN)
- Halogens and their compounds (Cl_2, Br_2, HF, HCl, HBr)
- Incomplete combustion compounds, such as CO and CxHy
- Volatile organic compounds (VOC) which might encompass compounds with carcinogenic potential
- Particulate matter (such as dust, soot, alkali, heavy metals) with possible carcinogenic properties.

The main category of air pollutants from the production of Petrochemicals are combustion emissions, VOCs and acid gases.

Raw material supply and work-up

- Vents on distillation columns and stripping columns for removal of impurities in raw materials
- Vents on pre-mixing vessels (VOCs, particulates)

Synthesis

- Discrete vents serving reaction equipment (*e.g.,* purges, inert vents from condensers, letdown vessels, process scrubbers)
- Vents associated with catalyst preparation and catalyst regeneration (containing VOCs, NOx, SOx)
- Relief devices to maintain safe operation *(e.g*., pressure relief valves, bursting discs).

Product separation and refinement

- Vents serving separation equipment (*e.g.,* distillation columns, stripping columns, crystallisers, condensers)
- Particulate from drying and handling of solids
- VOCs from the regeneration of purification beds
- Solvent regeneration.

Product storage and handling

- Tank losses from displacement during filling and breathing during ambient temperature changes (mainly VOCs with rate of loss depending on vapour pressure)
- Loading/unloading of containers and vessels (tankers for road, rail and boat)
- Blanket gases used in storage tanks
- Evaporative losses from spills.

Emission abatement

- Waste gas combustion units (*e.g.,* flares, incinerators)
- Stripping of wastewater (with air or steam) will transfer dissolved organics into the gaseous phase
- VOCs from wastewater collection systems (*e.g*., drains, balancing tanks)
- VOCs from wastewater treatment facilities
- VOCs and particulates from storage and treatment of solid wastes.

Energy / utilities

- Combustion units are widely used for raising steam, heat and electricity (*e.g.,* process heaters, furnaces).

Atmospheric Emissions from Specific Processes are discussed in subsequent sub-sections.

3.4.1 Ethylene cracker

Steam cracking is the heart of petrochemical operations. The sources of atmospheric emission in ethylene cracking process are:

Furnace area (steady state operation): The furnace area is defined as that part of the process comprising pyrolysis heaters, complete with heat exchange equipment for generating high pressure steam, and any separately fired steam superheaters. It excludes

auxiliary boilers and regeneration furnaces. In volume and pollutant terms, the most significant emissions to air result from the combustion of fuels in the pyrolysis cracking furnaces. The operating conditions of cracking furnaces are frequently changed in order to provide the desired product distribution and this may affect optimal control of the combustion process.

Furnace area (decoke operations): All cracking furnaces require periodic de-coking to remove carbon build-up on the radiant coils. The carbon layer acts as an insulator, and requires the use of higher tube metal temperatures to maintain desired feedstock conversion. At a pre-determined level, dictated by the coil metallurgy, the furnace must be de-coked to restore its performance and carbon is burned to carbon dioxide. Number of cycles varies significantly with different feedstock, coil configurations and the operating severity, but it is typically in the range 14-100 days. It should be noted, however, that the extent of coke build-up is time dependent, so those furnaces requiring frequent de-cokes will generally have a much lower coke build-up than those with extended cycles. De-coking emissions are not monitored by dedicated equipment (*e.g.*, online analysers) since furnace de-coking is an infrequent operational mode (typically only 3 % of the time). During the de-coking phase, process control is important to minimize particulate emissions and there is typically visual inspection of the emission point and close supervision of process parameters (*e.g.*, temperatures).

Flaring: All crackers are provided with flare gas systems to allow safe disposal of any hydrocarbons or hydrogen that cannot be recovered in the process. This is particularly the case during unplanned shutdowns, and during start-ups, when the intermediate streams have not reached the compositions required to enable the production of full-specification products.

VOCs from point sources: During normal operation there are very few VOC emissions from the cracking process because they are recycled into process, used as a fuel or routed to associated processes on an integrated site. Elevated VOC emissions from ethylene plants are intermittent, but occur during plant start-up and shutdown, process upsets and emergencies. VOCs may be emitted from pressure relief devices, intentional venting of off-specification materials or depressurizing and purging of equipment for maintenance. In general, intermittent emissions, all pressure relief devices, and emergency vents are routed to flare. The relief valve from demethaniser usually vents to atmosphere, but the valve is not operated very frequently and results in emissions of hydrogen and methane.

Fugitive emissions: Steam crackers are large complex units that have a high number of components with potential to give rise to fugitive emissions. Fugitive emissions may arise from valve glands, pipeline flanges, open-ended (non-blanked) lines, pressure relief valves and other piping components, in addition to the pump/compressor seals and sample points. Many of the process streams are light (containing at least 20 % of substances with vapour pressure greater than 300 Pa at 20 ºC) and at high pressure (1500 - 3000 kPa). Fugitive losses can therefore constitute a significant proportion of overall steam cracking process emissions and there are examples reported in literature of fugitive emissions accounting for two-thirds of total VOC emissions.

Hence, hydrocarbons from steam cracking unit are mostly emitted due to leakage and flaring of the residual gases. VOC emissions from steam cracking are composed of paraffins, ethylene, olefins (including propylene) and other hydrocarbons.

3.4.2 Aromatics plants

The major sources of atmospheric emissions from aromatics plants are:

Catalyst Regenerator vents: Depending on the feedstock availability some of the aromatic plants may be based on Reformer units within the complex. The reformer may be semi-regenerative or continuous regeneration type. In the regeneration process of catalyst in the continuous reforming unit, a slip stream of catalyst is withdrawn, the coke is burned off, with hot air/steam, trace quantities of a promoter, normally an organic form of chlorine (such as tri or perchloroethylene) are added to retain catalyst activity, moisture is removed and the regenerated catalyst is returned back to the reformer. In the cyclic or semi regenerative units, regeneration of catalyst and consequent emissions are discontinuous. The off gas from regenerator contains, steam, air, hydrocarbons, CO_2, HCl, H_2S a small quantity of catalyst fines, traces of Cl_2, CO, SO_2 and dioxins and furans.

Hydrogenation reactions: The continuous vents from hydrogenations (pygas hydrostabilisation, cyclohexane reaction) may contain hydrogen sulphide (from the feedstock desulphurisation), methane and hydrogen. The off-gas is normally discharged to a fuel gas network to recover calorific value. If necessary, for example, under emergency conditions, the off-gas may be flared giving emissions of CO, NOx, VOC and particulates, depending on the gas composition, as well as the flare type, size and load.

Dealkylation reactions: The dealkylation off-gases can be separated in a hydrogen purification unit to produce hydrogen (for recycle) and methane (for use as a fuel gas).

Combustion emissions: The heating furnaces will give rise to combustion gases. Fired heaters which are used in industries producing petrochemical complexes may be major source of sulphur emission as they use fuel oil. Fuel oil desulphurisation, flue gas desulphurisation and use of low sulphur fuel may be some of the methods/options to reduce sulphur emissions from these industries.

VOCs: There are usually no continuous VOC emission sources on aromatics plants, although some plants may use vacuum systems that have a continuous air emission. Most VOC emissions are normally from fugitives (*e.g.*, valve, flange and pump seal leaks) and from non-routine operations (maintenance, inspection). Also due to lower operating temperatures and pressures, the fugitive emissions from some aromatics processes are considerably less when compared to other petrochemical processes where higher temperatures and pressures are employed. The quantification of fugitives is dependent on the calculation method, but some documents consider that a release of 50 t/ year of hydrocarbons (including benzene) is a plausible order of magnitude for non-routine emissions from a typical aromatics installation.

VOCs may also arise from storage tank breathing losses and displacement of tanks for raw materials, intermediate products and final products. The VOCs may be aromatics (benzene, toluene), saturated aliphatics (C_1–C_4) or other aliphatics (C_2–C_{10}).

3.4.3 Control technologies for air emissions

The treatment of air emissions normally takes place on-site and usually at the point of generation. Waste gas treatment units are specifically designed for a certain waste gas composition and may not provide treatment for all pollutants. The petrochemical industry has increasingly reduced the emissions from point sources, and this makes losses from fugitive sources relatively more important.

Petrochemical processes usually operate with closed process equipment because of reactant/product characteristics (*e.g.,* high volatility, high toxicity, high hazard risk), and reaction conditions (*e.g.*, high temperatures and pressures) and this has associated environmental benefits.

Special fields of attention with regard to air emission prevention are:

- Raw materials and fuel composition;
- Required volume of process air;
- Presence of, and need for, inert gases in the process (*e.g.*, N_2 from ambient air);
- Energy consumption and the combustion conditions.

As mentioned, the major concern in atmospheric emissions from petrochemical complexes is emissions of VOCs. Release of toxic/hazardous components and their impact on plant surroundings needs special attention. The petrochemical industry is characterized by toxic / hazardous chemicals that are handled and processed in large volumes and so external safety is an important issue.

3.4.3.1 VOCs

Generally the control on hydrocarbon emissions has been attempted by employing equipment design standards, control technologies and inspection/maintenance requirements.

Improved technology has a great potential in fugitive emission control. In recent years, manufacturers of seals, packing, and gaskets for process equipment have designed their products to control fugitive vapor leaks. These more effective seals, packing, *etc.,* are expected to result in lower emissions and lower costs for monitoring and maintenance programs. Hydrocarbon emissions can pose not only environmental risk but also safety risks. Indian petrochemical industries have been following inspection routine to ensure that any leaks do not lead to incidents. In such inspections sensory perceptions of the operators and LEL detectors play a vital role. This same program when extended with the use of monitoring instruments and appropriate frequency will lead to control of environmental risks and has been commonly called as Leak detection & Repair (LDAR).

The effectiveness and costs of VOC prevention and control depend on VOC species, VOC concentration, the flow rate, and the source. Resources are typically targeted at high flow, high concentration, process vents, but recognition should be given to the cumulative impact of low concentration diffuse generation sources. Following table identifies the properties needed to select the appropriate control technique for each identified stream generated by a process source.

Table 3-6: Selection of Appropriate Control Technique

Emission Stream Property	Toxic Gas Property
▪ Toxic gas content ▪ Organic content ▪ Heat content ▪ Oxygen content ▪ Moisture content ▪ Halogen/metal content ▪ Flow rate	▪ Molecular Weight ▪ Vapor Pressure ▪ Solubility ▪ Adsorption properties

Emission Stream Property	Toxic Gas Property
▪ Temperature ▪ Pressure	

The following sections describe some of the prevention and control techniques that are applicable to these sources.

3.4.3.2 Process vents

Process vents usually represent the largest source of VOCs generation from petrochemical processes. Wherever possible, VOCs should be reused within the process. The potential for recovery depends on:

- **Composition:** In technical and economic terms, a gas stream containing one VOC (or a simple mixture) will be more amenable to re-use than one containing a complex mix. Likewise, high concentration streams (with low levels of inerts) are more amenable to reuse.
- **Restrictions on reuse:** The quality of recovered VOCs should be of a suitable quality for re-use within the process, and should not generate new environmental issues.
- **VOC value:** VOCs that are derived from expensive raw materials will be able to sustain higher recovery costs.

The next best alternative is to recover the calorific content of carbon by using VOCs as a fuel. If this is not possible, then there may be a requirement for abatement. The choice of abatement technique is dependent on factors that include VOC composition (concentration, type and variability) and targeted emission levels. For example:

- Pre treatment to remove moisture and particulates, followed by
- Concentration of a dilute gas stream, followed by
- Primary removal to reduce high concentrations, followed by
- Polishing to achieve the desired release levels.

The most frequent approach to point source control is the application of add-on control device. These devices can be of two types: combustion and recovery. Applicable combustion devices are thermal incinerators, catalytic incinerators, flares and boilers/process heaters. Applicable recovery devices include condenser, absorbers, and adsorbers. The combustion devices are more commonly applied control devices, since they are capable of high removal efficiencies for almost any type of toxic gases. Selection of applicable control technique is made on the basis of stream specific characteristics and desired control efficiency.

The choice of the best technique will depend on site-specific circumstances.

3.4.3.3 Storage, Handling and Transfer

At a generic level for petrochemical processes, storage tank releases may result from air displacement during ambient temperature changes, during tank filling and from the use of inert gas blankets.

Minimization techniques are particularly applicable to environmentally hazardous substances, odorous substances and any substances with a true vapour pressure (TVP) in excess of 14 kPa. Losses from tanks can be minimized by the use of such techniques as:

- External floating roof, which can effect a 70 - 90% reduction in losses
- Secondary seals can further improve reductions to 95%
- Fixed roof tanks with internal floating covers and rim seals, which are used for more volatile liquids and can achieve 70 - 85% reduction
- Fixed roof tanks with inert gas blanket
- Storage under pressure provides a higher level of containment (*e.g.*, for highly odorous amines)
- Inter-connecting storage vessels and mobile containers with balance lines, reducing losses by 75%.

The loading and unloading of transport containers (rail or road tankers or boats), and transfer of material between vessels pose a risk of losses to air, ground and water. The techniques available to reduce these risks include:

- Tank filling pipes that extend beneath the liquid surface
- Bottom loading to avoid splashing
- Vapour balance lines that transfer the displaced vapour from the container being filled to the one being emptied
- An enclosed system with extraction to suitable arrestment plant.

Displaced gases that necessarily occur from storage and handling are preferably recovered by condensation, absorption or adsorption before consideration is given to destruction by combustion (in a flare, incinerator, or energy raising unit). Flame arresters (or other detonation safeguards) will be required in the case of abatement by combustion.

3.4.3.4 Fugitives

Fugitive emissions to the air environment are caused by vapour leaks from pipe systems and from closed equipment as a result of gradual loss of the intended tightness. Although the loss rates per individual piece of equipment are usually small, there are so many pieces of equipment in a typical petrochemical plant that the total loss of VOCs via fugitive routes may be very significant. LDAR programmes are therefore important to identify leak sources and to minimise losses. Fugitive emissions can be controlled by elaborate leak detection, repair and equipment modifications. Many plants have implemented LDAR programmes in which various sources of fugitive emission like leaks from valves, flanges, pump seals, *etc*., are routinely monitored for leaks and maintained on regular basis.

Sources of fugitives and reduction techniques

There are many potential sources of fugitive emissions in petrochemical plants but they can be classified into a few common categories, typically; stem packing on valves and control valves, flanges / connections, open ends, safety valves, pump and compressor seals, equipment manholes and sampling points.

Valves: Stem leaks can be caused by such factors as: the use of low quality packing material, inaccurate machining of the stem / packing housing, improper valve assembly, ageing of the packing, inadequate packing compression, and corrosion / abrasion of the packing by dirt. High quality valves have very low fugitive emissions as a result of improved packing systems that are built to stringent tolerances and carefully assembled. In some instances, departing from raising stem valves and using another type of valve can be justified. Good quality quarter turn valves often have lower emissions than raising stem valves and, along with sleeved plug valves, have two independent seals but other considerations may limit their use. Bellows valves have no stem emission at all, but the resulting emission reduction (compared with good quality raising stem valves) may not be sufficient to justify the additional costs. Bellows valves are mainly used for health or safety reasons in highly toxic services (to reduce operator exposure to toxic vapours) or highly corrosive service (to avoid corrosion of the valve components that could lead to a loss of containment). As a rough guide, bellow valves up to 50 mm will cost four times as much as the same size conventional valve. Valves between 50 and 200 mm will cost three times as much, and valves above 200 mm twice as much as a conventional valve.

Control valves: Because they are frequently opened and closed, control valves are more prone to leakage than shut-off valves. It is not uncommon to find more than 20 % of control valves leaking above 1000 ppm, even in well-maintained plants that have a stringent fugitive emission reduction programme. Using rotating control valves instead of raising stem control valves can help reduce fugitive emissions. Another possibility is to consider process control using variable speed drivers on pumps rather than control valves.

Flanges: On a typical plant, the percentage of leaking flanges is relatively low but due to large number of flanges they can contribute significantly to total fugitive emissions. Piping systems in cyclic thermal service are likely to have higher leak rates. Leaks from flanges are often caused by misalignment and can be reduced by increased attention to the bolting technique. The flange rating and gasket material must be adequate for the service. Minimising the number of flanges (by replacement with welded connections) can be considered, compatible with the operations and maintenance requirements of the plant.

Open ends: 'Open ends' are the vents and drain outlets from pipes, equipment or sampling points. The open ends are fitted with a (normally closed) valve but are prone to very high leak rates if poorly maintained. All vents and drains that are not operated on a regular basis should be blinded, capped or plugged. Those that need to be operated regularly should be fitted with two block valves. Sampling points can be fitted with a ram-type sampling valve or with a needle valve and a block valve to minimize emissions. Losses from sampling systems and analyzers can also be reduced by optimizing the sampling volume/frequency, minimizing the length of sampling lines, fitting enclosures, venting to flare systems and closed loop flush (on liquid sampling points).

Safety valves: Leaks through safety valves discharging to air can be significant. Losses can be reduced by the installation of a rupture disk upstream of the safety valve. Alternatively, safety relief devices and equipment blow-down connections can be connected to a flare or to another vapour abatement system, although this option may be prevented by safety considerations. Balanced bellows-type relief valves are also used to minimise the valve leakage outside of design lift range.

Pumps: Although pump seals can have high leak rates, their contribution to total fugitive emissions is relatively small owing to the limited number of pumps installed in a plant. Fugitive emissions can be minimised by the use of high quality and double seal systems. Centrifugal pumps use a double mechanical seal with a seal barrier fluid although this

system is quite expensive. In many cases, simpler high performance seal systems can achieve the desired performance regarding fugitive emission. Whenever applicable, seal-less pumps (either magnetically driven or canned) eliminate the fugitive emission completely. Seal-less pumps are not available for all duties and not suitable in services containing particles, particularly iron (which may come from corrosion).

Compressors: Issues with compressors are similar to pumps. However, leak rates from large compressors can be very significant, particularly for positive displacement machines. In addition to the solutions available for pumps, it may also be possible to collect the seal losses and route these to a lower pressure system, if it exists, or to flare.

General factors that apply to all equipment are:

- Minimizing the number of valves, control valves and flanges will reduce potential leak sources, but this must be consistent with plant safe operability and maintenance needs
- Improving the access to potential leaking components will enable effective future maintenance.

In many cases, using better quality equipment can result in significant reductions in fugitive emissions. On new plants, this does not generally increase the investment cost but, on existing plants, replacing existing equipment with equipment of improved quality may be a significant cost. On both new and existing plants, the control of fugitive emissions also relies on LDAR programmes.

A. Leak detection

The first step in reducing fugitive emissions is to detect which numerous potential leak points on a plant are leaking. The usual detection method is 'sniffing' using a hand-held organic vapour analyser (OVA) to measure the vapour concentration at the interface of the potential leak. The best 'sniffing' method is generally regarded to be Method 21 as developed by the USEPA. The OVA is either a FID (flame ionisation detector) or a PID (photo ionization detector), depending on the nature of the vapours. PID techniques can be used in plant areas that have an explosion risk but they are insensitive to many substances. FID techniques are therefore more widely used. The measured concentration (in ppm) is called the screening value and becomes a 'leak' when it exceeds a defined level. The concentration measurements collected by sniffing are not very accurate because measurement and interpretation are influenced by factors, such as:

- OVA type and manufacturer - the measured concentration is influenced by the pumping rate and by the size and shape of the probe tip.
- Operator skill - the speed at which the probe tip is moved and the distance to the leak point interface, have an influence. Good practice is described in USEPA Method 21.
- Weather conditions during measurements - measurements undertaken in high winds are useless. The intensity of precipitation and the ambient may also play a role.
- Background concentration - an average background concentration can be measured and deducted from measurements but this does not take account of the background variability.
- Nature of the emitted vapour - the response factor of instrument to the substances being emitted must be taken into account. However, the exact composition of the vapours is often not precisely defined for every potential leak point.

- OVA calibration – the detector must be re-calibrated on a regular basis to avoid drift.
- Pressure in the system - appendages at elevated pressure have a higher tendency for leaking than appendages in service at atmospheric pressure, but the use of better construction standards reduces this tendency.
- Substances present in the equipment - information on the substances is important for classification purposes (gaseous, low boiling, high boiling) so that the emission load can be calculated (*e.g.*, using the EPA correlation method).

Some leak sources that have a very low risk of causing fugitive emissions are not covered by leak detection programme. For example, sniffing is not an appropriate method for leak detection from systems that only contain heavy liquids with a vapour pressure below 0.3 kPa at 20°C. These leaks can anyway be detected visually and the losses do not contribute significantly to overall fugitive emissions.

B. Leak repair

Leak detection is carried out so that repairs can be affected and fugitive emissions reduced. If the repairs are not completed or are ineffective, then no emission reduction is achieved. Repairs should therefore be carried out as soon as possible after leak detection and a staged repair approach is often applied to reduce the costs:

- Immediate, minor repairs can be performed while the equipment is still operating by, for example, tightening bolts to eliminate leaks from valve stems or flanges, or installing / tightening caps on open ends. This is often effective for open ends and flanges but not always so for valve stem packing as over-tightening may prevent valve operation or may completely destroy the packing thus causing a larger leak. In any case, bolt tightening on equipment under pressure needs to be executed carefully by skilled operators and may not always be appropriate due to safety reasons (*e.g.,* high pressure).
- Leaks that cannot be stopped by immediate minor repair are considered for more intensive repair. As this can involve changing a gasket or valve packing it typically requires the equipment to be taken out of service. Repairs to equipment that is continuously in service are usually delayed until the next plant shut-down or turnaround.
- When no effective repair can be performed, replacement of the equipment needs to be considered.

The threshold leak rate at which repairs are performed depends on the plant situation and the type of repair required. Minor repairs are low cost interventions and can be performed on all leaks above a low threshold. Setting the threshold for repair at a low level reduces the number of leaks that evolve into bigger leaks (requiring more difficult and expensive repair).

In the Netherlands the threshold levels for leak repair are more stringent and also distinguish between carcinogenic and non-carcinogenic substances.

In general terms, the level of fugitive emissions will depend on such factors as:

- vapour pressure of the substance being handled
- number and type of sources
- method of determination (estimation or monitoring)
- inspection and maintenance regime for sources

- rate of production (to a lesser extent)

There are several established techniques for the quantification of fugitive losses from a plant. Most techniques first require an accurate component count and the establishment of a database. This can be carried out using unit flow plans, by field inspection or a combination of both. In making the component count, all process pipe work is normally considered, but small diameter instrument connections are not (since these include a large number of very small valves with relatively low potential leak rate). Components are classified in terms of type, service and process conditions to identify those elements with the highest potential for fugitive loss and to facilitate the application of industry standard leak factors. An estimate of overall fugitive emissions from the plant can be derived but experience shows that this can give an over-estimation of fugitive losses.

A more accurate emission quantification typically involves deducing a leak rate (kg/year) from the screening value for each point, adding the leak rates of all leak sources and integrating over the reporting time period (typically one year). At each stage, uncertainties creep into the calculation and so the quantification of fugitive emissions is fairly inaccurate, even if it is based on the results of an extensive sniffing campaign. Estimations of emission levels may be validated by gas imaging [European Sealing Association], dispersion modeling (to predict atmospheric mass flux and concentrations) and environmental monitoring techniques (to compare the predicted and measured situations).

C. Targeted monitoring

Since leak detection is a labor intensive and expensive activity it is important to develop a methodology that minimizes the work whilst maximizing the reductions in fugitive emissions. Monitoring programmes for sniffing consider and adjust the following parameters to define the most suitable programme:

- The monitoring frequency: at what time interval should potential leak points be screened for leaks?
- The percentage of hardware that needs to be monitored: sampling can help reduce costs while providing reliable indications on the trend in emissions from the related components
- The type of hardware that needs to be monitored: what are the limits in size, service or type of hardware beyond which screening for leaks is not beneficial?

'Targeted Monitoring' defines a programme that directs the main effort at the leak points with the highest rate of leakage. It involves the following steps:

- Make a survey of all potential leak points on the plant: Ideally, a complete plant survey should be carried out using up-to-date piping and instrumentation drawings to establish population counts of equipment and fittings. The survey should cover gas, vapour and light liquid duties. In large plants the survey costs force a staged approach, either by dividing the plant into units or by first screening only valves / rotating equipment followed later by the screening of flanges. Alternatively, sampling can be used on items on which low leak rates are expected (*e.g.,* flanges) to assess their rate of leakage.
- Analyze the results of first screening survey: There are always large differences in the leak rates of components and it is often impossible to predict which components will leak most. This analysis is best performed with the aid of a database that records

relevant data on each potential leak point. The potential leak points can be divided into families (*e.g.,* by type of component, size, service) and the percentage of elements leaking above a defined threshold (*e.g.,* 1000 ppm) can be defined for each family.

- Focus further monitoring and repair on those families with the highest percentage of leaking elements: This maximizes the reduction in fugitive emissions per unit of expenditure. Sometimes it may be expensive to repair items with high leak percentages and the contribution of these items to the total fugitive emission must be considered. If the family contribution to total emission is low (*i.e.,* few items in the family), then expensive repair may be less justified than to other items contributing more to the total (but with a smaller percentage of leaking elements).
- Define whether high leak percentages are caused by structural causes (*e.g.,* inadequate gasket material, wrong type of valve) and define corrective action accordingly.
- As effective repairs are carried out on the components having the highest focus, shift the priority to new families of components that rise to the top of the list.
- Use a sampling strategy to check that families of components having a low percentage leaking components remain at this level.

This approach has several advantages:

- It maximizes the reduction in fugitive emissions and minimizes the cost
- It defines improvements that are required in the specification of plant components
- It identifies improvements to the repair methods
- It means that a significant percentage of all potential leak points do not need to be screened on an annual basis. Emission calculations are therefore based on a partial set of screening values and on average emission rates from previous surveys for the remaining points.

A variety of management systems may also be needed to support the LDAR programme, for example:

- Physical labeling of sources with a unique reference number
- Up-to-date maintenance of process and instrumentation diagrams (P&IDs) showing the sources
- A database of sources (with reference number, equipment manufacturer, gasket material, *etc.*), programmed detection survey dates, leak detection results, completed repair work and planned repair work.

Diffuse and other fugitives sources

The term fugitive emissions can also apply to emissions that arise from process operations (*e.g.,* opening of vessels, filtering, stirring / agitator seals) and due to volatilization from liquid spills, effluent collection systems and effluent treatment plants. These fugitive emissions are measured and controlled using different techniques to those described for piping and equipment leaks. Relevant operational and maintenance techniques may include:

- Enclose effluent collection systems and tanks used for effluent storage / treatment to reduce evaporative losses (as long as this does not compromise system safety)

- Monitor cooling water for contamination with organics (*e.g.,* from heat exchangers).

Summary of the above VOC control is:

- As a result of the efforts to reduce point sources, leaking losses may form a significant part of the total emissions from the petrochemical industry
- Leaking losses are hard to determine and a monitoring programme is a good starting point to gain insight into the emissions and the causes. This can be the basis of the action plan
- The successful abatement of leaking losses depends heavily on both technical improvements and the managerial aspects
- Abatement programmes can reduce the unabated losses (as calculated by average US-EPA emission factors) by 80 - 95%
- Most reported fugitive emissions are calculated rather than monitored and not all calculation formats are comparable. Monitoring at well-maintained plants shows that the average emissions factors are generally higher than measured values
- Abatement of fugitive emissions is less process related than process emissions.

Emissions from Wastewater Collection & Treatment: The first level of control is to ensure that these VOC emissions are minimised by preventing oil from contaminating storm water drainage and cooling water systems and reducing, as far as possible, the contamination of process water. The next level of control is to install water seals (traps) on sewers and drains and gas tight covers on junction boxes in the system. The use of covers on oil/water separators with good oil removal facilities will prevent or reduce evaporation of liquid hydrocarbons from exposed surfaces.

3.4.3.5 Combustion gases - NOx control

In terms of pollutants from combustion units, the main emissions are of nitrogen dioxide, sulphur dioxide and particulates. In view of clean fuels generally used in the integrated petrochemical complexes, sulphur dioxide and particulate emissions are usually low and not considered in this section.

NOx control techniques fall into three main categories:

- Pre-combustion operational changes
- Combustion modifications
- Post-combustion flue gas treatment

Pre-combustion operational changes include change in fuel and are not considered further considering low flexibility in fuel management at petrochemical complex. Technological options to check NOx emissions can be controlled either by adjusting the combustion process, or by adjusting the parameters responsible for high NOx emission or by flue gas treatment. Low NOx burner technology for ethylene cracking furnaces has been developed for reducing NOx emissions from combustion processes to less than 10 ppm. Combustion modifications involve changes to the combustion equipment or operating conditions that either lower the flame temperature or change the concentration of reactants to minimize NOx formation. They include: low NOx combustors; either low NOx burners or dry low NOx combustors for gas turbines; flue gas recirculation (FGR) or steam diluent injection. Post-combustion techniques include Selective Non-Catalytic Reduction (SNCR) and Selective Catalytic Reduction (SCR).

A brief description of NOx control technologies with particular reference to petrochemical industries is furnished below.

- Diluent Injection: Inert diluents, such as flue gas, steam, water, or nitrogen, added to combustion equipment reduce the temperature and the concentration of NOx producing reactants in the flame zone thereby reducing thermally formed NOx.
- Flue Gas Recirculation: External FGR is applied to boilers to increase the diluent effect, hence to reduce combustion temperature. Safety considerations due to the possibility of explosion in the event of a tube burst make FGR impractical for fired heater applications.
- Steam or Water Injection: This technique is widely applied to gas turbines both in new installations and retrofits and is also applicable to fired heaters and boilers. Capital cost is less than that of SCR, making the technology a good first choice for substantial levels of NOx reductions, with SCR often added on if higher NOx reduction is needed. Substantial recurring operating costs are however encountered for producing high purity steam, and also maintenance costs for re-blading may be high.
- Low NOx Burners: Low NOx burners, either air staged or fuel staged, aim in reducing peak temperature, reducing oxygen concentration in the primary combustion zone and reducing the residence time at high temperature, thereby decreasing thermally formed NOx. Staging of fuel addition is also thought to provide a reburning effect, further reducing the NOx. The decreases obtained by low NOx burners average around 40%. Ultra-low NOx burners add internal recirculation of flue gases to the features of the low NOx burner, enabling NOx reductions of 75 % or better. Application is straightforward for new installations of both fired heaters and boilers. Retrofitting of low NOx burners depends on the furnace design and may be simple, difficult or impossible due to the increased flame volume, *i.e.,* the flame size is too large for the size of radiant box. In many cases retrofitting requires major changes to the furnace floor structure and controls that add greatly to the capital cost. This substantially increases the cost per unit of NOx removed, thus reducing the cost effectiveness of this technique. For new installations capital expenditure may be higher, but operating and maintenance costs of low NOx burners are comparable to that of standard burners.
- SNCR: SNCR is a non-catalytic process for removing oxides of nitrogen from the flue gas by gas phase reaction of ammonia or urea at high temperature, *i.e.,* around 950°C. The reactant is injected through multiple nozzles into the radiant or convection section of process furnaces and boilers. To achieve good mixing, the small amount of reactant is injected along with a carrier gas, usually air or steam. NOx reductions up to 60% have been demonstrated, if the flue gas temperature is as per design. At lower or higher than design loads however, the effectiveness decreases. Cost considerations include the initial capital costs for modifying the furnace or boiler, piping to inject the reactant, the reactant supply system and a recurring cost for ammonia or urea to react with the NOx.
- SCR: The SCR process removes nitrogen oxides by reaction of ammonia vapour with flue gas over a catalyst bed where NOx is reduced to nitrogen and water vapour. Catalysts are available to achieve a high level of NOx reduction in narrow temperature windows from 250 to 550 °C. This greatly increases the flexibility of SCR for retrofit applications. However, considerable plot space is needed for its installation, often making SCR impractical or cost ineffective for retrofit installations. Capital investment includes the structure to hold the catalyst and the cost of the catalyst. Additional charges for retrofit applications include the cost of structural

modifications and ductwork. Like SNCR, an ammonia injection and supply system and a recurring cost for ammonia to react with NOx is required. SCR can achieve near 90% reduction of NOx except at very low NOx concentrations, where NOx reduction is typically about 75%.

3.4.4 VOC emissions

Typical sources of VOC emissions in petrochemical industry are: fugitive leaks from equipments, loading and transfer operations, wastewater treatment units, storage tanks, Such fugitive VOCs leaks from equipment, loading, wastewater treatment and storage tanks account to 50-60%, 20-30%, 10-15% and 10-15% respectively.

Storage Tanks: Emissions from storage tanks may contribute significantly to the total hydrocarbon emissions. The controls to be specified for each type of fluid, needs to be worked out preferably based on assessment of quantum of emissions, nature of hydrocarbons emitted (*i.e.,* their toxicity) and the percentage reduction achieved by the controls.

Oil-Water Separators: Assessing the safety of control technologies is of paramount importance. Since the covering of API separators can potentially lead to explosive environment in the Oil Water separators, suitable safety measures need to be incorporated.

LDAR: LDAR program for typical Indian petrochemical industries may include:

Development of count and characteristics of leaking equipment. Each petrochemical complex needs to develop a complete checklist of pumps, compressors, valves and pressure relief devices existing in the plant. The checklist should also include associated characteristics such as:

- Type of equipment and type of seal
- Nature of fluid handled including the percentage of fluid that can be characterized as “hazardous” or toxic meaning the components being suspected to cause human health problems
- A limited survey to be carried out in the Indian petrochemical industries to assess the emission factors. The emission factors provided by API and USEPA may not be valid and this is discussed in the section on assessment of impacts from VOC emissions later in this chapter

Judicious selection of the items in LDAR can be made based on the above efforts resulting in a programme, which returns significant fugitive VOC reductions at a unit cost far below a programme that is very conservative in defining all the above items.

LDAR may sound to be simple; however it calls for significant time, effort and attention once implemented with commitment. Safety inspection procedures do exist for the inspection and maintenance of these equipment and best results are expected if the same program (currently catering to the safety requirement) can be tailored so as to address fugitive emissions. Plants and storage handling feed/product which is contributing to significant VOC emissions are to be identified and prioritized for implementing control options.

Table 3-7: Levels of Control for Atmospheric Emissions

Source	Type/ Pollutant	Level I	Level II	Level III
Fugitive Emissions				
Valve	Fugitive/ HC	▪ Low leak valves in new installations ▪ Inspections as per safety requirements	▪ Same as in Level I ▪ Limited leak detection & repair	▪ Low leak valves in new installations ▪ Defined LDAR
Flanges	Fugitive/ HC	▪ Inspection as per safety requirements	▪ Same as in Level I ▪ Limited leak detection & repair	▪ Defined LDAR
Pumps	Fugitive/ HC	▪ Mechanical seals (single/ double) on new installations ▪ Inspection as per safety requirements	▪ Same as in Level I ▪ Limited leak detection & repair	▪ Double mechanical seals on centrifugal pumps in new installations ▪ Defined LDAR
Compressors	Fugitive/ HC	▪ Low leak seals in new installations ▪ Inspection as per safety requirements	▪ Same as in Level I ▪ Limited leak detection & repair	▪ Same as in Level I ▪ Defined LDAR
Pressure Relief Valves	Fugitive/ HC	▪ Design & Inspection as per safety requirements	▪ Same as in Level I	▪ Same as in Level I ▪ Defined LDAR
API separator	Fugitive/ HC	▪ Minimizing oil in the inlet	▪ Same as in Level I and ▪ Removable covers	▪ Covers with or without vapor control
Storage Tanks	Fugitive/ HC	▪ Design as per safety requirements ▪ Floating roofs for lighter materials	▪ Floating roof tanks for lighter materials ▪ Fixed cum floating roof tanks for toxic materials such as benzene, toluene ▪ Vapor recovery for toxic material loading ▪ Double seals in floating roof tanks	▪ Same as in Level II
Process Emissions (Vents)				
Various Process Units	VOCs	▪ Flare ▪ Furnace ▪ Incinerator ▪ Atmosphere	▪ Same as in level I	▪ Same as in level I
Fuel Combustion				
Boilers and Process	Stack/SO_2	▪ Energy conservation measures	▪ Use of low sulphur fuel < 1%	▪ Same as in Level II

Source	Type/ Pollutant	Level I	Level II	Level III
heaters				
	Stack/NOx	▪ Energy conservation measures	▪ Use of low NOx burners	▪ Same as in Level II and ▪ SCR/ SNCR

3.4.5 Monitoring & reporting of air emissions

Atmospheric emissions from petrochemical complexes are characterized by large number of small volume sources hence the considerations for monitoring of air emissions have evolved accordingly.

SO_2 emission monitoring

Monitoring of SO_2 emissions can be carried out using following techniques:

- Direct monitoring of stack emissions by use of analyzers
- Indirect estimation via measuring of relevant process parameters such as fuel consumption and sulphur content of the fuel

The method used in arriving at the figures reported in the Environmental statements is not clear. There is a need to standardize this aspect.

A point of attention here is the robustness of the apparatus used for direct monitoring in view of fouling, which may occur in a flue gas duty. Indirect monitoring is much more cost effective than directly measuring the SO_2 content of flue gases. However, the method used should be transparent and verifiable. Petrochemical industries may suggest indirect monitoring methods, which can be verifiable and transparent.

NOx emission monitoring

In addition to periodic flue gas sampling normally required by regulations, Continuous Emission Monitoring Systems (CEMS) are sometimes required. Such monitoring has been done in several Industrial installations using NOx specific analysers in the CEMS. However, recently, predictive emission monitoring systems (PEMS) have been demonstrated in some countries to be accurate and reliable monitoring devices and have begun to be accepted by regulatory authorities as an alternative analyzer system. PEMs make use of existing process sensors already installed at the facility for operational and other environmental compliance measurements, along with an understanding of how these measurements affect NOx emissions, to predict NOx emission levels. Using existing process sensors provides a more cost-effective approach than continuous measurement of NOx emissions. In the of NOx monitoring, PEMS would likely include measurements of air preheat temperature, furnace operating temperature, fuel hydrogen content, oxygen concentration in the flue gas and ambient humidity.

Monitoring of VOCs

Following two issues may be taken into consideration for VOC emission monitoring and reporting:

- Technologies available for plant surveillance
- Estimation and reporting of emissions from major sources

Plant surveillance is for monitoring of emissions and ensuring that levels in the ambient air are within acceptable limits. Plant surveillance for the purpose of hydrocarbon emission control can be carried out by use of portable hand held monitors.

However, the issue of estimating emissions is more closely related to assessment of impacts, reporting of emission quantity and quality, benchmarking and also for prioritizing the areas for application of control technology.

i. Monitoring technologies available

Monitoring/ Surveillance for VOC emissions has been done by use of portable hand held devices or installation of continuous analyzers at selected locations in the hydrocarbon processing plants. Any systematic approach will involve following:

- Frequency of monitoring
- Number of analyzers
- Location
- Speciation of the hydrocarbons

Petrochemical complexes may formulate a plan for monitoring/surveillance using a combination of portable hand held and continuous analyzers detailing the above aspects. Summary of reports generated from this may be included in the environmental statements.

ii. Estimation of VOC emissions

Estimation of VOC emissions requires emission factors, count and characteristic of equipment/source. In general separate procedures are used for leak and non-leak sources.

Leak sources

The estimate of population of each type of fitting is as important as the emission factor in determining total emissions. Further, the fitting counts need to be broken down into service categories such as Light liquid, Heavy liquid, HC Gas and Hydrogen which correspond to the emission factors. It is essential that Indian petrochemical industries develop a count of equipment sources along with their type and design features. This information will be valuable not only for the estimation of emissions but also in implementing control programs.

Non-Leak sources

The approach will involve following three steps:

- Distribution of total hydrocarbon unit emissions among the appropriate streams
- Application of stream analysis to get component emissions from each stream
- Summing up of the stream components to get unit component emissions

iii. Impacts of VOC emissions and prioritizing controls

Environmental impacts due to VOC emissions and the hazardous components of the same will depend on the following variables:

- Plant configuration and products
- Plant layout
- Calculated emissions
- Meteorological conditions
- Hydrocarbon component breakdown

A gas-based petrochemical complex with small number of products will have significantly different emissions and quite different component breakdown, probably resulting in lower impacts. The plant layout may be even more critical than the emission rate, especially from the hydrocarbon species. Fugitive emissions are released near ground level, and thus are subject to much less dispersion than stack emissions. A petrochemical plant layout with process units right on the boundary line will show much higher hydrocarbon concentrations at the boundary than one with a buffer zone around the processing area. The situation is further complicated when looking at individual species. For instance, a complex consisting of a reformer, an aromatics extraction unit, and a BTX fractionation unit would result in moderate to low total hydrocarbons, but they would probably result in higher impacts.

3.5 Energy and Fuel Management

Energy and fuel management is an important aspect in the environmental performance of a petrochemical complex. Fuel combustion to meet energy requirements contributes a major component of petrochemical plant atmospheric emission.

3.5.1 Environmental considerations

Elements for environmental considerations of the energy system are:

- Fuel consumption and efficient energy use
- Fuel sulphur content and SO_2 emissions
- Nitrogen oxide formation in the combustion process
- Particle formation from ash and incomplete burnout

Fuel saving, especially of residual fuel, by increasing energy efficiency, has a beneficial influence on all four parameters.

Petrochemical fuel gas predominantly comprises hydrogen, methane, C_2-C_5 hydrocarbons (saturated/unsaturated), hydrogen sulphide, mercaptans, sometimes and nitrogen in varying quantities.

3.6 Non-routine conditions

These operations relate to two main events. Firstly, the infrequent or unplanned shutdown or upset and the planned 'turnarounds' or shutdowns of petrochemical plant and equipment for maintenance or inspection. As all these operations involve the controlled release of hydrocarbons from plant and equipment, there is potential release of VOCs, contaminated water and solid materials (*e.g.,* sludge and catalysts). As such,

petrochemical units are designed and operated to prevent unnecessary emissions during these periods.

3.6.1 Unplanned events

These often involve the need to dispose off large quantities of VOC materials due to overpressure effects during upset conditions. Standard technology is to route most hydrocarbon service relief to the flare system, where the gases can be combusted and disposed of in elevated flares.

3.7 Waste management

Petrochemical plants generate a wide variety of solid waste streams. Basically, petrochemical solid waste streams fall into two main groups, *i.e.*, intermittently generated wastes and continuously generated wastes. Intermittent wastes are generally those that result from cleaning within the process areas and off-site facilities. The following are typical intermittent waste streams:

- Spent catalysts from certain processing units and product treatment wastes such as spent filter clay
- Process vessel sludge, storage tank sediments, vessel scale, and other deposits generally removed during turnarounds
- Annual volume of intermittent wastes is strongly a function of individual plant waste management and housekeeping practices.

Continuous wastes (those requiring disposal at less than two weeks interval) can be further can be categorized into two groups *viz.* process unit wastes and wastewater treatment wastes.

3.7.1 Solid/hazardous waste generation from ethylene cracker

Relatively little solid waste is generated in steam cracking process when running on gas or naphtha. The bulk of steam cracker solid waste is organic sludge and coke, but there are also specific generations of spent catalyst, spent adsorbents and solvent purges. In addition, there are generic wastes, such as spent oil, oil filters/cartridges and air-drying adsorbents.

- Organic sludge: Organic sludge is liquid, pasty or solid materials collected during normal operation, start-up, shutdown, drainage and cleaning of the unit. They typically arise from API separators, the quench oil system, spent methanol, spent lubricating oil, bottoms drains of vessels and settlers, and polymeric material removed from pump strainers and filters.
- Coke: Coke fines are recovered from gas dedusting during decoking.
- Spent catalysts: Catalysts (from acetylene, butadiene, and steam cracked naphtha hydrogenation units) have an economic lifetime of roughly 5 years. Once efficiency declines to an unacceptable level spent catalysts are generally returned to the catalyst supplier for recovery of the noble metal.
- Spent adsorbents: Drying adsorbents (alumina, molecular sieves) have a typical economic lifetime of 3 - 4 years. They are generally landfilled after regeneration/ deactivation.

3.7.2 Solid/hazardous waste generation from aromatics plants

The major solid waste categories are:

- **Catalysts**: from the liquid or gas phase hydrogenation of olefins/diolefins and sulphur. Catalysts have a typical lifetime of 2 to 5 years. Spent catalysts are typically processed by a reclaimer, often the catalyst supplier himself, to separate the valuable metal for re-use from an inert support usually disposed of via landfill. Catalysts used in Toluene Disproportionation or Xylene isomerization can have lifetimes up to 10 years.
- **Clay:** from olefins removal and typically having a lifetime of 6 months to 2 years. Clay is typically processed via landfill or incineration for disposal.
- **Adsorbents:** from xylenes separations and typically consisting of alumina or molecular sieves which can have a lifetime as low as 3 to 4 years, but typically more like 10 years. Adsorbents are typically disposed to landfill.
- **Sludge / solid polymerization material:** recovered from process equipment during maintenance activities. It is typically incinerated offsite but can be used on-site as a fuel source. Solvent regeneration is typically used in many aromatics complexes to remove a more concentrated stream of sludge from the process. This reduces solvent losses to the environment.
- **Oil contaminated materials and oily sludge:** (from solvents, bio-treatment and water filtration) are incinerated under carefully controlled conditions, with associated heat recovery.

Waste generated in petrochemical industries fall into two main categories:

- Non-hazardous waste, including industrial and domestic *e.g.*, scrap metal and "domestic" wastes.
- Hazardous waste, *e.g.,* sludge with toxic organic and heavy metal content.
  - Oven Debris
  - Oil-containing bleaching earth
  - Acid tar
  - Sulphur-containing residue from sulphur removal
  - Oil-containing sludge
  - Oil emulsions
  - Oil-containing acid
  - Tar residue made with coal tar
  - Sludge from wastewater purification
  - Residual liquid and paste-like organic substances made with aromatic, aliphatic and napthenic hydrocarbons
  - Residue from alkali wash of fuels

3.7.3 Composition of petrochemical industry waste streams

Composition of waste streams is a very important aspect in the management of wastes. Composition determines to a large extent the handling, treatment and disposal options.

Characterization of waste streams poses challenges because the contaminants of concern may be present only in trace levels.

The hazardous substances found in the petrochemical waste are:

- Trace metals
- Trace Organics (including halogenated)

It is also to be noted that in addition to presence of toxic contaminants, the waste also needs to be analyzed for toxic characteristics. The toxic characteristics include:

- Reactivity
- Corrosivity
- Reactivity
- Toxicity

Toxicity test is of special concern in petrochemical waste streams. This basically comprises Leachate Procedure tests and the one most widely used has been Toxicity Characteristic Leachate Procedure (TCLP) as defined by USEPA.

It is recommended that petrochemical industries carry out systematic analysis of waste generated. It is suggested that petrochemical industries develop competence either in-house or in reputed certified laboratories for the purpose of waste characterization. Standard methods specified in SW 846 (USEPA) or ASTM may be used for this purpose.

3.7.4 Technology for waste treatment

Three levels of technology for treatment and disposal of petrochemical wastes may be as follows:

- Level I: Technology currently employed by typical facilities
- Level II: Better technologies currently employed on a commercial scale
- Level III: Technology necessary to provide adequate health and environmental protection

It is to be noted that environmental adequacy is to be evaluated under varied geologic and climatologic conditions and the technology in this context should primarily prevent environmental stress on ground water supplies. Following tables contain a description of three levels of treatment and disposal technology associated with some of the waste streams generated by the petrochemical industry. Hazardous waste management is a complex task requiring investigation in field for evaluating performance and developing action plans.

Table 3-8: Technology Levels for API (Oil/Water) Separator Sludge

Factor	
Waste Description	An oil-water emulsion containing large quantities of water, which has settled to the bottom of the separator. A considerable diversity of wastewater streams are routed to this unit influencing waste generation rates, waste characteristics and potential hazards.
Generation rate	Highly variable
Physical and chemical	High in water content the chemical characteristics of material are dependent on the oil which is routed to the units. Organics are of concern.

Factor			
properties			
	Level I	**Level II**	**Level III**
Treatment/ Disposal Technology	▪ Deoiling/ dewatering using centrifuge ▪ Storage in pit	▪ Same as Level I	▪ Oil recovery process to ensure absence of leachable hazardous organic constituents ▪ Land-farming in hydro-geologically secure area, and assisted by specially cultured microorganism and protected by berm to pond any storm runoff ▪ Solidification ▪ Secured landfill
Adequacy of technology	▪ Insufficient information ▪ Inadequate	▪ Insufficient information	▪ Adequate ▪ Adequate ▪ Adequate ▪ Adequate
Problems	▪ Residual oil which may have hazardous constituents ▪ Migration of constituents	▪ Minimal	▪ Minimal ▪ Minimal ▪ Minimal ▪ Minimal
Monitoring & Surveillance	▪ (1), (2) Minimal at present	▪ (1) Minimal at present	▪ (1) Use observation wells, Monitor for hazardous constituents ▪ (2) Air pollution monitoring

Table 3-9: Technology Levels for Temporary Waste Storage

Factor			
Waste description	All hazardous wastes generated at site and stored before further treatment/disposal		
Generation rate	NA		
Physical and chemical properties	Liquids, Sludge or solid		
	Level I	**Level II**	**Level III**
Technology	▪ Drums ▪ Concrete pads ▪ Drying beds	▪ Dedicated Storage facility with runoff protection ▪ Sludge in HDPE bags ▪ Liquids in drums	▪ Same as Level II ▪ Storage facility bottom protection
Adequacy of technology	▪ Inadequate information ▪ Inadequate information ▪ Inadequate information	▪ Adequate ▪ Adequate ▪ Adequate	▪ Adequate ▪ Adequate
Problems	▪ Drum leakage ▪ Surface runoff & bottom layer leakage ▪ Bottom layer leakage	▪ Bottom layer leakage ▪ Damage to bags ▪ Drum leakage	▪ Level II ▪ None
Monitoring & Surveillance	▪ Minimal	▪ Minimal	▪ Regular inspection of bags, containers, drums ▪ Groundwater monitoring

3.7.5 Waste storage

Wastes awaiting disposal must be stored in an environmentally acceptable manner, and shall not lead to secondary environmental problems such as odor or pollution of groundwater due to rainwater percolation through or run-off from the site. Storage should best be in closed vessels, containers or bags, on a site surrounded by a bund wall or toe wall, with drainage to a prepared system. Special precautions are of course required for pyrophoric materials to eliminate the risk of fires; they must be kept wet, sealed or blanketed with inert gas.

3.7.6 Recycle and reuse

In the last decades, the quantity of waste from the industry which is recycled and reused has grown in many countries and continues to do so. The methods applied vary with the type of waste, *e.g.,* for sludge, recovery of oil during treatment. The aim of recycle and reuse methods is to reuse the waste for its original purpose or to find an alternative use for it to avoid its final disposal. Therefore, waste production is reduced while natural resources are conserved and/or protected.

Most of the reuse practices reported in the environmental statements are for off-site recovery from waste stream. Industries opting for this route are required to take due care to avoid secondary pollution from recyclers facility. The material is to be sold to only authorized agencies with necessary approvals.

3.7.7 Waste pre-treatment- sludge reduction processes

Treatment methods are used for two main purposes:

- To reduce the quantity of waste requiring disposal
- To recover the oil for recycling

A large proportion of petrochemical wastewater sludge is being treated for one or both of the above reasons.

The choice of whether to treat and if so which treatment to use depends on many factors including the composition of the sludge and the choice of disposal route.

Centrifugation exploits the difference in density between solids and liquids (or two liquid phases) to separate them by applying centrifugal force. Two main types of decanter centrifuge can be applied at petrochemical wastewater facilities: 2-phase, which yields a solids cake plus a single effluent stream (mixed oil and water); and 3-phase which, as the name suggests, yields separate oil and water streams, as well as the cake. The applications in ETP have been use of decanter centrifuges.

Advantages of decanter centrifuges include resource recovery, flexibility and high volume reduction. With good operation, cake suspended solid contents of up to 20% can be achieved.

Dewatering/deoiling is used to decrease the quantity of sludge for disposal and to recover oil from them.

The performance of these technologies is not known. It is expected that with the use of new format for reporting this detail will be available.

3.7.8 Waste disposal methods

All disposals must be carried out at authorized and assessed landfill facilities.

3.8 Summary of Applicable National Regulations

3.8.1 General description of major statutes

A compilation of legal instruments which are applicable to the petrochemical industry is annexed as **Annexure III**.

3.8.2 General standards for discharge of environmental pollutants

General standards are applicable wherever industry-specific standards are not mentioned or notified. General standards for discharge of environmental pollutants as per CPCB are given in **Annexure IV**.

3.8.3 Industry-specific requirements

Petrochemicals (Basic & Intermediates): Standards for Liquid Effluent

Table 3-10: Petrochemicals (Basic & Intermediates): Standards for Liquid Effluent

Parameter	Concentration not to exceed limits in mg/l (except pH)
pH	6.5-8.5
BOD (3 days at 27^{o}C)	50
Phenol**	5
Sulphide as S	2
COD	250
Cyanide as CNO	2
Fluoride as F***	15
Total suspended solids	100
Chromium****	
Hexavalent	0.1
Total	2.0

** The state boards may prescribed the BOD value of 30mg/l if the recipient system so demands*

*** The limit for phenol shall be conformed at the outlet of effluent treatment of phenol cumeme plant. However, at the disposal point, the limit shall be less than 1mg/l.*

****The limit for fluoride shall be conformed at the outlet of fluoride removal unit. However, at the disposal point fluoride concentration shall be lower than 5mg/l.*

*****This implies for total and hexavalent chromium shall be conformed at the outlet of the chromate removal unit. This implies that in the final treated effluent, total and hexavalent chromium shall be lower than prescribed herein.*

3.8.4 Pending and proposed regulatory requirements

3.8.4.1 Proposed national emission standards for petrochemical plants

Table 3-11: Emission Standards for Heater/Furnace/Boilers/Vaporizers

S.No.	Parameter		Maximum emission Limit (mg/Nm^3)	
			Existing plants	New plants/expansion (commissioned after January 01, 2007)
1	NOx	Gas firing	350	150
		Liquid firing	400	250
2	SOx	Liquid firing	1700	850
3	CO	Carbon mono oxide limit in case of partial oxidation in PA, MA, PTA and DMT plant	150	150
4	SPM	Liquid firing	150	100

Note: (1). All values are corrected to 3% O2. (2).At the time of decoking, wet scrubber shall be operated.

Table 3-12: Emission Standards for Organic Particulates

S.No.	Petrochemical compound	Maximum emission Limit (mg/Nm^3)		Mass flow limit (gm/hr)
		Existing plants	New plants/expansion (commissioned after January 01,2 007)	
1	Phthalic anhydride (PA), Maleic anhydride (MA), Toluene Di-isocyanate (TDI)	50	25	100*

*Note: * - Mass flow limit (gm/hr) is applicable for new plants and expansion plants.*

Table 3-13: Emission Standards for Process Emission (Specific Organic Pollutants)

S.No.	Parameter	Source	Maximum emission Limit (mg/Nm^3)
1	Chlorine	EDC/VCM plant and incinerator	10
2	HCl	EDC/VCM plant and incinerator	30
3	Ammonia	Process vent (wastewater stripper) acrylonitrile plant, caprolactum plant	75
4	H_2S	Naphtha pre-treatment plant, olefin plant	05
5	Phosgene	Generated in TDI and MDI plants	01

6	HCN	Acrylonitrile plant	10

Table 3-14: Emission Standards for VOC-HAPs from Process Vents

S.No.	Parameters	Maximum emission Limit		
		Existing plant (mg/Nm^3)	New plants/ Expansion	
			(mg/Nm^3)	(gm/hr)
1	(Toluene Di-isocyanate) TDI, Methylenediphenyl Di-isocyanate (MDI)	0.1	0.1	0.5
2	Benzene, Butadiene	5.0	5.0	25.0
3	EO, VCM, EDC, ACN, PO	20.0	10.0	50.0

Table 3-15: Emission Standards for VOC (General) from Process Vents

S.No.	Petrochemical process/compounds	Maximum emission Limit (mg/Nm^3), dry basis
1	MA, PA, Phenol	20
2	Ethyl benzene (EB), Styrene, Toluene, Xylene, Aromatics, EG, PG	100
3	Non-methane HC (paraffin), Acetone, olefins	150

Table 3-16: Standards for Atmospheric Storage Tanks of Petrochemical Products

S.No.	TVP, kPa at 20 ^0C	Storage Tank Capacity (M^3)
1	>10	4 – 75
2	10 – 76	75 – 500
3	10 – 76	>500
4	>76	>75

Note:

1. Requirement for seals in Floating Roof Tanks:

(i) IFRT & EFRT are to be provided with secondary seal with minimum vapour recovery of 96%.

(ii) Primary seal will be liquid or shoe mounted for EFRT and vapour mounted for IFRT. Maximum seal gap width will be 4 cm and maximum gap area will be 200 cm2/m of tank diameter.

(iii) Secondary seal will be rim mounted. Maximum seal gap width will be 1.3 cm and maximum gap area will be 20 cm2/m of tank diameter.

(iv) Material of seal and construction should ensure high performance and durability.

2. Fixed Roof Tanks will have vapour control efficiency of 95% or vapour recovery/balancing efficiency of 90%.

3. Inspection and maintenance of storage tanks should be carried out under strict control. For the inspection, API RP 575 may be adopted. In-service inspection with regard seal gap should be carried out once in every six months and repair to be implemented in short time. In future, possibility of on-stream repair of both seals will be examined.

4. Tanks shall have paint with white colour shade, except for derogation of visually sensitive area.

Table 3-17: Storage of Benzene, VCM and ACN

1. FRT with vapour to incineration with 99.9% of removal efficiency for VOCs.
(or)
2. EFRT with double seals, emission-reducing roof fitting and fitted with fixed roof with vapor removal efficiency of at least 99%.
(or)
3. Internal floating roof and nitrogen blanketing in between fixed and floating roofs.

Table 3-18: Standards for Emission from Loading of Volatile Products

S.No.	Item	(Standards) Maximum Emission Limit
1	Naphtha: ▪ VOC reduction, % (or) ▪ Emission, gm/m^3	 ▪ 99.5 % (or) ▪ 5 gm/m^3
2	Benzene and Butadiene: ▪ VOC reduction, % (or) ▪ Emission, gm/m^3	 ▪ 99.99 % (or) ▪ 20 gm/m^3
3	Toluene/Xylene: ▪ VOC reduction, % (or) ▪ Emission, gm/m^3	 ▪ 99.98 % (or) ▪ 150 gm/m^3

3.8.4.2 Guidelines

Guidelines for atmospheric storage tank practices

- For true vapour pressure up to 10 kPa with tank capacity in the range of 4-75 m^3, Fixed Roof Tank (FRT) with pressure valve vent may be provided.
- For true vapour pressure of 10-76 kPa with tank capacity in the range of 75-500 m^3, Internal Floating Roof Tank (IFRT) or External Floating Roof Tank (EFRT) or Fixed Roof Tank with vapour control or vapour balancing system may be provided.
- For true vapour pressure more than 10-76 kPa with tank capacity more than 500 m^3, Internal Floating Roof Tank or External Floating Roof Tank or Fixed Roof Tank with vapour control system may be provided.
- For true vapour pressure more than 76 kPa with tank capacity more than 75 m^3, Fixed Roof Tank with vapour control system may be provided.

LDAR and monitoring protocol

LDAR programme include (i) Block valves; (ii) Control valves; (iii) Pump seals; (iv) Compressor seals; (v) Pressure relief valves; (vi) Flanges – Heat Exchangers; (vii) Flanges – Piping; (viii) Connectors – Piping; (ix) Open ended lines; and (x) Sampling connections. Equipment and line sizes more than 2.54 cm are to be covered.

LDAR programme would be applicable to components for following products/ compounds: (i) hydrocarbon gases; (ii) Light liquid with vapour pressure @ 20°C > 1.0 kPa; and (iii) Heavy liquid with vapour pressure @ 20°C between 0.3 to 1.0 kPa.

LDAR programme would not be applicable for (i) heavy liquids with vapour pressure < 0.3 kPa, it will be desirable to check for liquid dripping as indication of leak (ii) Equipment and line sizes less than 2.54 cm, less than 300 h service and in vacuum service. (iii) Equipments and piping during start up and shut down.(iv)Pumps (Canned, diaphragm, magnetic), Valves (Diaphragm, bellow) and close loop Sampling points and (v) Non-access able points to the extent of 5% of total plant.

A leak is defined as the detection of VOC concentration more than the values (in ppm) specified below at the emission source using a hydrocarbon analyser according to measurement protocol (US EPA – 40 CFR part 60 Appendix-A, method 21 for determination of VOC leaks may be referred):

Table 3-19: HAP and Volatile HAP Concentrations in LDAR Components

S.No.	Component	HAP (General) in ppm		Volatile HAP* in ppm	
		w.e.f. 1.1.07	w.e.f. 1.1.10	w.e.f. 1.1.07	w.e.f. 1.1.10
1	Pump / Compressor	10000	5000	3000	2000
2	Valves / Flanges	10000	3000	2000	1000
3	Other components	10000	3000	2000	1000

*Note : * - Benzene, butadiene, VCM, EDC, ACN, EO, PO*

In addition, any component observed to be leaking by sight, sound or smell, regardless of concentration (liquid dripping, visible vapour leak) or presence of bubbles using soap solution should be considered as leak. Frequency of monitoring of leaks and schedule for repair of leaks as given in Table 3-20 shall be followed:

Table 3-20: Frequency of Monitoring of Leaks and Schedule for Repair of Leaks

S.No.	Component	Frequency of monitoring	Repair schedule
1	Valves/Flanges	Quarterly (semi-annual after two consecutive periods with <2% leaks and annual after 5 periods with < 2% leaks)	Repair will be started within 5 working days and shall be completed within 15 working days after detection of leak for general hydrocarbons. In case of benzene, the leak shall be attended
2	Pump seals	Quarterly	
3	Compressor seals	Quarterly	
4	Pressure relief devices	Quarterly	

S.No.	Component	Frequency of monitoring	Repair schedule
5	Pressure relief (devices after venting)	Within 24 hours	immediately for repair.
6	Heat Exchangers	Quarterly	
7	Process drains	Annually	
8	Components that are difficult to monitor	Weekly	
9	Pump seals with visible liquid dripping	Weekly	Immediately
10	Any component with visible leaks	Weekly	Immediately
11	Any component after repair/replacement	Within a week	-

Following types of monitoring methods may be judiciously employed for detection of leaks: (i) Photo ionization detector (PID) or flame ionization detector (FID) Instrumental method of measurement of leaks; (ii) Audio, visual and olfactory (AVO) leak detection; and (iii) Soap bubble method.

- Data on time of measurement & concentration value for leak detection; time of repair of leak; and time of measurement & concentration value after repair of leak should be documented for all the components.
- Pressure relief and blow down systems should discharge to a vapour collection and recovery system or to flare.
- Open-ended lines should be closed by a blind flange or plugged.
- Totally closed-loop should be used in all routine samples.
- Low emission packing should be used for valves.
- High integrity sealing materials should be used for flanges.

3.8.4.3 General notes

Emission monitoring shall be carried out as per the Emission Regulations – Part III, published by CPCB. Methods as given in Table 3-21 may be used for measurement of pollutant concentrations in the emissions.

Table 3-21: Methods for Measurement of Pollutant Concentrations in the Emissions

S.No.	Parameter	Method of measurement
1	Sulphur Dioxide (SO_2)	USEPA CFR – 40 Part 60 Appendix A Method 6
2	Oxides of Nitrogen (NOx)	USEPA CFR – 40 Part 60 Appendix A Method 7
3	Particulate Matter (PM)	USEPA CFR – 40 Part 60 Appendix A Method 5
4	Carbon Monoxide (CO)	USEPA CFR – 40 Part 60 Appendix A

		Method IOA / Combustion analyzer with electro chemical detect or / NDIR detector

3.8.4.4 CREP action points

CREP action points for petrochemical industry include the following:

- Adoption of state-of-art technology
  - State of Art technology will be adopted for both process technologies as well sound engineering practices required for control of emission, at the stage of design itself in case of new plants
- Management of storm water
  - For the storm water generated from process area and tank farm area during initial hours of rain. An arrangement will be made for collection and oil separation including further treatment as required. Such arrangement will include provision for buffer tank (holding tank) and monitoring of effluent quality.
- Effective detoxification and wastewater treatment scheme
  - In order to control high COD and persistent organic pollution including toxic constituents, industry will select appropriate unit operations for pre-treatment of effluent within ISBL before sending to the biological treatment systems for better functioning of ETPs. Action plan for the same will be submitted within 6 months and implemented within one year (March, 2004)
- Control of emission from combustion
  - The industry will submit an action plan within six months for improving thermal efficiency and control of NOx.
- Proper functioning of point source emission control systems
  - The industry will make efforts for proper operation of pollution control system (mostly scrubbers) and attainment of desired efficiency within six months. This will include backup of power supply to the control equipment and arrangement for frequent sampling and analysis of all critical pollution in the tall gases.
- LDAR programme
  - As a good operating, the industry will adopt LDAR programme periodically to check fugitive emissions within six months. The frequency of programme will be proportionate to the risk potential of carrying fluid. Based on leak detection as per LDAR programme, action will be taken to eliminate fugitive emissions. This will be a continuous activity.
- Handling of halogenated organics
  - The industry will submit an action plan to ensure that no halogenated organics is sent to the flares in order to avoid formation of persistent organic pollutants. All HAPs had halogenated organics will be routed to the incineration system having end- on –pollution control facility.
- Control of fugitive emissions of carcinogenic compounds
  - Fugitive emissions of carcinogenic compounds (*e.g.,* Benzene) will be controlled by closed vapor collection and recovery system. Measures will be taken to monitor health of the work

- Management of solid waste
  - Proper facilities will be provided for handling and storage of hazardous waste with manifest system in case transported to other places. For incinerable waste, properly designed incinerator will be installed within the premises or as a common facility. The non-incinerable hazardous waste should be disposed off in a secure-land fill.

- Proper operation of incinerator
  - Industry will check the design and will adopt sound engineering practices for proper operation of incinerators. Continuous monitoring will be done for operational parameters and specific parameters in tail gas to ensure the efficient functioning.
- Optimizing the inventory of hazardous chemicals
  - Efforts will be made to optimize the inventory, particularly of hazardous chemicals. Such information will be made available to the Regulatory Agencies (SPCB). Inspector of Factory & District Collector.
- Self – regulation by industry through monitoring and environmental auditing.
  - Industry will go for self –assessment and regulation by conducting environmental auditing regularly, besides having regular monitoring of pollutants in air emission, liquid effluent and receiving environment.
- Organizational restructuring and accreditation of environmental manager of industry
  - For self-evaluation, organizational restructuring will be done and the environmental manager of the industry will be accredited to bring professionalism in environmental management.

4. OPERATIONAL ASPECTS OF EIA

Prior environmental clearance process has been revised in the Notification issued on 14th September, 2006, into following four major stages *i.e.*, screening, scoping, public consultation and appraisal. Each stage has certain procedures to be followed. This section deals with all the procedural and technical guidance, for conducting objective-oriented EIA studies, their review and decision-making. Besides, the Notification also classifies projects into Category A, which requires prior environmental clearance from MoEF and Category B from SEIAA/UTEIAA.

Consistency with other requirements

- Clearance from other regulatory bodies is not a pre-requisite for obtaining the prior environmental clearance and all such clearances will be treated as parallel statutory requirements.
- Consent for Establishment (CFE) and Prior Environmental Clearance are two different legal requirements, a project proponent should acquire. Therefore, these two activities can be initiated and proceeded with simultaneously.
- If a project falls within the purview of CRZ and EIA Notifications, then the project proponent is required to take separate clearances from the concerned Authorities.
- Rehabilitation and Resettlement (R&R) issues need not be dealt under the EIA Notification as other statutory bodies deal with these issues. However, socio-economic studies may be considered while taking environmental decisions.

4.1 Coverage of the Industry under the Purview of Notification

All the new petro-chemical industrial projects including expansion and modernization require prior environmental clearance. Based on pollution potential, all these projects are classified into Category A.

The sequence of steps in the process of prior environmental clearance for Category A projects are shown in Figure 4.1. The timelines indicated against each stage are the maximum permissible time lines set in the Notification for said task. In case the said task is not cleared/objected by the concerned Authority, within the specified time, said task is deemed to be cleared, in accordance to the proposal submitted by the proponent. Each stage in the process of prior environmental clearance for the proposed petro-chemical industry is discussed in subsequent sections.

In case of Expansion or Modernization of the developmental Activity:

- Any developmental activity, which has an EIA clearance (existing plant), when undergoes expansion or modernization (change in process or technology) with increase in production capacity or any change in product mix beyond the list of products cleared in the issued clearance is required to submit new application for EIA clearance.

- Any developmental activity, which is listed in Schedule of the EIA Notification and due to expansion of its total capacity, if falls under the purview of either Category B or Category A, then such developmental activity requires clearance from respective Authorities.

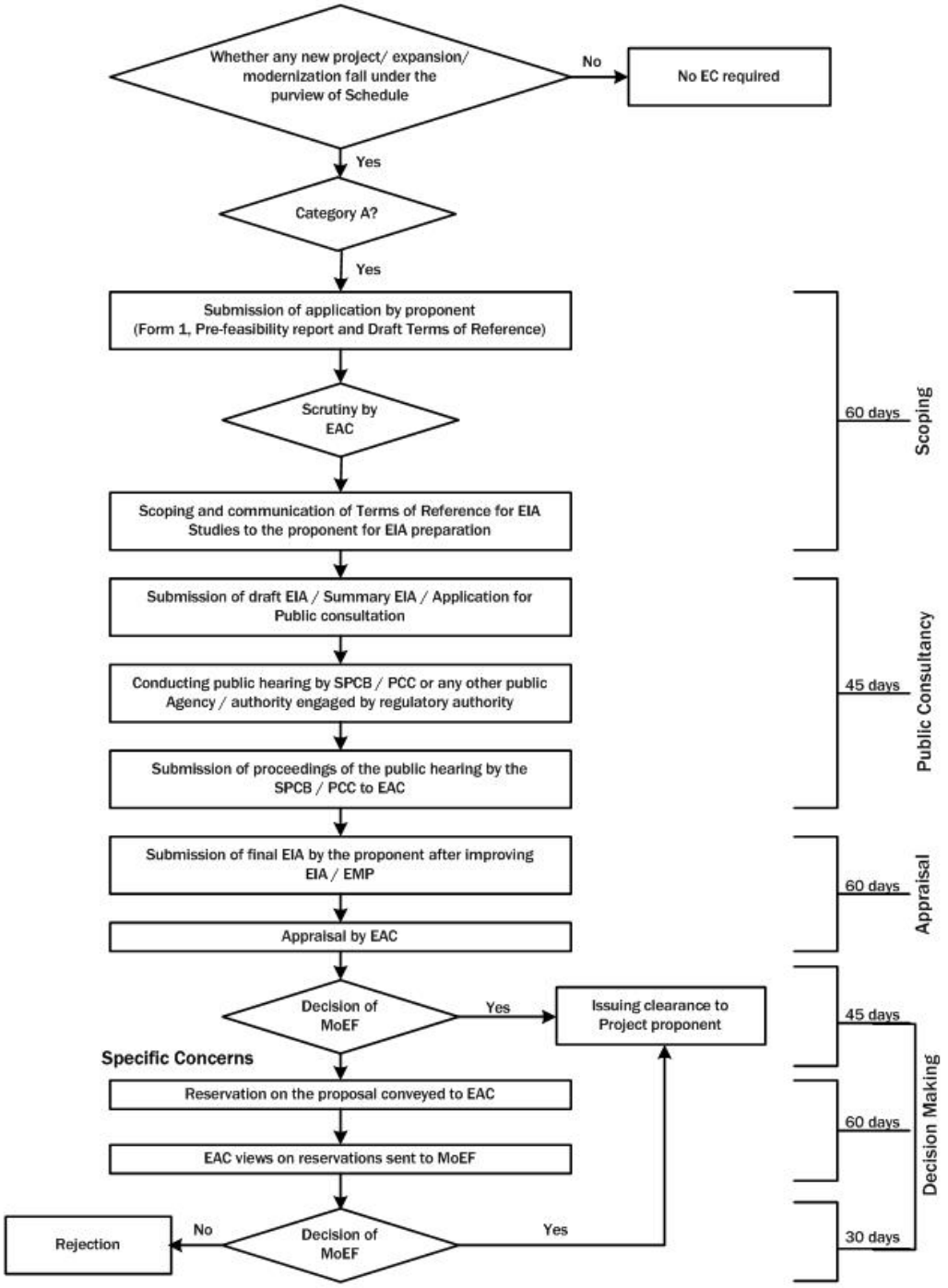

Figure 4-1: Prior Environmental Clearance Process

4.1.1 Application for prior environmental clearance

- The project proponent, after identifying the site and carrying out a pre-feasibility study, is required to apply for the prior environmental clearance using Form 1 given in **Annexure V**. The proponent has to submit the filled in Form 1 along with the pre-feasibility report and draft terms of reference for EIA studies to the MoEF, Government of India. Please refer subsequent sections for the information on how to fill the Form 1, contents of pre-feasibility report and draft sector-specific ToRs.
- Prior environmental clearance is required before starting any construction work, or preparation of land on the identified site/project or activity by the project management, except for securing the land.
- If the application is made for a specific developmental activity, which has an inherent area development component as a part of its project proposal and the same project also attracts the construction and area development provisions under 8a and 8b of the Schedule, then the project will be seen as a developmental activity other than 8a and 8b of the Schedule.

4.1.2 Siting guidelines

These are the guidelines, stakeholders may consider while siting the developmental projects, to minimize the associated possible environmental impacts. In some situations, adhering to these guidelines is difficult and unwarranted. Therefore, these guidelines may be kept in the background, as far as possible, while taking the decisions.

Areas preferably be avoided

While siting industries, care should be taken to minimize the adverse impact of the industries on immediate neighborhood as well as distant places. Some of the natural life sustaining systems and some specific landuses are sensitive to industrial impacts because of the nature and extent of fragility. With a view to protect such sites, the industries may maintain the following distances, as far as possible, from the specific areas listed:

- Ecologically and/or otherwise sensitive areas: Preferably 5 km; depending on the geo-climatic conditions the requisite distance may be decided appropriately by the agency.
- Coastal areas: Preferably ½ km away from high tide line (HTL).
- Flood plain of the riverine system: Preferably ½ km away from flood plain or modified flood plain affected by dam in the upstream or flood control systems.
- Transport/Communication System: Preferably ½ km. away from highway and railway line.
- Major settlements (3,00,000 population): Distance from major settlements is difficult to maintain because of urban sprawl. At the time of siting of the industry, if the notified limit of any major settlement is found to be within 50 km from the project boundary, the spatial direction of growth of the settlement for at least a decade must be assessed. Subsequently, the industry may be sited at least 25 km from the projected growth boundary of the settlement.
- Critically polluted areas identified by MoEF, from time to time. Current list of critically polluted areas is given in **Annexure VI**.

Note:

*Ecological and/or otherwise sensitive areas include (i) Religious and Historic Places; (ii) Archaeological Monuments (*e.g., *identified zone around Taj Mahal); (iii) Scenic Areas; (iv) Hill Resorts; (v) Beach Resorts; (vi) Health Resorts; (vii) Coastal Areas rich in Corals, Mangroves, Breeding Grounds of Specific Species; (viii) Estuaries rich in Mangroves, Breeding grounds of Specific Species; (ix) Gulf Areas; (x) Biosphere Reserves; (xi) National Parks and Sanctuaries; (xii) Natural lakes, Swamps; (xiii) Seismic Zones; (xiv) Tribal Settlements; (xv) Areas of Scientific and Geological Interest; (xvi) Defence Installations, specially those of security importance and sensitive to pollution; (xvii) Border Areas (International) and (xviii) Air Ports.*

Pre-requisite: State and Central Governments are required to identify such areas on a priority basis.

General siting factors

In any particular selected site, the following factors must also be recognized.

- No forest land shall be converted into non-forest activity for the sustenance of the industry (Ref: Forest Conversation Act, 1980).
- No prime agricultural land shall be converted into industrial site.
- Land acquired shall be sufficiently large to provide space for appropriate green cover including green belt, around the battery limit of the industry.
- Lay out of the industry that may come up in the area must conform to the landscape of the area without affecting the scenic features of that place.
- Associated township of the industry may be created at a space having physiographic barrier between the industry and the township.

4.2 Scoping for EIA Studies

Scoping exercise is taken-up soon after the project contours are defined. The primary purpose of scoping is to identify the concerns and issues which may affect the project decisions. Besides, scoping defines the requirements and boundaries of an EIA study.. The results of the scoping exercise form the basis for the rest of the EIA process.

Scoping refers to the process by which the EAC, including applications for expansion and/or modernization of existing projects, determine ToR for EIA studies addressing all relevant environmental concerns for the preparation of an EIA Report for a particular project.

- Project proponent shall submit the application to concerned Authority. The application (Form 1 as given in **Annexure V** shall be attached with pre-feasibility report and proposed ToR for EIA Studies. The proposed sequence to arrive at the draft ToR is discussed below:
  - Pre-feasibility report summarizes the project details and also the likely environmental concerns based on secondary information, which will be availed for filling the Form 1.
  - From pre-feasibility report and Form 1, valued environmental components (VECs) may be identified for a given project (the receiving environment/social

components, which are likely to get affected due to the project operations/ activities).

- Once the project details from the pre-feasibility report & Form 1; and VECs are identified, a matrix establishing the interactions which can lead to the effects/ impacts could be developed (Qualitative analysis).
- For each identified possible effect in the matrix, significance analysis could be conducted to identify the impacts, which needs to be studied further (quantitative analysis) in the subsequent EIA studies. All such points will find a mention in the draft ToR to be proposed by the project proponent along with the application form. The draft ToR shall include applicable baseline parameters (refer **Annexure IX**) and impact prediction tools (refer **Annexure XI**) proposed to be applied
- The information to be provided in pre-feasibility report, guidelines for filling Form 1 and guidelines for developing draft ToR is summarized in the subsequent sections.
- Authority consults the EAC to reply to the proponent. The EAC reviews the application form, pre-feasibility report and proposed draft ToR by the proponent and make necessary additions/deletions to make it a comprehensive ToR that suits the statutory requirements for conducting the EIA studies.

- A site visit by sub-committees of EAC will be planned, only if considered necessary by the EAC with the written approval of the chairperson of EAC. Project proponent will facilitate such site visits of the sub-committees.
- EAC shall provide an opportunity to the project proponent for presentation and discussions on the proposed project and related issues as well as the proposed ToR for EIA studies. If the State Government desires to present its views on any specific project in the scoping stage, it can depute an officer for the same at the scoping stage to EAC, as an invitee but not as a member of EAC. However, non-appearance of the project proponent before EAC at any stage will not be a ground for rejection of the application for the prior environmental clearance.
- In case of a new or expansion project in an identified problem area by the CPCB, then the MoEF may present their views, if any at the stage of scoping, to the EAC.
- The final set of ToR for EIA studies shall be conveyed to the proponent by the EAC within sixty days of the receipt of Form 1 and pre-feasibility report. If the finalized ToR for EIA studies is not conveyed to the proponent within sixty days of the receipt of Form 1, the ToR suggested by the proponent shall be deemed as the final and will be approved for the EIA studies.
- Final ToR for EIA studies shall be displayed on the website of the MoEF.
- Applications for prior environmental clearance may be rejected by the concerned Authority based on the recommendations by the EAC at this stage itself. In case of such rejection, the decision together with reasons for the same shall be communicated to the proponent in writing within sixty days of the receipt of the application.
- The final EIA report and other relevant documents submitted by the applicant shall be scrutinized by the MoEF strictly with reference to the approved ToR for EIA studies.

4.2.1 Pre-feasibility report

The pre-feasibility report should include, but not limited to highlight the proposed project information, keeping in view the environmental sensitivities of the selected site, raw

material (feedstock such as naphtha/gas), technology options (cracking process, coking, *etc*.) and its availability. Information required in pre-feasibility report varies from case to case even in same sector depending upon the local environmental setting within which the plant is located/proposed. However, the information which may be furnished in the pre-feasibility report may include as under:

I. Executive summary

II. Project details: Description of the project including in particular;

- a description of the main characteristics of the production processes, for instance, nature and quantity of materials used,
- an estimate, by type and quantity, of expected residues and emissions (water, air and soil pollution, noise, vibration, light, heat, radiation, *etc.*) resulting from the operation of the proposed project.
- a description of the physical characteristics of the whole project and the land-use requirements during the construction and operational phases

III. Selection of site based on least possible impacts

- An outline of the main alternatives studied by the developer and an indication of the main reasons for this choice, taking into account the environmental effects.

IV. Anticipated impacts based on project operations on receiving environment

- A description of the aspects of the environment likely to be significantly affected by the proposed project, including, in particular, population, fauna, flora, soil, water, air, climatic factors, material assets, including the architectural and archaeological heritage, landscape and the inter-relationship between the above factors.
- A description of the likely significant effects of the proposed project on the environment resulting from:
  - existence of the project
  - use of natural resources
  - emission of pollutants, the creation of nuisances and the elimination of waste
  - project proponent's description of the forecasting methods used to assess the effects on the environment

V. Proposed broad mitigation measures which could effectively be internalized as project components to have environmental and social acceptance of the proposed site

- A description of key measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment

VI. An indication of any difficulties (technical deficiencies or lack of know-how) encountered by the developer in compiling the required information

Details of the above listed points which may be covered in pre-feasibility report are listed in **Annexure VII**.

4.2.2 Guidance for providing information in Form 1

The information given in specifically designed pre-feasibility report for this developmental activity may also be availed for filling Form 1.

Form 1 is designed to help users identify the likely significant environmental effects of proposed projects right at the scoping stage. There are two stages for providing information under two columns:

- First - identifying the relevant project activities from the list given in Column 2 of Form 1. Start with the checklist of questions set out below and complete Column 3 by answering:
  - Yes - if the activity is likely to occur during implementation of the project
  - No - if it is not expected to occur
  - May be - if it is uncertain at this stage whether it will occur or not
- Second - Each activity for which the answer in Column 3 is "Yes" the next step is to refer to the fourth column which quantifies the volume of activity which could be judged as significant impact on the local environmental characteristics, and identify the areas that could be affected by that activity during construction /operation / decommissioning of the project. Form 1 requires information within 15 km around the project, whereas actual study area for EIA studies will be as prescribed by EAC. Project proponent will need information about the surrounding VECs in order to complete this Form 1.

4.2.3 Identification of appropriate valued environmental components

VECs are components of natural resources and human world that are considered valuable and are likely to be affected by the project activities. Value may be attributed for economic, social, environmental, aesthetic or ethical reasons. VECs represent the investigative focal point for further EIA process. The indirect and/or cumulative effects can be concerned with indirect, additive or even synergistic effects due to other projects or activities or even induced developments on the same environmental components as would be considered direct effects. But such impacts tend to involve larger scale VECs such as within entire region, river basins or watersheds; and, broad social and economic VECs such as quality of life and the provincial economy. Once VECs are identified then appropriate indicators are selected for impact assessments on the respective VECs.

4.2.4 Methods for identification of impacts

There are various factors which influence the approach adopted for the assessment of direct, indirect, cumulative impacts, *etc*. for a particular project. The method should be practical and suitable for the project given the data, time and financial resources available. However, the method adopted should be able to provide a meaningful conclusion from which it would be possible to develop, where necessary, mitigation measures and monitoring. Key points to consider when choosing the method(s) include:

- Nature of the impact(s)
- Availability and quality of data
- Availability of resources (time, finance and staff)

The method chosen should not be complex, but should aim at presenting the results in a way that can be easily understood by the developer, decision maker and the public. A comparative analysis of major impact identification methods is given in Table 4-1.

Table 4-1: Advantages and Disadvantages of Impact Identification Methods

	Description	Advantages	Disadvantages
Checklists	▪ Annotate the environmental features that need to be addressed when identifying the impacts of activities in the project	▪ Simple to understand and use ▪ Good for site selection and priority setting ▪ Simple ranking and weighting	▪ Do not distinguish between direct and indirect impacts ▪ Do not link action and impact ▪ The process of incorporating values can be controversial
Matrices	▪ Identify the interaction between project activities (along one axis) and environmental characteristics (along other axis) using a grid like table ▪ Entries are made in the cells which highlights impact severity in the form of symbols or numbers or descriptive comments	▪ Link action to impact ▪ Good method for displaying EIA results	▪ Difficult to distinguish direct and indirect impacts ▪ Significant potential for double-counting of impacts
Networks	▪ Illustrate cause effect relationship of project activities and environmental characteristics ▪ Useful in identifying secondary impacts ▪ Useful for establishing impact hypothesis and other structured science based approaches to EIA	▪ Link action to impact ▪ Useful in simplified form for checking for second order impacts ▪ Handles direct and indirect impacts	▪ Can become very complex if used beyond simplified version
Overlays	▪ Map the impacts spatially and display them pictorially ▪ Useful for comparing site and planning alternatives for routing linear developments ▪ Can address cumulative effects ▪ Information incentive	▪ Easy to understand ▪ Good to display method ▪ Good siting tool	▪ Address only direct impacts ▪ Do not address impact duration or probability
GIS	▪ Maps the impacts spatially and display them pictorially ▪ Useful for comparing site	▪ Easy to understand ▪ Good to display method	▪ Do not address impact duration or probability ▪ Heavy reliance on

	Description	Advantages	Disadvantages
	and planning alternatives for routing linear developments ▪ Can address cumulative effects ▪ Information incentive	▪ Good siting tool ▪ Excellent for impact identification and analysis	knowledge and data ▪ Often complex and expensive
Expert System	▪ Assist diagnosis, problem solving and decision making ▪ Needs inputs from user by answering systematically developed questions to identify impacts and determine their mitigability and significance ▪ Information intensive, high investment methods of analysis	▪ Excellent for impact identification and analysis ▪ Good for experimenting	▪ Heavy reliance on knowledge and data ▪ Often complex and expensive

The project team made an attempt to construct an impact matrix considering major project activities (generic operations) and stage-specific likely impacts which is given in Table 4-2.

While the impact matrix is each project-specific, Table 4-2 may facilitate the stakeholders in identifying a set of components and phase-specific project activities for determination of likely impacts. However, the location-specific concerns may vary from case to case; therefore, the components even without likely impacts are also retained in the matrix for the location-specific reference.

Table 4-2: Matrix of Impacts

			PHASE I					PHASE II							PHASE III						
			Pre-Construction					Construction/ Establishment							Operation and Maintenance						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
ENVIRONMENT	Component	Project Activities / Parameter/ factor	Detailed Topographic Survey	Land Acquirement	Site Clearing	Burning of wastes, refuse and cleared vegetation	Site Preparation / Change in Topography	Civil works such as earth moving and building of structures including temporary structures	Heavy Equipment operations	Disposal of construction wastes	Generation of sewerage	Influx of construction workers	Deforestation	Transportation of material	Feedstock handling and storage	Chemical reactions in unit processes and unit operations - Cracking process	Product separation and refinement	Product handling and storage	Waste management –liquid and solid waste		
Physical	**Soil**	Erosion Risks											*								
		Contamination						*		*											
		Soil Quality						*													
	Resources	Fuels/ Electricity												*	*	*	*				
		Raw materials						*							*	*					
		Land especially undeveloped or agricultural land								*											
	Water	Interpretation or Alteration of River Beds					*														
		Alteration of Hydraulic Regime											*								
		Alteration of surface run-off and interflow					*	*													
		Alteration of aquifers					*	*													
		Water quality						*			*										
		Temperature																	*		
	Air	Air quality				*		*	*					*		*	*				
		Noise						*	*					*		*	*				

				PHASE I					PHASE II							PHASE III						
				Pre-Construction					Construction/ Establishment							Operation and Maintenance						
1	2	3		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
		Climate					*							*								
Biological	**Terrestrial Flora**	Effect on grass & flowers				*		*			*			*								
		Effect on trees & shrubs				*		*						*								
		Effect on farmland				*		*			*											
		Endangered species				*		*						*								
	Aquatic Biota	Habitat removal				*		*														
		Contamination of habitats				*		*														
		Reduction of aquatic biota				*		*														
	Terrestrial Fauna	Fragmentation of terrestrial habitats				*		*						*								
		Disturbance of habitats by noise or vibration				*		*														
		Reduction of Biodiversity				*		*						*								
Social	**Economy**	Creation of new economic activities	*										*									
		Commercial value of properties											*									
		Conflict due to negotiation and/ compensation payments																				
		Generation of temporary and permanent jobs											*									
		Effect on crops				*			*			*										
		Reduction of farmland productivity		*																		
		Income for the state and private sector																				
		Savings for consumers & private consumers																				
		Savings in foreign currency for the state																				

				PHASE I					PHASE II							PHASE III						
				Pre-Construction					Construction/ Establishment							Operation and Maintenance						
1	2	3		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	Education	Training in new technologies		*																		
		Training in new skills to workers		*																		
	Public Order	Political Conflicts			*														*			
		Unrest, Demonstrations & Social conflicts			*														*			
	Infrastructure and Services	Conflicts with projects of urban, commercial or Industrial development		*					*													
	Security and Safety	Increase in Crime									*											
		Accidents caused by								*							*				*	
	Health						*															
	Cultural	Land use				*		*														
		Recreation																				
		Aesthetics and human interest									*			*								
		Cultural status																				

Note:

1. Above table represents a model for likely impacts, which will have to be arrived at on a case-to-case basis considering VECs and significance analysis (Ref Section 2.9).

2. Project activities are shown as indicative. However, in Form 1 (application for EIA Clearance), for any question for which answer is 'Yes', then the corresponding activity shall reflect in project activities. Similarly 'parameters'/'factors' will also be changed within a component in order to reflect the target species of prime concern in the receiving local environment.

4.2.5 Testing the Significance of Impacts

The following set of conditions may be used as the checklist for testing the significance of the impacts and also to provide information in Column IV of Form 1.

- Will there be a large change in environmental conditions?
- Will new features be out-of-scale with the existing environment?
- Will the effect be unusual in the area or particularly complex?
- Will the effect extend over a large area?
- Will there be any potential for trans-frontier impact?
- Will many people be affected?
- Will many receptors of other types (fauna and flora, businesses, facilities) be affected?
- Will valuable or scarce features or resources be affected?
- Is there a risk that environmental standards will be breached?
- Is there a risk that protected sites, areas, and features will be affected?
- Is there a high probability of the effect occurring?
- Will the effect continue for a long time?
- Will the effect be permanent rather than temporary?
- Will the impact be continuous rather than intermittent?
- If it is intermittent will it be frequent rather than rare?
- Will the impact be irreversible?
- Will it be difficult to avoid, or reduce or repair or compensate for the effect?

For each "Yes" answer in column 3, the nature of effects and reasons for it should be recorded in the column 4. The questions are designed so that an "Yes" answer in column 3, will generally point towards the need for analyzing for the significance and requirement for conducting impact assessment for the effect.

4.2.6 Terms of reference for EIA studies

ToR for EIA studies in respect of the petro-chemical industry may include, but not limited to the following:

1. Executive summary of the project – giving a *prima facie* idea of the objectives of the proposal, use of resources, justification, *etc*. In addition, it should provide a compilation of EIA report including EMP and the post-project monitoring plan in brief.

Project description

2. Justification for selecting the proposed plant capacity.
3. Land requirement for the project including its break up for various purposes, availability and optimization.
4. Details of proposed layout clearly demarcating various facilities/units of the plant.
5. Complete process flow diagram describing each unit, its processes and operations, along with material and energy inputs and outputs (material and energy balance) for the production of olefins and aromatics.
6. Details of proposed source-specific pollution control schemes and equipments to meet the national standards.

7. Details on requirement of raw material (naphtha/gas feedstock), its source, supply and storage at the plant. Also include details on feedstock preparation.
8. Details on requirement of auxiliary chemicals and utilities to support the unit processes.
9. Details of cracker and its yield *i.e*, ethylene, propylene, butadiene.
10. Details of catalytic reformers/aromatic plant process for its different products – benzene, toluene, xylene, p-xylene.
11. Details on special environmental precautions during startup and shutdown operations.
12. Details on VOC balance including point sources, fugitive emissions, flare management, *etc*.
13. Details on management of Hazardous Air Pollutants – specific plant equipment for least release rates, closed conveyance of effluents for treatment, *etc*.
14. Details on proposed LDAR protocol.
15. Details on requirement of energy and water along with its source and authorization from the concerned department.
16. Details on water balance including quantity of effluent generated, recycled & reused. Efforts to minimize effluent discharge and to maintain quality of receiving water body.
17. Details of effluent treatment plant, inlet and treated water quality with specific efficiency of each treatment unit in reduction in respect of all concerned/regulated environmental parameters.
18. Details of the proposed methods of water conservation and recharging.
19. Management plan for solid/hazardous waste generation including its composition/ characterization/categorization, storage, utilization and disposal.
20. Details regarding infrastructure facilities such as sanitation, fuel storage, restroom, *etc*., to the workers during construction and operation phase.
21. In case of expansion of existing industries, remediation measures adopted to restore the environmental quality if the groundwater, soil, crop, air, *etc*., are affected and a detailed compliance to the prior environmental clearance/consent conditions.
22. Any litigation pending against the project and /or any direction /order passed by any Court of Law related to the environmental pollution and impacts in the last two years, if so, details thereof.

Description of the environment

23. The study area shall be up to a distance of 10 km from the boundary of the proposed project site.
24. Location of the project site and nearest habitats with distances from the project site to be demarcated on a toposheet (1: 50000 scale).
25. Land use based on satellite imagery including location specific sensitivities such as national parks / wildlife sanctuary, villages, industries, *etc*., for the study area.
26. Demography details of all the villages within the study area.
27. Topography details of the study area.

28. The baseline data to be collected from the study area w.r.t. different components of environment viz. air, noise, water, land, and biology and socio-economic (please refer Section 4.4.2 for guidance for assessment of baseline components and identify attributes of concern). Actual monitoring of baseline environmental components shall be strictly according to the parameters prescribed in the ToR after considering the proposed coverage of parameters by the proponent in draft ToR and shall commence after finalization of ToR by the competent Authority.
29. Geological features and geo-hydrological status of the study area.
30. Details on groundwater and surface water quality of nearby water sources and other surface drains for the parameters such as pH*, BOD*, COD*, Phenol*, Sulphide*, Cyanide*, Fluoride*, Total suspended solids*, Chromium*, *etc*. (* - as applicable)
31. Details on existing ambient air quality and expected, stack and fugitive emissions for NOx*, SOx*, CO*, SPM*, Chlorine*, HCl*, Ammonia *, H_2S*, Phosgene*, HCN*, Benzene*, HAPs*, *etc.,* and evaluation of the adequacy of the proposed pollution control devices to meet standards for point sources and to meet AAQ standards. (* - as applicable)
32. The air quality contours may be plotted on a location map showing the location of project site, habitation nearby, sensitive receptors, if any and wind roses.
33. Details on noise levels at sensitive/commercial receptors.
34. Site-specific micro-meteorological data including mixing height.
35. One season site-specific data excluding monsoon season.
36. Proposed baseline monitoring network for the consideration and approval of the Competent Authority.
37. Ecological status (terrestrial and aquatic) of the study area such as habitat type and quality, species, diversity, rarity, fragmentation, ecological linkage, age, abundance, *etc*.
38. If any incompatible landuse attributes fall within the study area, proponent shall describe the sensitivity (distance, area and significance) and propose the additional points based on significance for review and acceptance by the EAC. Incompatible landuse attributes include:

    – Public water supply areas from rivers/surface water bodies, from ground water
    – Scenic areas/tourism areas/hill resorts
    – Religious places, pilgrim centers that attract over 10 lakh pilgrims a year
    – Protected tribal settlements (notified tribal areas where industrial activity is not permitted)
    – Monuments of national significance, World Heritage Sites
    – Cyclone, Tsunami prone areas (based on last 25 years);
    – Airport areas
    – Any other feature as specified by the State or local government and other features as locally applicable, including prime agricultural lands, pastures, migratory corridors, *etc*.

39. If ecologically sensitive attributes fall within the study area, proponent shall describe the sensitivity (distance, area and significance) and propose additional points based on significance for review and acceptance by the EAC. Ecological sensitive attributes include:

    – National parks

- Wild life sanctuaries
- Tiger reserve/elephant reserve/turtle nesting ground
- Mangrove area
- Wetlands
- Reserved and Protected forests
- Any other closed/protected area under the Wild Life (Protection) Act, 1972, any other area locally applicable
- Any other eco-sensitive areas

40. If the location falls in Valley, specific issues connected to the natural resources management shall be studied and presented.

41. If the location falls in CRZ area: A CRZ map duly authenticated by one of the authorized agencies demarcating LTL, HTL, CRZ area, location of the project and associate facilities w.r.t. CRZ, coastal features such as mangroves, if any.

    - Provide the CRZ map in 1:10000 scale in general cases and in 1:5000 scale for specific observations.
    - Proposed site for disposal of dredged material and environmental quality at the point of disposal/impact areas.
    - Fisheries study should be done w.r.t. Benthos and Marine organic material and coastal fisheries.

Anticipated environmental impacts and mitigation measures

42. Anticipated generic environmental impacts due to this project are indicated in Table 4-2, which may be evaluated for significance and based on corresponding likely impacts VECs may be identified. Baseline studies may be conducted for all the concerned VECs and likely impacts will have to be assessed for their magnitude in order to identify mitigation measures (please refer Chapter 4 of the manual for guidance).

43. Tools as given in Section 4.4.3 may be referred for the appropriate assessment of environmental impacts and same may be submitted in draft ToR for consideration and approval by EAC.

44. While identifying the likely impacts, also include the following for analysis of significance and required mitigation measures:

    - impacts due to transportation of raw materials (feedstock, auxiliary chemicals, *etc*.) and end products on the surrounding environment
    - impacts due to release of water pollutants (suspended solids, acid/alkaline effluents, nitrogen compounds, biodegradable organics, mixtures of oil/organics in water, volatile organics, heavy metals, heat, *etc*.) from unit processes on soil, surface water and groundwater
    - impacts due to release of air pollutants (SOx, NOx, VOCs, particulate matter, acid gases, combustion gases, dioxins, *etc*.) from catalyst regeneration, tank vents, loading operations and other unit processes such as distillation, purification, storage tanks, *etc*
    - impacts due to fugitive and stack emissions
    - impacts due to odour pollution
    - impacts due to noise during plant operations
    - impacts due to release of hazardous waste from storage facilities, unit processes, construction materials, corrosion/erection mechanisms, maintenance materials, *etc*

– impact on health of workers due to proposed project activities

45. In case of likely impact from the proposed project on the surrounding reserve forests, plan for the conservation of wild fauna in consultation with the State Forest Department.
46. For identifying the mitigation measures, please refer Chapter III for source control and treatment. Besides typical mitigation measures which may also be considered are discussed in Table 4-5.
47. Action plan for the greenbelt development – species, width of plantations, planning schedule *etc*. in accordance to CPCB published guidelines.

Analysis of alternative resources and technologies

48. Comparison of alternate sites considered and the reasons for selecting the proposed site. Conformity of the site with prescribed guidelines in terms of CRZ, river, highways, railways, *etc*.
49. Details on improved technologies.
50. Details on proposed reuse/recycle/recovery options including regeneration of catalysts.
51. Details on waste minimization options.

Environmental monitoring program

52. Monitoring programme for pollution control at source.
53. Monitoring pollutants at receiving environment for the appropriate notified parameters – air quality, groundwater, surface water, gas quality, *etc*., during operational phase of the project.
54. Specific programme to monitor safety and health protection of workers.
55. Appropriate monitoring network has to be designed and proposed, to assess the possible residual impacts on VECs.
56. Details of in-house monitoring capabilities and the recognized agencies if proposed for conducting monitoring.

Additional studies

57. Details on risk assessment and damage control during different phases of the project and proposed safeguard measures.
58. Details on socio-economic development activities such as commercial property values, generation of jobs, education, social conflicts, cultural status, accidents, *etc*.
59. Proposed plan to handle the socio-economic influence on the local community. The plan should include quantitative dimension as far as possible.
60. Details on compensation package for the people affected by the project, considering the socio-economic status of the area, homestead oustees, land oustees, and landless labourers.
61. Points identified in the public hearing and commitment of the project proponent to the same. Detailed action plan addressing the issues raised, and the details of necessary allocation of funds.

62. Details on plan for corporate social responsibility including the villages, population spread, SC/ST/backward communities, upgradation of existing schools, establishing new schools with facilities (such as laboratories, toilets, *etc.*), link roads, community halls, primary health facilities, health camps, *etc*.

Environmental management plan

63. Administrative and technical organizational structure to ensure proposed post-project monitoring programme for approved mitigation measures.
64. EMP devised to mitigate the adverse impacts of the project should be provided along with item-wise cost of its implementation (capital and recurring costs).
65. Allocation of resources and responsibilities for plan implementation.
66. Details of the emergency preparedness plan and on-site and off-site disaster management plan.

Note:

Above points shall be adequately addressed in the EIA report at corresponding chapters, in addition to the contents given in the reporting structure (Table 4-6).

4.3 Environmental Impact Assessment

The generic approach for accomplishing EIA studies is shown in Figure 4.3. Each stage is discussed, in detail in subsequent sections.

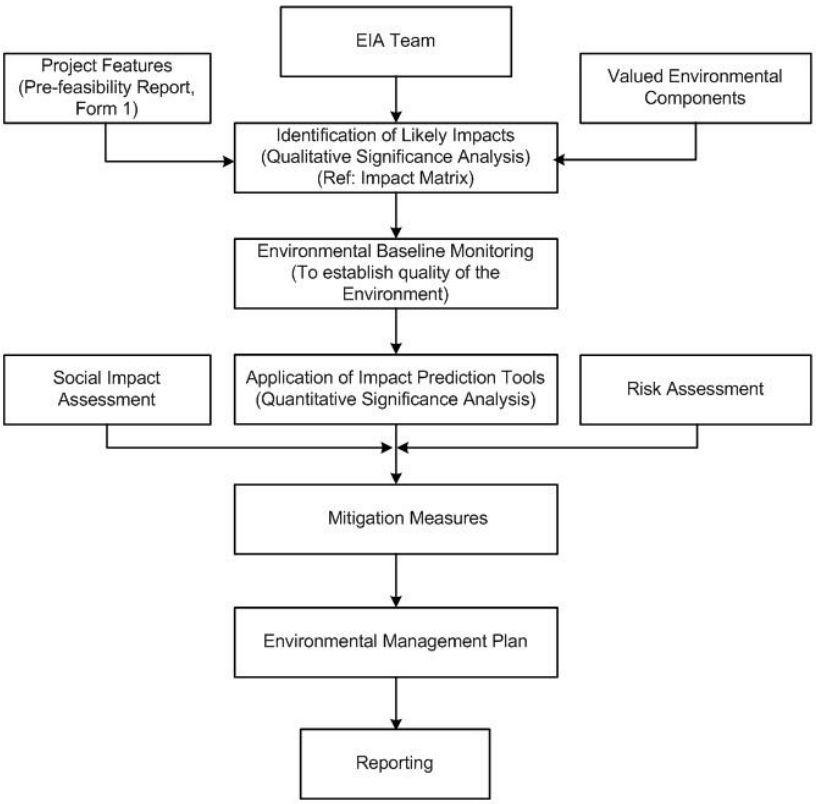

Figure 4-2: Approach for EIA Study

4.3.1 EIA team

The success of a multi-functional activity like an EIA primarily depends on constitution of a right team at the right time (preferable at the initial stages of an EIA) in order to assess the significant impacts (direct, indirect as well as cumulative impacts).

The professional Team identified for a specific EIA study should consist of qualified and experienced professionals from various disciplines in order to address the critical aspects identified for the specific project. Based on the nature and the environmental setting, following professionals may be identified for EIA studies:

- Environmental management specialist/Regulator
- Environmental urban landuse planner
- Air and noise quality
- Organic chemistry specialist
- Agronomy
- Toxicology/occupational health
- Geology/geo-hydrology
- Ecologist
- Transportation specialist
- Safety and risk assessment specialist
- Chemical engineer
- Social scientist, *etc.*

4.3.2 Baseline quality of the environment

EIA Notification 2006 specifies that an EIA Report should contain a description of the existing environment that would be or might be affected directly or indirectly by the proposed project. Environmental Baseline Monitoring (EBM) is a very important stage of EIA. On one hand EBM plays a very vital role in EIA and on the other hand it provides feedback about the actual environmental impacts of a project. EBM, during the operational phase, helps in judging the success of mitigation measures in protecting the environment. Mitigation measures, in turn are used to ensure compliance with environmental standards, and to facilitate the needed project design or operational changes.

Description of the existing environment should include natural, cultural, socio-economic systems and their interrelationships. The intention is not to describe all baseline conditions, but to focus the collection and description of baseline data on those VECs that are important and are likely to be affected by the proposed industrial activity.

4.3.2.1 Objectives of EBM in EIA context

The term 'baseline' refers to conditions existing before development. EBM studies are carried out to:

- identify environmental conditions which might influence project design decisions (*e.g.*, site layout, structural or operational characteristics);
- identify sensitive issues or areas requiring mitigation or compensation;
- provide input data to analytical models used for predicting effects;
- provide baseline data against which the results of future monitoring programs can be compared.

At this stage of EIA process, EBM is primarily discussed in the context of first purpose wherein the feedback from EBM programs may be used to:

- determine available assimilative capacity of different environmental components within the designated impact zone and whether more or less stringent mitigation measures are needed
- improve predictive capability of EIAs

There are many institutional, scientific, quality control, and fiscal issues that must be addressed in implementation of an environmental monitoring program. Careful consideration of these issues in the design and planning stages will help avoid many of the pitfalls associated with environmental monitoring programs.

4.3.2.2 Environmental monitoring network design

Monitoring refers to the collection of data through a series of repetitive measurements of environmental parameters (or, more generally, to a process of systematic observation). Design of the environmental quality monitoring programme design depends up on the monitoring objectives specified for the selected area of interest. Types of monitoring and network design considerations are discussed in **Annexure VIII**.

4.3.2.3 Baseline data generation

List of important physical environmental components and indicators of EBM are given in Table 4-3.

Table 4-3: List of Important Physical Environment Components and Indicators of EBM

Environmental Component	Environmental Indicators
Climatic variables	▪ Rainfall patterns – mean, mode, seasonality ▪ Temperature patterns ▪ Extreme events ▪ Climate change projections ▪ Prevailing wind - direction, speed, anomalies ▪ Relative humidity ▪ Stability conditions and mixing height
Topography	▪ Slope form ▪ Landform and terrain analysis ▪ Specific landform types
Drainage	▪ Surface hydrology ▪ Natural drainage pattern and network ▪ Rainfall runoff relationships ▪ Hydrogeology ▪ Groundwater characteristics – springs, *etc*.
Soil	▪ Type and characteristics ▪ Porosity and permeability ▪ Sub-soil permeability ▪ Run-off rate ▪ Infiltration capacity ▪ Effective depth (inches/centimeters) ▪ Inherent fertility

Environmental Component	Environmental Indicators
	▪ Suitability for method of sewage disposal
Geology	▪ Underlying rock type, texture ▪ Surgical material ▪ Geologic structures (faults, shear zones, *etc*.) ▪ Geologic resources (minerals, *etc*.)
Water	▪ Raw water availability ▪ Water quality ▪ Surface water (rivers, lakes, ponds, gullies) – quality, water depths, flooding areas, *etc*. ▪ Ground water – water table, local aquifer storage capacity, specific yield, specific retention, water level depths and fluctuations, *etc*. ▪ Coastal ▪ Floodplains ▪ Wastewater discharges ▪ Thermal discharges ▪ Waste discharges
Air	▪ Ambient ▪ Respirable ▪ Airshed importance ▪ Odour levels
Noise	▪ Identifying sources of noise ▪ Noise due to traffic/transportation of vehicles ▪ Noise due to heavy equipment operations ▪ Duration and variations in noise over time
Coastal dynamics and morphology	▪ Wave patterns ▪ Currents ▪ Shoreline morphology – near shore, foreshore ▪ Sediment – characteristics and transport
Biological	▪ Species composition of flora and fauna ▪ Flora – type, density, exploitation, *etc*. ▪ Fauna – distribution, abundance, rarity, migratory, species diversity, habitat requirements, habitat resilience, economic significance, commercial value, *etc*. ▪ Fisheries – migratory species, species with commercial/ recreational value
Landuse	▪ Landuse pattern, *etc*.

Guidance for assessment of baseline components and attributes describing sampling network, sampling frequency, method of measurement is given in **Annexure IX**.

Infrastructure requirements for EBM

In addition to devising a monitoring network design and monitoring plans/program, it is also necessary to ensure adequate resources in terms of staffing, skills, equipment, training, budget, *etc*., for its implementation. Besides assigning institutional responsibility, reporting requirements, QA/QC plans and its enforcement capability are essential. A monitoring program that does not have an infrastructural support and QA/QC component will have little chance of success.

Defining data statistics/analyses requirements

The data analyses to be conducted are dictated by the objectives of environmental monitoring program. Statistical methods used to analyze data should be described in detail prior to data collection. This is important because repetitive observations are recorded in time and space. Besides, the statistical methods could also be chosen so that uncertainty or error estimates in the data can be quantified. For *e.g.*, statistical methods useful in an environmental monitoring program include: 1) frequency distribution analysis; 2) analysis of variance; 3) analysis of covariance; 4) cluster analysis; 5) multiple regression analysis; 6) time series analysis; 7) the application of statistical models.

Use of secondary data

The EBM program for EIA can at best address temporal and/or spatial variations limited to a limited extent because of cost implications and time limitations. Therefore analysis of all available information or data is essential to establish the regional profiles. So all the relevant secondary data available for different environmental components should be collated and analyzed.

To facilitate stakeholders, IL&FS Ecosmart Ltd., has made an attempt to compile the list of information required for EIA studies and sources of secondary data, which are given in **Annexure XA** and **Annexure XB**.

4.3.3 Impact prediction tools

The scientific and technical credibility of an EIA relies on the ability of EIA practitioners to estimate the nature, extent, and magnitude of change in environmental components that may result from project activities. Information about predicted changes is needed for assigning impact significance, prescribing mitigation measures, and designing & developing EMPs and monitoring programs. The more accurate the predictions, the more confident the EIA practitioner will be in prescribing specific measures to eliminate or minimize the adverse impacts of development project.

Choice of models/methods for impact predictions in respect to air, noise, water, land, biological and socio-economic environment are tabulated in **Annexure XI**.

4.3.4 Significance of the impacts

Evaluating the significance of environmental effects is perhaps the most critical component of impact analysis. The interpretation of significance bears directly on the subsequent EIA process and also during prior environmental clearance on project approvals and condition setting. At an early stage, it also enters into screening and scoping decisions on what level of assessment is required and which impacts and issues will be addressed.

Impact significance is also a key to choosing among alternatives. In total, the attribution of significance continues throughout the EIA process, from scoping to EIS review, in a gradually narrowing "cone of resolution" in which one stage sets up the next. But at this stage it is the most important as better understanding and quantification of impact significance is required.

One common approach is based on determination of the significance of predicted changes in the baseline environmental characteristics and compares these w.r.t regulatory standards, objective criteria and similar 'thresholds' as eco-sensitivity, cultural /religious values. Often, these are outlined in guidance. A better test proposed by the CEAA (1995) is to determine if 'residual' environmental effects are adverse, significant, and likely (given under). But at this stage, the practice of formally evaluating significance of residual impacts, *i.e.*, after predicting the nature and magnitude of impacts based on before-versus-after-project comparisons, and identifying measures to mitigate these effects is not being followed in a systematic way.

i. Step 1: Are the environmental effects adverse?

Criteria for determining if effects are "adverse" include:

- effects on biota health
- effects on rare or endangered species
- reductions in species diversity
- habitat loss
- transformation of natural landscapes
- effects on human health
- effects on current use of lands and resources for traditional purposes by aboriginal persons
- foreclosure of future resource use or production

ii. Step 2: Are the adverse environmental effects significant?

Criteria for determining 'significance' are to judge that the impacts:

- are extensive over space or time
- are intensive in concentration or proportion to assimilative capacity
- exceed environmental standards or thresholds
- do not comply with environmental policies, landuse plans, sustainability strategy
- adversely and seriously affect ecologically sensitive areas
- adversely and seriously affect heritage resources, other land uses, community lifestyle and/or indigenous peoples traditions and values

iii. Step 3: Are the significant adverse environmental effects likely?

Criteria for determining 'likelihood' include:

- probability of occurrence, and
- scientific uncertainty

4.4 Social Impact Assessment

Social Impact Assessment (SIA) is an instrument used to analyze social issues and solicit stakeholder views for the design of projects. SIA helps in making the project responsive to social development concerns, including options that enhance benefits for poor and vulnerable people while mitigating risk and adverse impacts. It analyzes distributional impacts of intended project benefits on different stakeholder groups, and identifies differences in assets and capabilities to access the project benefits.

The scope and depth of SIA should be determined by the complexity and importance of the issues studied, taking into account the skills and resources available. SIA should include studies related to involuntary resettlement, compulsory land acquisition, impact of imported workforces, job losses among local people, damage to sites of cultural, historic or scientific interest, impact on minority or vulnerable groups, child or bonded labour, use of armed security guards. However, SIA may primarily include the following:

Description of the socio-economic, cultural and institutional profile

Conduct a rapid review of available sources of information to describe the socio-economic, cultural and institutional interface in which the project operates.

Socio-economic and cultural profile: Describe the most significant social, economic and cultural features that differentiate social groups in the project area. Describe their different interests in the project, and their levels of influence. Explain specific effects the project may have on the poor and underprivileged. Identify any known conflicts among groups that may affect project implementation.

Institutional profile: Describe the institutional environment; consider both the presence and function of public, private and civil society institutions relevant to the operation. Are there important constraints within existing institutions *e.g.*, disconnect between institutional responsibilities and the interests and behaviors of personnel within those institutions? Or are there opportunities to utilize the potential of existing institutions, *e.g.,* private or civil society institutions, to strengthen implementation capacity.

Legislative and regulatory considerations

To review laws and regulations governing the project's implementation and access of poor and excluded groups to goods, services and opportunities provided by the project. In addition, review the enabling environment for public participation and development planning. SIA should build on strong aspects of legal and regulatory systems to facilitate program implementation and identify weak aspects while recommending alternative arrangements.

Key social issues

SIA provides baseline information for designing the social development strategy. The analysis should determine the key social and institutional issues which affect the project objectives; identify the key stakeholder groups in this context and determine how relationships between stakeholder groups will affect or be affected by the project; and identify expected social development outcomes and actions proposed to achieve those outcomes.

Data collection and methodology

Describe the design and methodology for social analysis. In this regard:

- Build on existing data;
- Clarify the units of analysis for social assessment: intra-household, household level, as well as communities/settlements and other relevant social aggregations on which data is available or will be collected for analysis;

- Choose appropriate data collection and analytical tools and methods, employing mixed methods wherever possible; mixed methods include a mix of quantitative and qualitative methods.

Strategy to achieve social development outcomes

Identify the likely social development outcomes of the project and propose a social development strategy, including recommendations for institutional arrangements to achieve them, based on the findings of the social assessment. The social development strategy could include measures that:

- strengthen social inclusion by ensuring that both poor and excluded groups and intended beneficiaries are included in the benefit stream and in access to opportunities created by the project
- empower stakeholders through their participation in the design and implementation of the project, their access to information, and their increased voice and accountability (*i.e.,* a participation framework); and
- enhance security by minimizing and managing likely social risks and increasing the resilience of intended beneficiaries and affected persons to socioeconomic shocks

Implications for analysis of alternatives

Review proposed approaches for the project, and compare them in terms of their relative impacts and social development outcomes. Consider what implications the findings of the social assessment might have on those approaches. Should some new components be added to the approach, or other components be reconsidered or modified?

If SIA and consultation processes indicate that alternative approaches may have better development outcomes, such alternatives should be described and considered, along with the likely budgetary and administrative effects these changes might have.

Recommendations for project design and implementation arrangements

Provide guidance to project management and other stakeholders on how to integrate social development issues into project design and implementation arrangements. As much as possible, suggest specific action plans or implementation mechanisms to address relevant social issues and potential impacts. These can be developed as integrated or separate action plans, for example, as Resettlement Action Plans, Indigenous Peoples Development Plans, Community Development Plans, *etc*.

Developing a monitoring plan

Through SIA process, a framework for monitoring and evaluation should be developed. To the extent possible, this should be done in consultation with key stakeholders, especially beneficiaries and affected people.

The framework shall identify expected social development indicators, establish benchmarks, and design systems and mechanisms for measuring progress and results related to social development objectives. The framework shall identify organizational responsibilities in terms of monitoring, supervision, and evaluation procedures. Wherever possible, participatory monitoring mechanisms shall be incorporated. The framework should establish:

- a set of monitoring indicators to track the progress achieved. The benchmarks and indicators should be limited in number, and should combine both quantitative and qualitative types of data. The indicators for outputs to be achieved by the social development strategy should include monitor the process of stakeholder participation, implementation and institutional reform
- indicators to monitor social risk and social development outcomes; and indicators to monitor impacts of the project's social development strategy. It is important to suggest mechanisms through which lessons learnt from monitoring and stakeholder feedback can result in changes to improve the operation of the project. Indicators should be of such a nature that results and impacts can be disaggregated by gender and other relevant social groups
- define transparent evaluation procedures. Depending on context, these may include a combination of methods, such as participant observation, key informant interviews, focus group discussions, census and socio-economic surveys, gender analysis, Participatory Rural Appraisal (PRA), Participatory Poverty Assessment (PPA) methodologies, and other tools. Such procedures should be tailored to the special conditions of the project and to the different groups living in the project area; Estimate resource and budget requirements for monitoring and evaluation activities, and a description of other inputs (such as institutional strengthening and capacity building) needs to be carried out.

4.5 Risk Assessment

Industrial accidents results in great personal and financial loss. Managing these accidental risks in today's environment is the concern of every industry including petro-chemical plants, because either real or perceived incidents can quickly jeopardize the financial viability of a business. Many facilities involve various manufacturing processes that have the potential for accidents which may be catastrophic to the plant, work force, environment, or public.

The main objective of risk assessment study is to propose a comprehensive but simple approach to carry out risk analysis and conducting feasibility studies for industries, planning and management of industrial prototype hazard analysis study in Indian context.

Risk analysis and risk assessment should provide details on Quantitative Risk Assessment (QRA) techniques used world-over to determine risk posed to people who work inside or live near hazardous facilities, and to aid in preparing effective emergency response plans by delineating a Disaster Management Plan (DMP) to handle onsite and offsite emergencies. Hence, QRA is an invaluable method for making informed risk-based process safety and environmental impact planning decisions, as well as being fundamental to any decision while siting a facility. QRA whether, site-specific or risk-specific for any plant is complex and needs extensive study that involves process understanding, hazard identification, consequence modeling, probability data, vulnerability models/data, local weather and terrain conditions and local population data. QRA may be carried out to serve the following objectives;

- Identification of safety areas
- Identification of hazard sources
- Generation of accidental release scenarios for escape of hazardous materials from the facility
- Identification of vulnerable units with recourse to hazard indices

- Estimation of damage distances for the accidental release scenarios with recourse to Maximum Credible Accident (MCA) analysis
- Hazard and Operability studies (HAZOP) in order to identify potential failure cases of significant consequences
- Estimation of probability of occurrences of hazardous event through fault tree analysis and computation of reliability of various control paths
- Assessment of risk on basis of above evaluation against the risk acceptability criteria relevant to the situation
- Suggest risk mitigation measures based on engineering judgement, reliability and risk analysis approaches
- Delineation/up-gradation of DMP
- Safety Reports: with external safety report/ occupational safety report

The risk assessment report may cover the following in terms of the extent of damage with resource to MCA analysis and delineation of risk mitigations measures with an approach to DMP.

- Hazard identification – identification of hazardous activities, hazardous materials, past accident records, *etc*.
- Hazard quantification – consequence analysis to assess the impacts
- Risk Presentation
- Risk Mitigation Measures
- Disaster Management Plans

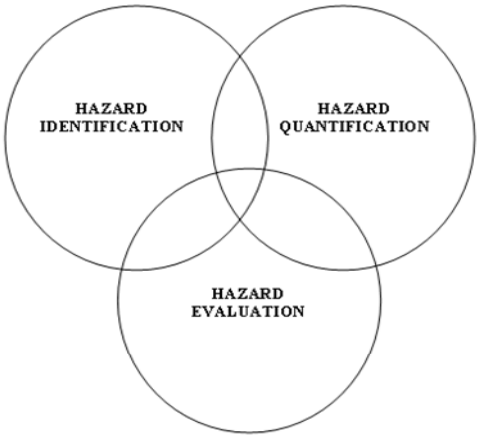

Figure 4-3: Risk Assessment – Conceptual Framework

Methods of risk prediction should cover all the design intentions and operating parameters to quantify risk in terms of probability of occurrence of hazardous events and magnitude of its consequence. Table 4-4 shows the predictive models for risk assessment.

Table 4-4: Choice of Models for Impact Predictions: Risk Assessment

Name	Application	Remarks
EFFECT	Consequence Analysis for Visualization of accidental chemical release scenarios & its consequence	Heat load, press wave & toxic release exposure neutral gas dispersion
WHAZAN	Consequence Analysis for Visualization of accidental chemical release scenarios & its consequence	

Name	Application	Remarks
EGADIS	Consequence Analysis for Visualization of accidental chemical release scenarios & its consequence	Dense gas dispersion
HAZOP and Fault Tree Assessment	For estimating top event probability	Failure frequency data is required
Pathways reliability and protective system hazard analysis	For estimating reliability of equipments and protective systems	Markov models
Vulnerability Exposure models	Estimation of population exposure	Uses probit equation for population exposure
F-X and F-N curves	Individual / Societal risks	Graphical Representation

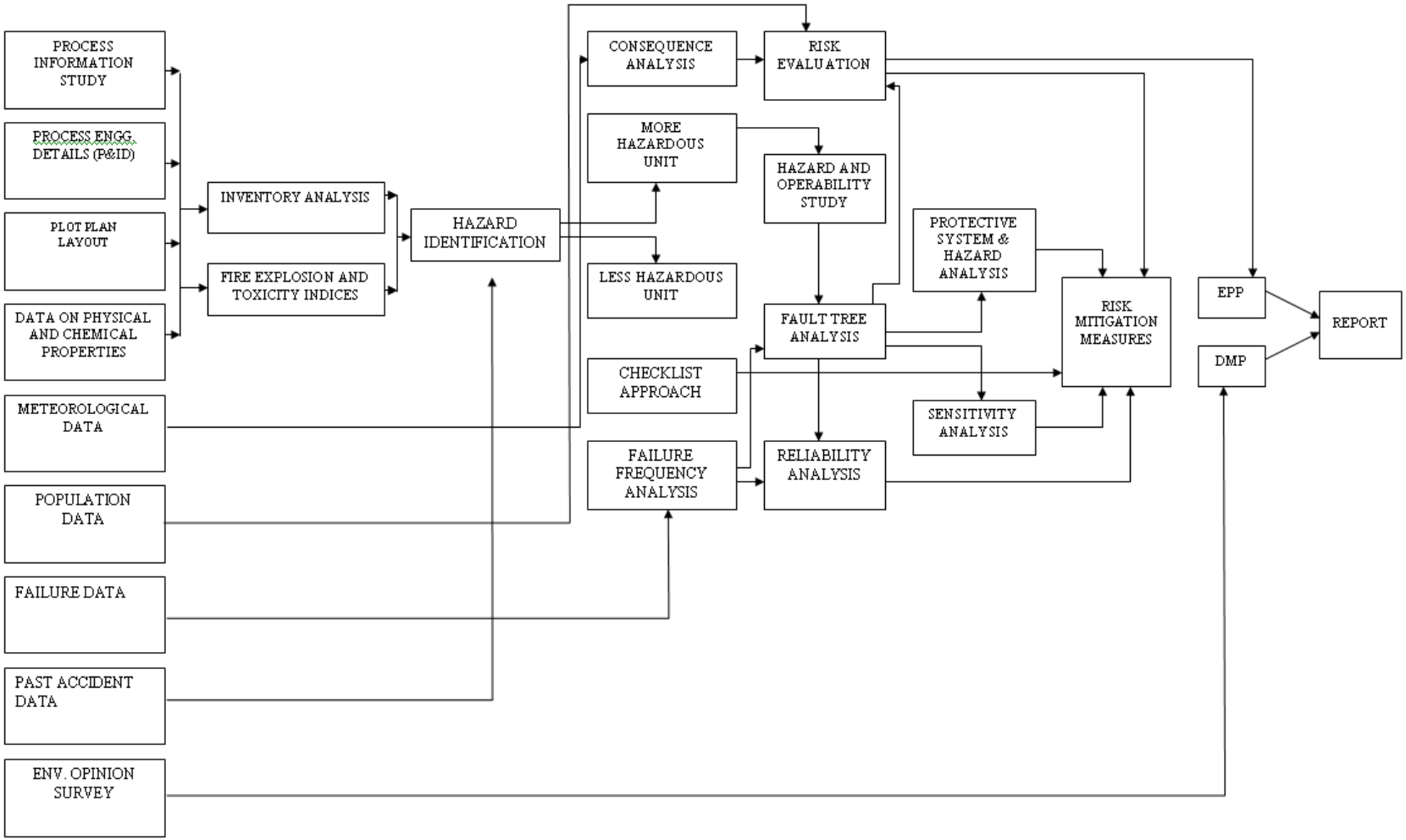

Figure 4-4: Comprehensive Risk Assessment - At a Glance

4.5.1 Storage and handling of hazardous materials

Both hazardous and non-hazardous materials generated within the project facility shall be temporarily accommodated in appropriate units placed within the project facility built/made in line with the safety, health and environmental standards.

The size of these temporary units would depend on the quantity and type of hazardous waste materials like asbestos, PCB, oils, fuels, *etc*., with appropriate storage capacities placed in the project facility in compliance with the Hazardous Waste Management and Handling Rules. In case of radioactive wastes, storage and handling should be based on Rules for Management of Radioactive Waste under AERB. Also, if gas cylinders must be stored in the facility, rules applicable for gas cylinders under the Explosives Act shall be followed. Later, these materials must be disposed off at a centralized disposal facility with utmost care following safety norms. Each unit in the facility should be have fire hydrant system to handle fire hazards.

4.5.2 Hazard identification

Hazard is the characteristic of any system or process which has the potential for accident. Identification of hazards, in presence of any hazardous waste generating units within the project facility is of primary significance in the analysis, quantification and cost-effective control of accidents involving chemicals and process.

Hence, all components of a system/unit need to be thoroughly examined to assess their potential for initiating or propagating an unplanned event/sequence of events, which can be termed as an accident.

Typical methods for hazard identification employed are:

- Identification of major hazardous units based on Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 of Government of India (as amended in 2000)
- Identification of hazardous units and segments of plants and storage units based on relative ranking technique, viz. Fire-Explosion and Toxicity Index (FE&TI).

Hazardous substances may be classified into three main categories namely flammable, unstable and toxic substances. Flammable substances require interaction with air for their hazard to be realized. Under certain circumstances, vapours arising from flammable substances when mixed with air may become explosive, especially in confined spaces. However, if present in sufficient quantity, such clouds may explode in open air also. Unstable substances are liquids or solids, which may decompose with such violence giving rise to blast waves. Besides, toxic substances are dangerous and cause substantial damage to life when released into the atmosphere. The ratings for a large number of chemicals based on flammability, reactivity and toxicity are provided in NFPA Codes 49 and 345 M.

4.5.3 Hazard assessment and evaluation

A preliminary hazard analysis shall be carried out to identify major hazards associated with storages in the facility. This is followed by consequence analysis to quantify these hazards. Finally the vulnerable zones are plotted for which risk reducing measures are deduced and implemented.

Frequent causes of accidents

- Fire and explosion: explosives, flammable material
- Being struck by falling objects
- Caught in/compressed
- Snapping of cables, ropes, chains, slings
- Handling heavy objects
- Electricity (electrocution)
- Poor illumination
- Falls from height inside industrial units or on the ground
- Struck by moving objects
- Slipping on wet surfaces
- Sharp objects
- Oxygen deficiency in confined spaces
- Lack of personal protective equipment (PPE), housekeeping practices, safety signs
- Hackles, hooks, chains
- Cranes, winches, hoisting and hauling equipment;

Hazardous substances and wastes

- Heavy and toxic metals (lead, mercury, cadmium, copper, zinc, *etc*.)
- Organometallic substances (tributyltin, *etc*.)
- Lack of hazard communication (storage, labelling, material safety data sheets)
- Batteries, fire-fighting liquids
- PCBs and PVC (combustion products)
- Welding fumes
- VOCs (solvents)
- Inhalation in confined and enclosed spaces
- Physical hazards
- Noise
- Extreme temperatures
- Vibration
- Radiation (UV, radioactive materials)

Physical hazards

- Noise
- Extreme temperatures
- Vibration
- Radiation (UV, radioactive materials)

Mechanical hazards

- Trucks and transport vehicles
- Scaffolding, fixed and portable ladders
- Impact by tools, sharp-edged tools
- Power-driven hand tools, saws, grinders and abrasive cutting wheels
- Failure of machinery and equipment
- Poor maintenance of machinery and equipment
- Lack of safety guards in machines
- Structural failure

Biological hazards

- Toxic marine organisms (If the project facility is located in Coastal Regions)
- Risk of communicable diseases transmitted by pests, vermin, rodents, insects and other animals that may infest the project facility.
- Animal bites
- Vectors of infectious diseases (TB, malaria, dengue fever, hepatitis, respiratory infections, others)

Ergonomic and psychosocial hazards

- Repetitive strain injuries, awkward postures, repetitive and monotonous work, excessive workload
- Long working hours, shift work, night work, temporary employment
- Mental stress, human relations (aggressive behaviour, alcohol and drug abuse, violence)
- Poverty, low wages, minimum age, lack of education and social environment

General concerns

- Lack of safety and health training
- Poor work organization
- Inadequate housing and sanitation
- Inadequate accident prevention and inspection
- Inadequate emergency, first-aid and rescue facilities
- Lack of medical facilities and social protection

4.5.4 Disaster management plan (DMP)

A disaster is a catastrophic situation in which suddenly, people are plunged into helplessness and suffering and, as a result, need protection, clothing, shelter, medical & social care and other necessities of life.

Disaster is an undesirable occurrence of events of such magnitude and nature so as to adversely affect production and cause damage to environment. Emergency response & DMP has an important aspect of sound safety management to reduce the probability of serious loss to people, equipment, material, environment, process, reservoir, *etc*. Petrochemical complexes handle s wide variety of hydrocarbons and processes which are prone to explosion hazard and risk associate may be very serious some times. A DMP should include risk and hazard, assessment, loss prevention methodology, emergency response programmes and overall disaster management system.

The risk and hazard analysis stage is a very important part of the risk management process. Petrochemical complex processes comprise complex processes, which are not intrinsically safe. Hazard Identification and preventive measures are therefore an integral part of setting up of any petrochemical complex and its operation to avoid huge losses to mankind and environment.

The DMP is aimed to ensure safety of life, protection of environment, protection of installation, restoration of production and salvage operations in this same order of priorities. For effective implementation of DMP, it should be widely circulated and a personnel training is to be provided through rehearsals/drills.

To tackle the consequences of a major emergency inside the plant or immediate vicinity of the plant, a DMP has to be formulated and this planned emergency document is called DMP.

The objective of the DMP is to make use of the combined resources of the plant and the outside services to achieve the following:

- Effective rescue and medical treatment of casualties
- Safeguard other people
- Minimize damage to property and the environment
- Initially contain and ultimately bring the incident under control
- Identify any dead
- Provide for the needs of relatives
- Provide authoritative information to the news media
- Secure the safe rehabilitation of affected area
- Preserve relevant records and equipment for the subsequent inquiry into the cause and circumstances of the emergency

In effect, it is to optimize operational efficiency to rescue rehabilitation and render medical help and to restore normalcy.

The DMP should include emergency preparedness plan, emergency response team, emergency communication, emergency responsibilities, emergency facilities, and emergency actions.

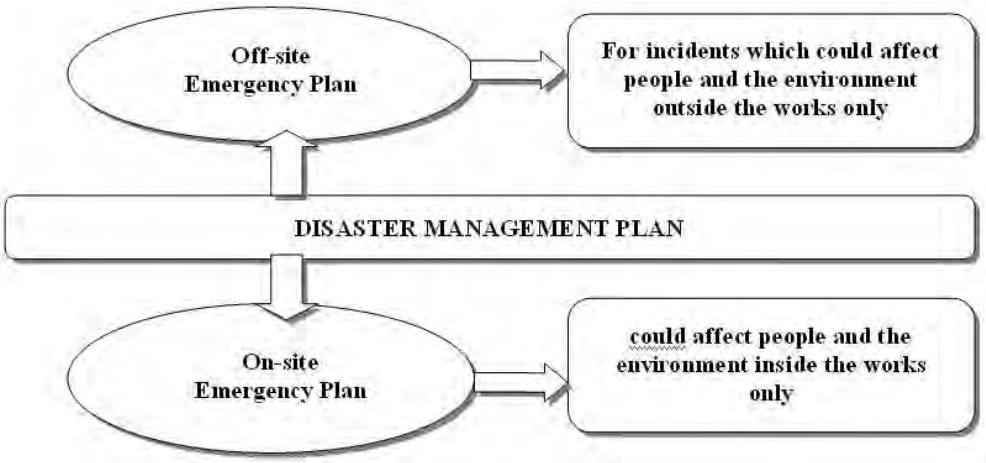

Figure 4-5: Disaster Management Plan

4.5.4.1 Emergency preparedness plan

Incidents, accidents and contingency preparedness should be accounted during construction and operation process. This shall be a part of EMS. Emergency Preparedness Plan (EPP) should be prepared following the National Environmental Emergency Plan and OSHA guidelines. According to these guidelines, an environmental emergency plan would essentially provide the following information:

- Assignment of duties and responsibilities among the authorities, participating agencies, response team, their coordinators and/or those responsible for the pollution incident

- Relationship with other emergency plans
- A reporting system that ensures rapid notification in the event of a pollution incident
- The establishment of a focal point for coordination and directions connected to the implementation of the plan
- Response operations should always cover these four phases:
  - Discovery and alarm
  - Evaluation, notification and plan invocation
  - Containment and counter measures
  - Cleanup and disposal
- Identification of expertise and response resources available for assistance for the implementation of plan
- Directions on the necessary emergency provisions applicable to the handling, treatment or disposal of certain pollutants
- Link to the local community for assistance, if necessary
- Support measures, such as procedures for providing public information, carrying out surveillance, issuing post-incident reports, review and updating of the plan, and periodic exercising of the plan.

4.5.4.2 Emergency response

Various units within the project facility are always subjected to accidents and incidents of many a kind. Therefore, a survey of potential incidents and accidents is to be carried out. Based on this, a plan for response to incidents, injuries and emergencies should be prepared. Response to emergencies should ensure that:

- The exposure of workers should be limited as much as possible during the operation
- Contaminated areas should be cleaned and, if necessary disinfected
- Limited impact on the environment at the extent possible.

Written procedures for different types of emergencies should be prepared and the entire workforce should be trained in emergency response. All relevant emergency response equipment should also be readily available.

With regard to dangerous spills, associated cleanup and firefighting operations should be carried out by specially allocated and trained personnel.

4.5.4.3 Response team

It is important to setup an Emergency Organization. A senior executive who has control over the affairs of the plant would be heading the Emergency Organization. He would be designated at Site Controller. Manager (Safety) would be designated as the Incident Controller. In case of stores, utilities, open areas, which are not under control of the Production Heads, Senior Executive responsible for maintenance of utilities would be designated as Incident Controller. All the Incident Controllers would be reporting to the Site Controller.

Each Incident Controller organizes a team responsible for controlling the incidence with the personnel under his control. Shift in charge would be the reporting officer, who would bring the incidence to the notice of the Incidence Controller and Site Controller.

Emergency Coordinators would be appointed who would undertake the responsibilities like firefighting, rescue, rehabilitation, transport and provide essential & support services. For this purposes, Security In charge, Personnel Department, Essential services personnel would be engaged. All these personnel would be designated as key personnel.

In each shift, electrical supervisor, electrical fitters, pump house in charge, and other maintenance staff would be drafted for emergency operations. In the event of power or communication system failure, some of staff members in the office/facility would be drafted and their services would be utilized as messengers for quick passing of communications. All these personnel would be declared as essential personnel.

4.5.4.4 Response to injuries

Based on a survey of possible injuries, a procedure for response to injuries or exposure to hazardous substances should be established. All staff should have minimum training to such response and the procedure ought to include the following:

- Immediate first aid, such as eye splashing, cleansing of wounds and skin, and bandaging
- Immediate reporting to a responsible designated person
- If possible, retention of the item and details of its source for identification of possible hazards
- Rapid additional medical care from medical personnel
- Medical surveillance
- Recording of the incident
- Investigation, determination and implementation of remedial action

It is vital that incident reporting should be straightforward so that reporting is actually carried out.

4.5.4.5 Emergency communication

Whoever notices an emergency situation such as fire, growth of fire, leakage, *etc*. would inform his immediate superior and Emergency Control Center. The person on duty in the Emergency Control Center, would appraise the Site Controller. Site Controller verifies the situation from the Incident Controller of that area or the Shift In charge and takes a decision about an impending On-site Emergency. This would be communicated to all the Incident Controllers, Emergency Coordinators. Simultaneously, the emergency warning system would be activated on the instructions of the Site Controller.

4.5.4.6 Emergency responsibilities

The responsibilities of the key personnel should be defined for the following:

- Site controller
- Incident controller
- Emergency coordinator - rescue, fire fighting
- Emergency coordinator-medical, mutual aid, rehabilitation, transport and communication
- Emergency coordinator - essential services
- Employers responsibility

4.5.4.7 Emergency facilities

- Emergency Control Center – with access to important personnel, telephone, fax, telex facility, safe contained breathing apparatus, hand tools, emergency shut down procedures, duties and contact details of key personnel and government agencies, emergency equipments, *etc*.
- Assembly Point – with minimum facilities for safety and rescue
- Emergency Power Supply – connected with diesel generator, flame proof emergency lamps, *etc*.
- Fire Fighting Facilities – first aid fire fighting equipments, fire alarms, *etc*.
- Location of wind Stock – located at appropriate location to indicate the direction of wind for emergency escape
- Emergency Medical Facilities – Stretchers, gas masks, general first aid, emergency control room, breathing apparatus, other emergency medical equipment, ambulance

4.5.4.8 Emergency actions

- Emergency warning
- Evacuation of personnel
- All clear signal
- Public information and warning
- Coordination with local authorities
- Mutual aid
- Mock drills

4.6 Mitigation Measures

The purpose of mitigation is to identify measures that safeguard the environment and the community affected by the proposal. Mitigation is both a creative and practical phase of the EIA process. It seeks to find the best ways and means of avoiding, minimizing and remedying impacts. Mitigation measures must be translated into action in right way and at the right time, if they are to be successful. This process is referred to as impact management and takes place during project implementation. A written plan should be prepared for this purpose, and should include a schedule of agreed actions. Opportunities for impact mitigation will occur throughout the project cycle.

4.6.1 Important considerations for mitigation methods

The responsibility of project proponents to 'internalize' the full environmental costs of development proposals is now widely accepted under "Polluter Pay" principle. In addition, many proponents have found that good design and impact management can

result in significant savings applying the principles of cleaner production to improve their environmental performance.

- The predicted adverse environmental as well as social impacts for which mitigation measures are required should be identified and briefly summarized along with cross referencing them to the significance, prediction components of the EIA report or other documentation.
- Each mitigation measure should be briefly described w.r.t the impact of significances to which it relates and the conditions under which it is required (for example, continuously or in the event of contingencies). These should also be cross-referenced to the project design and operating procedures which elaborate on the technical aspects of implementing the various measures.
- Cost and responsibilities for mitigation and monitoring should be clearly defined, including arrangements for coordination among various Authorities responsible for mitigation.
- The proponent can use the EMP to develop environmental performance standards and requirements for the project site as well as supply chain. An EMP can be implemented through EMS for the operational phase of the project.

Prior to selecting mitigation plans it is appropriate to study the mitigation alternatives for cost-effectiveness, technical and socio-political feasibility. Such mitigation measures could include:

- avoiding sensitive areas such as eco-sensitive area *e.g.,* fish spawning areas, dense mangrove areas or areas known to contain rare or endangered species
- adjusting work schedules to minimize disturbance
- engineered structures such as berms and noise attenuation barriers
- pollution control devices such as scrubbers and electrostatic precipitators
- changes in fuel feed, manufacturing, process, technology use, or waste management practices, *etc.*

4.6.2 Hierarchy of elements of mitigation plan

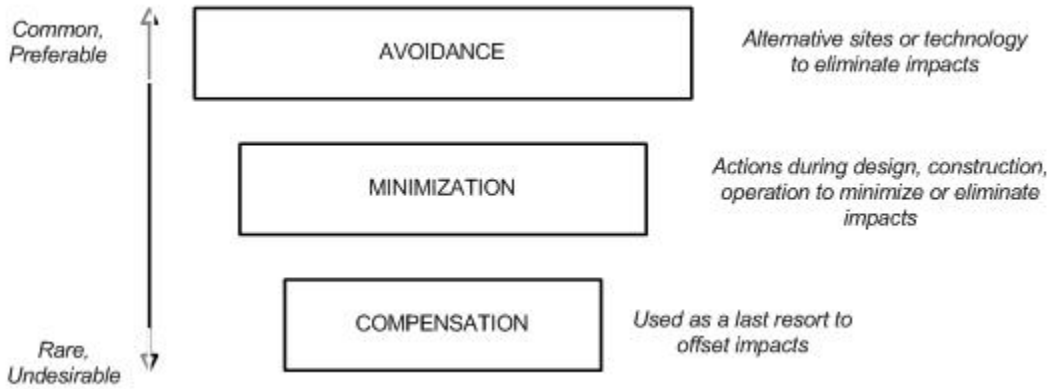

Figure 4-6: Elements of Mitigation

A good EIA practice requires technical understanding of relevant issues and the measures that work in such given circumstances: The priority of selection of mitigation measures should be in the order:

Step One: Impact avoidance

This step is most effective when applied at an early stage of project planning. It can be achieved by:

- not undertaking certain projects or elements that could result in adverse impacts
- avoiding areas that are environmentally sensitive
- putting in place the preventative measures to stop adverse impacts from occurring, for example, release of water from a reservoir to maintain a fisheries regime

Step Two: Impact minimization

This step is usually taken during impact identification and prediction to limit or reduce the degree, extent, magnitude, or duration of adverse impacts. It can be achieved by:

- scaling down or relocating the proposal
- redesigning elements of the project
- taking supplementary measures to manage the impacts

Step Three: Impact compensation

This step is usually applied to remedy unavoidable residual adverse impacts. It can be achieved by:

- rehabilitation of the affected site or environment, for example, by habitat enhancement and restocking fish
- restoration of the affected site or environment to its previous state or better, as typically required for mine sites, forestry roads and seismic lines
- replacement of the same resource values at another location. For example, by wetland engineering to provide an equivalent area to that lost to drainage or infill

Important compensation elements

Resettlement Plans: Special considerations apply to mitigation of proposals that displace or disrupt people. Certain types of projects, such as reservoirs and irrigation schemes and public works, are known to cause involuntary resettlement. This is a contentious issue because it involves far more than re-housing people; in addition, income sources and access to common property resources are likely to be lost. Almost certainly, a resettlement plan will be required to ensure that no one is worse off than before, which may not be possible for indigenous people whose culture and lifestyle is tied to a locality. This plan must include the means for those displaced to reconstruct their economies and communities and should include an EIA of the receiving areas. Particular attention should be given to indigenous, minority and vulnerable groups who are at higher risk from resettlement.

In-kind compensation

When significant or net residual loss or damage to the environment is likely, in kind compensation is appropriate. As noted earlier, environmental rehabilitation, restoration or replacement have become standard practices for many proponents. Now, increasing emphasis is given to a broader range of compensation measures to offset impacts and assure the sustainability of development proposals. These include impact compensation 'trading', such as offsetting CO_2 emissions by planting forests to sequester carbon.

4.6.3 Typical mitigation measures

Choice of location for the developmental activity plays an important role in preventing the adverse impacts on surrounding environment. Detailed guidelines on siting of industries are provided in Section 4.2. However, if the developmental activity produces any more adverse impacts, mitigation measures should be taken.

Previous subsections of the Section 4.6 could be precisely summarized into following:

- Impacts from a developmental project could have many dimensions. As most of the direct impacts are caused by releases from developmental projects, often control at source is the best opportunity to either eliminate or mitigate the impacts, in case these are cost-effective. In other words, the best way to mitigate impacts is to prevent them from occurring. Choice of raw materials/technologies/processes which produce least impact would be one of the options to achieve it.
- After exploring cost-effective feasible alternatives to control impacts at source, various interventions to minimize adverse impacts may be considered. These interventions, primarily aim at reducing the residual impacts on VECs of the receiving environment to acceptable concentrations.
- Degree of control at source and external interventions differs from situation-to - situation and is largely governed by techno-economic feasibility. While the regulatory bodies stress for further source control (due to high reliability), the project proponents bargain for other interventions which may be relatively cost-effective than further control at source (in any case, project authority is required to meet the industry-specific standards by adopting the best practicable technologies. However, if the location demands further control at source, then the proponents are required to adopt further advanced control technologies, *i.e.*, towards best available control technologies). After having discussions with the project proponent, EAC reaches to an agreed level of source control+other interventions (together called as mitigation measures in the given context) that achieve the targeted protection levels for VECs in the receiving environment. These levels will become the principal clearance conditions.
- Chapter 3 of this TGM offers elaborate information on cleaner technologies, waste minimization opportunities, and control technologies for various kinds of polluting parameters that emanate from this developmental activity. This information may be used to draw appropriate control measures applicable at source.

The choice of interventions for mitigation of impacts may also be numerous and depend on various factors. Mitigation measures based on location-specific suitability and some other factors are discussed in sub-sections 4.6.1 and 4.6.2. A few typical measures which may also be explored for mitigation of impacts are listed in Table 4-5.

Table 4-5: Typical Mitigation Measures

Impacts	Typical Mitigation Measures
Soil	▪ Windscreens, maintenance, and installation of ground cover ▪ Installation of drainage ditches ▪ Runoff and retention ponds ▪ Minimize disturbances and scarification of the surface ▪ Usage of appropriate monitoring and control facilities for construction equipments deployed ▪ Methods to reuse earth material generated during excavation
Resources – fuel/construction material, *etc*.	▪ Availing the resources which could be replenished by natural systems, *etc*.
Deforestation	▪ Plant or create similar areas ▪ Initiate a tree planning program in other areas ▪ Donate land to conservationalist groups
Water pollution (Ground water/ Surface water)	▪ Conjunctive use of ground/surface water, to prevent flooding/water logging/depletion of water resources. Included are land use pattern, land filling, lagoon/reservoir/garland canal construction, and rainwater harvesting and pumping rate. ▪ Stormwater drainage system to collect surface runoff ▪ Minimise flow variation from the mean flow ▪ Storing of oil wastes in lagoons should be minimised in order to avoid possible contamination of the ground water system. ▪ All effluents containing acid/alkali/organic/toxic wastes should be properly treated. ▪ Monitoring of ground waters ▪ Use of biodegradable or otherwise readily treatable additives ▪ Neutralization and sedimentation of wastewaters, where applicable ▪ Dewatering of sludge and appropriate disposal of solids ▪ In case of oil waste, oil separation before treatment and discharge into the environment ▪ By controlling discharge of sanitary sewage and industrial waste into the environment ▪ By avoiding the activities that increases erosion or that contributes nutrients to water (thus stimulating alga growth) ▪ For wastes containing high TDS, treatment methods include removal of liquid and disposal of residue by controlled landfilling to avoid any possible leaching of the fills ▪ All surface runoffs around mines or quarries should be collected treated and disposed. ▪ Treated wastewater (such as sewage, industrial wastes, or stored surface runoffs) can be used as cooling water makeup. ▪ Wastewater carrying radioactive elements should be treated separately by means of de-watering procedures, and solids or brine should be disposed of with special care. ▪ Develop spill prevention plans in case of chemical discharges and spills ▪ Develop traps and containment system and chemically treat discharges on site
Air Pollution	▪ Periodic checking of vehicles and construction machinery to ensure compliance to emission standards ▪ Attenuation of pollution/protection of receptor through green belts/green cover

Impacts	Typical Mitigation Measures
	▪ Dilution of odourant (dilution can change the nature as well as strength of an odour), odour counteraction or neutralise (certain pairs of odours in appropriate concentrations may neutralise each other), odour masking or blanketing (certain weaker malodours may be suppressed by a considerably stronger good odour). ▪ Regular monitoring of air polluting concentrations
Dust pollution	▪ Adopt sprinkling of water ▪ Wetting of roadways to reduce traffic dust and reentrained particles ▪ Control vehicle speed on sight ▪ Ensure priodical wahsing of construction equipment and transport vehicles to prevent accumulated dust ▪ Ensure that vehicles should be covered during transportation ▪ Installation of windscreens to breakup the wind flow ▪ Burning of refuse on days when meteorological conditions provide for good mixing and dispersion ▪ Providing dust collection equipment at all possible points ▪ Maintaining dust levels within permissible limits ▪ Provision for masks when dust level exceeds
Noise pollution	▪ Use of suitable muffler systems/enclosures/sound-proof glass panelling on heavy equipment/pumps/blowers ▪ Pumps and blowers may be mounted on rubber pads or any other noise absorbing materials ▪ Limiting certain activities ▪ Proper scheduling of high noise generating activities to minimise noise impacts ▪ Usage of well maintained construction equipment meeting the regulatory standards ▪ Placement of equipments emitting high noise in an orientation that directs the noise away from sensitive receptors ▪ Periodic maintenance of equipments/repalcing whenever necessary/ lubrication of rotating parts, *etc*. ▪ By using damping, absorption, dissipation, and deflection methods ▪ By using common techniques such as constructing sound enclosures, applying mufflers, mounting noise sources on isolators, and/or using materials with damping properties ▪ Performance specifications for noise represent a way to insure the procured item is controlled ▪ Use of ear protective devices. ▪ In case of steady noise levels above 85-dB (A), initiation of hearing conservation measures ▪ Implementation of greenbelt for noise attentuation may be taken up
Biological	▪ Installation of systems to discourage nesting or perching of birds in dangerous environments ▪ Increased employee awareness to sensitive areas
Social	▪ Health and safety measures for workers ▪ Development of traffic plan that minimizes road use by workers ▪ Upgrade of roads and intersections ▪ Provide suffiecient counselling and time to the affected population for relocation ▪ Discuss and finalize alternate arrangements and associated infrastructure in places of religious importance ▪ Exploration of alternative approach routes in consultation with local community and other stakeholders

Impacts	Typical Mitigation Measures
	▪ Provision of alternate jobs in unskilled and skilled categories
Marine	▪ Water quality monitoring program ▪ Limit construction activities to day time to provide recuperation time at night and reduce turbidity ▪ Prevention of spillage of diesel, oil, lubes, *etc*. ▪ Usage of appropriate system to barges/workboats for collection of liquid/solid waste generated onboard ▪ Avoid discharge of construction/dredging waste (lose silt) into sea. It may be disposed at the identified disposal point. ▪ Ensure usage of suitable/proper equipment for dredging in order to minimize the turbidity and suspensions at the dredging site. ▪ Checking with the complainace conditions before discharging wastes into the sea water ▪ Have a post-dregding monitoring programme in place ▪ Take up periodic maintenance dredging including inspectionof sub-sea conditions, *etc*.
Occupational health and safety	▪ Provision of worker camps with proper santiation and medical facilities, as well as making the worker camps self- sufficient with resources like water supply, power supply, *etc* ▪ Arrangement of periodic health check-ups for early detection and control of communicable diseases. ▪ Arrangement to dispose off the wastes at approved disposal sites. ▪ Provide preventive measures for potentital fire hazards with requisite fire detection, fire-fighting facilities and adequate water storage
Construction	▪ Have a Transport Management Plan in place in order to prevent/ minimize the disturbance on surrounding habitats ▪ Initiate traffic density studies
Solid/Hazardous waste	▪ Proper handling of excavated soil ▪ Proper plan to collect and dispose off the solid waste generated onsite. ▪ Identify an authorized waste handler for segregation of construction and hazardous waste and its removal on a regular basis to minimise odour, pest and litter impacts ▪ Prohibit burning of refuse onsite.

4.7 Environmental Management Plan

A typical EMP shall be composed of the following:

1. summary of potential impacts of the proposal
2. description of recommended mitigation measures
3. description of monitoring programme to ensure compliance with relevant standards and residual impacts
4. allocation of resources and responsibilities for plan implementation
5. implementation schedule and reporting procedures
6. contingency plan when impacts are greater than expected

Summary of impacts: The predicted adverse environmental and social impacts for which mitigation measures are identified in earlier sections to be briefly summarized with cross referencing to the corresponding sections in EIA report.

Description of mitigation measures: Each mitigation measure should be briefly described w.r.t the impact to which it relates and the conditions under which it is required. These should be accompanied by/referenced to, project design and operating procedures which elaborate on the technical aspects of implementing various measures.

Description of monitoring programme to ensure compliance with relevant standards and residual impacts: Environmental monitoring refers to compliance monitoring and residual impact monitoring. Compliance monitoring refers to meeting the industry-specific statutory compliance requirements (Ref. Applicable National regulations as detailed in Chapter 3).

Residual impact monitoring refers to monitoring of identified sensitive locations with adequate number of samples and frequency. The monitoring programme should clearly indicate the linkages between impacts identified in the EIA report, measurement indicators, detection limits (where appropriate), and definition of thresholds that signal the need for corrective actions.

Allocation of resources and responsibilities for plan implementation: These should be specified for both the initial investment and recurring expenses for implementing all measures contained in the EMP, integrated into the total project costs, and factored into loan negotiation.

The EMP should contain commitments that are binding on the proponent in different phases of project implementation *i.e.,* pre-construction or site clearance, construction, operation, decommissioning.

Responsibilities for mitigation and monitoring should be clearly defined, including arrangements for coordination between various factors responsible for mitigation. Details should be provided w.r.t deployment of staff (detailed organogram), monitoring network design, parameters to be monitored, analysis methods, associated equipments, *etc*.

Implementation schedule and reporting procedures: The timing, frequency and duration of mitigation measure should be specified in an implementation schedule, showing links with overall project implementation. Procedures to provide information on the progress and results of mitigation and monitoring measures should also be clearly specified.

Contingency Plan when the impacts are greater than expected: There shall be a contingency plan for attending the situations where the residual impacts are higher than expected. It is an imperative requirement for all project Authorities to plan additional programmes to deal with the situation, after duly intimating the concerned local regulatory bodies.

4.8 Reporting

Structure of the EIA report (Appendix III of the EIA Notification) applicable for petro-chemical industry is given in the Table 4-6. Each task prescribed in ToR shall be incorporated appropriately in the contents in addition to the contents described in the table.

Table 4-6: Structure of EIA Report

S.No	EIA Structure	Contents
1.	Introduction	▪ Purpose of the report ▪ Identification of project & project proponent ▪ Brief description of nature, size, location of the project and its importance to the country, region ▪ Scope of the study – details of regulatory scoping carried out (As per Terms of Reference)
2.	Project Description	Condensed description of those aspects of the project (based on project feasibility study), likely to cause environmental effects. Details should be provided to give clear picture of the following: ▪ Type of project ▪ Need for the project ▪ Location (maps showing general location, specific location, project boundary & project site layout) ▪ Size or magnitude of operation (incl. Associated activities required by or for the project) ▪ Proposed schedule for approval and implementation ▪ Technology and process description ▪ Project description including drawings showing project layout, components of project *etc*. Schematic representations of the feasibility drawings which give information important for EIA purpose ▪ Description of mitigation measures incorporated into the project to meet environmental standards, environmental operating conditions, or other EIA requirements (as required by the scope) ▪ Assessment of new & untested technology for the risk of technological failure
3.	Description of the Environment	▪ Study area, period, components & methodology ▪ Establishment of baseline for VECs, as identified in the scope ▪ Base maps of all environmental components
4.	Anticipated Environmental Impacts & Mitigation Measures	▪ Details of Investigated Environmental impacts due to project location, possible accidents, project design, project construction, regular operations, final decommissioning or rehabilitation of a completed project ▪ Measures for minimizing and / or offsetting adverse impacts identified ▪ Irreversible and irretrievable commitments of environmental components ▪ Assessment of significance of impacts (Criteria for determining significance, Assigning significance) ▪ Mitigation measures
5.	Analysis of Alternatives (Technology & Site)	▪ Incase, the scoping exercise results in need for alternatives: ▪ Description of each alternative ▪ Summary of adverse impacts of each alternative ▪ Mitigation measures proposed for each alternative and selection of alternative
6.	Environmental Monitoring Program	▪ Technical aspects of monitoring the effectiveness of mitigation measures (incl. measurement methodologies, frequency, location, data analysis, reporting schedules, emergency procedures, detailed budget & procurement schedules)

S.No	EIA Structure	Contents
7.	Additional Studies	▪ Public consultation ▪ Risk assessment ▪ Social impact assessment, R&R action plans
8.	Project Benefits	▪ Improvements in the physical infrastructure ▪ Improvements in the social infrastructure ▪ Employment potential –skilled; semi-skilled and unskilled ▪ Other tangible benefits
9.	Environmental Cost Benefit Analysis	▪ If recommended at the scoping stage
10.	EMP	▪ Description of the administrative aspects that ensures proper implementation of mitigative measures and their effectiveness monitored, after approval of the EIA
11.	Summary & Conclusion (This will constitute the summary of the EIA Report)	▪ Overall justification for implementation of the project ▪ Explanation of how, adverse effects have been mitigated
12.	Disclosure of Consultants engaged	▪ Names of the Consultants engaged with their brief resume and nature of Consultancy rendered

4.9 Public Consultation

Public consultation refers to the process by which the concerns of local affected people and others who have plausible stake in the environmental impacts of the project or activity are ascertained.

- Public consultation is not a decision taking process, but is a process to collect views of the people having plausible stake. If the SPCB/Public agency conducting public hearing is not convinced with the plausible stake, then such expressed views need not be considered.
- Public consultation involves two components, one is public hearing, and other one is inviting written responses/objections through Internet/by post, *etc*., by placing the summary of EIA report on the web site.
- All Category A and Category B1 projects require public hearing except the following:
  - Once prior environmental clearance is granted to an industrial estates/SEZs/EPZs *etc*., for a given composition (type and capacity) of industries, then individual units will not require public hearing
  - Expansion of roads and highways, which do not involve any further acquisition of land
  - Maintenance dredging provided the dredged material shall be disposed within port limits
  - All building/construction projects/area development projects/townships
  - All Category B2 projects
  - All projects concerning national defense and security or involving other strategic considerations as determined by the Central Government
- Public hearing shall be carried out at the site or in its close proximity, district-wise, for ascertaining concerns of local affected people.

- Project proponent shall make a request through a simple letter to the Member–Secretary of the SPCB/UTPCC to arrange public hearing.
- Project proponent shall enclose with the letter of request, at least 10 hard copies and 10 soft copies of the draft EIA report including the summary EIA report in English and in official language of the State/local language prepared as per the approved scope of work, to the concerned Authority.
- Simultaneously, project proponent shall arrange to send, one hard copy and one soft copy, of the above draft EIA report along with the summary EIA report to the following Authorities within whose jurisdiction the project will be located:
  - District magistrate/District Collector/Deputy Commissioner (s)
  - Zilla parishad and municipal corporation or panchayats union
  - District industries office
  - Urban local bodies (ULBs)/PRIs concerned/development authorities
  - Concerned regional office of the MoEF/SPCB
- Above mentioned Authorities except regional office of MoEF shall arrange to widely publicize the draft EIA report within their respective jurisdictions requesting the interested persons to send their comments to the concerned regulatory Authorities. They shall also make draft EIA report for inspection electronically or otherwise to the public during normal office hours till the public hearing is over.
- Concerned regulatory Authority (MoEF) shall display the summary of EIA report on its website and also make full draft EIA report available for reference at a notified place during normal office hours at their head office.
- SPCB or UTPCC concerned shall also make similar arrangements for giving publicity about the project within the State/UT and make available the summary of draft EIA report for inspection in select offices, public libraries or any other suitable location, *etc*. They shall also additionally make available a copy of the draft EIA report to the above five authorities/offices as mentioned above.
- The Member–Secretary of the concerned SPCB or UTPCC shall finalize the date, time and exact venue for the conduct of public hearing within seven days of the date of the receipt of the draft EIA report from the project proponent and advertise the same in one major National Daily and one Regional vernacular Daily/official State language.
- A minimum notice period of 30 (thirty) days shall be provided to the public for furnishing their responses.
- No postponement of the date, time, venue of the public hearing shall be undertaken, unless some untoward emergency situation occurs. Only incase of emergencies and up on recommendation of the concerned District Magistrate/District Collector/Deputy Commissioner, the postponement shall be notified to the public through the same National and Regional vernacular dailies and also prominently displayed at all the identified offices by the concerned SPCB/UTPCC
- In the above exceptional circumstances fresh date, time and venue for the public consultation shall be decided by the Member–Secretary of the concerned SPCB/ UTPCC only in consultation with the District Magistrate/District Collector/Deputy Commissioner and notified afresh as per the procedure.
- The District Magistrate/District Collector/Deputy Commissioner or his or her representative not below the rank of an Additional District Magistrate assisted by a representative of SPCB or UTPCC, shall supervise and preside over the entire public hearing process.

- The SPCB/UTPCC shall arrange to video film the entire proceedings. A copy of the videotape or a CD shall be enclosed with the public hearing proceedings while forwarding it to the Regulatory Authority concerned.
- The attendance of all those who are present at the venue shall be noted and annexed with the final proceedings
- There shall be *no quorum* required for attendance for starting the proceedings
- Persons present at the venue shall be granted the opportunity to seek information or clarifications on the project from the proponent. The summary of the public hearing proceedings accurately reflecting all the views and concerns expressed shall be recorded by the representative of the SPCB/UTPCC and read over to the audience at the end of the proceedings explaining the contents in the local/vernacular language and the agreed minutes shall be signed by the District Magistrate/District Collector/ Deputy Commissioner or his or her representative on the same day and forwarded to the SPCB/UTPCC concerned.
- A statement of the issues raised by the public and the comments of the proponent shall also be prepared in the local language or the official State language, as the case may be and in English and annexed to the proceedings.
- The proceedings of the public hearing shall be conspicuously displayed at the office of the Panchayats within whose jurisdiction the project is located, office of the concerned Zilla Parishad, District Magistrate/District Collector/Deputy Commissioner, and the SPCB or UTPCC. The SPCB/ UTPCC shall also display the proceedings on its website for general information. Comments, if any, on the proceedings, may be sent directly to the concerned regulatory authorities and the Applicant concerned.
- The public hearing shall be completed within a period of 45 (forty five) days from date of receipt of the request letter from the Applicant. Therefore the SPCB or UTPCC concerned shall send public hearing proceedings to the concerned regulatory authority within eight days of the completion of the public hearing. Simultaneously, a copy will also be provided to the project proponent. The proponent may also directly forward a copy of the approved public hearing proceedings to the regulatory authority concerned along with the final EIA report or supplementary report to the draft EIA report prepared after the public hearing and public consultations incorporating the concerns expressed in the public hearing along with action plan and financial allocation, item-wise, to address those concerns.
- Upon receipt of the same, the Authority will place executive summary of the report on the website to invite responses from other concerned persons having a plausible stake in the environmental aspects of the project or activity.
- If SPCB/UTPCC is unable to conduct public hearing in the prescribed time, the Central Government incase of Category A projects at the request of the SEIAA may engage any other agency or Authority for conducting the public hearing process within a further period of 45 days. The Government shall pay the appropriate fee to the public agency for conducting public hearing.
- A public agency means a non-profit making institution/ body such as technical/academic institutions, government bodies not subordinate to the concerned Authority.
- If SPCB/Public Agency authorized for conducting public hearing informs the Authority, stating that it is not possible to conduct the public hearing in a manner, which will enable the views of the concerned local persons to be freely expressed,

then Authority may consider such report to take a decision that in such particular case, public consultation may not have the component of public hearing.

- Often restricting the public hearing to the specific district may not serve the entire purpose, therefore, NGOs who are local and registered under the Societies Act in the adjacent districts may also be allowed to participate in public hearing, if they so desire.
- Confidential information including non-disclosable or legally privileged information involving intellectual property right, source specified in the application shall not be placed on the website.
- The Authority shall make available on a written request from any concerned person the draft EIA report for inspection at a notified place during normal office hours till the date of the public hearing.
- While mandatory requirements will have to be adhered to, utmost attention shall be given to the issues raised in the public hearing for determining the modifications needed in the project proposal and the EMP to address such issues.
- Final EIA report after making needed amendments, as aforesaid, shall be submitted by the applicant to the concerned Authority for prior environmental clearance. Alternatively, a supplementary report to draft EIA and EMP addressing all concerns expressed during the public consultation may be submitted.

4.10 Appraisal

Appraisal means the detailed scrutiny by the EAC of the application and the other documents like the final EIA report, outcome of the public consultation including public hearing proceedings submitted by the applicant for grant of prior environmental clearance.

- The appraisal shall be made by EAC to the Central Government.
- Project proponent either personally or through consultant can make a presentation to the EAC for the purpose of appraising the features of the project proposal and also to clarify the issues raised by the members of the EAC.
- On completion of these proceedings, EAC shall make categorical recommendations to the respective Authority, either for grant of prior environmental clearance on stipulated terms & conditions, if any, or rejection of the application with reasons.
- In case EAC needs to visit the site or obtain further information before being able to make categorical recommendations, EAC may inform the project proponent accordingly. In such an event, it should be ensured that the process of prior environmental clearance is not unduly delayed to go beyond the prescribed timeframe.
- Up on the scrutiny of the final report, if EAC opines that ToR finalized at the scoping stage are covered by the proponent, then the project proponent may be asked to provide such information. If such information is declined by the project proponent or is unlikely to be provided early enough so as to complete the environmental appraisal within prescribed time of 60 days, the EAC may recommend for rejection of the proposal with the same reason.
- Appraisal shall be strictly in terms of ToR finalized at the scoping stage and the concerns expressed during public consultation.

- This process of appraisal shall be completed within 60 days from the receipt of the updated EIA and EMP reports, after completing public consultation.
- The EIA report will be typically examined for following:
  - Project site description supported by topographic maps & photographs – detailed description of topography, land use and activities at the proposed project site and its surroundings (buffer zone) supported by photographic evidence.
  - Clarity in description of drainage pattern, location of eco-sensitive areas, vegetation characteristics, wildlife status - highlighting significant environmental attributes such as feeding, breeding and nesting grounds of wildlife species, migratory corridor, wetland, erosion and neighboring issues.
  - Description of the project site – how well the interfaces between the project related activities and the environment have been identified for the entire project cycle *i.e.,* construction, operation and decommissioning at the end of the project life.
  - If it is envisaged that the project is to be closed after a specified period in case of mining projects, the interface at the closure stage also needs to be described.
  - How complete and authentic are the baseline data pertaining to flora and fauna and socio economic aspects?
  - Citing of proper references, with regard to the source(s) of baseline data as well as the name of the investigators/ investigating agency responsible for collecting the primary data.
  - How consistent are the various values of environmental parameters with respect to each other?
  - Is a reasonable assessment of the environmental and social impact made for the identified environmental issues including project affected people?
  - To what extent the proposed environmental plan will mitigate the environmental impact and at what estimated cost, shown separately for construction, operation and closure stages and also separately in terms of capital and recurring expenses along with details of agencies that will be responsible for the implementation of environmental plan/ conservation plan.
  - How well the concerns expressed/highlighted during public hearing have been addressed and incorporated in the EMP giving item wise financial provisions and commitments (in quantified terms)?
  - How far the proposed environmental monitoring plan will effectively evaluate the performance of EMP? Are details for environmental monitoring plan provided in the same manner as the EMP?
  - Identification of hazard and quantification of risk assessment and whether appropriate mitigation plan has been included in the EMP?
  - Does the proposal include a well formulated time bound green belt development plan for mitigating environmental problems such as fugitive emission of dust, gaseous pollutants, noise, odour, *etc*.
  - Does EIA make a serious attempt to guide the project proponent for minimizing the requirement of natural resources including land, water energy and other non renewable resources?
  - How well has the EIA statement been organized and presented so that the issues, their impact and environmental management strategies emerge clearly from it and

how well organized was the power point presentation made before the expert committee?

– Is the information presented in the EIA adequately and appropriately supported by maps, imageries and photographs highlighting site features and environmental attributes?

4.11 Decision Making

The Chairperson reads the sense of the Committee and finalizes the draft minutes of the meeting, which are circulated by the Secretary to all expert members invited to the meeting. Based on the response from the members, the minutes are finalized and signed by the Chairperson. This process for finalization of the minutes should be so organized that the time prescribed for various stages is not exceeded.

Approval / Rejection / Reconsideration

- The Authority shall consider the recommendations of concerned appraisal Committee and convey its decision within 45 days of the receipt of recommendations.
- If the Authority disagrees with the recommendations of the Appraisal Committee, then reasons shall be communicated to concerned Appraisal Committee and applicant within 45 days from the receipt of the recommendations. The Appraisal Committee concerned shall consider the observations of the Authority and furnish its views on the observations within further period of 60 days. The Authority shall take a decision within the next 30 days based on the views of appraisal Committee.
- If the decision of the Authority is not conveyed within the time, then the proponent may proceed as if the prior environmental clearance sought has been granted or denied by the regulatory authority in terms of the final recommendation of the concerned appraisal Committee. For this purpose, the decision of the Appraisal Committee will be public document, once the period specified above for taking the decision by the Authority is over.
- Deliberate concealment and/or submission of false or misleading information or data which is material to screening or scoping or appraisal or decision on the application shall make the application liable for rejection, and cancellation of prior environmental clearance granted on that basis. Rejection of an application or cancellation of a prior environmental clearance already granted, on such ground, shall be decided by the regulatory authority, after giving a personal hearing to the applicant, and following the principles of natural justice.

If approved

- The MoEF will issue a prior environmental clearance for the project.
- The project proponent should make sure that the award of prior environmental clearance is properly publicized in at least two local newspapers of the district or state where the proposed project is located. For instance, the executive summary of the prior environmental clearance may be published in the newspaper along with the information about the location (website/office where it is displayed for public) where the detailed prior environmental clearance is made available. The MoEF shall also place the prior environmental clearance in the public domain on Government Portal. Further copies of the prior environmental clearance shall be endorsed to the Heads of

local bodies, Panchayats and Municipal bodies in addition to the relevant offices of the Government.

- The prior environmental clearance will be valid from the start date to actual commencement of the production of the developmental activity.
- Usual validity period will be 5 years from the date of issuing environmental clearance, unless specified by EAC.
- A prior environmental clearance issued to a project proponent can be transferred to another legal person entitled to undertake the project, upon application by the transferor to the concerned Authority or submission of no-objection of the transferor by the transferee to the concerned Authority for the concurrence. In this case, EAC concurrence is not required, but approval from the concerned authority is required to avail the same project configurations, validity period transferred to the new legally entitled person to undertake the project.

4.12 Post-clearance Monitoring Protocol

The MoEF, Government of India will monitor and take appropriate action under the EP Act, 1986.

- In respect of Category A projects, it shall be mandatory for the project proponent to make public the environmental clearance granted for their project along with the environmental conditions and safeguards at their cost by advertising it at least in two local newspapers of the district or State where the project is located and in addition, this shall also be displayed in the project proponents website permanently.
- The MoEF shall also place the environmental clearance in the public domain on Government Portal.
- Copies of environmental clearance shall be submitted by the project proponents to the Heads of the local bodies, Panchayats and Municipal bodies in addition to the relevant offices of the Government who in turn have to display the same for 30 days from the date of receipt.

The project proponent must submit half-yearly compliance reports in respect of the stipulated prior environmental clearance terms and conditions in hard and soft copies to the regulatory authority concerned, on 1st June and 1st December of each calendar year.

All such compliance reports submitted by the project management shall be public documents. Copies of the same shall be given to any person on application to the concerned regulatory authority. Such latest such compliance report shall also be displayed on the web site of the concerned regulatory authority

The SPCB shall incorporate EIA clearance conditions into consent conditions in respect of Category A and Category B projects and in parallel shall monitor and enforce the same.

5. STAKEHOLDERS' ROLES AND RESPONSIBILITIES

Prior environmental clearance process involves many stakeholders *i.e.*, Central Government, State Government, EAC at the National Level, Public Agency, SPCB, the project proponent, and the public.

- Roles and responsibilities of the organizations involved in different stages of prior environmental clearance are listed in Table 5-1.
- Organization-specific functions are listed in Table 5-2.

In this Chapter, constitution, composition, functions, *etc*., of the Authorities and the Committees are discussed in detail.

Table 5-1: Roles and Responsibilities of Stakeholders Involved in Prior Environmental Clearance

Stage	MoEF	EAC	Project Proponent	EIA Consultant	SPCB/ Public Agency	Public and Interest Group
Screening	Receives application and takes advice of EAC	Advises the MoEF	Submits application (Form 1) and provides necessary information	Advises and assists the proponent by providing technical information		
Scoping	Approves the ToR, communicates the same to the project proponent and places the same in the website	Reviews the ToR, visits the proposed site, if required and recommends the ToR to the MoEF	Submits the draft ToR to MoEF and facilitates the visit of the EAC members to the project site	Prepares ToR		
EIA Report & Public Hearing	Reviews and forwards copies of the EIA report to SPCB /public agency for conducting public hearing Places the summary of EIA report in the		Submits detailed EIA report as per the finalized ToR Facilitates the public hearing by arranging presentation on the project, EIA and EMP – takes note of objections and updates the	Prepares the EIA report Presents and appraises the likely impacts and pollution control measures proposed in the public hearing	Reviews EIA report and conducts public hearing in the manner prescribed Submits proceedings and views of SPCB, to the Authority	Participates in public hearings and offers comments and observations. Comments can be sent directly to SEIAA through Internet in

Stage	MoEF	EAC	Project Proponent	EIA Consultant	SPCB/ Public Agency	Public and Interest Group
	website Conveys objections to the project proponent for update		EMP accordingly		and the project proponent as well	response to the summary placed in the website
Appraisal and Clearance	Receives updated EIA Takes advice of EAC, approves EIA and attaches the terms and conditions	Critically examines the reports, presentation of the proponent and appraises MoEF (recommendations are forwarded to MoEF)	Submits updated EIA , EMP reports to MoEF. Presents the overall EIA and EMP including public concerns to EAC	Provides technical advise to the project proponent and if necessary presents the proposed measures for mitigation of likely impacts (terms and conditions of clearance)		
Post Clearance Monitoring			Implements environmental protection measures prescribed and submits periodic monitoring results	Conducts periodic monitoring	Incorporates the clearance conditions into appropriate consent conditions and ensures implementation	

Table 5-2: Organization-specific Functions

Organization	Functions
Central Government	▪ Constitutes the EAC ▪ Considering recommendations of the State Government, constitutes the SEIAA & State EAC (SEAC) ▪ Receives application from the project proponent in case of Category A projects or Category B projects attracting general condition ▪ Communicates the ToR finalized by the EAC to the project proponent. ▪ Receives EIA report from the project proponent and soft copy of summary of the report for placing in the website ▪ Summary of EIA report will be placed in website. Forwards the received responses to the project proponent ▪ Engages other public agency for conducting public hearings in cases where the SPCB does not respond within time ▪ Receives updated EIA report from project proponent incorporating the considerations from the proceedings of public hearing and responses received through other media

Organization	Functions
	▪ Forwards updated EIA report to the EAC for appraisal ▪ Either accepts the recommendations of EAC or asks for reconsideration of specific issues for review by the EAC. ▪ Takes the final decision – acceptance/ rejection – of the project proposal and communicates the same to the project proponent
EAC	▪ Reviews Form 1 and its attachments ▪ Visits site(s), if necessary ▪ Finalizes ToR and recommends to the Central Government, which in turn communicates the finalized ToR to the project proponent, if not exempted by the Notification ▪ Reviews EIA report, proceedings and appraises their views to the Central government ▪ If the Central Government has any specific views, then the EAC reviews again for appraisal
SPCB	▪ Receives request from project proponent and conducts public hearing in the manner prescribed. ▪ Conveys proceedings to concerned authority and project proponent
Public Agency	▪ Receives request from the respective Governments to conduct public hearing ▪ Conducts public hearing in the manner prescribed. ▪ Conveys proceedings to the concerned Authority/EAC /Project proponent

5.1 EAC

EAC is an independent Committee to review each developmental activity and offer its recommendations for consideration of the Central Government.

A. Constitution

- EAC shall be constituted by the Central Government comprising a maximum of 15 members including a Chairperson and Secretary.
- The Central Government will notify committee.
- The Chairperson and the non-official member shall have a fixed term of three years, from the date of Notification by the Central Government.
- The Chairperson shall be an eminent environmental expert with understanding on environmental aspects and environmental impacts.

B. Composition

- Composition of EAC as per the Notification is given in **Annexure XII.**
- Secretary to EAC may invite a maximum of two professionals/experts with the prior approval of the Chairperson, if desired, for taking the advisory inputs for appraisal. In such case, the invited experts will not take part in the decision making process.
- The Secretary of each EAC preferably be an officer of the level equivalent to or above the level of Director, MoEF, GoI.

C. Decision making

The EAC shall function on the principle of collective responsibility. The Chairperson shall endeavour to reach a consensus in each case, and if consensus cannot be reached, the view of the majority shall prevail.

D. Operational issues

- Secretary may deal with all correspondence, formulate agenda and prepare agenda notes. Chairperson and other members may act only for the meetings.
- Chairperson of EAC shall be one among the expert members having considerable professional experience with proven credentials.
- EAC shall meet at least once every month or more frequently, if so needed, to review project proposals and to offer recommendations for the consideration of the Authority.
- EAC members may inspect the site at various stages *i.e.,* during screening, scoping and appraisal, as per the need felt and decided by the Chairperson of the Committee.
- The MoEF through the Secretary of the Committee may pay/reimburse the participation expenses, honorarium *etc*., to the Chairperson and members.

i. Tenure of EAC

The tenure of Authority/Committee(s) shall be for a fixed period of three years. At the end of the three years period, the Authority and the committees need to be re-constituted. However, staggered appointment dates may be adopted to maintain continuity of members at a given point of time.

ii. Qualifying criteria for nomination of a member to EAC

While recommending nominations and while notifying the members of the Authority and Expert Committees, it shall be ensured that all the members meet the following three criteria:

- Professional qualification
- Relevant experience/Experience interfacing with environmental management
- Absence of conflict of interest

These are elaborated subsequently.

a) Professional qualification

The person should have at least (i) 5 years of formal University training in the concerned discipline leading to a MA/MSc Degree, or (ii) in case of Engineering/Technology/ Architecture disciplines, 4 years formal training in a professional training course together with prescribed practical training in the field leading to a B.Tech/B.E./B.Arch. Degree, or (iii) Other professional degree (*e.g.,* Law) involving a total of 5 years of formal University training and prescribed practical training, or (iv) Prescribed apprenticeship/articleship and pass examinations conducted by the concerned professional association (*e.g.,* MBA/IAS/IFS). In selecting the individual professionals, experience gained by them in their respective fields will be taken note of.

b) Relevant experience

- Experience shall be related to professional qualification acquired by the person and be related to one or more of the expertise mentioned for the expert members. Such experience should be a minimum of 15 years.
- When the experience mentioned in the foregoing sub-paragraph interfaces with environmental issues, problems and their management, the requirement for the length of the experience can be reduced to a minimum of 10 years.

c) Absence of conflict of interest

For the deliberations of the EAC to be independent and unbiased, all possibilities of potential conflict of interests have to be eliminated. Therefore, serving government officers; persons engaged in industry and their associations; persons associated with the formulation of development projects requiring prior environmental clearance, and persons associated with environmental activism shall not be considered for membership of EAC.

iii. Age

Below 70 years for the members and below 72 years for the Chairperson of the EAC. The applicability of the age is at the time of the Notification of the EAC by the Central Government.

Summary regarding the eligibility criteria for Chairperson and Members of the EAC is given in Table 5-3.

Table 5-3: EAC: Eligibility Criteria for Chairperson / Members / Secretary

S. No.	Attribute		Requirement		
			Expert members	Member-Secretary	Chairperson
1	Professional qualification as per the Notification		Compulsory	Compulsory	Compulsory
2	Experience (Fulfilling any one of a, b, c)	a	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI
		b	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in Appendix VI
		c	Professional Qualification +10 years of experience in one of the expertise area mentioned in the Appendix VI + 5 years interface with	Professional Qualification +10 years of experience in one of the expertise area mentioned in the Appendix VI + 5 years interface with	----------

S. No.	Attribute	Requirement		
		Expert members	Member-Secretary	Chairperson
		environmental issues, problems and their management	environmental issues, problems and their management	
3	Test of independence (conflict of interest) and minimum grade of the Secretary of the Committees	Shall not be a serving government officer Shall not be a person engaged in industry and their associations Shall not be a person associated with environmental activism	In case of EAC, not less than a Director from the MoEF, Government of India Incase of SEAC, not below the level of Director/Chief Engineer from the State Government (DoE)	Shall not be a serving government officer Shall not be a person engaged in industry and their associations Shall not be a person associated with environmental activism
4	Age	Below 67 years at the time of Notification of the Committee	As per state Government Service Rules	Below 72 Years at the time of the Notification of the Committee
5	Membership in Central/State Expert Appraisal committee	Only one other than this nomination is permitted	Shall not be a member in other SEIAA/EAC/SEAC	Shall not be a member in any other SEIAA/EAC/SEAC
6	Tenure of earlier appointment (continuous)	Only one term before this in continuity is permitted	Not applicable	Only one term before this in continuity is permitted
7	Eminent environmental expertise with understanding on environmental aspects and impacts	Desirable	Not applicable	Compulsory

Notes:

1. A member after continuous membership in two terms (six years) shall not be considered for further continuation. His/her nomination may be reconsidered after a gap of one term (three years), if other criteria meet.

2. Chairperson/Member once notified may not be removed prior to the tenure of 3 years with out cause and proper enquiry. A member after continuous membership in two terms (6 years) shall not be considered for further continuation. The same profile may be considered for nomination after a gap of three years, i.e.*, one term, if other criteria are meeting.*

E. Other conditions that may be considered

- An expert member of one State/UT, can have at the most another State/UT Committee membership, but in no case more than two Committees at a given point of time.
- An expert member of a Committee shall not have membership continuously in the same committee for more than two terms, *i.e.*, six years. They can be nominated after

a gap of three years, *i.e.*, one term. When a member of Committee has been associated with any development project, which comes for prior environmental clearance, he/she may not participate in the deliberations and the decisions in respect to that particular project.

- At least four members shall be present in each meeting to fulfill the quorum
- If a member does not consecutively attend six meetings, without prior intimation to the Committee his/her membership may be terminated by the Notifying Authority. Prior information for absence due to academic pursuits, career development and national/state-endorsed programmes may be considered as genuine grounds for retention of membership.

ANNEXURE I
Modifications to Equipments Can Also Prevent Pollution - Opportunities

Modifications to Equipment Can Also Prevent Pollution - Oppurtunities*

Equipment	Potential Environment Problem	Possible Approach	
		Design Related	Operational Related
Compressors, blowers, fans	■ Shaft seal leaks, piston rod seal leaks, and vent streams	■ Seal-less designs (diaphragmatic, hermetic or magnetic) ■ Design for low emissions (internal balancing, double inlet, gland eductors) ■ Shaft seal designs (carbon rings, double mechanical seals, buffered seals) ■ Double seal with barrier fluid vented to control device	■ Preventive maintenance program
Concrete pads, floors, sumps	■ Leaks to groundwater	■ Water stops ■ Embedded metal plates ■ Epoxy sealing ■ Other impervious sealing	■ Reduce unnecessary purges, transfers, and sampling ■ Use drip pans where necessary
Controls	■ Shutdowns and start-ups generate waste and releases	■ Improve on-line controls ■ On-line instrumentation ■ Automatic start-up and shutdown ■ On-line vibration analysis ■ Use "consensus" systems (e.g., shutdown trip requires 2 out of 3 affirmative responses)	■ Continuous versus batch ■ Optimize on-line run time ■ Optimize shutdown interlock inspection frequency ■ Identify safety and environment critical instruments and equipment
Distillation	■ Impurities remain in process streams	■ Increase reflux ratio ■ Add section to column ■ Column intervals ■ Change feed tray	■ Change column operating conditions - reflux ratio - feed tray - temperature - pressure - etc.

(Continued)

Equipment	Potential Environment Problem	Possible Approach	
		Design Related	**Operational Related**
Distillation (cont.)	■ Impurities remain in process streams (cont.)	■ Insulate to prevent heat loss ■ Preheat column feed ■ Increase vapor line size to lower pressure drop	■ Clean column to reduce fouling
	■ Large amounts of contaminated water condensate from stream stripping	■ Use reboilers or inert gas stripping agents	■ Use higher temperature steam
General manufacturing equipment areas	■ Contaminated rainwater	■ Provide roof over process facilities ■ Segregate process sewer from storm sewer (diking) ■ Hard-pipe process streams to process sewer	■ Return samples to process ■ Monitor stormwater discharge
	■ Contaminated sprinkler and fire water	■ Seal floors ■ Drain to sump ■ Route to waste treatment	
	■ Leaks and emissions during cleaning	■ Design for cleaning ■ Design for minimum rinsing ■ Design for minimum sludge ■ Provide vapor enclosure ■ Drain to process	■ Use drip pans for maintenance activities ■ Rinse to sump ■ Reuse cleaning solutions
Heat exchangers	■ Increased waste due to high localized temperatures	■ Use intermediate exchangers to avoid contact with furnace tubes and walls ■ Use staged heating to minimize product degradation and unwanted side reactions. (waste heat >>low pressure steam >>high pressure steam)	■ Select operating temperatures at or near ambient temperature when-ever possible. These are generally most desirable from a pollution prevention standpoint ■ Use lower pressure steam to lower temperatures

(Continued)

Equipment	Potential Environment Problem	Possible Approach	
		Design Related	**Operational Related**
Heat exchangers (cont.)	■ Increased waste due to high localized temperatures (cont.)	■ Use scraped wall exchangers in viscous service ■ Using falling film reboiler, piped recirculation reboiler or high-flux tubes ■ Use lowest pressure steam possible	■ Monitor exchanger fouling to correlate process conditions which increase fouling, avoid conditions which rapidly foul exchangers ■ Use on-line tube cleaning techniques to keep tube surfaces clean
	■ Contaminated materials due to tubes leaking at tube sheets	■ Use welded tubes or double tube sheets with inert purge. Mount vertically	■ Monitor for leaks
	■ Furnace emissions	■ Use superheat of high-pressure steam in place of a furnace	
Piping	■ Leaks to groundwater; fugitive emissions	■ Design equipment layout so as to minimize pipe run length ■ Eliminate underground piping or design for cathodic protection if necessary to install piping underground ■ Welded fittings ■ Reduce number of flanges and valves ■ All welded pipe ■ Secondary containment ■ Spiral-wound gaskets ■ Use plugs and double valves for open end lines ■ Change metallurgy ■ Use lined pipe	■ Monitor for corrosion and erosion ■ Paint to prevent external corrosion

(Continued)

Equipment	Potential Environment Problem	Possible Approach	
		Design Related	**Operational Related**
Piping (cont.)	■ Releases when cleaning or purging lines	■ Use "pigs" for cleaning ■ Slope to low point drain ■ Use heat tracing and insulation to prevent freezing ■ Install equalizer lines	■ Flush to product storage tank
Pumps	■ Fugitive emissions from shaft seal leaks	■ Mechanical seal in lieu of packing ■ Double mechanical seal with inert barrier fluid ■ Double machined seal with barrier fluid vented to control device ■ Seal-less pump (canned motor magnetic drive) ■ Vertical pump	■ Seal installation practices ■ Monitor for leaks
	■ Fugitive emissions from shaft seal leaks	■ Use pressure transfer to eliminate pump	
	■ Residual "heel" of liquid during pump maintenance	■ Low point drain on pump casing	■ Flush casing to process sewer for treatment ■ Increase the mean time between pump failures by: - selecting proper seal material; - good alignment; - reduce pipe-induced stress - Maintaining seal lubrication
	■ Injection of seal flush fluid into process stream	■ Use double mechanical seal with inert barrier fluid where practical	
Reactors	■ Poor conversion or performance due to inadequate mixing	■ Static mixing ■ Add baffles ■ Change impellers	■ Add ingredients with optimum sequence

(Continued)

Equipment	Potential Environment Problem	Possible Approach	
		Design Related	Operational Related
Reactors (cont.)	■ Poor conversion (cont.)	■ Add horsepower ■ Add distributor	■ Allow proper head space in reactor to enhance vortex effect
	■ Waste by-product formation	■ Provide separate reactor for converting recycle streams to usable products	■ Optimize reaction conditions (temperature, pressure, etc.)
Relief Valve	■ Leaks	■ Provide upstream rupture disc	
	■ Fugitive emissions	■ Vent to control or recovery device	■ Monitor for leaks and for control efficiency
	■ Discharge to environment from over pressure	■ Pump discharges to suction of pump ■ Thermal relief to tanks ■ Avoid discharge to roof areas to prevent contamination of rainwater	■ Monitor for leaks
	■ Frequent relief	■ Use pilot operated relief valve ■ Increase margin between design and operating pressure	■ Reduce operating pressure ■ Review system performance
Sampling	■ Waste generation due to sampling (disposal, containers, leaks, fugitives, etc.)	■ In-line insitu analyzers ■ System for return to process ■ Closed loop ■ Drain to sump	■ Reduce number and size of samples required ■ Sample at the lowest possible temperature ■ Cool before sampling
Tanks	■ Tank breathing and working losses	■ Cool materials before storage ■ Insulate tanks ■ Vent to control device (flare, condenser, etc.) ■ Vapor balancing ■ Floating roof	■ Optimize storage conditions to reduce losses

(Continued)

Equipment	Potential Environment Problem	Possible Approach	
		Design Related	**Operational Related**
Tanks (cont.)	■ Tank breathing and working losses (cont.)	■ Floating roof ■ Higher design pressure	
	■ Leak to groundwater	■ All aboveground (situated so bottom can routinely be checked for leaks) ■ Secondary containment ■ Improve corrosion resistance	■ Monitor for leaks and corrosion
	■ Large waste heel	■ Design for 100% de-inventory	■ Recycle to process if practical
Vacuum Systems	■ Waste discharge from jets	■ Substitute mechanical vacuum pump ■ Evaluate using process fluid for powering jet	■ Monitor for air leaks ■ Recycle condensate to process
Valves	■ Fugitive emissions from leaks	■ Bellow seals ■ Reduce number where practical ■ Special packing sets	■ Stringent adherence to packing procedures
Vents	■ Release to environment	■ Route to control or recovery device	■ Monitor performance

* Source: Profile of the Organic Chemical Industry, 2nd Edition, Sector Notebook Project, November 2002

ANNEXURE II
Process Flow Diagrams of Olefins and Aromatics

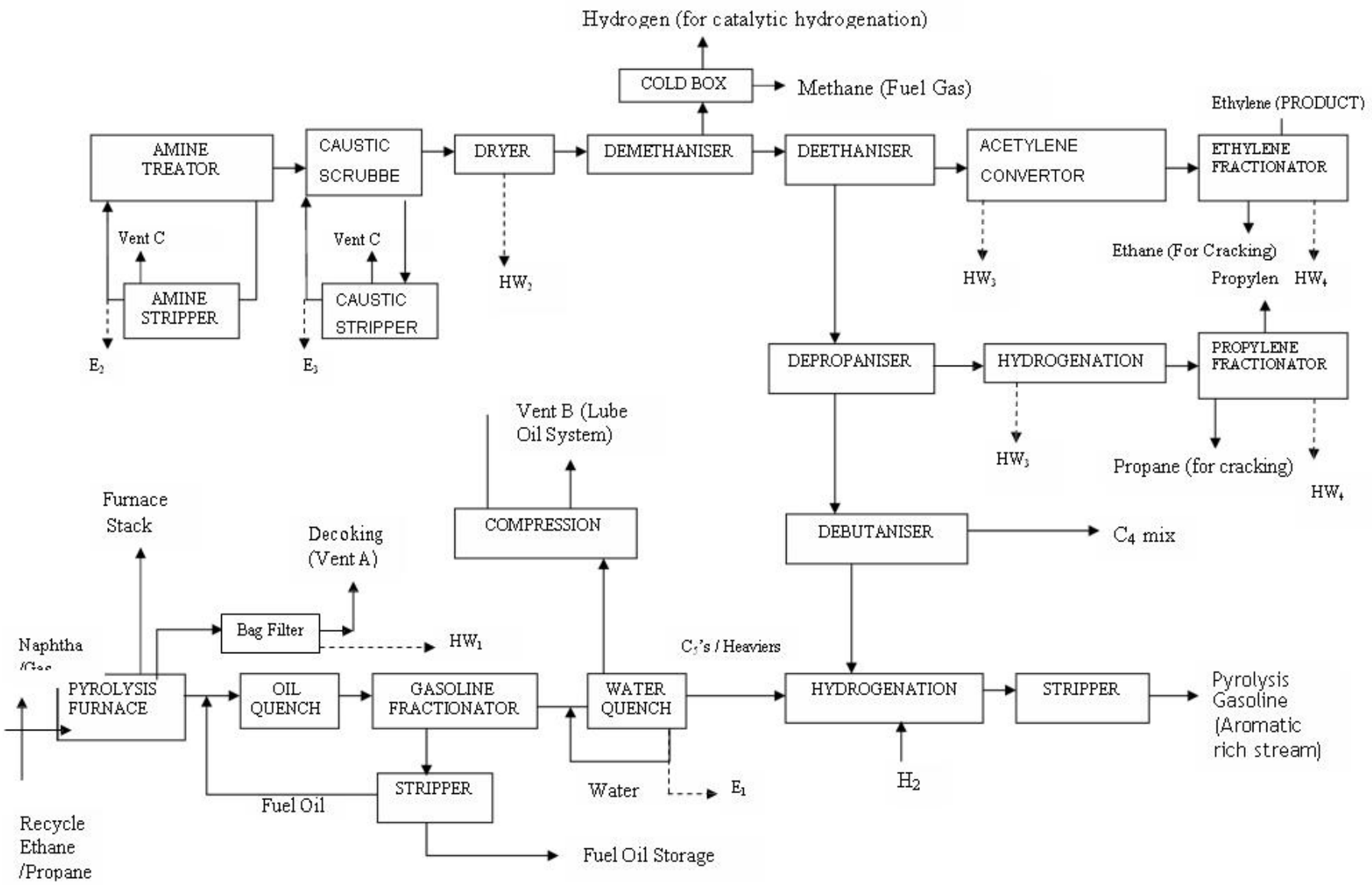

Figure 1: Block Diagram: Olefin Manufacture*

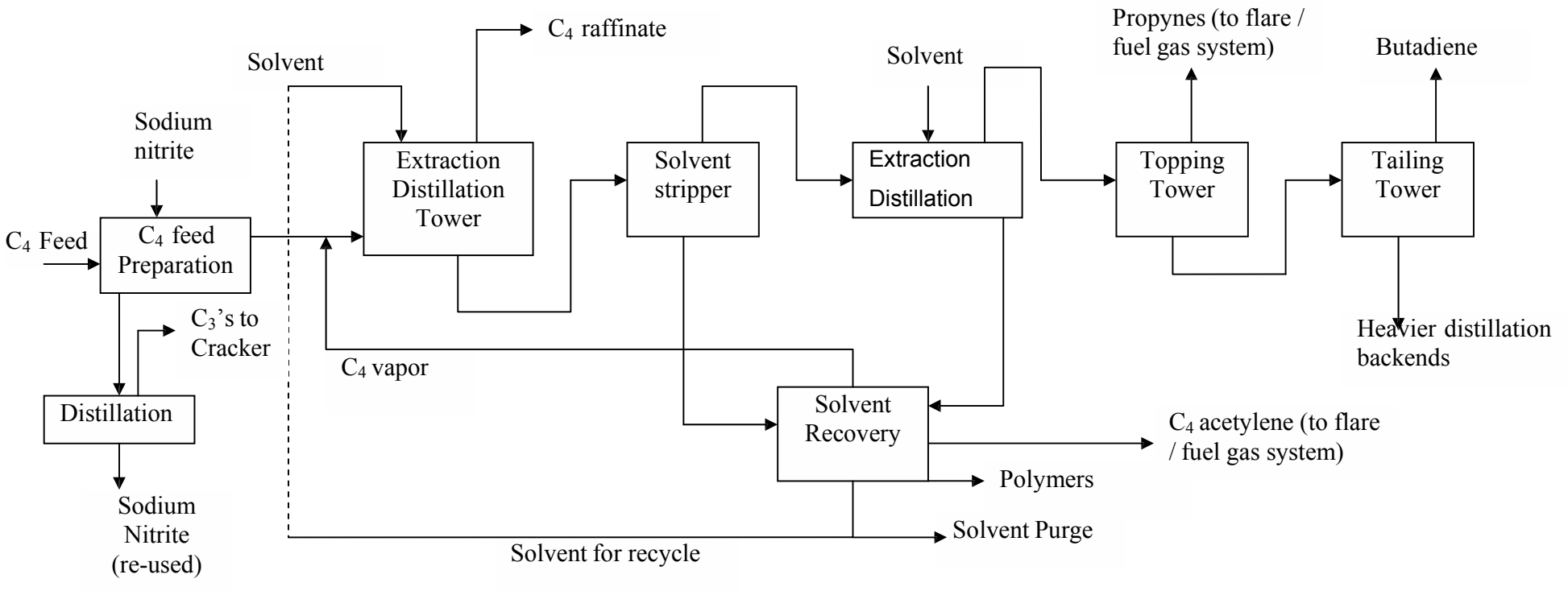

Figure 2: Simplified Flow Diagram – Butadiene Manufacture*

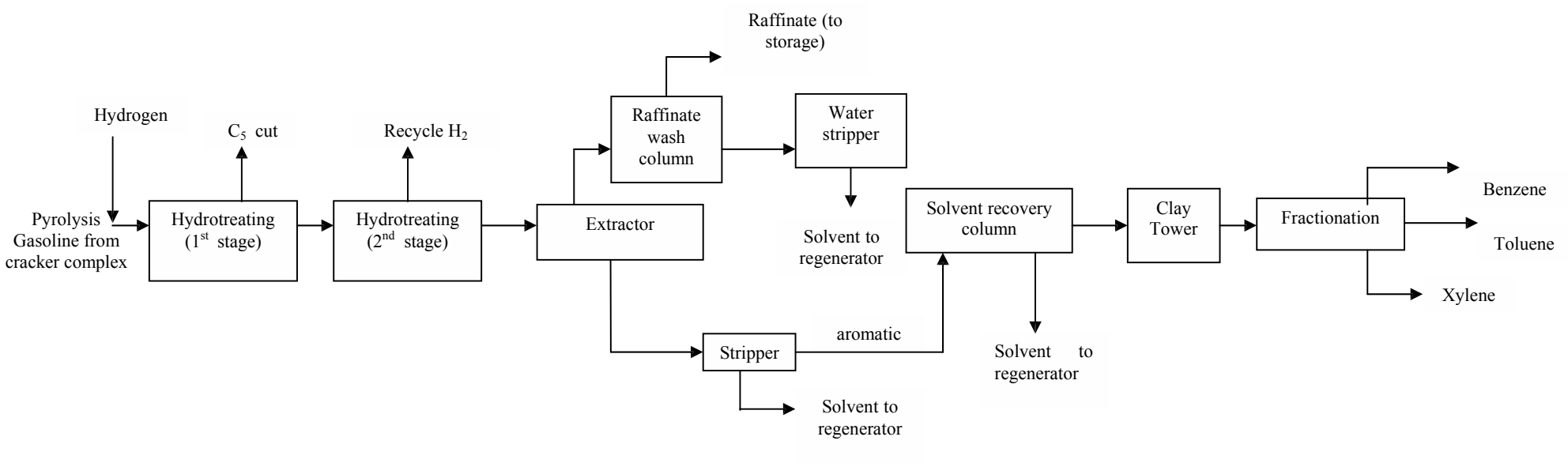

Figure 3: Benzene / Toluene Extraction From Pyrolysis Gasoline (using Liquid – Liquid Extraction)*

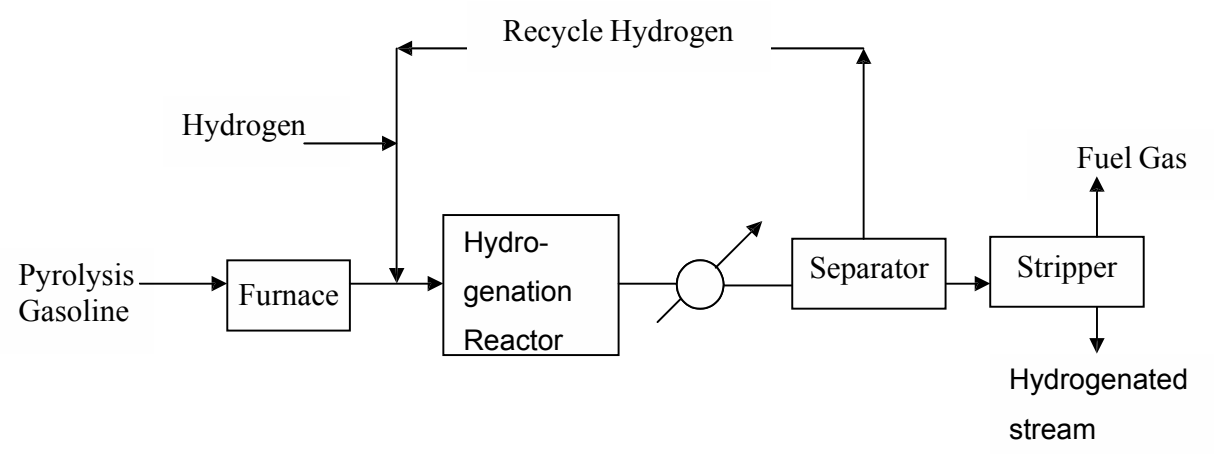

Figure 4: Process Flow Diagram for Hydrotreating*

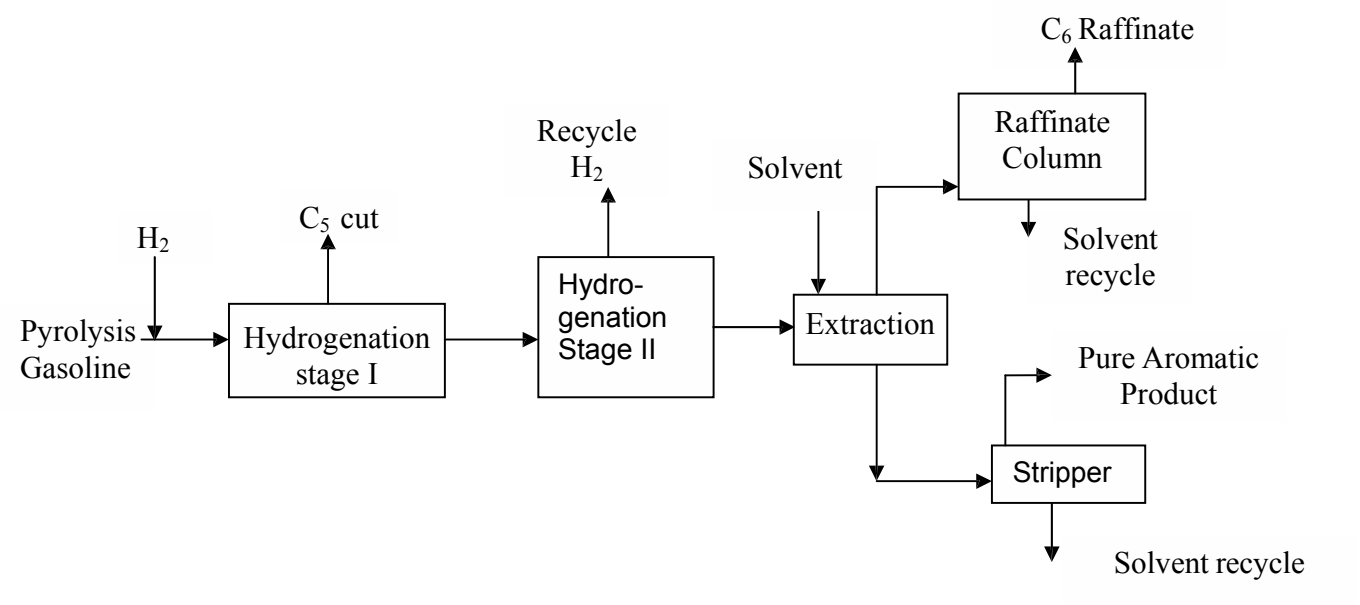

Figure 5: Benzene / Toluene Extraction from Pygas using Extractive Distillation*

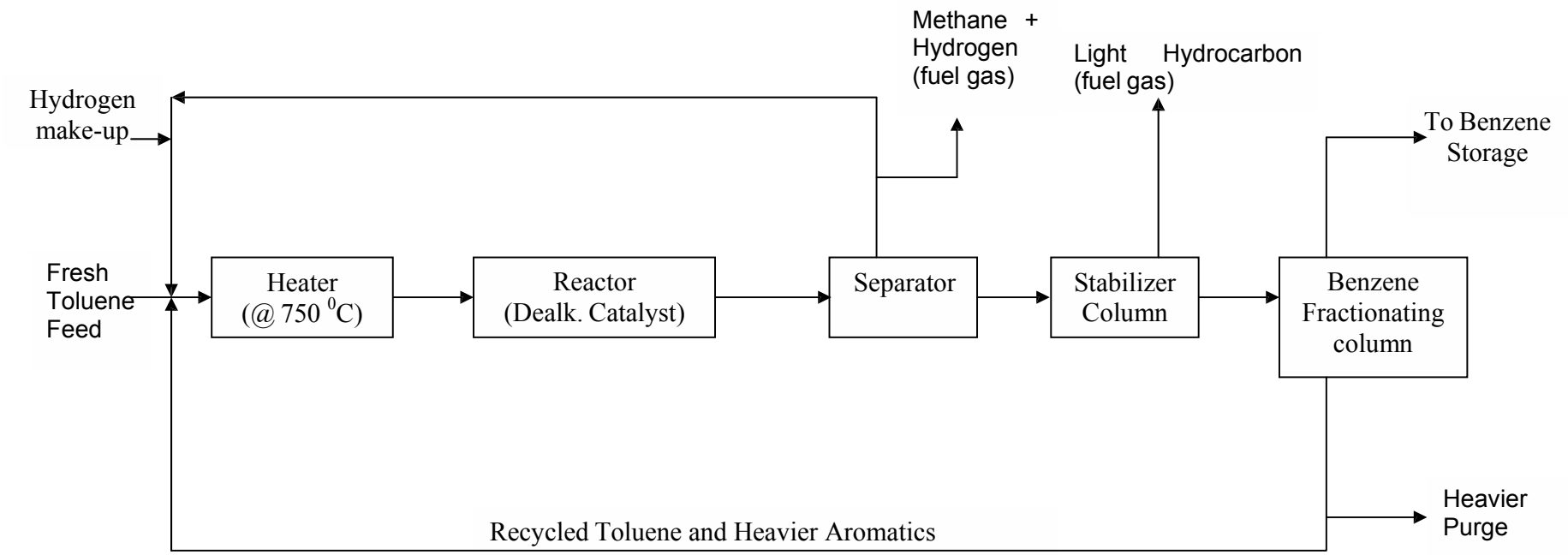

Figure 6: Process Flow Diagram of a Toluene Dealkylation Unit (HDA)*

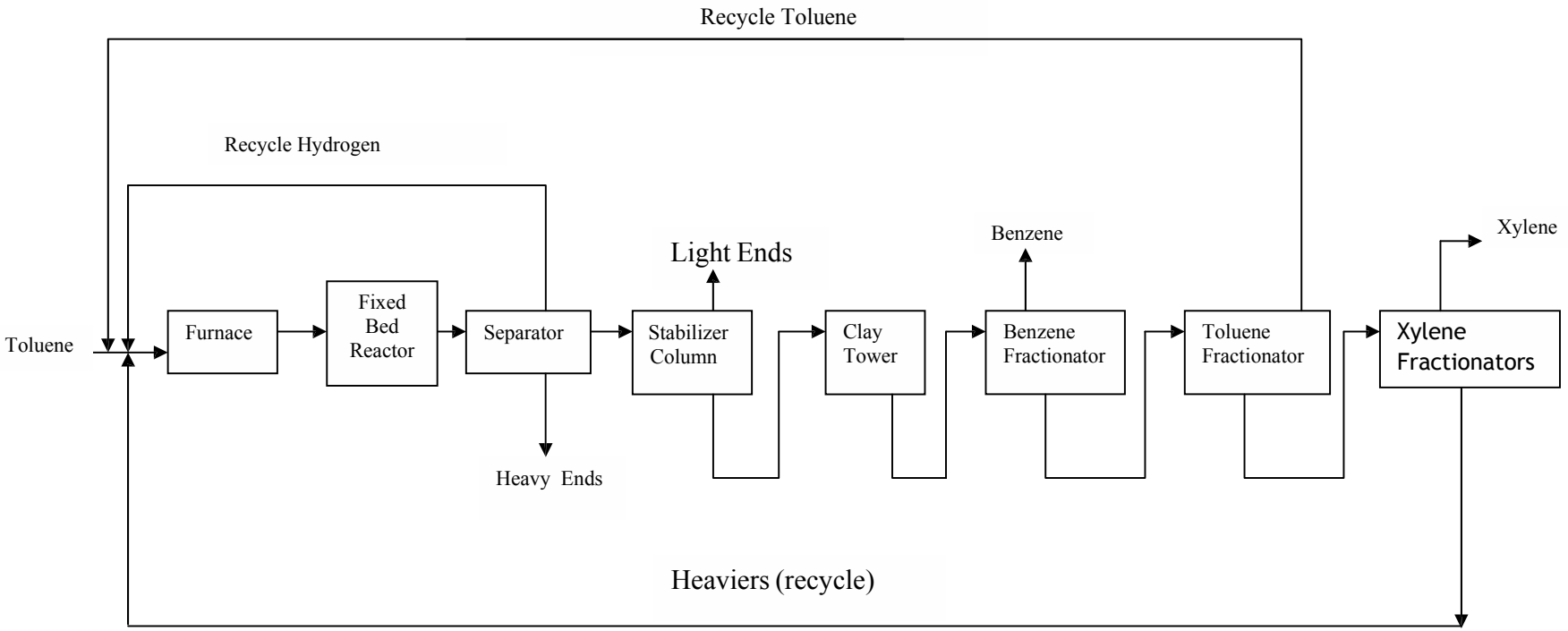

Figure 7: Toluene Disproportionation Process Flow Diagram (Tatoray Process)*

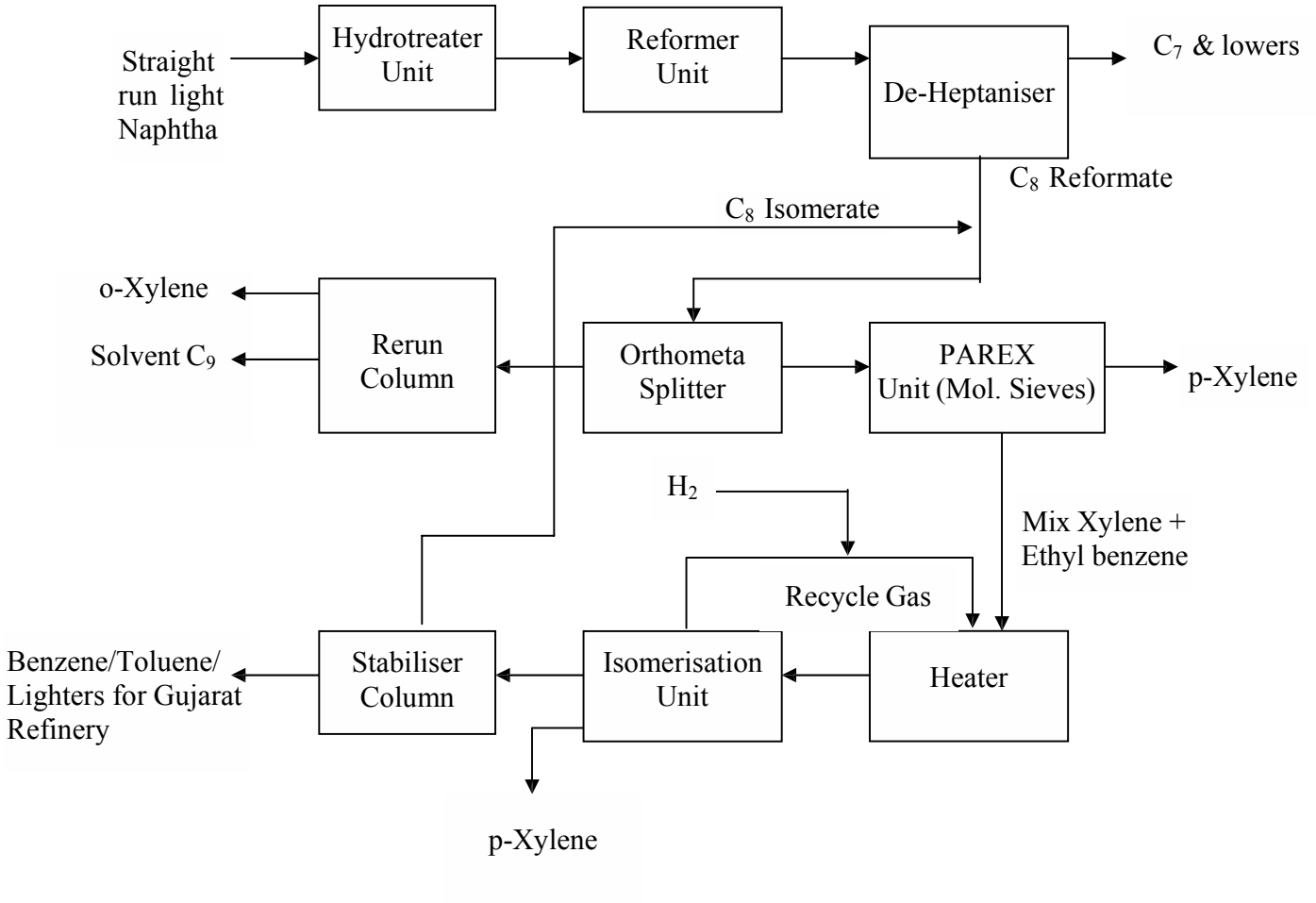

Figure 8: Block Diagram of Xylene Process (IPCL, Vadodara)*

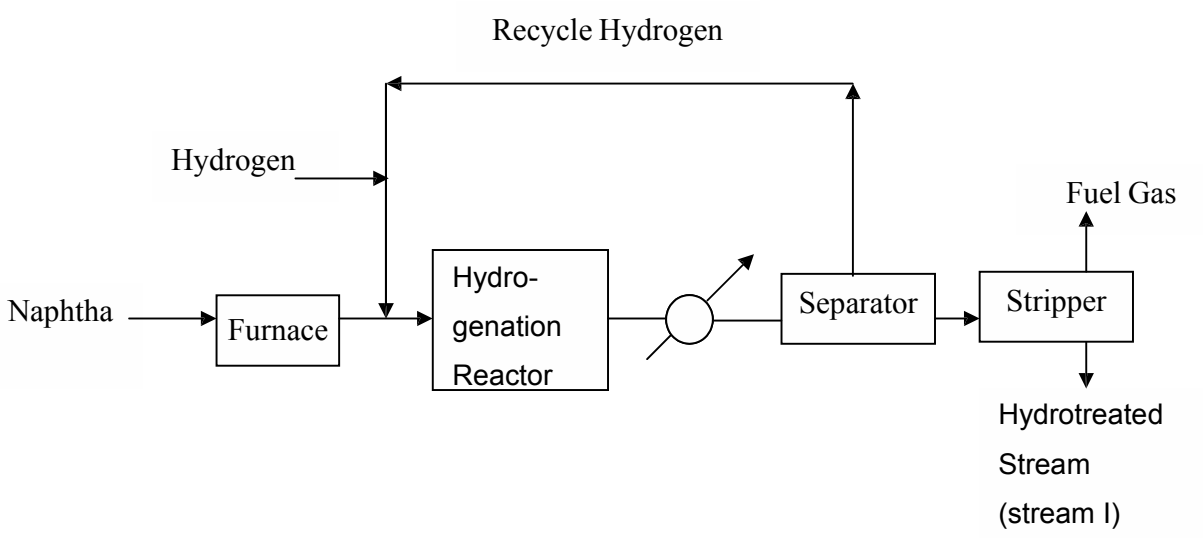

Figure 9: Process Flow Diagram for Hydro-Treating*

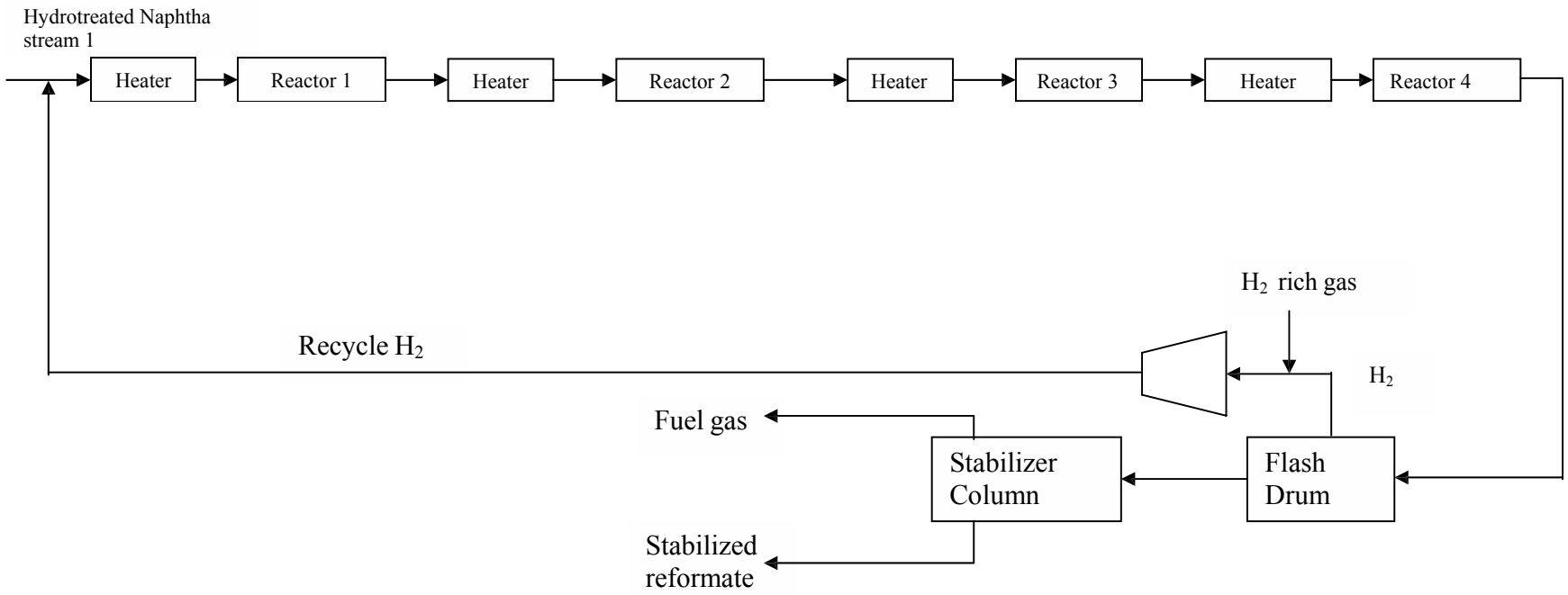

Figure 10: Process Flow Diagram for Reformer Unit*

Note:

* Development of National Emission Standards for Petrochemical Plants, CPCB, 2008

ANNEXURE III
A Compilation of Legal Instruments

Sl. No.	Legal Instrument (Type, Reference, Year)	Responsible Ministries or Bodies	Chemical Use Categories/ Pollutants	Objective of Legislation	Relevant Articles/Provisions
1	Air (Prevention and Control of Pollution) Act, 1981 amended 1987	Central Pollution Control Board and State Pollution Control Boards	Air pollutants from chemical industries	The prevention, control and abatement of air pollution	Section 2: Definitions Section 21: Consent from State Boards Section 22: Not to allow emissions exceeding prescribed limits Section 24: Power of Entry and Inspection Section 25: Power to Obtain Information Section 26: Power to Take Samples Section 37-43: Penalties and Procedures
2	Air (Prevention and Control of Pollution) (Union Territories) Rules, 1983	Central Pollution Control Board and State Pollution Control Boards	Air pollutants from chemical industries	The prevention, control and abatement of air pollution	Rule 2: Definitions Rule 9: Consent Applications
3	Water (Prevention and Control of Pollution) Act, 1974 amended 1988	Central Pollution Control Board and State Pollution Control Boards	Water Pollutants from water polluting industries	The prevention and control of water pollution and also maintaining or restoring the wholesomeness of water	Section 2: Definitions Section 20: Power to Obtain Information Section 21: Power to Take Samples Section 23: Power of Entry and Inspection Section 24: Prohibition on Disposal Section 25: Restriction on New Outlet and New Discharge Section 26: Provision regarding existing discharge of sewage or trade effluent Section 27: Refusal or withdrawal of consent by state boards Section 41-49: Penalties and Procedures
4	Water (Prevention and Control of Pollution) Rules, 1975	Central Pollution Control Board and State Pollution Control Boards	Water Pollutants from water polluting industries	The prevention and control of water pollution and also maintaining or restoring the wholesomeness of water	Rule 2: Definitions Rule 30: Power to take samples Rule 32: Consent Applications
5	The Environment (Protection) Act, 1986,	Ministry of Environment and	All types of environmental pollutants	Protection and Improvement of the Environment	Section 2: Definitions Section 7: Not to allow emission or discharge of

Sl. No.	Legal Instrument (Type, Reference, Year)	Responsible Ministries or Bodies	Chemical Use Categories/ Pollutants	Objective of Legislation	Relevant Articles/Provisions
	amended 1991	Forests, Central Pollution Control Board and State Pollution Control Boards			environmental pollutants in excess of prescribed standards Section 8: Handing of Hazardous Substances Section 10: Power of Entry and Inspection Section 11: Power to take samples Section 15-19: Penalties and Procedures
6	Environmental (Protection) Rules, 1986 (Amendments in 1999, 2001, 2002, 2002, 2002, 2003, 2004)	Ministry of Environment and Forests, Central Pollution Control Board and State Pollution Control Boards	All types of Environmental Pollutants	Protection and Improvement of the Environment	Rule 2: Definitions Rule 3: Standards for emission or discharge of environmental pollutants Rule 5: Prohibition and restriction on the location of industries and the carrying on process and operations in different areas Rule 13: Prohibition and restriction on the handling of hazardous substances in different areas Rule 14: Submission of environmental statement
7	Hazardous Waste (Management and Handling) Rules, 1989 amended 2000 and 2003	MoEF, CPCB, SPCB, DGFT, Port Authority and Customs Authority	Hazardous Wastes generated from industries using hazardous chemicals	Management & Handling of hazardous wastes in line with the Basel convention	Rule 2: Application Rule 3: Definitions Rule 4: Responsibility of the occupier and operator of a facility for handling of wastes Rule 4A: Duties of the occupier and operator of a facility Rule 4B: Duties of the authority Rule 5: Grant of authorization for handling hazardous wastes Rule 6: Power to suspend or cancel authorization Rule 7: Packaging, labeling and transport of hazardous wastes Rule 8: Disposal sites Rule 9: Record and returns Rule 10: Accident reporting and follow up

Sl. No.	Legal Instrument (Type, Reference, Year)	Responsible Ministries or Bodies	Chemical Use Categories/ Pollutants	Objective of Legislation	Relevant Articles/Provisions
					Rule 11: Import and export of hazardous waste for dumping and disposal Rule 12: Import and export of hazardous waste for recycling and reuse Rule 13: Import of hazardous wastes Rule 14: Export of hazardous waste Rule 15: Illegal traffic Rule 16: Liability of the occupier, transporter and operator of a facility Rule 19: Procedure for registration and renewal of registration of recyclers and re-refiners Rule 20: Responsibility of waste generator
8	Manufacture Storage and Import of Hazardous Chemicals Rules, 1989 amended 2000	Ministry of Environment & Forests, Chief Controller of Imports and Exports, CPCB, SPCB, Chief Inspector of Factories, Chief Inspector of Dock Safety, Chief Inspector of Mines, AERB, Chief Controller of Explosives, District Collector or District Emergency Authority, CEES under DRDO	Hazardous Chemicals - Toxic, Explosive, Flammable, Reactive	Regulate the manufacture, storage and import of Hazardous Chemicals	Rule 2: Definitions Rule 4: responsibility of the Occupier Rule 5: Notification of Major Accidents Rule 7-8: Approval and notification of site and updating Rule 10-11: Safety Reports and Safety Audit reports and updating Rule 13: Preparation of Onsite Emergency Plan Rule 14: Preparation of Offsite Emergency Plan Rule 15: Information to persons likely to get affected Rule 16: Proprietary Information Rule 17: Material Safety Data Sheets Rule 18: Import of Hazardous Chemicals
9	Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996	CCG, SCG, DCG, LCG and MAH Units	Hazardous Chemicals - Toxic, Explosive, Flammable, Reactive	Emergency Planning Preparedness and Response to chemical accidents	Rule 2: Definitions Rule 5: Functions of CCG Rule 7: Functions of SCG Rule 9: Functions of DCG Rule 10: Functions of LCG
10	EIA Notification, 2006	MoEF, SPCB	For all the identified developmental activities in the	Requirement of environmental clearance before establishment of or	Requirements and procedure for seeking environmental clearance of projects

Sl. No.	Legal Instrument (Type, Reference, Year)	Responsible Ministries or Bodies	Chemical Use Categories/ Pollutants	Objective of Legislation	Relevant Articles/Provisions
			notification	modernization / expansion of identified developmental projects.	
11	Public Liability Insurance Act, 1991 amended 1992	Ministry of Environment & Forests, District Collector	Hazardous Substances	To provide immediate relief to persons affected by accident involving hazardous substances	Section 2: Definitions Section 3: Liability to give relief in certain cases on principle of no fault Section 4: Duty of owner to take out insurance policy Section 7A: Establishment of Environmental Relief Fund Section 14-18: Penalties and Offences
12	Public Liability Insurance Rules, 1991 amended 1993	Ministry of Environment & Forests, District Collector	Hazardous Substances	To provide immediate relief to persons affected by accident involving hazardous substances and also for Establishing an Environmental Relief fund	Rule 2: Definitions Rule 6: Establishment of administration of fund Rule 10: Extent of liability Rule 11: Contribution of the owner to environmental relief fund
13	Factories Act, 1948	Ministry of Labour, DGFASLI and Directorate of Industrial Safety and Health/Factories Inspectorate	Chemicals as specified in the Table	Control of workplace environment, and providing for good health and safety of workers	Section 2: Interpretation Section 6: Approval, licensing and registration of factories Section 7A: General duties of the occupier Section 7B: General duties of manufacturers etc., as regards articles and substances for use in factories Section 12: Disposal of wastes and effluents Section 14: Dust and fume Section 36: Precautions against dangerous fumes, gases, etc. Section 37: Explosion or inflammable dust, gas, etc. Chapter IVA: Provisions relating to Hazardous processes Section 87: Dangerous operations Section 87A: Power to prohibit employment on account of serious hazard Section 88: Notice of certain accident

Sl. No.	Legal Instrument (Type, Reference, Year)	Responsible Ministries or Bodies	Chemical Use Categories/ Pollutants	Objective of Legislation	Relevant Articles/Provisions
					Section 88A: Notice of certain dangerous occurrences Chapter X: Penalties and procedures
14	The Petroleum Act, 1934	Ministry of Petroleum and Natural Gas	Petroleum (Class A, B and C - as defined in the rules)	Regulate the import, transport, storage, production, refining and blending of petroleum	Section 2: Definitions Section 3: Import, transport and storage of petroleum Section 5: Production, refining and blending of petroleum Section 6: Receptacles of dangerous petroleum to show a warning Section 23-28 Penalties and Procedure
15	The Petroleum Rules, 2002	Ministry of Petroleum and Natural Gas, Ministry of Shipping (for notification of authorized ports for import), Ministry of Environment & Forests or SPCB (for clearance of establishment of loading/unloading facilities at ports) Chief Controller of Explosives, district authority, Commissioner of Customs, Port Conservator, State Maritime Board (Import)	Petroleum (Class A, B and C - as defined in the rules)	Regulate the import, transport, storage, production, refining and blending of petroleum	Rule 2: Definition Chapter I part II: General Provision Chapter II: Importation of Petroleum Chapter III: Transport of Petroleum Chapter VII: Licenses
16	The Calcium Carbide Rules, 1987	Ministry of Petroleum and Natural Gas, Chief Controller of Explosives, Customs	Calcium Carbide	To regulate the import, production, storage, transportation, sale, use and handling and disposal of	Rule 2: Definitions Chapter II: General provisions Chapter III: Importation of Carbide Chapter IV: Transportation of carbide

Sl. No.	Legal Instrument (Type, Reference, Year)	Responsible Ministries or Bodies	Chemical Use Categories/ Pollutants	Objective of Legislation	Relevant Articles/Provisions
		Collector, Port Conservator, DGCA, District Authority		Calcium carbide with a view to prevent accidents	Chapter V: Storage of carbide Chapter VI: Licensing Chapter VII: Notice of accident
17	The Explosives Act, 1884	Ministry of Commerce and Industry (Department of Explosives)	Explosive substances as defined under the Act	To regulate the manufacture, possession, use, sale, transport, export and import of explosives with a view to prevent accidents	Section 4: Definition Section 6: Power for Central government to prohibit the manufacture, possession or importation of especially dangerous explosives Section 6B: Grant of Licenses
18	The Explosive Rules, 1983	Ministry of Commerce and Industry and Chief Controller of Explosives, port conservator, customs collector, railway administration	Explosive substances as defined under the Act	To regulate the manufacture, possession, use, sale, transport, export and import of explosives with a view to prevent accidents	Rule 2: Definition Chapter II: General Provisions Chapter III: Import and Export Chapter IV: Transport Chapter V: Manufacture of explosives Chapter VI: Possession sale and use Chapter VII: Licenses
19	The Gas Cylinder Rules, 2004	Ministry of Commerce and Industry and Chief Controller of Explosives, port conservator, customs collector, DGCA, DC, DM, Police (sub inspector to commissioner)	Gases (Toxic, non toxic and non flammable, non toxic and flammable, Dissolved Acetylene Gas, Non toxic and flammable liquefiable gas other than LPG, LPG	Regulate the import, storage, handling and transportation of gas cylinders with a view to prevent accidents	Rule 2: Definition Chapter II: General Provisions Chapter III: Importation of Cylinder Chapter IV: Transport of Cylinder Chapter VII: Filling and Possession
20	The Static and Mobile Pressure Vessels (Unfired) Rules, 1981	Ministry of Commerce and Industry and Chief Controller of Explosives, port conservator, customs collector, DGCA, DC, DM, Police (sub inspector to commissioner)	Gases (Toxic, non toxic and non flammable, non toxic and flammable, Dissolved Acetylene Gas, Non toxic and flammable liquefiable gas other than LPG, LPG	Regulate the import, manufacture, design, installation, transportation, handling, use and testing of mobile and static pressure vessels (unfired) with a view to prevent accidents	Rule 2: Definition Chapter III: Storage Chapter IV: Transport Chapter V: Licenses

Sl. No.	Legal Instrument (Type, Reference, Year)	Responsible Ministries or Bodies	Chemical Use Categories/ Pollutants	Objective of Legislation	Relevant Articles/Provisions
21	The Motor Vehicle Act, 1988	Ministry of Shipping, Road Transport and Highways	Hazardous and Dangerous Goods	To consolidate and amend the law relating to motor vehicles	Section 2: Definition Chapter II: Licensing of drivers of motor vehicle Chapter VII: Construction equipment and maintenance of motor vehicles
22	The Central Motor Vehicle Rules, 1989	Ministry of Shipping, Road Transport and Highways	Hazardous and Dangerous Goods	To consolidate and amend the law relating to motor vehicles including to regulate the transportation of dangerous goods with a view to prevent loss of life or damage to the environment	Rule 2: Definition Rule 9: Educational qualification for driver's of goods carriages carrying dangerous or hazardous goods Rule 129: Transportation of goods of dangerous or hazardous nature to human life Rule 129A: Spark arrestors Rule 130: Manner of display of class labels Rule 131: Responsibility of the consignor for safe transport of dangerous or hazardous goods Rule 132: Responsibility of the transporter or owner of goods carriage Rule 133: Responsibility of the driver Rule 134: Emergency Information Panel Rule 135: Driver to be instructed Rule 136: Driver to report to the police station about accident Rule 137: Class labels
23	The Custom Act, 1962	CBEC, Ministry of Finance	Hazardous Goods	To prevent entry of illegal hazardous goods or banned goods including hazardous or banned chemicals	Section 2: definitions Section 11: Power to Prohibit Importation or Exportation of Goods
24	The Merchant Shipping Act, 1958 amended in 2002 and 2003	Ministry of Shipping, Road Transport and Highways	All packaged cargo including Dangerous and hazardous goods as defined in the rules	For safe handling and transportation of cargo including dangerous goods to prevent accident	Section 3: Definitions Section 331: Carriage of Dangerous Goods
25	Merchant Shipping (carriage of Cargo) Rules 1995	Ministry of Shipping, Road Transport and Highways	All packaged cargo including Dangerous and hazardous goods as defined in the rules	For safe handling and transportation of cargo including dangerous goods to	

Sl. No.	Legal Instrument (Type, Reference, Year)	Responsible Ministries or Bodies	Chemical Use Categories/ Pollutants	Objective of Legislation	Relevant Articles/Provisions
				prevent accident	
26	The Indian Port Act, 1908	Ministry of Shipping, Road Transport and Highways	All Chemicals - handling and storage	For control of activities on ports including safety of shipping and conservation of ports	Section 2: Definitions Chapter IV: Rules for the safety of shipping and the conservation of ports Chapter VII: Provisions with respect to penalties
27	The Dock Workers, (Safety, Health and Welfare) Act, 1986	Ministry of Labour, DGFASLI and Directorate of Dock Safety	All Chemicals termed as dangerous goods	Safety of Dock workers including handling of dangerous goods	
28	The Dock Workers, (Safety, Health and Welfare) Rules, 1990	Ministry of Labour, DGFASLI and Directorate of Dock Safety	All Chemicals termed as dangerous goods	Safety of Dock workers including handling of dangerous goods	

ANNEXURE IV
General Standards for Discharge of Environmental Pollutants as per CPCB

Table: Water Quality Standards

S. No.	Parameter	Standards			
		Inland Surface Water	Public Sewer	Land for Irrigation	Marine Coastal Areas
1.	2.	3.			
		(a)	(b)	(c)	(d)
1.	Colour and odour	See Note-1	—	See Note-1	See Note-1
2.	Suspended Solids, mg/l, Max	100	600	200	(a) For process waste water-100 (b) For cooling water effluent-10 per cent above total suspended matter of influent cooling water.
3.	Particle size of suspended solids	Shall pass 850 micron IS Sieve	—	—	(a) Floatable solids, Max 3 mm (b) Settleable solids Max 850 microns.
4.	Dissolved solids (inorganic), mg/a, mac	2100	2100	2100	—
5.	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
6.	Temperature ^{o}C, Max	Shall not exceed 40 in any section of the stream within 15 meters down stream from the effluent outlet	45 at the point of discharge	—	45 at the point of discharge
7.	Oil and grease, mg/l, max	10	20	10	20
8.	Total residual chlorine, mg/l, Max.	1.0	—	—	1.0
9.	Ammonical nitrogen (as N), mg/l, Max.	50	50	—	50
10.	Total Kjeldahl nitrogen (as N), mg/l, Max.	100	—	—	100
11.	Free Ammonia (as NH3), mg/l, Max.	5.0	—	—	5.0
12.	Biochemical Oxygen Demand (5 days at 20^{o}C) Max.	30	350	100	100
13.	Chemical Oxygen Demand, mg/l, Max.	250	—	—	250
14.	Arsenic (as As), mg/l, Max.	0.2	0.2	0.2	0.2
15.	Mercury (as Hg), mg/l, Max.	0.01	0.01	—	0.01
16.	Lead (as Pb), mg/l, Max.	0.1	1.0	—	1.0
17.	Cadmium (as Cd), mg/l, Max.	2.0	1.0	—	2.0

S. No.	Parameter	Standards			
		Inland Surface Water	Public Sewer	Land for Irrigation	Marine Coastal Areas
1.	2.	3.			
		(a)	(b)	(c)	(d)
18.	Hexavalent chromium (as Cr+6) mg/l, Max.	0.1	2.0	—	1.0
19.	Total chromium as (Cr), mg/l, Max.	2.0	2.0	—	2.0
20.	Copper (as Cu), mg/l, Max.	3.0	3.0	—	3.0
21.	Zinc (as Zn), mg/l, Max.	5.0	15	—	15
22.	Selenium (as Se), mg/l, Max.	0.05	0.05	—	0.05
23.	Nickel (as Ni), mg/l, Max.	3.0	3.0	—	5.0
24.	Boron (as B), mg/l, Max.	2.0	2.0	2.0	—
25.	Percent Sodium, Max.	—	60	60	—
26.	Residual sodium carbonate, mg/l, Max.	—	—	5.0	—
27.	Cyanide (as CN), mg/l, Max.	0.2	2.0	0.2	0.2
28.	Chloride (as Cl), mg/l, Max.	1000	1000	600	(a)
29.	Fluoride (as F), mg/l, Max.	2.0	15	—	15
30.	Dissolved Phosphates (as P), mg/l, Max.	5.0	—	—	—
31.	Sulphate (as SO4), mg/l, Max.	1000	1000	1000	—
32.	Sulphide (as S), mg/l, Max.	2.0	—	—	5.0
33.	Pesticides	Absent	Absent	Absent	Absent
34.	Phenolic compounds (as C6H5OH), mg/l, Max.	1.0	5.0	—	5.0
35.	Radioactive materials (a) Alpha emitters MC/ml, Max. (b) Beta emitters uc/ml, Max.	10^{-7} 10^{-6}	10^{-7} 10^{-6}	10^{-8} 10^{-7}	10^{-7} 10^{-6}

Note :-

1. All efforts should be made to remove colour and unpleasant odour as far as practicable.
2. The standards mentioned in this notification shall apply to all the effluents discharged such as industrial mining and mineral processing activities municipal sewage etc.

Table: Noise Standards

Ambient air quality standards in respect of noise

Area Code	Category of Area	Limits in dB (A) Leq	
		Day Time	Night Time
(A)	Industrial area	75	70
(B)	Commercial area	65	55
(C)	Residential area	55	45
(D)	Silence zone	50	40

Note :

1. Day time is reckoned in between 6.00 AM and 9.00 PM
2. Night time is reckoned in between 9.00 PM and 6.00 AM
3. Silence zone is defined as areas upto 100 meters around such premises as hospitals, educational institutions and courts. The Silence zones are to be declared by the Competent Authority.
4. Use of vehicular horns, loudspeakers and bursting of crackers shall be banned in these zones.
5. Mixed categories of areas should be declared as one of the four above mentioned categories by the Competent Authority and the corresponding standards shall apply.

Standards/Guidelines for Control of Noise Pollution from Stationary Diesel Generator (DG) Sets

(A) Noise Standards for DG Sets (15-500 KVA)

The total sound power level, Lw, of a DG set should be less than, 94+10 log10 (KVA), dB (A), at the manufacturing stage, where, KVA is the nominal power rating of a DG set.

This level should fall by 5 dB (A) every five years, till 2007, i.e. in 2002 and then in 2007.

(B) Mandatory acoustic enclosure/acoustic treatment of room for stationary DG sets (5 KVA and above)

Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the room acoustically.

The acoustic enclosure/acoustic treatment of the room should be designed for minimum 25 dB(A) Insertion Loss or for meeting the ambient noise standards, whichever is on the higher side (if the actual ambient noise is on the higher side, it may not be possible to check the performance of the acoustic enclosure/acoustic treatment. Under such circumstances the performance may be checked for noise reduction upto actual ambient noise level, preferably, in the night time). The measurement for Insertion Loss may be done at different points at 0.5m from the acoustic enclosure/room, and then averaged.

The DG set should also be provide with proper exhaust muffler with Insertion Loss of minimum 25 dB(A).

(C) Guidelines for the manufacturers/users of DG sets (5 KVA and above)

1. The manufacturer should offer to the user a standard acoustic enclosure of 25 dB(A) Insertion Loss and also a suitable exhaust muffler with Insertion Loss of 25 dB(A).

2. The user should make efforts to bring down the noise levels due to the DG set, outside his premises, within the ambient noise requirements by proper siting and control measures.
3. The manufacturer should furnish noise power levels of the unlicensed DG sets as per standards prescribed under (A)
4. The total sound power level of a DG set, at the user's end, shall be within 2 dB(A) of the total sound power level of the DG set, at the manufacturing stage, as prescribed under (A).
5. Installation of a DG set must be strictly in compliance with the recommendation of the DG set manufacturer.
6. A proper routine and preventive maintenance procedure for the DG set should be set and followed in consultation with the DG set manufacturer which would help prevent noise levels of the DG set from deteriorating with use.

Order of the Lt. Governor of Delhi in respect of D.G. Sets (5th December, 2001)

In exercise of the powers conferred by section 5 of the Environment (Protection) Act, 1986, (29 of 1986), read with the Government of India, Ministry of Home Affairs notification S.O. 667 (E) bearing No. F.No. U-11030/J/91-VTL dated 10th September, 1992, the Lt. Governor of Government of National Capital of Delhi hereby directs to all owners/users of generators sets in the National Capital Territory of Delhi as follows :-

1. that generator sets above the capacity of 5 KVA shall not be operated in residential areas between the hours of 10.00 PM to 6.00 AM;
2. that the generator sets above the capacity of 5 KVA in all areas residential/commercial/industrial shall operate only with the mandatory acoustic enclosures and other standards prescribed in the Environment (Protection) Rules, 1986;
3. that mobile generator sets used in social gatherings and public functions shall be permitted only if they have installed mandatory acoustic enclosures and adhere to the prescribed standards for noise and emission as laid down in the Environment (Protection) Rules, 1986.

The contravention of the above directions shall make the offender liable for prosecution under section 15 of the said Act which stipulates punishment of imprisonment for a term which may extend to five years with fine which may extend to one lakh rupees, or with both, and in case the failure of contravention continues, with additional fine which may extend to five thousand rupees for every day during which such failure or contravention continues after the conviction for the first such failure or contravention and if still the failure or contravention continues beyond a period of one year after the date of contravention, the offender continues beyond a period of one year after the date of contravention, the offender shall be punishable with imprisonment for a term which may extend to seven years.

Order Dated: 21st June, 2002

In exercise of the powers conferred by section 5 of the Environment (Protection) Act, 1986 (29 of 1986) read with the Govt. of India, Ministry of Home Affairs notification S.O. 667(E) bearing No. U-11030/J/91-VTL dated the 10th September, 1992, the Lt. Governor Govt. of the National Capital Territory of Delhi hereby makes the following amendment/modification in his order dated the 5th December, 2001 regarding the operation of generator sets, namely:-

Amendments/modifications

In the above said order, for clause(1), the following shall be substituted, namely:-

"(1) that the generator sets above 5KVA shall not be operated in residential areas between the hours from 10.00 p.m. to 6.00 a.m. except generator sets of Group Housing Societies and Multi-storey residential apartments".

DIESEL GENERATOR SETS: STACK HEIGHT

The minimum height of stack to be provided with each generator set can be worked out using the following formula:

$H = h + 0.2 \times \sqrt{KVA}$

H = Total height of stack in metre

h = Height of the building in metres where the generator set is installed

KVA = Total generator capacity of the set in KVA

Based on the above formula the minimum stack height to be provided with different range of generator sets may be categorized as follows:

For Generator Sets	Total Height of stack in metre
50 KVA	Ht. of the building + 1.5 metre
50-100 KVA	Ht. of the building + 2.0 metre
100- 150 KVA	Ht. of the building + 2.5 metre
150-200 KVA	Ht. of the building + 3.0 metre
200-250 KVA	Ht. of the building + 3.5 metre
250-300 KVA	Ht. of the building + 3.5 metre

Similarly for higher KVA ratings a stack height can be worked out using the above formula

Source: Evolved By CPCB

[Emission Regulations Part IV: COINDS/26/1986-87]

ANNEXURE V
Form 1 (Application Form for Obtaining EIA Clearance)

FORM 1

(I) BASIC INFORMATION

S. No.	Item	Details
1.	Name of the project/s	
2.	S.No. in the schedule	
3.	Proposed capacity/area/length/tonnage to be handled/command area/lease area/number of wells to be drilled	
4.	New/Expansion/Modernization	
5.	Existing Capacity/Area etc.	
6.	Category of Project i.e., 'A' or 'B'	
7.	Does it attract the general condition? If yes, please specify.	
8.	Does it attract the specific condition? If yes, Please specify.	
9.	Location	
	Plot/Survey/Khasra No.	
	Village	
	Tehsil	
	District	
	State	
10.	Name of the applicant	
11.	Registered Address	
12.	Address for correspondence:	
	Name	
	Designation (Owner/Partner/CEO)	
	Address	
	Pin Code	
	E-mail	
	Telephone No.	
	Fax No.	
13.	Details of alternative Sites examined, if any location of these sites should be shown on a toposheet.	Village-District-State 1. 2. 3.

S. No.	Item	Details
14.	Interlined Projects	
15.	Whether separate application of interlined project has been submitted	
16.	If yes, date of submission	
17.	If no, reason	
18.	Whether the proposal involves approval/clearance under: The Forest (Conservation) Act, 1980 The Wildlife (Protection) Act, 1972 The C.R.Z. Notification, 1991	
19.	Forest land involved (hectares)	
20.	Whether there is any litigation pending against the project and/or land in which the project is propose to be set up Name of the Court Case No. Orders/directions of the Court, if any and its relevance with the proposed project.	

(II) ACTIVITY

1. Construction, operation or decommissioning of the Project involving actions, which will cause physical changes in the locality (topography, land use, changes in water bodies, etc.)

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities /rates, wherever possible) with source of information data
1.1	Permanent or temporary change in land use, land cover or topography including increase in intensity of land use (with respect to local land use plan)		
1.2	Clearance of existing land, vegetation and buildings?		
1.3	Creation of new land uses?		
1.4	Pre-construction investigations e.g. bore houses, soil testing?		
1.5	Construction works?		

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities /rates, wherever possible) with source of information data
1.6	Demolition works?		
1.7	Temporary sites used for construction works or housing of construction workers?		
1.8	Above ground buildings, structures or earthworks including linear structures, cut and fill or excavations		
1.9	Underground works including mining or tunneling?		
1.10	Reclamation works?		
1.11	Dredging?		
1.12	Offshore structures?		
1.13	Production and manufacturing processes?		
1.14	Facilities for storage of goods or materials?		
1.15	Facilities for treatment or disposal of solid waste or liquid effluents?		
1.16	Facilities for long term housing of operational workers?		
1.17	New road, rail or sea traffic during construction or operation?		
1.18	New road, rail, air waterborne or other transport infrastructure including new or altered routes and stations, ports, airports etc?		
1.19	Closure or diversion of existing transport routes or infrastructure leading to changes in traffic movements?		
1.20	New or diverted transmission lines or pipelines?		
1.21	Impoundment, damming, culverting, realignment or other changes to the hydrology of watercourses or aquifers?		
1.22	Stream crossings?		
1.23	Abstraction or transfers of water form ground or surface waters?		
1.24	Changes in water bodies or the land surface affecting drainage or run-off?		
1.25	Transport of personnel or materials for construction, operation or decommissioning?		

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities /rates, wherever possible) with source of information data
1.26	Long-term dismantling or decommissioning or restoration works?		
1.27	Ongoing activity during decommissioning which could have an impact on the environment?		
1.28	Influx of people to an area in either temporarily or permanently?		
1.29	Introduction of alien species?		
1.30	Loss of native species or genetic diversity?		
1.31	Any other actions?		

2. Use of Natural resources for construction or operation of the Project (such as land, water, materials or energy, especially any resources which are non-renewable or in short supply):

S.No.	Information/checklist confirmation	Yes/No	Details thereof (with approximate quantities /rates, wherever possible) with source of information data
2.1	Land especially undeveloped or agricultural land (ha)		
2.2	Water (expected source & competing users) unit: KLD		
2.3	Minerals (MT)		
2.4	Construction material – stone, aggregates, sand / soil (expected source – MT)		
2.5	Forests and timber (source – MT)		
2.6	Energy including electricity and fuels (source, competing users) Unit: fuel (MT), energy (MW)		
2.7	Any other natural resources (use appropriate standard units)		

3. Use, storage, transport, handling or production of substances or materials, which could be harmful to human health or the environment or raise concerns about actual or perceived risks to human health.

S.No	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
3.1	Use of substances or materials, which are hazardous (as per MSIHC rules) to human health or the environment (flora, fauna, and water supplies)		
3.2	Changes in occurrence of disease or affect disease vectors (e.g. insect or water borne diseases)		
3.3	Affect the welfare of people e.g. by changing living conditions?		
3.4	Vulnerable groups of people who could be affected by the project e.g. hospital patients, children, the elderly etc.,		
3.5	Any other causes		

4. Production of solid wastes during construction or operation or decommissioning (MT/month)

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
4.1	Spoil, overburden or mine wastes		
4.2	Municipal waste (domestic and or commercial wastes)		
4.3	Hazardous wastes (as per Hazardous Waste Management Rules)		
4.4	Other industrial process wastes		
4.5	Surplus product		
4.6	Sewage sludge or other sludge from effluent treatment		
4.7	Construction or demolition wastes		
4.8	Redundant machinery or equipment		

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
4.9	Contaminated soils or other materials		
4.10	Agricultural wastes		
4.11	Other solid wastes		

5. Release of pollutants or any hazardous, toxic or noxious substances to air (kg/hr)

S.No	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
5.1	Emissions from combustion of fossil fuels from stationary or mobile sources		
5.2	Emissions from production processes		
5.3	Emissions from materials handling including storage or transport		
5.4	Emissions from construction activities including plant and equipment		
5.5	Dust or odours from handling of materials including construction materials, sewage and waste		
5.6	Emissions from incineration of waste		
5.7	Emissions from burning of waste in open air (e.g. slash materials, construction debris)		
5.8	Emissions from any other sources		

6. Generation of Noise and Vibration, and Emissions of Light and Heat:

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data with source of information data
6.1	From operation of equipment e.g. engines, ventilation plant, crushers		
6.2	From industrial or similar processes		
6.3	From construction or demolition		
6.4	From blasting or piling		
6.5	From construction or operational traffic		
6.6	From lighting or cooling systems		
6.7	From any other sources		

7. Risks of contamination of land or water from releases of pollutants into the ground or into sewers, surface waters, groundwater, coastal waters or the sea:

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
7.1	From handling, storage, use or spillage of hazardous materials		
7.2	From discharge of sewage or other effluents to water or the land (expected mode and place of discharge)		
7.3	By deposition of pollutants emitted to air into the land or into water		
7.4	From any other sources		
7.5	Is there a risk of long term build up of pollutants in the environment from these sources?		

8. Risk of accidents during construction or operation of the Project, which could affect human health or the environment

S.No	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
8.1	From explosions, spillages, fires etc from storage, handling, use or production of hazardous substances		
8.2	From any other causes		
8.3	Could the project be affected by natural disasters causing environmental damage (e.g. floods, earthquakes, landslides, cloudburst etc)?		

9. Factors which should be considered (such as consequential development) which could lead to environmental effects or the potential for cumulative impacts with other existing or planned activities in the locality

S. No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
9.1	Lead to development of supporting facilities, ancillary development or development stimulated by the project which could have impact on the environment e.g.: ▪ Supporting infrastructure (roads, power supply, waste or waste water treatment, etc.) ▪ housing development ▪ extractive industries ▪ supply industries ▪ other		
9.2	Lead to after-use of the site, which could have an impact on the environment		
9.3	Set a precedent for later developments		
9.4	Have cumulative effects due to proximity to other existing or planned projects with similar effects		

(III) ENVIRONMENTAL SENSITIVITY

S.No.	Areas	Name/ Identity	Aerial distance (within 15 km.) Proposed project location boundary
1	Areas protected under international conventions, national or local legislation for their ecological, landscape, cultural or other related value		
2	Areas which are important or sensitive for ecological reasons - Wetlands, watercourses or other water bodies, coastal zone, biospheres, mountains, forests		
3	Areas used by protected, important or sensitive species of flora or fauna for breeding, nesting, foraging, resting, over wintering, migration		
4	Inland, coastal, marine or underground waters		
5	State, National boundaries		
6	Routes or facilities used by the public for access to recreation or other tourist, pilgrim areas		
7	Defence installations		
8	Densely populated or built-up area		
9	Areas occupied by sensitive man-made land uses *(hospitals, schools, places of worship, community facilities)*		
10	Areas containing important, high quality or scarce resources *(ground water resources, surface resources, forestry, agriculture, fisheries, tourism, minerals)*		
11	Areas already subjected to pollution or environmental damage. *(those where existing legal environmental standards are exceeded)*		
12	Areas susceptible to natural hazard which could cause the project to present environmental problems (*earthquakes, subsidence, landslides, erosion, flooding or extreme or adverse climatic conditions*)		

(IV) PROPOSED TERMS OF REFERENCE FOR EIA STUDIES

"I hereby given undertaking that the data and information given in the application and enclosure are true to the best of my knowledge and belief and I am aware that if any part of the data and information submitted is found to be false or misleading at any stage, the project will be rejected and clearance give, if any to the project will be revoked at our risk and cost.

Date:_____
Place:_____

Signature of the applicant
With Name and Full Address
(Project Proponent / Authorized Signatory)

NOTE:

1. The projects involving clearance under Coastal Regulation Zone Notification, 1991 shall submit with the application a C.R.Z. map duly demarcated by one of the authorized, agencies, showing the project activities, w.r.t. C.R.Z. and the recommendations of the State Coastal Zone Management Authority. Simultaneous action shall also be taken to obtain the requisite clearance under the provisions of the C.R.Z. Notification, 1991 for the activities to be located in the CRZ.
2. The projects to be located within 10km of the National Parks, Sanctuaries, Biosphere Reserves, Migratory Corridors of Wild Animals, the project proponent shall submit the map duly authenticated by Chief Wildlife Warden showing these features vis-à-vis the project location and the recommendations or comments of the Chief Wildlife Warden thereon."

ANNEXURE VI
Critically Polluted Industrial Areas and Clusters/Potential Impact Zones

Table 1: Details of Critically Polluted Industrial Areas and Clusters / Potential Impact Zone (Ref: Office Memorandum No. J-11013/5/2010-IA.II(I) Dated 13.1.2010)

S. No.	Critically Polluted Industrial Area and CEPI	Industrial Clusters/ Potential Impact Zones
1.	Ankeshwar (Gujarat) CEPI-88.50(Ac_Wc_Lc)	▪ GIDC Ankeshwar and GIDC, Panoli
2	Vapi (Gujarat) CEPI-88.09(Ac_Wc_Lc)	▪ GIDC Vapi
3	Ghaziabad (Uttar Pradesh) CEPI-87.37(Ac_Wc_Lc)	Sub-cluster A ▪ Mohan nagar industrial area ▪ Rajinder nagar industrial area ▪ Sahibabad industrial area Sub-cluster B ▪ Pandav nagar industrial area ▪ Kavi nagar industrial area ▪ Bulandshahar road industrial area ▪ Amrit nagar ▪ Aryanagar industrial area Sub-cluster C ▪ Merrut road industrial are Sub-cluster D ▪ Loni industrial area ▪ Loni Road industrial area ▪ Roop nagar industrial area Sub-cluster E ▪ Hapur Road industrial area ▪ Dasna ▪ Philkura Sub-cluster F (Other scattered industrial areas) ▪ South side of GT road ▪ Kavi Nagar ▪ Tronica city ▪ Anand Nagar ▪ Jindal Nagar ▪ Prakash Nagar ▪ Rural industrial estate
4	Chandrapur (Maharashtra) CEPI-83.88 (Ac_Wc_Lc)	▪ Chandrapur (MIDC Chandrapur, Tadali, Ghuggus, Ballapur)
5	Kobra (Chhatisgarh) CEPI-83.00 (Ac_Ws_Lc)	▪ Industrial areas and their townships of NTPC, BALCO, CSEB (East) & CSEB (West) ▪ Korba town
6	Bhiwadi (Rajasthan) CEPI-82.91 (Ac_Wc_Ls)	▪ RIICO industrial areas Phase I to IV ▪ Bhiwadi town ▪ Other surrounding industrial areas: Chopanki, Rampura Mundana, Khuskhera Phase I to III
7	Angul Talcer(Orissa) CEPI-82.09 (Ac_Wc_Lc)	▪ MCL Coal mining area, Augul – Talcer region ▪ Industrial area (60 km x 45 km) Following blocks of Augul district: ▪ Kohina block ▪ Talcher block

S. No.	Critically Polluted Industrial Area and CEPI	Industrial Clusters/ Potential Impact Zones
		▪ Angul block ▪ Chhendipada block ▪ Banarpal block ▪ Odapada block of Dhenkamal district
8	Vellore (North Arcot) (Tamil Nadu) CEPI-81.79 (Ac_Wc_Lc)	▪ Ranipet, SIPCOT industrial complex
9	Singrauli (Uttar Pradesh) CEPI-81.73 (Ac_Wc_Ls)	Sonebhadra (UP) ▪ Dala-Tola ▪ Obra ▪ Renukoot ▪ Anpara ▪ Renusagar ▪ Kakri ▪ Dudhichuwa ▪ Bina ▪ Khadia ▪ Shakti nagar ▪ Rihand nagar ▪ Bijpur Sigrauli (Madhya Pradesh) Vindhyachal nagar and Jaynat, Nigahi, Dudhichua, Amlohri & Jhingurdah townships
10	Ludhiana (Punjab) CEPI-81.66 (Ac_Wc_Ls)	Ludhiana municipal limits covering industrial clusters: ▪ Focal point along with NH-I- Total eight phase ▪ Industrial area-B- from sherpur chowk to Gill road & Gill road to Miller Kotla road (left side of road) ▪ Mixed industrial area – right side of Gill road ▪ Industrial area –C (near Juglana village) ▪ Industrial area A & extension: area between old GT road and Ludhiana bypass road ▪ Industrial estate: near Dholwal chowk ▪ Mixes industrial area (MIA) Miller gunj ▪ MIA – bypass road ▪ Bahdur industrial area ▪ Tejpur industrial complex
11	Nazafgarh drain basin, Delhi CEPI-79.54 (As_Wc_Lc)	▪ Industrial areas: Anand Parvat, Naraina, Okhla and Wazirpur
12	Noida (Uttar Pradesh) CEPI-78.90 (Ac_Wc_Lc)	Territorial Jurisdiction of: ▪ Noida Phase-1 ▪ Noida Phase-2 ▪ Noida Phase-3 ▪ Surajpur industrial area ▪ Greater Noida industrial area ▪ Village- Chhaparaula
13	Dhanbad (Jharkhand) CEPI-78.63 (Ac_Ws_Lc)	Four blocks of Dhanbad district: ▪ Sadar (Dhanbad Municipality) ▪ Jharia (Jharia Municipality, Sindri industrial area) ▪ Govindpur (Govindpur industrial estate) ▪ Nirsa

S. No.	Critically Polluted Industrial Area and CEPI	Industrial Clusters/ Potential Impact Zones
14	Dombivalli (Maharashtra) CEPI-78.41 (Ac_Wc_Ls)	▪ MIDC Phase- I, Phase- II
15	Kanpur (Uttar Pradesh) CEPI-78.09 (Ac_Wc_Ls)	Industrial areas: ▪ Dada nagar ▪ Panki ▪ Fazalganj ▪ Vijay nagar ▪ Jajmau
16	Cuddalore (Tamil Nadu) CEPI-77.45 (As_Wc_Lc)	▪ SIPCOT industrial complex, Phase I & II
17	Aurangabad (Maharashtra) CEPI-77.44 (Ac_Wc_Ls)	▪ MIDC Chikhalthana, MIDC Waluj, MIDC Shendra, and Paithan road industrial area
18	Faridabad (Haryana) CEPI-77.07 (Ac_Ws_Lc)	▪ Sector 27-A, B, C, D ▪ DLF phase- 1, sector 31,32 ▪ DLF phase- 2, sector 35 ▪ Sector 4, 6, 24, 27, 31, 59 ▪ Industrial area Hatin ▪ Industrial model township
19	Agra (Uttar Pradesh) CEPI-76.48 (As_Wc_Ls)	▪ Nunihai industrial estate, Rambag nagar, UPSIDC industrial area, and Runukata industrial area
20	Manali (Tamil Nadu) CEPI-76.32 (Ac_Ws_Ls)	▪ Manali industrial area
21	Haldia (West Bengal) CEPI-75.43 (As_Wc_Ls)	▪ 5 km wide strip (17.4 x 5.0 km) of industrial area on the southern side of the confluence point of Rivers Hugli and Rupnarayan, covering ▪ Haldia municipal area & Sutahata block – I and II
22	Ahmedabad (Gujarat) CEPI-75.28 (Ac_Ws_Ls)	▪ GIDC Odhav ▪ GIDC Naroda
23	Jodhpur (Rajasthan) CEPI-75.19 (As_Wc_Ls)	▪ Industrial areas including Basni areas (phase-I & II), industrial estate, light & heavy industrial areas, industrial areas behind new power house, Mandore, Bornada, Sangariya and village Tanwada & Salawas. ▪ Jodhpur city
24	Greater Cochin (Kerala) CEPI-75.08 (As_Wc_Ls)	▪ Eloor-Edayar industrial belt, ▪ Ambala Mogal industrial areas
25	Mandi Gobind Garh (Punjab) CEPI-75.08 (Ac_Ws_Lc)	▪ Mandi Govindgarh municipal limit and khanna area
26	Howrah (West Bengal) CEPI-74.84 (As_Ws_Lc)	▪ Liluah-Bamangachhi region, Howrah ▪ Jalan industrial complex-1, Howrah
27	Vatva (Gujarat) CEPI-74.77 (Ac_Wc_Ls)	▪ GIDC Vatva, Narol industrial area (Villages Piplaj, Shahwadi, Narol)
28	Ib Valley (Orissa) CEPI-74.00 (Ac_Ws_Ls)	▪ Ib Valley of Jharsuguda (Industrial and mining area)
29	Varansi-Mirzapur (Uttar Pradesh) CEPI-73.79 (As_Wc_Ls)	▪ Industrial estate, Mirzapur ▪ Chunar ▪ Industrial estate, Chandpur, Varansi

S. No.	Critically Polluted Industrial Area and CEPI	Industrial Clusters/ Potential Impact Zones
		▪ UPSIC, industrial estate, Phoolpur ▪ Industrial area, Ramnagar, Chandauli
30	Navi Mumbai (Maharashtra) CEPI-73.77 (Ac_Ws_Ls)	▪ TTC industrial area, MIDC, Navi Mumbai (including Bocks-D, C, EL, A, R, General, Kalva)
31	Pali (Rajasthan) CEPI-73.73 (As_Wc_Ls)	▪ Existing industrial areas: Mandia road, Puniyata road, Sumerpur ▪ Pali town
32	Mangalore (Karnataka) CEPI-73.68 (Ac_Ws_Ls)	▪ Baikampady industrial area
33	Jharsuguda (Orissa) CEPI-73.34 (Ac_Ws_Ls)	▪ Ib valley of Jharsuguda (Industrial and mining area)
34	Coimbatore (Tamil Nadu) CEPI-72.38 (Ac_Ws_Ln)	▪ SIDCO, Kurichi industrial Clusters
35	Bhadravati (Karnataka) CEPI-72.33 (Ac_Ws_Ln)	▪ KSSIDC Industrial area, Mysore paper mill & VISL township complex
36	Tarapur (Maharashtra) CEPI-72.01 (Ac_Ws_Ls)	▪ MIDC Tarapur
37	Panipat (Haryana) CEPI-71.91 (As_Ws_Ls)	▪ Panipat municipal limit and its industrial clusters
38	Indore (Madhya Pradesh) CEPI-71.26 (As_Ws_Ls)	Following 09 industrial area: ▪ Sanwer road ▪ Shivaji nagar ▪ Pologround ▪ Laxmibai nagar ▪ Scheme no.71 ▪ Navlakha ▪ Pipliya ▪ Palda ▪ Rau Indore city Other surrounding industrial areas: Manglia, Rajoda, Asrawad, Tejpur Gadwadi
39	Bhavnagar (Gujarat) CEPI-70.99 (As_Ws_Ls)	▪ GIDI Chitra, Bhavnagar
40	Vishakhapatnam (Andhra Pradesh) CEPI-70.82 (As_Ws_Ls)	▪ Bowl area (the area between Yarada hill range in the south to Simhachalam hill range in the north and sea on the east and the present NH-5 in the west direction)
41	Junagarh (Gujarat) CEPI-70.82 (As_Ws_Ls)	Industrial areas: ▪ Sabalpur ▪ Jay Bhavani ▪ Jay Bhuvneshwari ▪ GIDC Junagarh (I&II)
42	Asansole (West Bengal) CEPI-70.20 (As_Ws_Ls)	▪ Bumpur area surrounding IISCO
43	Patancheru - Bollaram (Andhra Pradesh)	Industrial area: ▪ Patancheru ▪ Bollaram

S. No.	Critically Polluted Industrial Area and CEPI	Industrial Clusters/ Potential Impact Zones
	CEPI-70.07 (As_Ws_Ls)	

Note:

Names of identified industrial clusters/potential impact zones are approximate location based on rapid survey and assessment and may alter partially subject to the detailed field study and monitoring. Detailed mapping will be made available showing spatial boundaries of the identified industrial clusters including zone of influence/ buffer zone, after in depth field study.

ANNEXURE VII
Pre-Feasibility Report: Points for Possible Coverage

Table 1: Points for Possible Coverage in Pre-feasibility Report

S. No.	Contents	Points of Coverage in Pre-feasibility Report
I.	**Executive summary**	▪ A miniature report of entire pre-feasibility report.
II.	**Project Details**	
	Need/Justification of the Project	▪ Current demand scenario of the petrochemical products (base/primary materials - Hydrocarbons) ▪ Alternatives to meet the demand ▪ Post project scenario on residual demand, *etc.*
	Capacity of the Petrochemical Industry	▪ Production capacity of the industry ▪ Sustainability of raw material supply and quality ▪ Optimization of plant capacity, *etc.*
	Process technology	▪ Analysis of available/advanced technologies, etc. ▪ Analysis of various possible configurations for each technology or a combination of these technologies from available manufactures ▪ Broad specifications for the proposed industrial units
	Resources/raw materials	▪ Details on raw material (naphtha, natural gas), co-products/byproducts ▪ Water - Water requirement for process, utilities, domestic, gardening etc. - Source of construction water and potable water - Source of circulating/consumptive water - Quality of raw water, treated water - Water budget calculations and effluent generation - Approved water allocation quota (drinking, irrigation and industrial use) and surplus availability - Feasible ways of bringing water to site indicating constraints if any. - Lean season water availability and allocation source in case main source not perennial. ▪ Manpower ▪ Infrastructure ▪ Electrical power ▪ Construction material like sand, brick, stone chips, borrow earth *etc.*
	Rejects (Pollution potential)	▪ Air emissions (VOCs, particulates, NOx, SOx, etc.) ▪ Water pollution (cooling water, process water, etc.) ▪ Solid / hazardous waste ▪ Noise ▪ Odour
	Technical profile	▪ Construction details - Estimated duration - Number of construction workers including migrating workers - Construction equipment - Vehicular traffic - Source, mode of transportation and storage of construction material ▪ Traffic that would arise during different phases of the project and transportation mechanism to handle such traffic

S. No.	Contents	Points of Coverage in Pre-feasibility Report
		▪ New facilities needed ▪ Technical parameters of the plant & equipments to be used ▪ Product storage and associated transportation system ▪ Product demand & supply position data on regional basis, *etc.*
	Project schedule	▪ Project implementation schedule
	Future prospects	▪ Ascertain the costs and benefits of the proposed project for project life ▪ Technical and logistic constraints/ requirements of project sustainability, *etc.*
III.	**Selection of site based on least possible impacts**	
i.	**Choice of site selection**	
	Major techno-economic feasibility considerations	▪ Land availability & its development ▪ Product demand around the selected site ▪ Access to site for transportation of equipments/ construction machinery, material, *etc*. ▪ Raw material availability and its transportation ▪ Water availability and consumptive use ▪ Product transportation ▪ Infrastructure availability at selected site ▪ Inter-state issue, if any, *etc.*
	Incompatible landuse and ecologically sensitive attributes with respect to identified suitable sites	▪ If any incompatible land-use attributes fall within the study area, the following details has to be provided: - Public water supply areas from rivers/surface water bodies, from groundwater - Scenic areas/tourism areas/hill resorts - Religious places, pilgrim centers that attract over 10 lakh pilgrims a year - Protected tribal settlements (notified tribal areas where industrial activity is not permitted); CRZ - Monuments of national significance, World Heritage Sites - Cyclone, Tsunami prone areas (based on last 25 years); - Airport areas - Any other feature as specified by the State or local government and other features as locally applicable, including prime agricultural lands, pastures, migratory corridors, etc. ▪ If ecologically sensitive attributes fall within the study area, please give details. Ecologically sensitive attributes include - National parks - Wild life sanctuaries - Tiger reserve/elephant reserve/turtle nesting ground - Mangrove area - Tropical forests - Important lakes - Endangered species of flora and fauna, *etc*.
	Social aspects	▪ Corporate social responsibilities ▪ Employments and infrastructure added in the vicinity of the plant ▪ Status of land availability, current and post project land

S. No.	Contents	Points of Coverage in Pre-feasibility Report
		use variation ▪ Social sensitivity and likely project affected people, *etc.*
ii.	**Details of selected site**	
	Land details	▪ Land requirement and availability ▪ Land ownership details such as Government, private, tribal, non-tribal, *etc*. ▪ Total area of the project/site ▪ Prevailing land cost details, *etc.*
	Location	▪ Geographical details - Longitude & latitude, village, taluka, district, state ▪ Approach to site – roads, railways and airports ▪ Distance from nearest residential and industrial areas ▪ Distance from nearest water bodies such as river, canal, dam, etc ▪ Distance from ecologically sensitive areas ▪ In case of flood prone areas, HFL of the site ▪ In case of seismic areas, seismic zone, active faults, occurrence on earthquakes, etc. ▪ Proximity from infrastructural facilities, *etc.*
	Physical characteristics	▪ Demography ▪ Meteorological data ▪ Landuse pattern such as agricultural, barren, forest, *etc.* and details thereof ▪ Topography of the area ▪ Drainage patterns ▪ Soil condition and soil investigation results ▪ Ground profile and levels, *etc.*
IV.	**Anticipated impacts based on project operations on receiving environment**	▪ Population ▪ Flora and fauna ▪ Water ▪ Soil ▪ Air ▪ Climate ▪ Landscape, *etc.*
V.	**Proposed broad mitigation measures which could effectively be internalized as project components to have environmental and social acceptance of the proposed site**	▪ Preventive measures ▪ Source control measures ▪ Mitigation measures at the receiving environment ▪ Health and safety measures, *etc*.
VI.	**An indication of any difficulties (technical deficiencies or lack of know-how) encountered by the developer in compiling the required information.**	

The above listing is not exhaustive. Thus the proponent may provide additional necessary information, felt appropriate, to include in the pre-feasibility study report in support of selecting the site for the proposed developmental activities. The Concerned EAC/SEAC during scrutiny may specifically ask for any additional information/data required to substantiate the requirement to prescribe the ToR for EIA studies. However, it is to make clear that all the required further information by EAC/SEAC may be mentioned in one single letter, within the prescribed time.

ANNEXURE VIII
Types of Monitoring and Network Design Considerations

TYPES OF MONITORING AND NETWORK DESIGN CONSIDERATIONS

A. Types of Monitoring

Monitoring refers to the collection of data using a series of repetitive measurements of environmental parameters (or, more generally, to a process of systematic observation). The environmental quality monitoring programme design will be dependent upon the monitoring objectives specified for the selected area of interest. The main types of EIA monitoring activities are:

- Baseline monitoring is the measurement of environmental parameters during the pre-project period for the purpose of determining the range of variation of the system and establishing reference points against which changes can be measured. This leads to the assessment of the possible (additional available) assimilative capacity of the environmental components in pre-project period w.r.t. the standard or target level.
- Effects monitoring is the measurement of environmental parameters during project construction and implementation to detect changes which are attributable to the project to provide the necessary information to:
  - verify the accuracy of EIA predictions; and
  - determine the effectiveness of measures to mitigate adverse effects of projects on the environment.
  - Feedback from environmental effect monitoring programs may be used to improve the predictive capability of EIAs and also determine whether more or less stringent mitigation measures are needed
- Compliance monitoring is the periodic sampling or continuous measurement of environmental parameters to ensure that regulatory requirements and standards are being met.

Compliance and effects monitoring occurs during the project construction, operation, and abandonment stages. The resources and institutional set-up should be available for the monitoring at these stages. All large-scale construction projects will require some construction stage monitoring. To control the environmental hazards of construction as specified in the EIA, a monitoring program should be established to ensure that each mitigation measure is effectively implemented. There are numerous potential areas for monitoring during operations.

The scope of monitoring topics discussed in this chapter is limited to Baseline and Effects monitoring. In addition, this chapter will also discuss the Compliance monitoring during the construction phase. Post-project monitoring requirements are discussed in the EMP.

Before any field monitoring tasks are undertaken there are many institutional, scientific, and fiscal issues that must be addressed in the implementation of an environmental monitoring program. Careful consideration of these issues in the design and planning stages will help avoid many of the pitfalls associated with environmental monitoring programs. Although these issues are important but the discussions here are confined to the monitoring network design component.

B. Network Design

Analysis of Significant Environmental Issues

At the outset of planning for an environmental monitoring network, the EIA manager may not know exactly what should be monitored, when monitoring should begin, where it should monitor, which techniques should be employed, and who should take responsibility for its conduct. Because there are usually a number of objective decisions associated with network design to be made, it is important to start with an analysis of environmental issues. The scoping phase of an EIA is designed to identify and focus on the major issues. Scoping should provide a valuable source of information on the concerns that need to be addressed by the monitoring network design. These are project specific as well as specific to the environmental setting of the location where the project is proposed to be located

Hence, the network designs are associated with questions like:

- What are the expected outputs of the monitoring activity?
- Which problems do we need to address to? *etc*.

Defining the output will influence the design of the network and optimize the resources used for monitoring. It will also ensure that the network is specially designed to optimize the information on the problems at hand

What to Monitor?

The question of what to monitor is associated with the identification of VECs.

VECs are generally defined as environmental attributes or components of the environment that are valued by society as identified during the scoping stage of the project. They are determined on the basis of perceived public concerns. For example, changes to water quality and quantity could have implications on fish by affecting habitat, food supply, oxygen, and contaminant uptake. Similarly, employment and business, and economies are both VECs that serve as pathways.

The choice of VECs is also related to the perceived significant impact of the project implementation on important environmental components. In general, the significance or importance of environmental components is judged based on:

- legal protection provided (for example, rare and endangered species)
- political or public concerns (for example, resource use conflicts and sustainable development)
- scientific judgment (for example, ecological importance); or
- commercial or economic importance

However, in addition to their economic, social, political or ecological significance, the chosen VEC should also have unambiguous operational ease, be accessible to prediction and measurement; and be susceptible to hazard. Once the VECs are defined, the VECs may be directly measured (for example, extent of habitat for an endangered species). In cases where it is impossible or impractical to directly measure the VECs, the chosen measurement endpoints or environmental indicators must correspond to, or be predictive of assessment endpoints.

The chosen environmental indicators must be: 1) measurable; 2) appropriate to the scale of disturbance/ contamination; 3) appropriate to the impact mechanism; 4) appropriate

and proportional to temporal dynamics; 5) diagnostic; and 6) standardized; as well as have: 1) a low natural variability; 2) a broad applicability; and 3) an existing data series.

Where, How and How Many Times to Monitor?

These are the other components of Monitoring Network Design. These questions are best answered based on local field conditions, capacity and resources available, prevailing legal and regulatory priorities, *etc*. For this screening or reconnaissance Surveys of the study area also necessary. This may also include some simple inexpensive measurements and assimilative/dispersion modeling. The data will give some information on the prevailing special and temporal variations, and the general background air pollution in the area. The number of monitoring stations and the indicators to be measured at each station in the final permanent network may then be decided upon based on the results of the screening study as well as on the knowledge of the sources of the proposed development and prevailing local environmental/meteorological conditions. The best possible definition of the air pollution problem, together with the analysis of the resources: personnel, budget and equipment available, represent the basis for the decision on the following questions:

- What spatial density (number) of sampling stations is required? How many samples are needed and during what period (sampling (averaging) time and frequency)?
- Where should the stations be located?
- What kind of equipment should be used?
- What additional background information is needed?
  - meteorology
  - topography
  - population density
  - emission sources and emission rates
  - effects and impacts
- How will the data be made available/communicated?

C. Site Selection

This normally means that for designing a monitoring programme in an (study) area which might have an impact, several monitoring stations are needed for characterizing the baseline conditions of the impacted area. When considering the location of individual samplers, it is essential that the data collected are representative for the location and type of area without the undue influence from the immediate surroundings. In any measurement point in the study area the total ambient concentration is the representative of:

- natural background concentration
- regional background
- impact of existing large regional sources such as Industrial emissions and other power plants

To obtain the information about the importance of these different contributions it is therefore necessary to locate monitoring stations so that they are representative for different impacts. In addition to the ambient pollution data, one would often need other data governing the variations such as meteorological data for air pollution, to identify and quantify the sources contributing to the measurements.. When considering the location of individual samplers, it is essential that the data collected are representative for the location and type of area without undue influence from the immediate surroundings.

ANNEXURE IX
Guidance for Assessment of Baseline Components and Attributes

GUIDANCE FOR ASSESSMENT OF BASELINE COMPONENTS AND ATTRIBUTES*

Attributes	Sampling		Measurement Method	Remarks
	Network	**Frequency**		
A. Air				
Meteorological ▪ Wind speed ▪ Wind direction ▪ Dry bulb temperature ▪ Wet bulb temperature ▪ Relative humidity ▪ Rainfall ▪ Solar radiation ▪ Cloud cover	▪ Minimum 1 site in the project impact area requirements ▪ Other additional site(s) are require depending upon the model applied or site sensitivities	▪ Min: 1 hrly observations from continuous records	▪ Mechanical / automatic weather station ▪ Rain gauge ▪ As per IMD ▪ As per IMD	▪ IS 5182 Part 1-20 Sit-specific primary data is essential ▪ Secondary data from IMD, New Delhi for the nearest IMD station
Pollutants ▪ SPM ▪ PM10, PM2.5 ▪ SO_2 ▪ NO_2 ▪ CO ▪ H_2S* ▪ $NH*_3$ ▪ HC* ▪ Fluoride* ▪ Pb* ▪ VOC-PAH* ▪ Ozone ▪ Benzene ▪ Benzo(a)pyrene (Particulate phase only) ▪ Arsenic ▪ Nickel (parameters to be proposed by the proponent, in draft ToR, which will be reviewed and approved by	▪ 10 to 15 locations in the project impact area	▪ 24 hrly twice a week ▪ 8 hrly twice a week ▪ 24 hrly twice a week	▪ Gravimetric (High – Volume) ▪ Gravimetric (High – Volume with Cyclone) ▪ EPA Modified West & Gaeke method ▪ Arsenite Modified Jacob & Hochheiser ▪ NDIR technique ▪ Methylene-blue ▪ Nessler's Method ▪ Infra Red analyzer ▪ Specific lon meter ▪ TOEM ▪ Beta attenuation ▪ UV photometric ▪ Chemilminescence ▪ Chemical method ▪ Gas chromatography based continuos analyzer ▪ Adsorption and desorption followed by GC analysis	▪ Monitoring Network ▪ Minimum 2 locations in upwind side, more sites in downwind side / impact zone ▪ All the sensitive receptors need to be covered ▪ Measurement Methods ▪ As per CPCB standards for NAQM, 1994

Attributes	Sampling		Measurement Method	Remarks
	Network	**Frequency**		
EAC/SEAC)			▪ Solvent extraction folllowed by HPLC/GC analysis ▪ AAS/ICP method after sampling on EPM 2000 or equivalent filter paper	
B. Noise				
Hourly equivalent noise levels	▪ Same as for Air Pollution along with others Identified in study area	▪ At lest one day continuous in each season on a working and non-working day	▪ Instrument : Sensitive Noise level meter (preferably recording type)	▪ Min: IS: 4954- 1968 as adopted by CPCB
Hourly equivalent noise levels	▪ Inplant (1.5 m from machinery or high emission processes)	▪ Same as above for day and night	▪ Instrument : Noise level metre	▪ CPCB / OSHA
Hourly equivalent noise levels	▪ Highways (within 500 metres from the road edge)	▪ Same as above for day and night	▪ Instrument : Noise level meter	▪ CPCB / IS : 4954-1968
Peak particle velocity	▪ 150- 200m from blast site	▪ Based on hourly observations	▪ PPV meter	▪
C. Water				
Parameters for water quality ▪ Ph, temp, turbidity, magnesium hardness, total alkalinity, chloride, sulphate, nitrate, fluoride, sodium, potassium salinity ▪ Total nitrogen, total phosphorus, DO, BOD, COD, Phenol ▪ Heavy metals ▪ Total coliforms, faecal coliforms ▪ Phyto plankton ▪ Zooplankton	▪ Set of grab samples during pre and post-monsoon for ground and surface water for the whole study zone. For lab analysis the samples should be preserved for transport safe	▪ Diurnal and season-wise	▪ Samples for water quality should be collected and analyzed as per: ▪ IS: 2488 (Part 1-5) methods for sampling and testing of industrial effluents ▪ Standard methods for examination of water and waste water analysis published by American Public Health Association. ▪ International standard practices for benthos and	

Attributes	Sampling		Measurement Method	Remarks
	Network	Frequency		
▪ Fish & other aquatic flora & fauna (parameters are given in ToR for EIA studies based on nature of project, raw material & process technology, location-nature/activities within of air basin)			aquatic flora & fauna	
For Surface Water Bodies				
▪ Total Carbon ▪ PH ▪ Dissolved Oxygen ▪ Biological Oxygen ▪ Demand ▪ Free NH_4 ▪ Boron ▪ Sodium Absorption ratio ▪ Electrical Conductivity	▪ Monitoring locations should include up-stream, on site, down stream of proposed discharge point. Besides sampling should cover width of the river in case water quality modeling is proposed. ▪ Standard methodology for collection of surface water (BIS standards) ▪ At least one grab sample per location per season	▪ Yield & impact on water sources to be measured during critical season ▪ River Stretch within project area be divided in grids (say 1 km length and 1/3 width) and samples should be from each grid at a time when the wastewater discharged by other sources of pollution is expected to be maximum	▪ Samples for water quality should be collected and analyzed as per: ▪ IS: 2488 (Part 1-5) methods for sampling and testing of industrial effluents ▪ Standard methods for examination of water and wastewater analysis published by American Public Health Association. ▪ ▪	▪ Historical data should be collected from relevant offices such as central water commission, state and central ground water board, Irrigation dept. ▪
Parameters for wastewater characterization				
▪ Temp, colour, odour, turbidity, TSS, TDS ▪ PH , alkalinity as CaCO3, p value, M value, tatal hardness as CaCO3, chloride as cl, sulphate as S04, Nitrate as NO3, Floride as F, Phosphate as P04, Chromium as Cr (Hexavalent, total) Ammonical Nitrogen as N, TKN, % sodium, BOD at 20 C, COD,	▪ Implant Source depending upon the different waste streams the parameters can be optimized ▪ Grab and composite sampling representing avg of different process operations as well as worst emission scenario should be represented	▪ Different operational cycles as well as raw material variations should be reflected in the analysis	▪ Samples for water quality should be collected and analyzed as per: ▪ IS: 2488 (Part 1-5) methods for sampling and testing of industrial effluents ▪ Standard methods for examination of water and wastewater analysis published by American	All plant sources categorized as: ▪ Different Process waste streams as well as run-off conditions ▪ ETP wastewater ▪ Domestic/ sanitary wastewater

Attributes	Sampling		Measurement Method	Remarks
	Network	Frequency		
DO, total residual chlorine as Cl_2, oil and grease, sulphide, phenolic compound			Public Health Association.	
D. Land Environment				
▪ Soil ▪ Particle size distribution ▪ Texture ▪ pH ▪ Electrical conductivity ▪ Caution exchange capacity ▪ Alkali metals ▪ Sodium Absorption Ratio (SAR) ▪ Permeability ▪ Porosity	▪ One surface sample from each landfill and/or hazardous waste site (if applicable) and prime villages, (soil samples be collected as per BIS specifications) in the study area	▪ Season-wise	▪ Collected and analyzed as per soil analysis reference book, M.I.Jackson and soil analysis reference book by C.A. Black ▪	▪ The purpose of impact assessment on soil (land environment) is to assess the significant impacts due to leaching of wastes or accidental releases and contaminating ▪
Landuse / Landscape				
▪ Location code ▪ Total project area ▪ Topography ▪ Drainage (natural) ▪ Cultivated, forest plantations, water bodies, roads and settlements	▪ At least 20 points along with plant boundary and general major land use categories in the study area.	▪ Drainage once in the study period and land use categories from secondary data (local maps) and satellite imageries	▪ Global positioning system ▪ Topo-sheets ▪ Satellite Imageries (1:25,000)	▪ Drainage within the plant area and surrounding is very important for storm water impacts. ▪ From land use maps sensitive receptors (forests, parks, mangroves etc.) can be identified

Attributes	Sampling		Measurement Method	Remarks
	Network	Frequency		
E. Solid Waste				
Quantity: ▪ Based on waste generated from per unit production ▪ Per capita contribution ▪ Collection, transport and disposal system ▪ Process Waste ▪ Quality (oily, chemical, biological)	▪ For green field unites it is based on secondary data base of earlier plants.	▪ Process wise or activity wise for respective raw material used. Domestic waste depends upon the season also	Guidelines ▪ IS 9569 : 1980 ▪ IS 10447 : 1983 ▪ IS 12625 : 1989 ▪ IS 12647 : 1989 ▪ IS 12662 (PTI) 1989	
Quality: ▪ General segregation into biological/organic/inert/hazardous ▪ Loss on heating ▪ pH ▪ Electrical Conductivity ▪ Calorific value, metals etc.	▪ Grab and Composite samples	▪ Process wise or activity wise for respective raw material used. Domestic waste depends upon the season also	Analysis ▪ IS 9334 : 1979 ▪ IS 9235 : 1979 ▪ IS 10158 : 1982	
Hazardous Waste				
▪ Permeability And porosity ▪ Moisture pH ▪ Electrical conductivity ▪ Loss on ignition ▪ Phosphorous ▪ Total nitrogen ▪ Caution exchange capacity ▪ Particle size distribution ▪ Heavy metal ▪ Ansonia ▪ Fluoride	▪ Grab and Composite samples. Recyclable components have to analyzed for the recycling requirements	▪ Process wise or activity wise for respective raw material used.	Analysis ▪ IS 9334 : 1979 ▪ IS 9235 : 1979 ▪ IS 10158 : 1982	▪ Impacts of hazardous waste should be performed critically depending on the waste characteristics and place of discharge. For land disposal the guidelines should be followed and impacts of accidental releases should be assessed
F. Biological Environment Aquatic				
▪ Primary productivity ▪ Aquatic weeds	▪ Considering probable impact, sampling points	▪ Season changes are very important	▪ Standards techniques (APHA et. Al. 1995, Rau	▪ Seasonal sampling for aquatic biota

Attributes	Sampling		Measurement Method	Remarks
	Network	**Frequency**		
▪ Enumeration of ▪ phytoplankton, zooplankton and benthos ▪ Fisheries ▪ Diversity indices ▪ Trophic levels ▪ Rare and endangered species ▪ Sanctuaries / closed areas / Coastal regulation zone (CRZ) ▪ Terrestrial ▪ Vegetation – species, list, economic importance, forest produce, medicinal value ▪ Importance value index (IVI) of trees ▪ Wild animals	and number of samples to be decided on established guidelines on ecological studies based on site eco-environment setting within 10/25 km radius from the proposed site ▪ Samples to collect from upstream and downstream of discharge point, nearby tributaries at down stream, and also from dug wells close to activity site		and Wooten 1980) to be followed for sampling and measurement	▪ One season for terrestrial biota, in addition to vegetation studies during monsoon season ▪ Preliminary assessment ▪ Microscopic analysis of plankton and meiobenthos, studies of macrofauna, aquatic vegetation and application of indices, viz. Shannon, similarity, dominance IVI etc ▪ Point quarter plot-less method (random sampling) for terrestrial vegetation survey.
Avifauna ▪ Rare and endangered species ▪ Sanctuaries / National park / Biosphere reserve	▪ For forest studies, chronic as well as short-term impacts should be analyzed warranting data on micro climate conditions			▪ Secondary data to collect from Government offices, NGOs, published literature ▪ Plankton net ▪ Sediment dredge ▪ Depth sampler ▪ Microscope ▪ Field binocular
G. Socio Economic				
▪ Demographic structure ▪ Infrastructure resource base ▪ Economic resource base ▪ Health status: Morbidity pattern ▪ Cultural and aesthetic attributes	▪ Socio-economic survey is based on proportionate, stratified and random sampling method	▪ Different impacts occurs during construction and operational phases of the project	▪ Primary data collection through R&R surveys (if require) or community survey are based on personal interviews and questionnaire	▪ Secondary data from census records, statistical hard books, toposheets, health records and relevant official records available with Govt. agencies

* Project Specific concerned parameters needs to be identified by the project proponent and shall be incorporated in the draft ToR, to be submitted to the Authority for the consideration and approval by the EAC/SEAC.

ANNEXURE X
Sources of Secondary Data

Annexure XA: Potential Sources of Data For EIA

	Information	Source
	Air Environment	
1.	Meteorology- Temperature, Rainfall, Humidity, Inversion, Seasonal Wind rose pattern (16 point compass scale), cloud cover, wind speed, wind direction, stability, mixing depth	⑨ Indian Meteorology Department, Pune
2.	Ambient Air Quality- 24 hourly concentration of SPM, RPM, SO_2, NO_x, CO	⑨ Central Pollution Control Board (CPCB), ⑨ State Pollution Control Board (SPCB), ⑨ Municipal Corporations ⑨ Ministry of Environment and Forests (MoEF) ⑨ State Department of Environment (DoEN)
	Water Environment	
3.	Surface water- water sources, water flow (lean season), water quality, water usage, Downstream water users Command area development plan Catchment treatment plan	⑨ Central Water Commission (CWC), ⑨ Central Pollution Control Board (CPCB), ⑨ State Pollution Control Board (SPCB), Central Water and Power Research Institute (CWPRS), Pune ⑨ State Irrigation Department ⑨ Hydel Power generation organizations such as NHPC, State SEBs
4.	Ground Water- groundwater recharge rate/withdrawal rate, ground water potential groundwater levels (pre monsoon, post monsoon), ground water quality, changes observed in quality and quantity of ground water in last 15 years	⑨ Central Ground Water Board (CGWB) ⑨ Central Ground Water Authority (CGWA) ⑨ State Ground Water Board (SGWB) ⑨ National Water Development Authority (NWDA)
5.	Coastal waters- water quality, tide and current data, bathymetry	⑨ Department of Ocean Development, New Delhi ⑨ State Maritime Boards ⑨ Naval Hydrographer's Office, Dehradun ⑨ Port Authorities ⑨ National Institute of Oceanography (NIO), Goa
	Biological Environment	
6.	Description of Biological Environment- inventory of flora and fauna in 7 km radius, endemic species, endangered species, Aquatic Fauna, Forest land, forest type and density of vegetation, biosphere, national parks, wild life sanctuaries, tiger reserve, elephant reserve, turtle nesting ground, core zone of biosphere reserve, habitat of migratory birds, routes of migratory birds	⑨ District Gazetteers ⑨ National Remote Sensing Agency (NRSA), Hyderabad ⑨ Forest Survey of India, Dehradun ⑨ Wildlife Institute of India ⑨ World Wildlife Fund ⑨ Zoological Survey of India ⑨ Botanical Survey of India ⑨ Bombay Natural History Society, (BNHS), Mumbai ⑨ State Forest Departments ⑨ State Fisheries Department ⑨ Ministry of Environment and Forests ⑨ State Agriculture Departments ⑨ State Agriculture Universities
	Land Environment	
7.	Geographical Information-Latitude, Longitude, Elevation (above MSL)	⑨ Toposheets of Survey of India, Pune ⑨ National Remote Sensing Agency (NRSA), Hyderabad ⑨ Space Application Centre (SAC), Ahmedabad

	Information	Source
8.	Nature of Terrain, topography map indicating contours (1:2500 scale)	⑨ Survey of India Toposheets ⑨ National Remote Sensing Agency (NRSA), Hyderabad ⑨ State Remote Sensing Centre, ⑨ Space Application Centre (SAC), Ahmedabad
9.	Hydrogeology- Hydrogeological report (in case of ground water is used/area is drought prone/wastewater is likely to discharged on land) Geomorphological analysis (topography and drainage pattern) Geological analysis (Geological Formations/Disturbances- geological and structural maps, geomorphological contour maps, structural features, including lineaments, fractures, faults and joints) Hydrogeological analysis (disposition of permeable formations, surface-ground water links, hydraulic parameter determination etc) Analysis of the natural soil and water to assess pollutant absorption capacity	⑨ NRSA, Hyderbad ⑨ Survey of India Toposheets ⑨ Geological Survey of India ⑨ State Geology Departments ⑨ State Irrigation Department ⑨ Department of Wasteland Development, Ministry of Rural Areas ⑨ National Water Development Authority (NWDA)
10.	Nature of Soil, permeability, erodibility classification of the land	⑨ Agriculture Universities ⑨ State Agriculture Department ⑨ Indian Council for Agriculture Research ⑨ State Soil Conservation Departments ⑨ National Bureau of Soil Survey and Landuse Planning ⑨ Central Arid Zone Research Institute (CAZRI), Jodhpur
11.	Landuse in the project area and 10 km radius of the periphery of the project	⑨ Survey of India- Toposheets ⑨ All India Soil and Landuse Survey; Delhi ⑨ National Remote Sensing Agency (NRSA), Hyderabad ⑨ Town and County Planning Organisation ⑨ State Urban Planning Department ⑨ Regional Planning Authorities (existing and proposed plans) ⑨ Village Revenue Map- District Collectorate ⑨ Directorate of Economics and Statistics-State Government ⑨ Space Application Centre, Ahmedabad
12.	Coastal Regulation Zones- CRZMP, CRZ classification, Demarcation of HTL and LTL*	⑨ Urban Development Department ⑨ State Department of Environment ⑨ State Pollution Control Board ⑨ Space Application Centre* ⑨ Centre for Earth Sciences Studies, Thiruvanthapuram* ⑨ Institute of Remote Sensing, Anna University Chennai* ⑨ Naval Hydrographer's Office, Dehradun* ⑨ National Institute of Oceanography, Goa* ⑨ National Institute of Ocean Technology, Chennai ⑨ Centre for Earth Science Studies

* *Agencies authorized for approval of demarcation of HTL and LTL*

	Information	Source
	Social	
13.	Socioeconomic - population, number of houses and present occupation pattern within 7 km from the periphery of the project	⑨ Census Department ⑨ District Gazetteers- State Government ⑨ District Statistics- District Collectorate ⑨ International Institute of Population Sciences, Mumbai (limited data) ⑨ Central Statistical Organisation
14.	Monuments and heritage sites	District Gazetteer Archeological Survey of India, INTACH District Collectorate Central and State Tourism Department State Tribal and Social Welfare Department
	Natural Disasters	
15.	Seismic data (Mining Projects)- zone no, no of earthquakes and scale, impacts on life, property existing mines	⑨ Indian Meteorology Department, Pune ⑨ Geological Survey of India
16.	Landslide prone zone, geomorphological conditions, degree of susceptibility to mass movement, major landslide history (frequency of occurrence/decade), area affected, population affected	⑨ Space Application Centre
17.	Flood/cyclone/droughts- frequency of occurrence per decade, area affected, population affected	⑨ Natural Disaster Management Division in Department of Agriculture and Cooperation ⑨ Indian Meteorological Department
	Industrial	
18.	Industrial Estates/Clusters, Growth Centres	⑨ State Industrial Corporation ⑨ Industrial Associations ⑨ State Pollution Control Boards ⑨ Confederation Indian Industries (CII) ⑨ FICCI
19.	Physical and Chemical properties of raw material and chemicals (Industrial projects); fuel quality	⑨ Material and Safety Data Sheets ⑨ ENVIS database of Industrial Toxicological Research Centre, Lucknow ⑨ Indian Institute Petroleum
20.	Occupational Health and Industrial Hygiene- major occupational health and safety hazards, health and safety requirements, accident histories	⑨ Central Labour Institute, Mumbai ⑨ Directorate of Industrial Safety ⑨ ENVIS Database of Industrial Toxicological Research Centre, Lucknow ⑨ National Institute of Occupational Health, Ahmedabad
21.	Pollutant release inventories (Existing pollution sources in area within 10 km radius)	⑨ Project proponents which have received EC and have commenced operations
22.	Water requirement (process, cooling water, DM water, Dust suppression, drinking, green belt, fire service)	⑨ EIA Reports ⑨ National and International Benchmarks

Annexure XB: Summary of Available Data with Potential Data Sources for EIA

	Agency	Information Available
1.	Archaeological Survey of India Department of Culture Government of India Janpath, New Delhi - 110011 Asi@del3.vsnl.net.in	⑨ Inventory of monuments and sites of national importance- Listing and documentation of monuments according to world heritage, pre historic, proto historic and secular, religious places and forts
2.	Botanical Survey Of India P-8, Brabourne Road Calcutta 700001 Tel#033 2424922 Fax#033 2429330 Email: envis@cal2.vsnl.net.in. . RO - Coimbatore, Pune, Jodhpur, Dehradun, Allahabad, Gantok, Itanagar, Port Blair	⑨ Photodiversity documentation of flora at National, State and District level and flora of protected areas, hotspots, fragile ecosystems, sacred groves etc ⑨ Identification of threatened species including endemics, their mapping, population studies ⑨ Database related to medicinal plants, rare and threatened plant species ⑨ Red data book of Indian plants (Vol 1,2, and 3) ⑨ Manual for roadside and avenue plantation in India
3.	Bureau of Indian Standards Manak Bhawan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002 Tel#3230131, 3233375, 3239402 (10 lines) Fax : 91 11 3234062, 3239399, 3239382 Email- bis@vsnal.com	⑨ Bureau of Indian Standards Committees on Earthquake Engineering and Wind Engineering have a Seismic Zoning Map and the Wind Velocity Map including cyclonic winds for the country
4.	Central Water Commission (CWC) Sewa Bhawan, R.K.Puram New Delhi - 110066 cmanoff@niccwc.delhi.nic.in RO- Bangalore, Bhopal, Bhubaneshwar, Chandigarh, Coimbatore/Chennai, Delhi, Hyderabad, Lucknow, Nagpur, Patna, Shillong, Siliguri and Vadodara	⑨ Central Data Bank -Collection, collation and Publishing of Hydrological, Hydrometeorological, Sediment and Water Quality data-. ⑨ Basin wise Master Plans ⑨ Flood atlas for India ⑨ Flood Management and Development and Operation of Flood Forecasting System- CWC operate a network of forecasting stations Over 6000 forecasts are issued every year with about 95% of the forecasts within the permissible limit. ⑨ Water Year Books, Sediment Year Books and Water Quality Year Books. ⑨ Also actively involved in monitoring of 84 identified projects through National, State and Project level Environmental Committees for ensuring implementation of environmental safeguards
5.	Central Ground Water Board (HO) N.H.IV, New CGO Complex, Faridabad - 121001 RO - Guwahati, Chandigarh, Ahemadabad, Trivandrum, Calcutta, Bhopal, Lucknow, Banglore, Nagpur, Jammu, Bhubneshwar, Raipur, Jaipur, Chennai, Hyderabad, Patna	⑨ surveys, exploration, monitoring of ground water development

[16] *Based on web search and literature review*

6.	Central Pollution Control Board Parivesh Bhawan, CBD-cum-Office Complex East Arjun Nagar, DELHI - 110 032 INDIA E-mail : cpcb@alpha.nic.in	⑨ National Air Quality Monitoring Programme ⑨ National River Water Quality Monitoring Programme- Global Environment Monitoring , MINARS ⑨ Zoning Atlas Programme ⑨ Information on 17 polluting category industries (inventory, category wise distribution, compliance, implementation of pollution control programmes
7.	Central Arid Zone Research Institute, Jodhpur Email : cazri@x400.nicgw.nic.in Regional Centre at Bhuj in Gujarat	⑨ AGRIS database on all aspects of agriculture from 1975 to date ⑨ Also have cell on Agriculture Research Information System; ⑨ Working on ENVIS project on desertification ⑨ Repository of information on the state of natural resources and desertification processes and their control ⑨ The spectrum of activities involves researches on basic resource inventories; monitoring of desertification, rehabilitation and management of degraded lands and other areas
8.	Central Inland Capture Fisheries Research Institute, Barrackpore-743101, Tel#033-5600177 Fax#033-5600388 Email : cicfri@x400.nicgw.nic.in	⑨ Data Base on Ecology and fisheries of major river systems of India. Biological features of commercially important riverine and estuarine fish species. Production functions and their interactions in floodplain wetlands. ⑨ Activities - Environmental Impact Assessment for Resource Management ; Fisheries Resource surveys
9.	Central Institute of Brackish Water Aquaculture 141, Marshalls Road, Egmore , Chennai - 600 008, Tel# 044-8554866, 8554891, Director (Per) 8554851 Fax#8554851,	⑨ Repository of information on brackish water fishery resources with systematic database of coastal fishery resources for ARIS ⑨ Agricultural Research Information System (ARIS) database covers State wise data on soil and water quality parameters, land use pattern, production and productivity trends, ⑨ Social, economic and environmental impacts of aquaculture farming, ⑨ Guidelines and effluent standards for aquaculture farming
10.	Central Marine Fisheries Research Institute (CMFRI), Cochin	⑨ Assessing and monitoring of exploited and un-exploited fish stocks in Indian EEZ ⑨ Monitoring the health of the coastal ecosystems, particularly the endangered ecosystems in relation to artisanal fishing, mechanised fishing and marine pollution ⑨ The institute has been collecting data on the catch and effort and biological characteristics for nearly half a century based on scientifically developed sampling scheme, covering all the maritime States of the country ⑨ The voluminous data available with the institute is managed by the National Marine Living Resources Data Centre (NMLRDC)
11.	Central Water and Power Research Station, Pune Tel#020-4391801-14; 4392511; 4392825 Fax #020-4392004,4390189	⑨ Numerical and Physical models for hydro-dynamic simulations
12.	Central Institute of Road Transport, Bhosari, Pune 411 026, India. Tel : +91 (20) 7125177, 7125292, 7125493, 7125494	⑨ Repository of data on all aspects of performance of STUs and a host of other related road transport parameters

13.	Department of Ocean Development	⑨ Assessment of environment parameters and marine living resources (primary and secondary) in Indian EEZ (Nodal Agency NIO Kochi) ⑨ Stock assessment, biology and resource mapping of deep sea shrimps, lobsters and fishes in Indian EEZ (Nodal agency-Fisheries Survey of India) ⑨ Investigations of toxical algal blooms and benthic productivity in Indian EEZ (Nodal agency- Cochin University of Science and technology) ⑨ Coastal Ocean Monitoring and Prediction System (COMAP) - monitoring and modelling of marine pollution along entire Indian coast and islands. Parameters monitored are temp, salinity, DO, pH, SS, BOD, inorganic phosphate, nitrate, nitrite, ammonia, total phosphorus, total nitrite, total organic carbon, petroleum hydrocarbons, pathogenic vibros, pathogenic E.coli, shigella, salmonella, heavy metals (Cd, Hg, Pb) and pesticide residues (DDT, BHC, Endosulfan). Monitoring is carried out along the ecologically sensitive zones and urban areas (NIO Mumbai- Apex coordinating agency). ⑨ Sea Level Measurement Programe (SELMAM)- sea level measurement at selected stations (Porbandar, Bombay, Goa, Cochin, Tuticorin, Madras, Machilipatnam, Visakhapatnam, Paradeep, Calcutta and Kavaratti (Lakshadweep Island)) along Indian coast and islands using modern tide gauges ⑨ Detailed coastal maps through Survey of India showing contour at 1/2 a metre interval in the scale of 1:25000. (Nellore- Machhalipatnam work already over) ⑨ Marine Data Centre (MDC) IMD for Ocean surface meteorology, GSI for marine geology, SOI for tide levels, Naval Hydrographic Office for bathymetry, NIO Goa for physical chemical and biological oceanography, NIO Mumbai for marine pollution, CMFRI for coastal fisheries, Institute of Ocean Management Madras for coastal geomorphology ⑨ DOD has setup Indian National Centre for Ocean Information Services (INCOIS) at Hyderabad for generation and dissemination of ocean data products (near real time data products such as sea surface temperature, potential fishing zones, upwelling zones, maps, eddies, chlorophyll, suspended sediment load etc). MDC will be integrated with INCOIS ⑨ Integrated Coastal and Marine Area Management (ICMAM) programme - GIS based information system for management of 11 critical habitats namely Pichavaram, Karwar, Gulf of Mannar, Gulf of Khambat, Gulf of Kutch, Malvan, Cochin, Coringa mangroves, Gahirmata, Sunderbans and Kadamat (Lakshadeep) ⑨ Wetland maps for Tamil Nadu and Kerala showing the locations of lagoons, backwaters, estuaries, mudflats etc (1:50000 scale) ⑨ Coral Reef Maps for Gulf of Kachch, Gulf of Mannar, Andaman and Nicobar and Lakshadeep Islands (1:50,000 scale) indicating the condition of corals, density etc
14.	Environment Protection Training and Research Institute Gachibowli, Hyderabad - 500 019, India Phone: +91-40-3001241, 3001242, 3000489 Fax: +91-40- 3000361 E-mail: info@eptri.com	⑨ Environment Information Centre- has appointed EPTRI as the Distributed Information Centre for the Eastern Ghats region of India. EIC Collaborates with the Stockholm Environment Institute Sweden Database on Economics of Industrial Pollution Prevention in India Database of Large and Medium Scale Industries of Andhra Pradesh Environmental Status of the Hyderabad Urban Agglomeration Study on 'water pollution-health linkages' for a few Districts of A.P

		⑨ Environment Quality Mapping Macro level studies for six districts in the State of Andhra Pradesh Micro level studies for two study zones presenting the permissible pollutant load and scoping for new industrial categories Zonation of the IDA, Parwada which helped APIIC to promote the land for industrial development Disaster management plan for Visakhapatnam Industrial Bowl Area
15.	Forest Survey of India (FSI) Kaulagarh Road, P.O., IPE Dehradun - 248 195 Tel# 0135-756139, 755037, 754507 Fax # 91-135-759104 E-Mail : fsidir@nde.vsnl.net.in fsihq@nde.vsnl.net.in RO- Banglore, Calcutta, Nagpur and Shimla	⑨ State of Forest Report (Biannual) ⑨ National Forest Vegetation Map (Biannual exercise) (on 1: 1 million scale) ⑨ Thematic mapping on 1:50,000 scale depicting the forest type, species composition, crown density of forest cover and other landuse National ⑨ Basic Forest Inventory System ⑨ Inventory survey of non forest area ⑨ Forest inventory report providing details of area estimates, topographic description, health of forest, ownership pattern, estimation of volume and other growth parameters such as height and diameter in different types of forest, estimation of growth, regeneration and mortality of important species, volume equation and wood consumption of the area studied
16.	Geological Survey of India 27 Jawaharlal Nehru Road, Calcutta 700 016, India Telephone +91-33-2496941 FAX 91-33-2496956 gsi_chq@vsnl.com	⑨ Environmental hazards zonation mapping in mineral sector ⑨ Codification of base line information of geo-environmental appreciation of any terrain and related EIA and EMP studies ⑨ Lineament and geomorphological map of India on 1:20,000 scale. ⑨ Photo-interpreted geological and structural maps of terrains with limited field checks.
17.	Indian Council of Agriculture Research, Krishi Bhawan, New Delhi, Tel#011-338206 – ICAR complex, Goa- Agro metrology – Central Arid Zone Research Institute- Agro forestry – Central Soil salinity Research Institute, – Indian Institute of Soil Science – Central Soil and Water Conservation Research and Training Institute – National Bureau of Soil Survey and Landuse Planning	⑨ A total of 80,000 profiles at 10 kms grid across the country were analyzed to characterize the soils of India. ⑨ Detailed soil maps of the Country (1:7 million), State (1:250,000) and districts map (1:50,000) depicting extent of degradation (1:4.4 millions) have been prepared. ⑨ Thematic maps depicting soil depth, texture drainage, calcareousness, salinity, pH, slope and erosion have been published ⑨ Agro-climate characterization of the country based on moisture, thermal and sunshine regimes ⑨ Agro-ecological zones (20) and sub-zones (60) for the country were delineated based on physiography, soils, climate, Length of Growing Period and Available Water Content, and mapped on 1:4.4 million scale. ⑨ Digitization of physiography and soil resource base on 1:50,000 scale for 14 States have been completed. ⑨ .Soil fertility maps of N,P,K,S and Zn have also been developed ⑨ Water quality guidelines for irrigation and naturally occurring saline/sodic water ⑨ Calibration and verification of ground water models for predicting water logging and salinity hazards in irrigation commands
18.	Indian Bureau of Mines Indira Bhawan, Civil Lines Nagpur Ph no - 0712-533 631, Fax- 0712-533 041	⑨ National mineral inventory for 61 minerals and mineral maps ⑨ Studies on environmental protection and pollution control in regard to the mining and mineral beneficiation operations ⑨ Collection, processing and storage of data on mines, minerals and mineral-based industries, collection and maintenance of world mineral intelligence, foreign mineral legislation and other related matters

19.	Indian Meteorology Department Shivaji nagar, Pune 41100 RO- Mumbai, Chennai, Calcutta, New Delhi, Nagpur, Guwahati	⑨ Meteorological data ⑨ Background air quality monitoring network under Global Atmospheric Watch Programme (operates 10 stations) ⑨ Seismicity map, seismic zoning map; seismic occurrences and cyclone hazard monitoring; list of major earthquakes ⑨ Climatological Atlas of India , Rainfall Atlas of India and Agroclimatic Atlas of India ⑨ Monthly bulletin of Climate Diagnostic Bulletin of India ⑨ Environmental Meteorological Unit of IMD at Delhi to provide specific services to MoEF
20.	INTACH Natural Heritage, 71 Lodi Estate, New Delhi-110 003 Tel. 91-11-4645482, 4632267/9, 4631818, 4692774, 4641304 Fax : 91-11-4611290 E-mail : nh@intach.net	⑨ Listing and documentation of heritage sites identified by municipalities and local bodies (Listing excludes sites and buildings under the purview of the Archaeological Survey of India and the State Departments of Archaeology)
21.	Industrial Toxicology Research Centre Post Box No. 80, Mahatma Gandhi Marg, Lucknow-226001, Phone: +91-522-221856,213618,228227; Fax : +91-522 228227 Email: itrc@itrcindia.org	⑨ Activities include health survey on occupational diseases in industrial workers, air and water quality monitoring studies, ecotoxicological impact assessment, toxicity of chemicals, human health risk assessment ⑨ Five databases on CD-ROM in the area of environmental toxicology viz: TOXLINE, CHEMBANK, POISINDEX, POLTOX and PESTBANK. The Toxicology Information Centre provides information on toxic chemicals including household chemicals ⑨ ENVIS centre and created a full-fledged computerized database (DABTOC) on toxicity profiles of about 450 chemicals
22.	Indian Institute of Forest Management Post Box No. 357, Nehru Nagar Bhopal - 462 003 Phone # 0755-575716, 573799, 765125, 767851 Fax # 0755-572878	⑨ Consultancy and research on joint forest management (Ford Foundation, SIDA, GTZ, FAO etc)
23.	Indian Institute of Petroleum Mohkampur , Dehradun, India, 248005 0135- 660113 to 116 0135- 671986	⑨ Fuel quality characterisation ⑨ Emission factors
24.	Ministry of Environment and Forest	⑨ Survey of natural resources ⑨ National river conservation directorate ⑨ Environmental research programme for eastern and western ghats ⑨ National natural resource management system ⑨ Wetlands conservation programme- survey, demarcation, mapping landscape planning, hydrology for 20 identified wetlands National ⑨ wasteland identification programme
25.	Mumbai Metropolitan Regional Development Authority	⑨ Mumbai Urban Transport Project ⑨ Mumbai Urban Development Project ⑨ Mumbai Urban Rehabilitation Project ⑨ Information on MMR; statistics on councils and corporations Regional ⑨ Information Centre- Basic data on population, employment, industries and other sectors are regularly collected and processed

26.	Municipal Corporation of Greater Mumbai	⑨ Air Quality Data for Mumbai Municipal Area ⑨ Water quality of lakes used for water supply to Mumbai
27.	Ministry of Urban Development Disaster Mitigation and Vulnerability Atlas of India Building Materials & Technology Promotion Council G-Wing,Nirman Bhavan, New Delhi-110011 Tel: 91-11-3019367 Fax: 91-11-3010145 E-Mail: bmtpc@del2.vsnl.net.in	⑨ Identification of hazard prone area ⑨ Vulnerability Atlas showing areas vulnerable to natural disasters ⑨ Land-use zoning and design guidelines for improving hazard resistant construction of buildings and housing ⑨ State wise hazard maps (on cyclone, floods and earthquakes)
28.	Natural Disaster Management Division in Department of Agriculture and Cooperation	⑨ Weekly situation reports on recent disasters, reports on droughts, floods, cyclones and earthquakes
29.	National Bureau Of Soil Survey & Land Use Planning P.O. Box No. 426, Shankar Nagar P.O., Nagpur-440010 Tel#91-712-534664,532438,534545 Fax#:91-712-522534 RO- Nagpur, New Delhi, Banglore, Calcutta, Jorhat, Udaipur	⑨ NBSS&LUP Library has been identified as sub centre of ARIC (ICAR) for input to AGRIS covering soil science literature generated in India ⑨ Research in weathering and soil formation, soil morphology, soil mineralogy, physicochemical characterisation, pedogenesis, and landscape-climate-soil relationship. ⑨ Soil Series of India- The soils are classified as per Soil Taxonomy. The described soil series now belong to 17 States of the country. ⑨ Landuse planning- watershed management, land evaluation criteria, crop efficiency zoning ⑨ Soil Information system is developed state-wise at 1:250,000 scale. Presently the soil maps of all the States are digitized, processed and designed for final output both digital and hardcopy. The thematic layers and interpreted layers of land evaluation (land capability, land irrigability and crop suitability), Agro-Ecological Zones and soil degradation themes are prepared. ⑨ Districts level information system is developed for about 15 districts at 1: 50, 000 scale. The soil information will be at soil series level in this system. Soil resource inventory of States, districts water-sheds (1:250,000; 1:50,000; 1:10,000/8000)
30.	National Institute of Ocean Technology, Velacherry-Tambaram main road Narayanapuram Chennai, Tamil Nadu Tel#91-44-2460063 / 2460064/ 2460066/ 2460067 Fax#91-44-2460645	⑨ Waste load allocation in selected estuaries (Tapi estuary and Ennore creek) is one the components under the Integrated Coastal and Marine Area Management (ICMAM) programme of the Department of Ocean Development ICMAM is conducted with an IDA based credit to the Government of India under the Environmental Capacity Building project of MoEF (waste assimilation capacity of Ennore creek is over) ⑨ Physical oceanographic component of Coastal & Ocean monitoring Predictive System (COMAPS) a long term monitoring program under the Department of Ocean Development ⑨ Identification of suitable locations for disposal of dredge spoil using mathematical models & environmental criteria ⑨ EIA Manual and EIA guidelines for port and harbour projects
31.	National Institute of Oceanography, Goa RO- Mumbai, Kochi	⑨ Coastal Ocean Monitoring and Predictions(COMAP)-Monitoring of coastal waters for physicochemical and biological parameters including petroleum hydrocarbons, trace metals, heavy metals, and biomass of primary (phytoplankton) and secondary (zooplankton, microbial and benthic organisms) ⑨ Marine Biodiversity of selected ecosystem along the West Coast of India

32.	National Botanical Research Institute, Post Box No 436 Rana Pratap Marg Lucknow- 226001, Tel: (+91) 522 271031-35 Fax: (+91) 522 282849, 282881 Lucknow	⑨ Dust filtering potential of common avenue trees and roadside shrubs has been determined, besides studies have also been conducted on heavy-metals accumulation potential of aquatic plants supposedly useful as indicators of heavy metal pollution in water bodies and capable of reducing the toxic metals from water bodies. ⑨ Assessment of bio-diversity of various regions of India
33.	National Geophysical Research Institute, Uppal Road, Hyderabad Telephone:0091-40-7171124, FAX:0091-40-7171564	⑨ Exploration, assessment and management of ground water resources including ground water modelling and pollution studies
34.	National Environmental Engineering Research Institute, Nagpur RO- Mumbai, Delhi, Chennai, Calcutta, Ahmedabad, Cochin, Hyderabad, Kanpur	⑨ National Air Quality Monitoring (NAQM) for CPCB ⑨ Database on cleaner technologies of industrial productions
35.	National Hydrology Institute, Roorkee RO- Belgaum (Hard Rock Regional Centre), Jammu (Western Himalayan Regional Centre), Guwahati (North Eastern Regional Centre), Kakinada (Deltaic Regional Centre), Patna (Ganga Plains North Regional Centre), and Sagar (Ganga Plains South)	⑨ Basin studies, hydrometeorological network improvement, hydrological year book, hydrological modelling, regional flood formulae, reservoir sedimentation studies, environmental hydrology, watershed development studies, tank studies, and drought studies.
36.	National Institute Of Urban Affairs, India Habitat Centre, New Delhi	⑨ Urban Statistics Handbook
37.	National Institute of Occupational Health Meghaninagar, Ahmedabad RO- Banglore, Calcutta	⑨ epidemiological studies and surveillance of hazardous occupations including air pollution, noise pollution, agricultural hazards, industrial hazards in organised sectors as well as small scale industries, carcinogenesis, pesticide toxicology, etc ⑨ WHO collaborative centre for occupational health for South East Asia region and the lead institute for the international programme on chemical safety under IPCS (WHO)
38.	NRSA Data Centre Department of Space, Balanagar, Hyderabad 500 037 Ph- 040-3078560 3078664 sales@nrsa.gov.in	⑨ Satellite data products (raw data, partially processed (radiometrically corrected but geometrically uncorrected), standard data (radiometrically and geometrically corrected), geocoded data(1:50,000 and 1:25000 scale), special data products like mosaiced, merged and extracted) available on photographic (B?W and FCC in form of film of 240 mm X 240mm or enlargements/paper prints in scale varying between 1:1M and 1:12500 and size varying between 240mm and 1000mm) and digital media (CD-ROMs, 8 mm tapes)
39.	Rajiv Gandhi National Drinking Water Mission	⑨ Database for groundwater using remote sensing technology (Regional Remote Sensing Service Centre involved in generation of ground water prospect maps at 1:50,000 scale for the State of Kerala, Karnataka, AP, MP and Rajasthan for RGNDWM)
40.	Space Application Centre Value Added Services Cell (VASC) Remote Sensing Application Area Ahmedabad 380 053 079-676 1188	⑨ National Natural Resource Information System ⑨ Landuse mapping for coastal regulation zone (construction setback line) upto 1:12500 scale ⑨ Inventory of coastal wetlands, coral reefs, mangroves, seaweeds ⑨ Monitoring and condition assessment of protected coastal areas

	Fax- 079-6762735	⑨ Wetland mapping and inventory ⑨ Mapping of potential hotspots and zoning of environmental hazards ⑨ General geological and geomorphological mapping in diverse terrain ⑨ Landslide risk zonation for Tehre area
41.	State Pollution Control Board	⑨ State Air Quality Monitoring Programme ⑨ Inventory of polluting industries ⑨ Identification and authorization of hazardous waste generating industries ⑨ Inventory of biomedical waste generating industries ⑨ Water quality monitoring of water bodies receiving wastewater discharges ⑨ Inventory of air polluting industries ⑨ Industrial air pollution monitoring ⑨ Air consent, water consent, authorization, environment monitoring reports
42.	State Ground Water Board	
43.	Survey of India	⑨ Topographical surveys on 1:250,000 scales, 1:50,000 and 1:25,000 scales ⑨ Digital Cartographical Data Base of topographical maps on scales 1:250,000 and 1:50,000 ⑨ Data generation and its processing for redefinition of Indian Geodetic Datum ⑨ Maintenance of National Tidal Data Centre and receiving/ processing of tidal data of various ports. ⑨ Coastal mapping along the Eastern coast line has been in progress to study the effect of submergence due to rise in sea-level and other natural phenomenon. Ground surveys have been completed for the proposed coastal region and maps are under printing. ⑨ District planning maps containing thematic information (135 maps) have been printed out of 249 maps covering half the districts of India. Districts planning maps for remaining half of the area are being processed by National Atlas and Thematic Mapping Organisation (NATMO)
44.	Town and Country Planning Organisation	⑨ Urban mapping - Thematic maps and graphic database on towns (under progress in association with NRSA and State town planning department)
45.	Wildlife Institute of India Post Bag No. 18, Chandrabani Dehradun - 248 001, Uttaranchal Tel#0135 640111 -15, Fax#0135 640117 email : wii@wii .	⑨ Provide information and advice on specific wildlife management problems. ⑨ National Wildlife Database
46.	Zoological Survey of India Prani Vigyan Bhawan 'M' Block, New Alipore Calcutta - 700 053 Phone # 91-33-4786893, 4783383 Fax # 91-33-786893 RO - Shillong, Pune, Dehradun, Jabalpur, Jodhpur, Chennai, Patna, Hyderabad, Canning, Behrampur, Kozikode, Itanagar, Digha, Port Bliar, Solan	⑨ Red Book for listing of endemic species ⑨ Survey of faunal resources

ANNEXURE XI
Impact Prediction Tools

Table 1: Choice of Models for Impact Prediction: Air Environment*

Model	Application	Remarks
ISCST 3	▪ Appropriate for point, area and line sources ▪ Application for flat or rolling terrain ▪ Transport distance up to 50 km valid ▪ Computes for 1 hr to annual averaging periods	▪ Can take up to 99 sources ▪ Computes concentration on 600 receptors in Cartesian on polar coordinate system ▪ Can take receptor elevation ▪ Requires source data, meteorological and receptor data as input.
AERMOD with AERMET	▪ Settling and dry deposition of particles; ▪ Building wake effects (excluding cavity region impacts); ▪ Point, area, line, and volume sources; ▪ Plume rise as a function of downwind distance; ▪ Multiple point, area, line, or volume sources; ▪ Limited terrain adjustment; ▪ Long-term and short-term averaging modes; ▪ Rural or urban modes; ▪ Variable receptor grid density; ▪ Actual hourly meteorology data	▪ Can take up to 99 sources ▪ Computes concentration on 600 receptors in Cartesian on polar coordinate system ▪ Can take receptor elevation ▪ Requires source data, meteorological and receptor data as input.
PTMAX	▪ Screening model applicable for a single point source ▪ Computes maximum concentration and distance of maximum concentration occurrence as a function of wind speed and stability class	▪ Require source characteristics ▪ No met data required ▪ Used mainly for ambient air monitoring network design
PTDIS	▪ Screening model applicable for a single point source ▪ Computes maximum pollutant concentration and its occurrences for the prevailing meteorological conditions	▪ Require source characteristics ▪ Average met data (wind speed, temperature, stability class *etc*.) required ▪ Used mainly to see likely impact of a single source
MPTER	▪ Appropriate for point, area and line sources applicable for flat or rolling terrain ▪ Transport distance up to 50 km valid ▪ Computes for 1 hr to annual averaging periods ▪ Terrain adjustment is possible	▪ Can take 250 sources ▪ Computes concentration at 180 receptors up to 10 km ▪ Requires source data, meteorological data and receptor coordinates
CTDM PLUS (Complex Terrain Dispersion Model)	▪ Point source steady state model, can estimate hrly average concentration in isolated hills/ array of hills	▪ Can take maximum 40 Stacks and computes concentration at maximum 400 receptors ▪ Does not simulate calm met conditions ▪ Hill slopes are assumed not to exceed 15 degrees ▪ Requires sources, met and terrain characteristics and receptor details
UAM (Urban Airshed Model)	▪ 3-D grid type numerical simulation model ▪ Computes O_3 concentration short term episodic conditions lasting for 1 or 2 days resulting from NOx and VOCs ▪ Appropriate for single urban area having significant O_3 problems	▪

Model	Application	Remarks
RAM (Rural Airshed Model)	▪ Steady state Gaussian plume model for computing concentration of relatively stable pollutants for 1 hr to 1 day averaging time ▪ Application for point and area sources in rural and urban setting	▪ Suitable for flat terrains ▪ Transport distance less than 50 km.
CRESTER	▪ Applicable for single point source either in rural or urban setting ▪ Computes highest and second highest concentration for 1hr, 3hr, 24hr and annual averaging times ▪ Tabulates 50 highest concentration for entire year for each averaging times	▪ Can take up to 19 Stacks simultaneously at a common site. ▪ Unsuitable for cool and high velocity emissions ▪ Do not account for tall buildings or topographic features ▪ Computes concentration at 180 receptor, circular wing at five downwind ring distance 36 radials ▪ Require sources, and met data
OCD (Offshore and coastal Dispersion Model)	▪ It determines the impact of offshore emissions from point sources on the air quality of coastal regions ▪ It incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shore line ▪ Most suitable for overwater sources shore onshore receptors are below the lowest shore height	▪ Requires source emission data ▪ Require hrly met data at offshore and onshore locations like water surface temperature; overwater air temperature; relative humidity *etc*.
FDM (Fugitive Dust Model)	▪ Suitable for emissions from fugitive dust sources ▪ Source may be point, area or line (up to 121 source) ▪ Require particle size classification max. up to 20 sizes ▪ Computes concentrations for 1 hr, 3hr, 8hr, 24hr or annual average periods	▪ Require dust source particle sizes ▪ Source coordinates for area sources, source height and geographic details ▪ Can compute concentration at max. 1200 receptors ▪ Require met data (wind direction, speed, Temperature, mixing height and stability class) ▪ Model do not include buoyant point sources, hence no plume rise algorithm
RTDM (Rough Terrain Diffusion Model)	▪ Estimates GLC is complex/rough (or flat) terrain in the vicinity of one or more co-located point sources ▪ Transport distance max. up to 15 km to up to 50 km ▪ Computes for 1 to 24 hr. or annual ave5rage concentrations	▪ Can take up to 35 co-located point sources ▪ Require source data and hourly met data ▪ Computes concentration at maximum 400 receptors ▪ Suitable only for non reactive gases ▪ Do not include gravitational effects or depletion mechanism such as rain/ wash out, dry deposition
CDM(Climatol ogically Dispersion Model)	▪ It is a climatologically steady state GPM for determining long term (seasonal or annual) ▪ Arithmetic average pollutant concentration at any ground level receptor in an urban area	▪ Suitable for point and area sources in urban region, flat terrain ▪ Valid for transport distance less than 50 km ▪ Long term averages: One month to one year or longer
PLUVUE-II (Plume Visibility Model)	▪ Applicable to assess visibility impairment due to pollutants emitted from well defined point sources ▪ It is used to calculate visual range reduction	▪ Require source characteristics, met data and receptor coordinates & elevation ▪ Require atmospheric aerosols

Model	Application	Remarks
	and atmospheric discoloration caused by plumes ▪ It predicts transport, atmospheric diffusion, chemical, conversion, optical effects, and surface deposition of point source emissions.	(back ground & emitted) characteristics, like density, particle size ▪ Require background pollutant concentration of SO_4, NO_3, NOx, NO_2, O_3, SO_2 and deposition velocities of SO_2, NO_2 and aerosols
MESO-PUFF II (Meso scale Puff Model)	▪ It is a Gaussian, Variable trajectory, puff superposition model designed to account fro spatial and temporal variations in transport, diffusion, chemical transformation and removal mechanism encountered on regional scale. ▪ Plume is modeled as a series of discrete puffs and each puff is transported independently ▪ Appropriate for point and area sources in urban areas ▪ Regional scale model.	▪ Can model five pollutants simultaneously (SO2, SO4, NOx, HNO3 and NO3) ▪ Require source characteristics ▪ Can take 20 point sources or 5 area source ▪ For area source – location, effective height, initial puff size, emission is required ▪ Computes pollutant concentration at max. 180 discrete receptors and 1600 (40 x 40) grided receptors ▪ Require hourly surface data including cloud cover and twice a day upper air data (pressure, temp, height, wind speed, direction) ▪ Do not include gravitational effects or depletion mechanism such as rain/ wash out, dry deposition

Table 2: Choice of Models for Impact Modeling: Noise Environment*

Model	Application
FHWA (Federal Highway Administration)	Noise Impact due to vehicular movement on highways
Dhwani	For predictions of impact due to group of noise sources in the industrial complex (multiple sound sources)
Hemispherical sound wave propagation Air Port	Fore predictive impact due to single noise source For predictive impact of traffic on airport and rail road

Table 3: Choice of Models for Impact Modeling: Land Environment*

Model	Application	Remarks
Digital Analysis Techniques	Provides land use / land cover distribution	
Ranking analysis for soil suitability criteria	Provides suitability criteria for developmental conversation activities	Various parameters viz. depth, texture, slope, erosion status, geomorphology, flooding hazards, GW potential, land use *etc*., are used.

Table 4: Choice of Models for Impact Modeling: Water Environment*

Model	Application	Remarks
QUAL-II E	Wind effect is insignificant, vertical dispersive effects insignificant applicable to streams Data required Deoxygenation coefficients, re-aeration coefficients for carbonaceous, nitrogenous and benthic substances, dissolved oxygen deficit	Steady state or dynamic model
	The model is found excellent to generate water quality parameters Photosynthetic and respiration rate of suspended and attached algae	
	Parameters measured up to 15 component can be simulated in any combination, e.g. ammonia, nitrite, nitrate, phosphorous, carbonaceous BOD, benthic oxygen demand, DO, coliforms, conservative substances and temperature	
DOSAG-3, USEPA: (1-D) RECEIV – II, USEPA	Water quality simulation model for streams & canal A general Water quality model	Steady-state
Explore –I, USEPA	A river basin water quality model	Dynamic, Simple hydrodynamics
HSPE, USEPA	Hydrologic simulation model	Dynamic, Simple hydrodynamics
RECEIVE-II, USEPA	A general dynamic planning model for water quality management	
Stanford watershed model	This model simulates stream flows once historic precipitation data are supplied The major components of the hydrologic cycle are modeled including interception, surface detention, overland inflow, groundwater, evapo-transpiration and routing of channel flows, temperature, TDS, DO, carbonaceous BOD coliforms, algae, zooplanktons, nitrite, nitrate, ammonia, phosphate and conservative substances can be simulated	
Hydrocomp model	Long-term meteorological and wastewater characterization data is used to simulate stream flows and stream water quality	Time dependant (Dynamic)
Stormwater Management model (SWMM)	Runoff is modeled from overland flow, through surface channels, and through sewer network Both combined and separate sewers can be modeled. This model also enables to simulate water quality effects to stormwater or combined sewer discharges. This model simulates runoff resulting from individual rainfall events.	Time Dependent
Battelle Reservoir model	Water body is divided into segments along the direction of the flow and each segment is divided into number of horizontal layers. The model is found to generate excellent simulation of temperature and good prediction of water quality parameters. The model simulates temperature, DO, total and	Two Dimensional multi-segment model

Model	Application	Remarks
	benthic BOD, phytoplankton, zooplankton, organic and inorganic nitrogen, phosphorous, coliform bacteria, toxic substances and hydrodynamic conditions.	
TIDEP (Turbulent diffusion temperature model reservoirs)	Horizontal temperature homogeneity Coefficient of vertical turbulent diffusion constant for charge of area with depth negligible coefficient of thermal exchange constant Data required wind speed, air temperature, air humidity, net incoming radiation, surface water temperature, heat exchange coefficients and vertical turbulent diffusion coefficients.	Steady state model
BIOLAKE	Model estimates potential fish harvest from a take	Steady state model
Estuary models/ estuarial Dynamic model	It is simulates tides, currents, and discharge in shallow, vertically mixed estuaries excited by ocean tides, hydrologic influx, and wind action Tides, currents in estuary are simulated	Dynamic model
Dynamic Water Quality Model	It simulates the mass transport of either conservative or non-conservative quality constituents utilizing information derived from the hydrodynamic model Bay-Delta model is the programme generally used. Up to 10 independent quality parameters of either conservative or non-conservative type plus the BOD-DO coupled relationship can be handled	Dynamic model
HEC -2	To compute water surface profiles for stead7y, gradually: varying flow in both prismatic & non-prismatic channels	
SMS	Lake circulation, salt water intrusion, surface water profile simulation model	Surface water Modeling system Hydrodynamic model
RMA2	To compute flow velocities and water surface elevations	Hydrodynamic analysis model
RMA4	Solves advective-diffusion equations to model up to six non-interacting constituents	Constituent transport model
SED2D-WES	Model simulates transport of sediment	Sediment transport model
HIVEL2D	Model supports subcritical and supercritical flow analysis	A 2-dimensional hydrodynamic model
MIKE-II, DHI	Model supports, simulations of flows, water quality, and sediment transport in estuaries, rives, irrigation systems, channels & other water bodies	Professional Engineering software package

Table 5: Choice of Models for Impact Modeling: Biological Environment*

Name	Relevance	Applications	Remarks
Flora			
Sample plot methods	Density and relative density Density and relative	Average number of individuals species per unit area Relative degree to which a	The quadrant sampling technique is applicable in all types of plant communities and for the study of submerged, sessile (attached at the base) or

Name	Relevance	Applications	Remarks
	dominance	species predominates a community by its sheer numbers, size bulk or biomass	sedentary plants
	Frequency and relative frequency importance value	Plant dispersion over an area or within a community	Commonly accepted plot size: 0.1 m^2- mosses, lichens & other mat-like plants
		Average of relative density, relative dominance and relative frequency	0.1 m^2- herbaceous vegetation including grasses
			10.20 m^2 – for shrubs and saplings up to 3m tall, and
			100 m^2 – for tree communities
Transects & line intercepts methods	Cover	Ratio of total amount of line intercepted by each species and total length of the line intercept given its cover	This methods allows for rapid assessment of vegetation transition zones, and requires minimum time or equipment of establish
	Relative dominance	It is the ratio of total individuals of a species and total individuals of all species	Two or more vegetation strata can be sampled simultaneously
Plot-less sampling methods	Mean point plant Mean area per plant	Mean point – plant distance Mean area per plant	Vegetation measurements are determined from points rather than being determined in an area with boundaries
	Density and relative density		Method is used in grass-land and open shrub and tree communities
	Dominance and relative dominance		It allows more rapid and extensive sampling than the plot method
	Importance value		Point- quarter method is commonly used in woods and forests.
Fauna			
Species list methods	Animal species list	List of animal communities observed directly	Animal species lists present common and scientific names of the species involved so that the faunal resources of the area are catalogued
Direct Contact Methods	Animal species list	List of animals communities observed directly	This method involves collection, study and release of animals
Count indices methods (Roadside and aerial count methods)	Drive counts Temporal counts	Observation of animals by driving them past trained observers	Count indices provide estimates of animal populations and are obtained from signs, calls or trailside counts or roadside counts
	Call counts	Count of all animals passing a fixed point during some stated	These estimates, through they do not provide absolute population

Name	Relevance	Applications	Remarks
		interval of time	numbers, Provide an index of the various species in an area
			Such indices allow comparisons through the seasons or between sites or habitats
Removal methods	Population size	Number of species captured	Removal methods are used to obtain population estimates of small mammals, such as, rodents through baited snap traps
Market capture methods	Population size estimate (M)	Number of species originally marked (T) Number of marked animals recaptured (t) and total number of animals captured during census (n) N = nT/t	It involves capturing a portion of the population and at some later date sampling the ratio of marked to total animals caught in the population

Table 6: Choice of Models for Impact Predictions: Socio-economic Environment*

Relevance		
Name	**Application**	**Remarks**
Extrapolative Methods	A prediction is made that is consistent with past and present socio-economic data, e.g. a prediction based on the linear extrapolation of current trends	
Intuitive Forecasting (Delphi techniques)	Delphi technique is used to determine environmental priorities and also to make intuitive predictions through the process of achieving group consensus	Conjecture Brainstorming Heuristic programming Delphi consensus
Trend extrapolation and correlation	Predictions may be obtained by extrapolating present trends Not an accurate method of making socio-economic forecasts, because a time series cannot be interpreted or extrapolated very far into the future with out some knowledge of the underlying physical, biological, and social factors	Trend breakthrough precursor events correlation and regression
Metaphors and analogies	The experience gained else where is used to predict the socio-economic impacts	Growth historical simulation commonsense forecasts
Scenarios	Scenarios are common-sense forecasts of data. Each scenario is logically constructed on model of a potential future for which the degrees of “confidence” as to progression and outcome remain undefined	Common-sense
Dynamic modeling (Input- Out model)	Model predicts net economic gain to the society after considering all inputs required for conversion of raw materials along with cost of finished product	
Normative Methods	Desired socio-economic goals are specified and an attempt is made to project the social environment backward in time to the present to examine whether existing or planned resources and	Morphological analysis technology scanning contextual mapping - functional array

Relevance		
Name	**Application**	**Remarks**
	environmental programmes are adequate to meet the goals	- graphic method Mission networks and functional arrays decision trees & relevance trees matrix methods scenarios

*** NOTE:** (i) If a project proponent prefer to use any model other than listed, can do so, with prior concurrence of concerned appraisal committee. (ii) Project-specific proposed prediction tools need to be identified by the project proponent and shall be incorporated in the draft ToR to be submitted to the Authority for the consideration and approval by the concerned EAC/SEAC.

ANNEXURE XII
Composition of EAC

Composition of the EAC

The Members of the EAC shall be Experts with the requisite expertise and experience in the following fields /disciplines. In the event that persons fulfilling the criteria of "Experts" are not available, Professionals in the same field with sufficient experience may be considered:

- Environment Quality Experts: Experts in measurement/monitoring, analysis and interpretation of data in relation to environmental quality
- Sectoral Experts in Project Management: Experts in Project Management or Management of Process/Operations/Facilities in the relevant sectors.
- Environmental Impact Assessment Process Experts: Experts in conducting and carrying out Environmental Impact Assessments (EIAs) and preparation of Environmental Management Plans (EMPs) and other Management plans and who have wide expertise and knowledge of predictive techniques and tools used in the EIA process
- Risk Assessment Experts
- Life Science Experts in floral and faunal management
- Forestry and Wildlife Experts
- Environmental Economics Expert with experience in project appraisal

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