An environmental impact assessment model for oil refinery: a case study of Tehran oil refinery

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Abstract: In present project, attempts have been made to consider oil general issues in addition to oil refinery environmental impact assessment because the oil general issues have direct and close connection oil refinery environmental impact assessment issues. In every oil refinery environmental impact assessment, initially the oil general issues shall be considered in order to achieve the desirable results. To this end, in the present project oil general issues are taken into consideration along with environmental impact assessment of oil refinery in different sections in order to achieve the final and desirable result through comparing and incorporating these two issues. On one hand, considering oil refining process and studying the approaches necessary for upgrading efficiency of model for oil refinery impact assessment in the framework of oil general issues and incorporating this model along with various issues of oil industry, it could be expected that many of environmental problems that countries with oil industries are grabbling with, partly due to lack of sufficient knowledge and required acquaintance with the environment, are removed via this model. Also, it has been tried to put forward a desirable procedure of technological developments in environmental issues and its application to improve environment in other countries in order to shed more light to the matter aiming at achieving appropriate result from the present project and extend and educate such a methods for save the natural resources. In this respect, Tehran oil refinery has chosen for case study to review of its environmental status and ability of this software.
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1. Introduction

This study helps to recognize the environmental impacts of refineries and can be a base for providing reports about environmental impact assessment. Of course, it is not aimed at limiting the creativity and innovations of providers of such reports. With the use of this study the process of environmental assessments in the country would be done in a more systematic way. Thus this would lead to more effective environmental assessment reports.

Risk assessment is the procedure in which the risks posed by inherent hazards involved in processes or situations are estimated either quantitatively or qualitatively. In the life cycle of a chemical for instance, risks can arise during manufacture, distribution, in use, or the disposal process. Risk assessment of the chemical involves the identification of the inherent hazards at every stage and an estimation of the risks posed by these hazards. Risk is estimated by incorporating a measure of the likelihood of the hazard actually causing harm and a measure of the severity of harm in terms of the consequences to people or the environment. Risk assessments vary widely in scope and application. Some look at single risks in a range of exposure scenarios such as the IPCS Environmental Health Criteria Document series, others are site-specific and look at the range of risks posed by an installation. In broad terms risk assessments are carried out to examine the effects of an agent on humans (Health Risk Assessment) and ecosystems (Ecological Risk Assessment). Environmental Risk Assessment (ERA) is the examination of risks resulting from technology that threaten ecosystems, animals and people. It includes human health risk assessments, ecological or ecotoxicological risk assessments, and specific industrial applications of risk assessment that examine end-points in people, biota or ecosystems. Many organizations are now actively involved in ERA, developing methodologies and techniques to improve this environmental management tool. Risk assessment and management approaches to environmental issues are increasingly being used at all levels of policy and regulation. The techniques have a wide range of application, including; the design of regulation, for instance in determining societally "acceptable" risk levels which may form the basis of environmental standards, providing a basis for site-specific decisions, for instance in land-use planning or sitting of hazardous installations, prioritization of environmental risks, for instance in the determination of which chemicals to regulate first, comparison of risks, for instance to enable comparisons to be made between the resources being allocated to the control of different types of risk, or to allow risk substitution decisions to be made

(Http://www.eea.europa/publications/GH-07-97-595-EN-C2/1.html). The use of a new computer-automated tool TORAP (TOol for Rapid risk Assessment in Petroleum refinery and Petrochemical industries) is demonstrated through a rapid and quantitative risk assessment of a typical petroleum refinery (Khan F.I., & Abbasi S.A., 2000). Petrochemical industries use hazardous chemicals and processes which have the potential to cause major accidents if human or equipment failure occurs. As most such industries are situated close to densely populated urban or rural locations, especially so in developing countries, it is very important to study the accidents that may take place, and the damage these may cause, so that preventive/mitigative measures may be taken before any tragedy does occur (Khan I.F., & Abbasi A.S., 1998). New software package for conducting rapid risk assessment (RRA) in chemical process industries and the system of methodologies on which it is based are described. The objectives behind the development of the package are to achieve greater breadth and depth, sophistication, and user-friendliness in conducting RRA (Khan I.F., & Abbasi A.S, 1999). Regional environmental risk assessment can be defined as risk assessment which deals with a spatial scale that contains multiple habitats with multiple sources of many stressors affecting multiple endpoints (Xu L., & Liu G., 2009). Environmental risk assessment is an essential element in any decision-making process in order to minimize the effects of human activities on the environment (Darbra M.R., & Eljarrat E., & Barcelo D., 2008). Methods for measuring environmental risk and environmental performance, in relation to all types of environmental effect, should be agreed and used in a consistent fashion across the business from strategic considerations to specific projects. Mechanisms for setting goals/targets based on these measures should be made explicit and agreed (Slater D., & Jones H., 1999). In any case, environmental studies conducted with local or nonlocal databases should include a discussion of the quality of the data in the database and its applicability to the local situation (Eicker M. O. D., & Hischier R., & Hurni H., & Zah R., 2010). Generally speaking, decision-making divides broadly into three levels: policy, plan/program, and project. The EIA was supposed to be a tool for both preventing damage to the environment and the early integration of environmental considerations into decision-making (Feldmann L, 1998). The potentials of environmental assessment as a sustainability instrument has long been recognized, but the criteria against which the development proposals traditionally are judged are not necessarily the criteria for sustainable development (George C., 1999). That is why the necessity for environment impacts assessments is felt greatly by all officials, related governmental and private employers, experts, people and their representatives. They want to learn about different parts or steps of a development project or plan and the probable consequences these may have on the environment (Ghanizadeh, Gh.,2001). Rivers, streams or underground water that are in contact with these pollutants are contaminated. In different processes of production done in coking and catalyst units' sour water containing phenol, ammonia and hydrocarbons are produced (Golestan, M., 1985). One of the ecological problems of refineries that are in coastal areas is their adverse impacts on marine ecosystems (Bahoush, 1991). The major environmental impacts and consequences of oil refineries include gas emissions, effluents, solid wastes, noise, odor and negative vision and aesthetic impacts (Ardalanie, 1989).

It is worthy to mention that because the processes of producing these assessment reports, and the processes of evaluating and ratifying them by the Iranian Environmental Protection Organization may be subject to change, we would bring to you whatever such changes are in the latest editions of this book. Environmental impacts assessment (the EIA) is being used globally, either as a planning or as a management tool, in order to minimize the harmful consequences of development (Ahammed A.K.M. R., & Nixon B.M., 2006). In Iran, there is no formal system of monitoring in the legislation or Guidelines. However, some limited informal monitoring system by the environmental agencies has been introduced to improve the EIA system by incorporating feedbacks from experience (Ahmadvand M., & Karami E., & Zamani G.H., & Vanclay F., 2009). Setting priorities for new projects is a complex task, since generally there is not enough available information to assess or forecast resulting environmental problems and their impacts on the economy or society. Therefore, strategic decisions have to be made with high levels of uncertainty (Al-Rashdan D., & Al-Kloub B., & Dean A., & Al-Shemmeri T., 1999). The impact of environmental regulation on macroeconomic performance has been studied in some depth over the last 15 years. Similarly, impacts on profit performance, investment intention and location decisions of firms has also been studied, although in less depth. There has been less academic interest, however, in the impacts that environmental regulations has on the strategic objectives of companies. A significant majority of firms indicated that the environmental approvals process should be considered to be an important determinant of investment strategies. The concept of defensive expenditures could be used to assess social responses

to adverse changes in environmental and resource conditions, as a means to distinguish stages in which local sectors respond individually from qualitatively different stages in which intersectoral events are more noticeable (Escofet A., & Bravo-Pena., 2007). Since the environmental assessment of the appropriate most criteria of sustainable development and environmental management Iran is considered a form of requirements must therefore encountering legal to be carried (Shariat, 1999).

Recently, many industrial, regulatory, and community leaders have expressed concern that the current environmental regulatory structures disregards multi-dimentional environmental impacts, and that they provide few incentives to develop and use new technologies, and fail to consider site-specific conditions (Elcock D., & Gasper J., & Moses D.O., & Emerson D., & Arguero R., 2000). The adoption of an environmental management system (the EMS) can guarantee several benefits, such as improved environmental performance, reduced liabilities, better compliance, improved public image, reduction of costs and better access to capital, therefore helping the firms to be more effective in achieving environmental goals (Bevilacqua M., & Braglia M., 2002). The science of risk analysis which has emerged as a major branch of knowledge in recent years to forecast the likelihood of accidents, to assess the consequences of likely accidents, to work out strategies to prevent accidents and also to lessen any adverse impacts in case an accident occurs (Khan F.I., & Abbasi S.A., 1999). The management of failure analysis has a strategic importance within a refinery from the organizational, engineering and economic point of view. The determination of an algorithm, that allows a methodical and as far as possible automatic approach to management of failure data, can make substantial improvements in the organization of work and in the decision-making processes (Bertolini M., & Bevilacqua M., & Ciarapica F.E., & Giacchetta G., 2009). Process industries involve handling of hazardous substances which on release may potentially cause catastrophic consequences in terms of assets lost, human fatalities or injuries and loss of public confidence in the company (Kalantarnia M., & Khan F., & Hawboldt K., 2010). Hydrocarbons are among the most important air pollutants that are emitted by petroleum refineries, since they are involved in almost every refinery process (Kalabokas P.D., & Hatzianestis J., & Bartzis J.G., & Papagiannakopoulos P., 2001). A number of processes within the petroleum industry that can cause climate change were examined through extensive surveys, investigations and analyses (Huang Y.F., & Huang G.H., & Hu Z.Y., & Maqsood I., & Chakma A., 2005). Developing the new method (combining the Environmental risk Assessment and Leopold matrix) we make the new software for environmental impacts assessment of oil refineries using the data from the reports of Health, Safety and Environmental (the HSE) department, Health, Safety and Environmental Auditing (the HSE Auditing) with special procedures weekly, monthly and annually and reports from different parts of an oil refinery give a rapid environmental impacts assessment, that can monitor the ways decisions are made for oil refineries. This model for environmental impacts assessment of oil refineries can give different results during two parts of design-construction and operation of parts of oil refineries. Reaction to environmental parameters can give the final results for environmental impacts assessment of oil refineries. The research objectives can be summarized as follows:

1. To upgrade methods used for EIA of oil refineries according to the operational needs with monitoring of the environment in various phases of environmental impact and environmental monitoring.
2. To make software with details of environmental parameters and items for design, construction and operation parts of oil refinery.
3. To evaluate and verify the accuracy validity of the software. The software gives appropriate insights to the managers and experts in the Iranian oil ministry especially for Iranian oil refineries.
4. The software capable to solve the problems of the environmental impact assessment of oil refineries and other similar projects in the field of Iran oil industry, based on environmental monitoring and decision-making, it helps to make the most appropriate choices.
5. The software will also help the decision makers to install and commissioning of new petroleum refineries, with consideration of environmental protection, prevent the current practices of uncontrolled designs in the Tehran oil refinery and other uncontrolled oil refineries construction in the environment, provide a field for decision-makers have the duty of bridging the gap between the indeterminacy of science and the political need to actively prevent harm, provide the precautionary principle has attained a wide degree of recognition, oil pollution risks and strategic planning.

2. Methodology

The main reasons for choosing the Environmental Impact Assessment of oil refinery in Iran are:

Recognition of environmental damages, identifying the effects of economic, social and cultural conditions, use of the public opinions in the process of decision-making of the project, identify

problems that lead to environmental damages due to the projects; prediction of important environmental impacts, identifying and evaluating the environmental effects of projects before, during and after the implementation. Balance between short and long term goals of developing the oil refineries in line with environmental protection, design software models to assess environmental impact of oil refineries in Iran, according to operational needs in the region. Using appropriate environmental impacts assessment software for specific application in oil refineries in Iran; lessening the negative effects of oil refineries, and speeding up the environmental impacts assessment of oil refineries in Iran with this new software; presenting the new model with modifying the Environmental Risk Assessment method and Leopold method and combining these two methods together.

For this research Leopold Matrix, Environmental Risk Assessment (ERA) and make software OREIA (Oil Refinery Environmental Impact Assessment) based on these methods has been considered for two phases: design-construction and operation of case study named Tehran oil refinery. The Leopold matrix is a qualitative environmental impact assessment method pioneered in 1971. It is used to identify the potential impact of a project on the environment. The system consists of a matrix with columns representing the various activities of the project, and rows representing the various environmental factors to be considered. Risk assessment is the procedure in which the risks posed by inherent hazards involved in processes or situations are estimated either quantitatively or qualitatively. In the life cycle of a chemical for instance, risks can arise during manufacture, distribution, in use, or the disposal process. Risk assessment of the chemical involves the identification of the inherent hazards at every stage and an estimation of the risks posed by these hazards. Risk is estimated by incorporating a measure of the likelihood of the hazard actually causing harm and a measure of the severity of harm in terms of the consequences to people or the environment. Risk assessments vary widely in scope and application.

For Leopold Matrix in two phases design-construction and operation these items has been considered; environmental parameters biological (fauna, flora), physical ambience (water, air, soil, solid waste, sound and their impacts), social ambience (economic impacts on social problems), cultural ambience (monuments and impacts on cultural and historical problems). For industrial and technical activities of design-construction and operation, all items related to oil refinery and especially for Tehran oil refinery has been considered for this research.

Totally ERA (Environmental Risk Assessment) based on five stages severity impact, probability impact, importance impact, impact type, significant impact. In each part some items have been considered. These items are the base of evaluation of environmental risk assessment method. Each part discuss of ERA details, terms and conditions. These details give a clear help of user for understanding of steps of decision making base on the ERA. Each subtitle of these five steps describes the effects of construction and operation phases on the environmental parameters by measuring the risks of these effects with the formulas that will come after these tables. These formulas are base calculations of ERA method. By using of these items the result of ERA will be consider in the software for getting results of EIA of oil refinery.

Table 1: Severity impact

1	Negligible	Tolerable –No significant impact over environment, human and communities
2	Moderate	Change of behaviour, immigration, tiny change of nature, negligible, limited, reversible impacts over humans, animals and social communities
3	Critical	Demolition of ecosystem, limited mortality, limited and reversible undesirable impact, moderate controllable pollution
4	Catastrophic	High mortality, high pollution, sever intoxication, undesirable and irreversible impacts over plants, animals, human and communities, undesirable ,irreversible, highly toxic, intolerable, profound pollution, uncontrollable

Table 2: Probability impact

Rare	Has not been seen yet, no history of the event
Seldom	Under emergencies and natural disasters (torrent, typhoon, earthquake, fire…)
Occasional	Under unusual circumstances and technical defect of equipments (machines)
Likely	Under periodical and planned conditions
Continuous	Occurs permanently and eternally

Table 3: Importance impact

Short term	Limited desirable or undesirable impact, short term pollution dissemination, short term operations
Long term	Limited desirable or undesirable impact, Long term pollution dissemination, long term operations
Reversible	Positive and negative impacts due to operations liable to restoration or correction, tolerable
Irreversible	Positive and negative impacts not due to operations liable to restoration or correction, intolerable
Indirect	Impacts of the operations indirectly affect ecological, economical, social and cultural environment. Derived from operations that are different temporally and spatially from place of consequence or impact occurrence which are nominated as secondary impacts.
Direct	Impacts due to operations directly affect physical and chemical environment. Operations that occur on same time and in the same place and seen as primary impacts.
Cumulative	The impacts that added to the past and present impacts and are not easily traceable. The cumulative impacts are derived from weak impacts accumulating during the time.

Table 4: Impact types

Positive	Desirable, with appropriate impact over physical, chemical, biological, economical, social and cultural environments.
Negative	Undesirable, with inappropriate impact over physical, chemical, biological, economical, social and cultural environments, unwanted.
No impact	No change, with no impact over physical, chemical, biological, economical, social and cultural environments.

Table 5: Significant impact

0-3	Green	no impact - low
4-6	Yellow	minor impact - moderate
7-10	Orange	major impact - high
10>	Red	critical impact - extreme high

$$\text{Extremely High Risk} = \frac{\text{Red Cells}}{\text{All Cells of Matrix}} * 100$$

$$\text{High Risk} = \frac{\text{Orange Cells}}{\text{All Cells of Matrix}} * 100$$

$$\text{Moderate Risk} = \frac{\text{Yellow Cells}}{\text{All Cells of Matrix}} * 100$$

$$\text{Low Risk} = \frac{\text{Green Cells}}{\text{All Cells of Matrix}} * 100$$

3. Result and discussion

The final results show the final report of environmental impact assessment of oil refinery in two phases below:

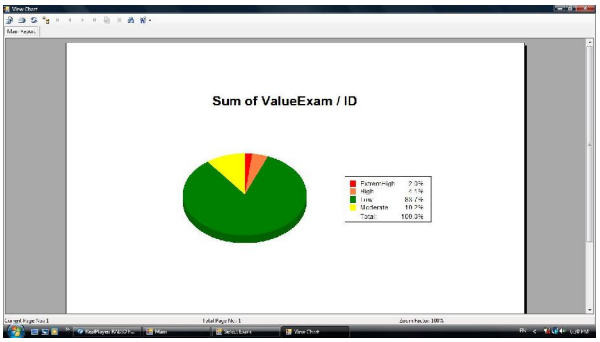

Figure 1: The final result of EIA design-construction phase

The results for construction phases show that important items:

1-Most parts of work are environmental friendly

2-For the phase design-construction nothing happened for extremely high

3-More information come from the results are:

3-1-Environmental Impact Assessment in design-construction phase has not extreme high effect on the environment because low effect (can pass) are more than other items. With consideration to the results it can find:

Tables 6: Compare the effect from design-construction phase result classified based on percentage

Items	Percent (%)
Low	83.7
Moderate	10.2
High	4.1
Extremely High	2.0

The table shows that low effect is more than every effect, so these effects from design-construction phase will not damage the environment. But for moderate items need to make decision in the site with experts and follow the environmental considerations to make it better for the environment. For moderate items need to have Technical meeting in the district office with site experts and follow the new solutions throe the environmental procedures. For high item in this case no need to have meeting for any items because no special impact is available. In processing phase 4 different effects happened. It means during this phase with operation in the site some problems maybe happened that was not expected during the design-construction phase. Something maybe happened during the operation and processing phase like: industrial accidents like (leakage, fire, and technical defect) and human errors (inattention, lack sufficient knowledge and insufficient education).

Decision-making

Base on results coming from data analysis for construction phase:

In this part by comparing results with standards, national regulations, international laws, environmental protection for oil refinery procedures and operational needed for each parts (low, moderate, high, extremely high) the EIA oil refinery will be analysis to achieve the solution, routes for environmental monitoring, natural resources protection and use the for another part means operation phase. On the other hand prepare a good background for similar projects in the oil industry to achieve the main target that is environmental solutions in the oil refinery project in the construction phase.

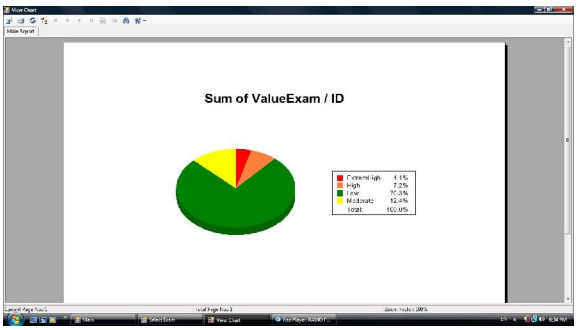

Figure 2: the final result of EIA operation phase

The results for operation phase show that important items:

1-Most parts of work are environmental friendly

2-For the phase operation something happened for extremely high

3-More information come from the results are:

In the operation phase 4 effects are available throe below table:

3-1-Environmental Impact Assessment in operation phase has extreme high effect. With consideration of the result it can find as follow:

Tables 7: Compare the effect from operation phase result classified based on percentage

Items	Percent (%)
Low	76.3
Moderate	12.4
High	7.2
Extremely High	4.1

In the processing phase low effect is more than other items, so all system is environmental friendly. Except these items (Low, Moderate, High), extremely high added in this phase. The solutions for another three item same as last phase. But for the extremely high need the special reaction throe the regulations of oil industry. It means need to have the meeting with experts in the main office of petroleum industry with general managers and shut down the facilities that need to maintenance and give the reserve part in the service till the main facilities repaired and come back to the service again. All these items follow the rules and regulation of petroleum industry, department of environment regulations; revised environmental procedures follow the new solution ways.

For this phase with consideration of each part of effects from EIA data in the case extremely high the process will shut-down. In this case, base on the data collection form environment, operational utilities, process facilities, technical details of oil refinery, operational procedures, review of data analysis with the software and technical meeting the best results will collected to make a solution way for extremely high part.

Decision-making

Results show the special terms for EIA oil refinery. However the most part of operation phase is environmental friendly but strongly parts of this phase have negative effects on the environment. So decision-making in this phase is difficult. For make the solutions routs should be considered in two important items:

(a) Environmental protection and values of natural resources such as: natural products, life cycle, economical values of natural resources, biodiversity and land use options and other factors.

(b) Economical values of oil refinery operation such as: cost-benefit of oil refinery productions, utilities systems, process facilities and goods and services and other options.

Due to these (a) and (b) items above decision-making generally depends on natural resources protection, environmental economy and oil refinery economy. So base on the environmental problems the process of each utility that make a problem for environment in any case such as (moderate, high and extremely high) should shut down and going under maintenance and repair. In any case risk probabilities are important for making much more environmental problems coming from utilities. With use these procedures decision-making is better: HSE (Heath, Safety and Environment) procedures of oil refinery, operational procedures, and maintenance and repair operational utilities standards. Because of importance of the environment achieve the basic solutions for operation phase is very important. So with using the standard oil refinery facilities base on API (American Petroleum Institute), NIOC (National Iranian Oil Company) safety regulations, NIOC-HSE criteria, standard for operation and process of oil refineries, environmental laws and regulations make better EIA of oil refinery results recovery for environmental problems.

4. Acknowledgment

To make the report more comprehensive and to accelerate the process of its reviewing, observation of the following issues are recommended:

1. The main information must be presented in the 1st page and before the non-technical Abstract of each report of synoptic evaluation. This information includes name and subject of the project, name of the administrator (employer or investor of the project, name of management organization or ministry, name and specifications of the representative of project for preservation of relation, name of consultant and producer of the report, type of report ad date of preparation.)

2. Using drawing, picture, graph and table for presentation of statistics and information and presentation of the results, are influential methods for getting familiar with the project and comprehending the materials by the examiners and decision makers.

3. Contents of the report must be simple, clear and explicit. Use of the ambiguous contents , heavy phrases and complicated analyses in the report, make the process of examining more difficult.

4. Presentation of too specialized information must be prevented. Such statistics and information can be presented along with their references in the appendices.

5. The report must be scientific, logical and without any comment in order that the readers can have the chance of independent analysis.

6. Order of the chapters and parts of the report must be according to the items inserted in the guide of preparing report of synoptic evaluation.

7. To complete the information and being assured of their correctness and care, the place of execution of the project, locations and regions must be possible to be inspected.

8. Presentation of real and exact information, survey of real effects and logical conclusion by the report producers, make the commenting easier and prevent from time and energy waste.

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