ROLE OF CDM IN OIL AND GAS INDUSTRY

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Bachelor of Technology
(Gas Engineering)

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CERTIFICATE

This is to certify that the Project Report on **"ROLE OF CDM IN OIL AND GAS INDUSTRY"** submitted to University of Petroleum & Energy Studies, Dehradun, by Mr. Dilip N. S. Srinivas Pallapothu in partial fulfillment of the requirement for the award of Degree of Bachelor of Technology in Gas Engineering (Academic Session 2004 - 08) is a bonafide work carried out by them under my supervision and guidance. This work has not been submitted anywhere else by anyone for any other degree or diploma.

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ABSTRACT

The main purpose of CDM is to enable sustainable development and fight climate change. Oil and Gas industry is one of the biggest source of Gren House Gas emissions in the world. The main objective of this project is to identify different processes in this huge industry where CDM can be implemented and emissions can be reduced and some contribution can be made in the fight against climate change and global warming.

The biggest advantage of implementing CDM for these emission reduction projects is that it improves the IRR of the project by a healthy margin. As the technology used is improvised, the developing countries will have access to cleaner technologies. Also, the skill and the knowledge of of the people working on these projects would improve. The entire project would make a positive impact on the society.

The cases used in this project are from the Oil and Natural Gas Corporation (ONGC) Limited which recognised the benefits of CDM and already implementesd it in three of its projects and has many more projects in the pipeline.

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1.1 History of CDM

Adopted at the Third Conference of Parties (COP-3) to the United Nations Convention on Climate Change, the Clean Development Mechanism is an emission trading mechanism designed to simultaneously benefit developing and industrialized countries. The CDM is the only flexibility mechanism created by the Kyoto Protocol that involves developing countries. Innovative and complex, the mechanism is designed to stimulate emission reductions in the developing countries, while also promoting sustainable development. Ideally, it will encourage additional capital flows into developing countries, accelerate technology transfer, and enable developing countries to leapfrog to cleaner technologies. At the same time, it is intended to help developed countries achieve their emission reduction commitments at a lower cost than would otherwise be possible. Whether the CDM achieves these aims or not will depend to a great extent on the ability of project developers, host countries and other stakeholders to implement it efficiently, and in ways that promote social, economic and environmental objectives and maintain the integrity of the Kyoto Protocol. This chapter describes the CDM's evolution and objectives and the kinds of human and institutional capacity necessary to make it a success.

1.2 Climate Change and Sustainable Development

Climate change is not simply an environmental issue. Rather, it is a part of the larger challenge of sustainable development. It is also one of the most serious threats to poverty eradication. In 2000, in committing themselves to the Millennium Declaration, the world's leaders resolved to improve the quality of life of poor people through the achievement of global development objectives. Of the eight fundamental Millennium Development Goals, foremost is the commitment of 189 nations to reduce by half the proportion of people living in abject poverty by 2015. The Millennium Development Goals recognize the fundamental connection between energy, environment and sustainable development. Similarly the Delhi Declaration on climate change and sustainable development (agreed to at the Eighth Conference of the Parties to the

UNFCCC in 2002) highlights the principle of common but differentiated responsibilities of countries to address climate change, reaffirms development and poverty eradication as overriding priorities in developing countries and emphasizes the integration of climate change objectives into national sustainable development strategies.The five key thematic areas for the sustainable development are water, energy, health, agriculture and biodiversity (collectively called WEHAB). Climate change is recognized as a cross-cutting issue that impacts all of the five WEHAB areas, one that is integral to a coherent approach to sustainable development. Thus, addressing climate change should be integrated into national strategies for poverty eradication. In theory, CDM can assist in accomplishing this objective through partnerships with diverse stakeholders and innovative policy formulation and implementation. This will require increased human, institutional and system-wide capacity at the national level and enabling policies, laws and regulations in the host countries.

1.3 Operatinalizing the CDM

An important outcome of COP-8 (Delhi, 2002) was to enact many decisions to make the CDM fully operational. At that meeting, simplified modalities and procedures for small-scale CDM project activities were also adopted.

Participation in a CDM project activity is voluntary and investments in CDM will be market driven. While both public and private entities are eligible to participate in CDM, investments are likely to be private sector driven. CDM activities must lead to quantified reductions in emissions, which will be transferable to the investor in the form of CERs, a marketable commodity in the carbon market under the Kyoto Protocol. Contributions to sustainable development shall be a primary product of CDM projects in the host countries. The definition of sustainable development or how CDM projects should contribute to it is considered the host country's prerogative.

CDM promises to generate additional resources for investment in renewable energy, energy efficiency and other projects to reduce greenhouse gas emissions. Although it will not solve all development problems of host countries, CDM can potentially influence investments, technology and economic growth. However, the non-Annex I countries differ widely in terms of national capacities to utilize technology, access finance and efficiently implement CDM activities.

There appears to be a high demand from the developing countries for initiating CDM transactions. Their successful implementation, however, will depend on the presentation of viable projects capable of attracting foreign investments and on the assurance of efficient transactions. This, in turn, will demand clearly defined sustainable development priorities by host countries, as well as the institutional capacity and system-wide support to make the project approval process transparent, fair and efficient.

CDM outcomes must be evaluated from a long-term equity perspective, that is, by considering how these projects can create capacity for implementation of mitigation activities and increase the number of win-win options that will result in a high-growth, low-carbon trajectory within the financial, institutional, and technological reach of host countries. Strengthening broad based capacity that fully integrates equity concerns into the CDM will foster the ability of host countries to eventually undertake emissions reductions of the magnitude that will be required globally, while maintaining their commitment to sustainable development. The key to this is long-term thinking.

1.4 The CDM in brief

The CDM has two primary goals:

1) To assist Annex I countries in reaching their emission reduction targets.
2) To promote sustainable development objectives in the host countries (non-Annex I countries).

The first goal allows developed countries to achieve part of their reduction obligations through projects in developing countries that reduce emissions through clean energy, energy efficiency and renewable energy projects or sequester CO_2 from the atmosphere in the form of biomass through reforestation or afforestation.

The main characteristics of CDM are:

1) Participation in a CDM project activity is voluntary and CDM investments will be market driven. Public and private parties are eligible to participate.
2) CDM activities must lead to measurable reduction in emissions, which will be transferable to the investor in the form of certified emission reductions, or CERs, upon quantification and certification by a third party.
3) Contributions to sustainable development in the host country are a primary aim of CDM projects. The definition of sustainable development or how CDM projects should contribute to it is considered to be the host country's prerogative.

The CDM allows transfer of CERs to a parties investing in such projects. This market-based system will allow individual firms, as well as countries, to select the most cost-effective solutions to mitigating greenhouse gas emissions.

1.5 Greenhouse Gases Addressed by CDM

The Kyoto Protocol addresses mitigation of the six gases believed to be the main contributors to the climate change effect, which is associated with an increase in the global temperature and disturbed climatic patterns. The relative impact caused by the release of greenhouse gases into the atmosphere is measured by the global warming potential or GWP. Global warming potential is an index defined as the cumulative radiative forcing between the present and some chosen time horizon caused by a unit mass of gas emitted now, expressed relative to a reference gas such as carbon dioxide. The Intergovernmental Panel on Climate Change is responsible for setting and adjusting the indices based on the most current scientific knowledge.

The three greenhouse gases most frequently found in nature are:

1) Carbon dioxide (CO_2) – a naturally occurring gas released as a by-product of fossil fuel combustion, selected industrial processes and changes in the patterns of land-use, particularly deforestation. In terms of gross volumes of emissions, it is

by far the most important greenhouse gas. Carbon dioxide is given the global warming potential (GWP) value, 1.

2) Methane (CH_4) – a gas released in coal mining, landfill operations, livestock raising and natural gas/oil drilling (among other processes). Methane has a GWP of 21.
3) Nitrous oxide (N_2O) – a gas emitted during fertilizer manufacturing and fossil fuel combustion. The transportation sector is usually a significant contributor to N_2O emissions. It has a GWP of 310.

Human activity clearly contributes to the increased concentrations of CO2, CH4 and N2O in the atmosphere, but they can also be released through natural processes. It is expected that the vast majority of CDM projects will involved these gases.

In addition to these three greenhouse gases, there are three additional classes of engineered gases, which occur on a very limited basis in nature.

1) Hydrofluorocarbons (HFCs) – a group of gases emitted in selected manufacturing processes and frequently used in refrigeration and air conditioning equipment. HFE-23, HFC-12, HFC-134a and HFC-152a have GWPs of 11700, 2800, 1300 and 140 respectively.
2) Perfluorocarbons (PFCs) – similar to HFCs, PFCs were developed and introduced as an alternative to ozone depleting CFCs and HCFCs. They are emitted in a variety of manufacturing processes. Their GWP ranges from 6500 for CF_4 to 9200 for C_2F_6.
3) Sulfur Hexafluoride (SF_6) – the most potent greenhouse gas, released in a very limited number of manufacturing processes where it is used as a dielectric fluid. The GWP of SF_6 is 23900, and one molecule of SF6 has an atmospheric lifetime of 3200 years. Hence SF6 represents the most dangerous group of anthropogenic-inducted greenhouse gas emissions.

Chapter 2: CDM Project Types

A generic description of CDM projects include:

2.1 Energy efficiency projects

- Increasing building efficiency.
- Increasing commercial/industrial energy efficiency.
- Implementing fuel switching from more carbon-intensive fuels (such as coal and oil) to less carbon-intensive fossils (such as natural gas and various alternative energy sources). Fuel switching also includes re-powering, upgrading instrumentation, controls and/or equipment. Fuel switching projects can also refer to new or to be developed projects.

2.2 Methane Recovery

- Animal waste methane recovery and utilization (methane recovery technologies include installing an anaerobic digester (microbial breakdown in a controlled environment capturing the Methane) and utilizing methane to produce energy).
- Coal mine methane recovery (collection and utilization of fugitive methane from coal mining).
- Capture of biogas (landfill methane recovery and utilization).
- Capture and utilization of fugitive gas from gas pipelines.
- Methane collection and utilization from sewage/industrial waste treatment facilities.
- Methane collection and utilization from any additional sources not mentioned above.

2.3 Industrial process changes

Any industrial process change resulting in the reduction of any category greenhouse gas emissions.

2.4 Cogeneration

The use of waste heat from power generation such as exhaust from gas turbines for industrial purposes or heating.

2.5 Transport

- Improvements in vehicle fuel efficiency by the introduction of new technologies.
- Changes in vehicles and/or fuel type, for example, switch to electric cars or fuel cell vehicles.
- Switch of transport mode, e.g. changing to less carbon intensive means of transport like trains.
- Reducing the frequency of the transport activity.

2.6 Agricultural sector

- Energy efficiency improvements or switching to less carbon intensive energy sources for water pumps (irrigation).
- Methane reductions in rice cultivation.
- Reducing animal waste or using produced animal waste for energy generation.
- Any other changes in an agricultural practices resulting in the reduction of any category of greenhouse gas emissions.

2.7 Land use

In the first commitment period (2008-2012), this category is limited to afforestation and reforestation activities.

Chapter 3: The Project Cycle

3.1 Steps in a Project Cycle

The various steps in a CDM project cycle are:

1) **Project identification**
2) **Project idea note**
3) **Project design document**
4) **Stakeholder participation**
5) **Host country approval**
6) **Validation by a designated operational entity**
7) **Registration**
8) **Implementation and monitoring**
9) **Verification**
10) **Certification and issuance of credits**

3.1.1 Project Identification

A potential CDM project can be identified by host country project developers/operators. These may be private companies, NGOs, governments, international organizations or international investors. Once a project is identified, the project developer must ascertain whether the project is eligible under the CDM and will have the support of the host country. Considering that the CDM rules are still evolving, a conservative approach should be taken when assessing the eligibility of the project under CDM.

As the first step, a project developer makes an initial assessment as to whether the project is eligible under the CDM.

3.1.2 Project Idea Note (PIN)

If the answers to the questions in eligibility exercise were favorable, the project developer and/or their advisors should develop and submit a project idea note, or PIN, to one or more carbon credit buyers in the marketplace to gauge a level of interest in the project. The project idea note will subsequently be screened by the recipient entities against the CDM rules and their investment criteria. The information requested in the project idea note depends on the specific rules of the buyer. Even so there are great similarities between most of the PIN formats. Most private buyers also prefer to see project idea notes as their first form of contact with potential projects.

Development of a project idea note is not a requirement of the CDM process. The benefit of preparing a project idea note is that the developer will receive feedback indicating whether or not the project is of interest to potential buyers. The project idea note represents an inexpensive way to get market feedback without engaging the entire CDM process. Different buyers may have dissimilar motivations in the marketplace and consequently look for different types of projects.

Basically a project idea note will consist of approximately five pages providing indicative information on:

- Type and size of the project
- Its location
- Anticipated total amount of greenhouse gas reduction compared to the 'business-as-usual' scenario
- Suggested crediting life time
- Suggested CER price in US$/tCO2 equivalent reduced
- Financial structuring (indicating which parties are expected to provide the project's financing)
- Project's other socio-economic or environmental effects/benefits

While every effort should be made to provide as complete and extensive information as possible, it is recognized that full information on every item listed in the template will not be available at all times for every project.

3.1.3 Project Design Document (PDD)

The project design document, or PDD, is the key documentation in the project cycle, and completing it is complex undertaking. The PDD is submitted to a designated operational entity for validation, and once validated, to the CDM Executive Board for registration. As opposed to a PIN, a project design document is a necessity. No project can earn CERs without the development, validation and Executive Board acceptance of it. The PDD can also be a valuable sales tool for potential investors.

3.1.4 Stakeholder Participation

Stakeholder participation and public meetings are effective – indeed vital – to ensure transparency in the CDM process. For CDM projects there is a specific requirement to invite local stakeholders for comments.

Accordingly project developers must:

- Invite local stakeholders to comment on the project design document
- Provide a summary of the comments received
- Review comments received and provide a report, demonstrating how relevant concerns were addressed. This report has to be submitted for validation by the operational entity

This local stakeholder's consultation process is distinct from the invitation for comments from stakeholders by the designated operational entity, during the project validation phase. Stakeholders at the international level are invited to provide their comments regarding the specific CDM components of the activity. In contrast to local stakeholders the international stakeholders are not actively approached; they are made aware of new CDM projects. The rationale is to empower the international and/or national community, especially NGOs, to monitor projects proposed for the CDM. While the Marrakech Accords refer to accredited NGOs, it is clear that some NGOs will be more competent than others to provide constructive feedback to the CDM activity in the host country.

3.1.5 Host Country Approval

CDM projects have to be approved by the host country. Host country approval is one of the key components to ensure that governments retain all sovereignty over their natural resources, including over their ability to mitigate emissions. Apart from approving the development of the proposed project under CDM, it is also the host country's responsibility to confirm whether a CDM project activity will help it meet its own sustainable development criteria. A host country is accorded an enormous amount of leeway in choosing to accept or reject the CDM component of particular projects.

The Marrakech Accords and Delhi Declaration do not provide specific guidance on the form or content this approval should take, except to note that it should be a 'written' approval from its designated national authority. Accordingly, subject to further clarification from the Executive Board and COP/MOP, an official Letter of Approval from the designated national authority will serve as evidence of host country acceptance. The letter should state that the host country accepts the project as well as recognizes its contribution to sustainable development. However, depending on the situation and national practices in the host country, other formats containing the necessary information may be used.

The project developer is responsible for the project submission to the appropriate authorities in the host country as part of the process of host country acceptance of the CDM project.

In order to facilitate this process the project developer should:

- Check the UNFCCC website to determine who/what entity (agency) has been designated as the national focal point or authority for climate change issues.
- Check with the focal point to see if the country has established any guidelines or procedures for approving CDM projects.

- Check the status of a host-country with regards to meeting eligibility criteria for the CDM. If a county did not ratify the Kyoto Protocol, projects within its borders will not be eligible under the CDM. The risk of starting a CDM project in a country that is not a Party to the Kyoto Protocol is borne by the project developer.

3.1.6 Validation by a designated operational entity

Once the project design document has been completed and the host country approval has been received, all documents have to be submitted to a designated operational entity, or DOE, for review and approval – a process called validation.

Validation is the process of evaluation of all relevant documents for a CDM project activity against the requirements for CDM as set out in the Kyoto Protocol, the Marrakech Accords and the Delhi Declaration. Validation occurs at the outset of a project and is distinct from verification, which occurs during the operation of the project. In effect, the validation process confirms that all the information conveyed and assumptions made within the project design document are accurate and/or reasonable. The designated operational entity will ground-truth data on greenhouse gas emissions, as well as data and assumptions made regarding technical, social, political, regulatory and economic impacts of the project activity, as included in the project design document.

It is generally the responsibility of the project developer to arrange for validation and to contract, and pay for, the services of a designated operational entity. Though there are purchasers who will absorb these costs, it should be expected that those costs will ultimately be subtracted from the eventual CER transaction. The project developer has to submit the following documents to the designated operational entity for validation:

- The project design document.
- Confirmation from the host government that the project meets host country requirements, fosters sustainable development and has been approved.

The designated operational entity solicits public comments on the validation report. The validation report is then submitted to the Executive Board. The Executive Board makes designated operational entity validations available for public comment for 30 days on the UNFCCC website and collects comments from the general public on the report.

3.1.7 Registration

Registration of the project with the CDM Executive Board is the act of formal acceptance of the validated project. The request for registration of a CDM project is the responsibility of the designed operational entity. The DOE submits the validation report and host country approval to the Executive Board for registration.

The review by the Executive Board must be related to issues associated with the validation requirements for CDM projects. Until the review is finalized by the Executive Board, the decision for validation is not final and thus the project cannot be registered. Apart from the mandatory registration of the CDM project with the Executive Board, the host country may also require registration of the project. It is advised to check with the designated national authority in the host country for requirements regarding registration of CDM projects.

3.1.8 Implementation and Monitoring

Once the project has been registered, it can be implemented. Since CERs can accrue from the point of validation during this first stage of the CDM, certain projects may already be implemented prior to registration during these first several years. From the point of implementation on, the project developer needs to start monitoring the project performance, according to the procedures laid out in the validated monitoring plan of the project design document. The monitoring results have to be submitted to a designated operational entity for verification and certification.

The project developer is responsible for monitoring the project's performance according to the requirements set out in the validated monitoring plan. However, the performance of the 'business as usual scenario' – or baseline – may or may not have to be monitored, depending on requirements of the buyer, during the period for which the baseline has been fixed and validated by a designated operational entity. Even if the buyer does require monitoring, the baseline is fixed for at least seven years, when it may have to be adjusted according to new data.

At the very minimum, technical project performance, including the project output and the related greenhouse gas emissions has to be monitored. In addition, environmental impacts and leakage effects of the project have to be monitored. Where possible, the monitoring should be carried out in accordance with existing monitoring activities, to the extent possible. For example, the monitoring of a power generation project should be linked with activities related to the sales of electricity.

Although the monitoring plan should specify the frequency of monitoring activities, no specific frequency is required. However, CERs can only be issued after verification of the monitored data. The frequency of monitoring does not necessarily have to be equal to the frequency of verification. Based on the monitoring results, the greenhouse gas emission reductions from the CDM project activity can be calculated and submitted for verification as CERs. CERs are based on reductions during the specific time period for which the monitoring results are provided.

3.1.9 Verification

The project developer is responsible for contracting a designated operational entity to carry out the verification process. Verification is the periodic review and ex-post determination of the monitored greenhouse gas emission reductions that have occurred as a result of the CDM project. The designated operational entity verifies the data collected by the developer according to the monitoring plan. As previously noted, the DOE contracted for verification should not be the same one that carried out the validation process, except in the case of small-scale projects or when specific approval has been granted by the CDM Executive Board. The verification process confirms the total number of CERs resulting from CDM projects during a specific period of time.

The frequency of verification is mainly a choice of the project developer, assuming the designated operational entity accepts the decision. Frequent verification (for example, every year instead of every three years) increases transaction costs, but also allows for more frequent transfer of CERs.

The designated operational entity shall make the monitoring report publicly available and submit a verification report to the Executive Board. This report is also to be made publicly available. The Executive Board provides a list of DOEs that can be contracted to carry out verification activities on its website.

3.1.10 Certification and Issuance of Credits

Certification is the written assurance by a designated operational entity that during the specified time period, a project activity achieved the reductions in greenhouse gas emissions as stated and verified, in compliance with all relevant criteria. This process of certification is required for CDM projects.

The designated operational entity also conducts validation and verification and is liable for eventual mistakes, misrepresentations, and fraud in this process. Certification is effectively a form of liability transfer; once the DOE has signed off, any underperformance of the CDM project with respect to the quantity or quality of the CERs is the responsibility of the DOE. Consequently a designated operational entity must carry adequate liability insurance.

The certification report prepared by the designated operational entity should consist of a request to the Executive Board to issue the amount of emission reductions that have been verified by the DOE as CERs. When the Executive Board approves the issuance of CERs, the CDM registry administrator, working under the authority of the Executive Board, will forward the CERs into the appropriate accounts. This includes, if applicable, the account for the share of proceeds, for administrative expenses and forwarding the remaining CERs to the project developer, and the 2 per cent of the CERs required to go into the adaptation fund.

Chapter 4: Developing the Project Design Document

4.1 Project Description

The first part of the project design document is a description of the project. While some of this information can be taken from the project idea note, the PDD requires some additional information as well. At the very minimum the following project information is required:

- Title of the project activity
- Purpose of the project
- List of project participants
- Technical description of the project, including location, category, technical performance information, description of opportunities for technology transfer, and explanation of how the reduction in greenhouse gas emissions is to be achieved
- Justification that public funding, if used, is not being diverted from other uses.

Additional recommended information:

- Project background
- Problems and barriers being addressed by the project
- Project planning (timetable)
- Description of the key issues and stages in project development (milestones)
- Any other information deemed relevant within reason – lengthy documents generally do not receive extra attention.

Much of this required information can be taken directly from a business plan or project proposal. Information marked as proprietary or confidential does not have to be disclosed, unless this is required under the national law of the host country. The following information cannot be considered as proprietary or confidential:

- The determination of whether the emission reductions in anthropogenic emissions are additional
- The description of the baseline methodology and its application
- Information supporting an environmental impact assessment requirements.

4.2 Baselines Methodology and Assessment of Additonality

According to Article 12.5c of the Kyoto Protocol, CDM activities must generate emission reductions additional to any that would have occurred in the absence of the project activity. The purpose of the baseline analysis is to provide a transparent picture of what would have happened without the proposed project. This is commonly referred to as the 'business-as-usual' scenario. The analysis also provides information on the estimated project emissions.

An estimate of greenhouse gas emissions, both in the project situation and in the absence of the project, is the foundation for determining the emissions reductions that can be claimed under the CDM. The baseline represents a scenario based on certain assumptions, and is therefore a subjective estimation. To maintain the project's environmental integrity, a conservative approach should be taken. The selections, assumptions and calculations made should be presented in a clear and transparent manner and the choices justified.

The steps to developing a credible and transparent baseline for a CDM project are:

- Choosing a baseline approach
- Adopting – or creating – a baseline methodology
- Defining the project boundaries
- Forecasting what emissions would occur under the 'business as usual' scenario
- Assessing future emissions from the project
- Assessing leakage

- Calculating projected emission reductions to be claimed upon future verification

4.2.1 Choosing a baseline approach

The most significant step in setting an emission baseline is selecting the baseline approach, which provides the basis for a baseline methodology. When presenting the baseline formula calculations, the emissions should be transparently presented. In the Marrakech Accords three different baseline approaches have been identified for CDM projects. These include:

- Use existing, actual or historical greenhouse gas emissions, as applicable.
- Use greenhouse gas emissions from a technology that represents an economically attractive course of action, taking into account the investment barriers.
- The average emissions of similar activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance ranks among the top 20 percent of their category.

4.2.2 Adopting or creating a baseline methodology

A baseline methodology is an application of any of the above approaches and can be identified on a case-by-case basis. Before developing the emission baseline it is recommended to check with the CDM Executive Board to see what baseline methodologies have been accepted. A project developer is free to develop a new methodology not included in the list. However, a new methodology has to be approved by the CDM Executive Board before any project developer can use it.

4.2.3 Defining the project boundary

In order to determine which greenhouse gas emissions need to be estimated and calculated for establishing the emission baseline and project emissions, the project boundary has to be defined. A project boundary comprises all anthropogenic emissions by sources of greenhouse gases under the control of the project participants that are significant and reasonable attributable to the CDM project activity. The activities and greenhouse gas emissions that are included in the project boundary reflect:

- Activities that will be included in the emission baseline and baseline calculations.
- Activities and greenhouse gas emissions that will be monitored once the project is operational.

Emissions from activities that are directly related to the project output and site location should be included within the project boundary. Emissions related to activities not directly related to the project can be excluded. Exceptions can be made when it can be clearly demonstrated that the impacts of a direct activity are very small, or negligible, compared to the total. These may be excluded from the project boundary. Conversely, when emissions from indirect or off-site activities are considered significant and within control of the project developer, these emissions should be included in the project boundary. These impacts should be estimated on a case-by-case basis and the decisions must be justified.

It is recommended that the project boundaries should be drawn in the form of a flowchart that clearly shows included and excluded emission sources. The emission sources that are included should be those that are considered to be within the control of the project.

4.2.4 Establishing additionality within the boundaries

The concept of additionality is critical to CER determination. CDM projects have to "generate emission reductions that are additional to any that would have occurred in the absence of the project activity." Additionality directly refers to whether of the project activity results in a lower volume of greenhouse gas emissions – or greater sequestration of carbon in the case of forest sinks projects – relative to the 'no-project' case. The issue of additionality is particularly important to prevent benefits from the CDM process going to projects that would have happened anyhow or have already been undertaken.

Not all projects that appear to have positive greenhouse gas impacts are additional. For example, renaming an existing hydroelectric plant as a CDM project will not result in additional greenhouse gas mitigation. Projects that are undertaken to meet legal or policy obligations also would have a difficult time demonstrating additionality. Eligibility demands that a project developer clearly demonstrate that the project's practices are 'additional' to what would otherwise have occurred (that is, compared to the 'business-as-usual' or baseline scenario). It is necessary to demonstrate that the project was initiated, at least in part, with the objective of reducing greenhouse gas emissions.

4.2.5 Developing an Emissions Baseline

In any case, the emission baseline has to be established in a transparent manner with regard to the choice of approaches, assumptions, methodologies, parameters, data sources and other key factors. Emission baselines have to take into account relevant national and sectoral policies and circumstances such as sectoral reform initiatives, local fuel availability, power sector expansion plans and the economic situation in the project sector. All these factors should be addressed when setting the emission baseline and then translated in the calculation of the baseline emissions.

The baselines assumptions and study are validated by an operational entity to ensure that the analysis is undertaken within all the relevant guidelines of the approved methodology. Members of the international CDM community also may comment and raise concerns about the baseline to the Executive Board during the 30-day commenting period.

4.2.6 Projecting project emissions

In order to determine whether a CDM project will make financial sense, its projected future emissions have to be estimated at the outset. Similar to the baseline emissions, project emissions need to be estimated and calculated in a transparent manner for each year during the crediting period. For purposes of the project design document, emissions have to be projected from the project startup to the end of the crediting period.

In most cases, the project boundary selected for the emission baseline will also apply to measuring greenhouse gas emissions resulting from the project. If the two boundaries are different, an explanation should be provided.

4.2.7 Accounting for Leakage

Leakage refers to indirect and off-site greenhouse gas emission flows that are outside the project boundary and thus not accounted for in the baseline. It can be extremely difficult to identify and/or control leakage. If the quantity or leakage is significant, the project boundary should probably be redrawn to capture it so that the emissions become a part of the baseline calculation. In any case, the project developer should assess account for and calculate potential points of leakage, and the same should subsequently be a part of the monitoring plan.

Leakage does not disqualify a project's validity, unless the projected values of emissions under leakage are potentially significant and cancel out a sizeable percentage of the projected greenhouse gas emission reductions from the project. In such a case, as noted above, all attempts should be made to formally incorporate the source of the leakage into the project boundaries (and therefore into the baseline and emission scenarios).

4.2.8 Calculating net emission reductions

The net emission reductions generated by a project is calculated by subtracting the total project emissions from the baseline emissions and adjusting for leakage. Calculations should be made for each year of the crediting period and expressed in tons of CO2 equivalent. As with the other calculations, all numbers and assumptions must be transparent.

4.3 Crediting Period

The PDD must define the period that the project developer seeks to earn credits. The crediting period is an important determinant of emission reductions that can be generated from and claimed for a CDM project. The crediting period thus has a direct impact on the value of the project.

During the crediting period the defined emission baseline cannot be adjusted or revised. The crediting period will often differ from the project lifetime. The project lifetime is, in general, longer than the period over which carbon credits can be claimed. For the CDM, project developers have two options to determine the crediting period. They are:

- A crediting period for a maximum of seven years, which may be renewed at most two times.
- A maximum crediting period of ten years with no option for renewal.

An important consideration in selecting the crediting period for a CDM project is the period over which the emission baseline (against which emission reductions are measured) is fixed. A fixed emission baseline is set and agreed upon when the project is designed. Once validated it cannot be renewed. This issue should be reviewed during project development. Choice of crediting period is a strategic decision that involves consideration of the emissions trajectory of the sector in question.

4.4 Monitoring Plan

A monitoring plan is a required element of the PDD. The plan outlines how data will be collected from the project once it is operational. Although the monitoring plan is supplied to the designated operational entity for validation (and must be validated as part of the project design document), the project developer is responsible for implementation of the monitoring plan and sending the results to the designated operational entity for future verifications of CER production.

Information required in the monitoring plan:

- The boundaries of what will be monitored are defined.
- The means by which relevant data will be collected and archived. (Monitored data should be kept for two years after the end of the last issuance of CERs.).
- The frequency of data collection.
- How future leakage may be assessed and estimated.
- What the control procedures are, and how quality control for the monitoring process is dealt with.
- How the data on non greenhouse gas environmental impacts will be collected and archived.
- A justification of the choice of monitoring methodology.

Other information that can be helpful:

- Specifications of verification activities that will take place.
- Method of measurements and calibration methods.
- If applicable, explanation on how to deal with missing data.
- Duration of the measurements.
- Who is responsible for collection of the data?
- Who is responsible for archiving the monitoring data?
- Backup system for data collection.

- Who has the ultimate responsibility for carrying out all stages of monitoring process?

4.5 Assessing Environmental Impacts

The project design document should include an assessment of the environmental impacts of the project. This includes an assessment of non-greenhouse gas related impacts. If there are significant negative environmental impacts, these can disqualify the project from participation in the CDM, particularly if local or international stakeholders raise significant objections. For example, large scale hydropower projects involving significant flooding and dislocations.

The developer should consider whether the project may have significant impact on one or more of the variables listed below:

- Biodiversity
- Local air quality
- Water resource availability
- Water resource quality
- Soil contamination
- Soil erosion
- Noise level
- Use of natural resources
- Chemical usage and disposal
- Landscape pollution (such as wind farms)
- Overall process efficiency and waste managements

Any mitigation efforts to address such impacts should be clearly stated in the project design document. The developer should expect that the designated operational entity and third party observers will give close consideration to these issues.

If potential environmental impacts of the project are considered significant, or if an environmental impact assessment (EIA) or review is legally required by the host country, this has to be conducted and documented in the project design document. There are no specific indicators for determining what is considered a 'significant impact'. This will have to be assessed on a case-by-case basis. Sustainable development criteria can also provide guidance for determining the environmental impact.

4.6 Creating Stakeholder Consultation

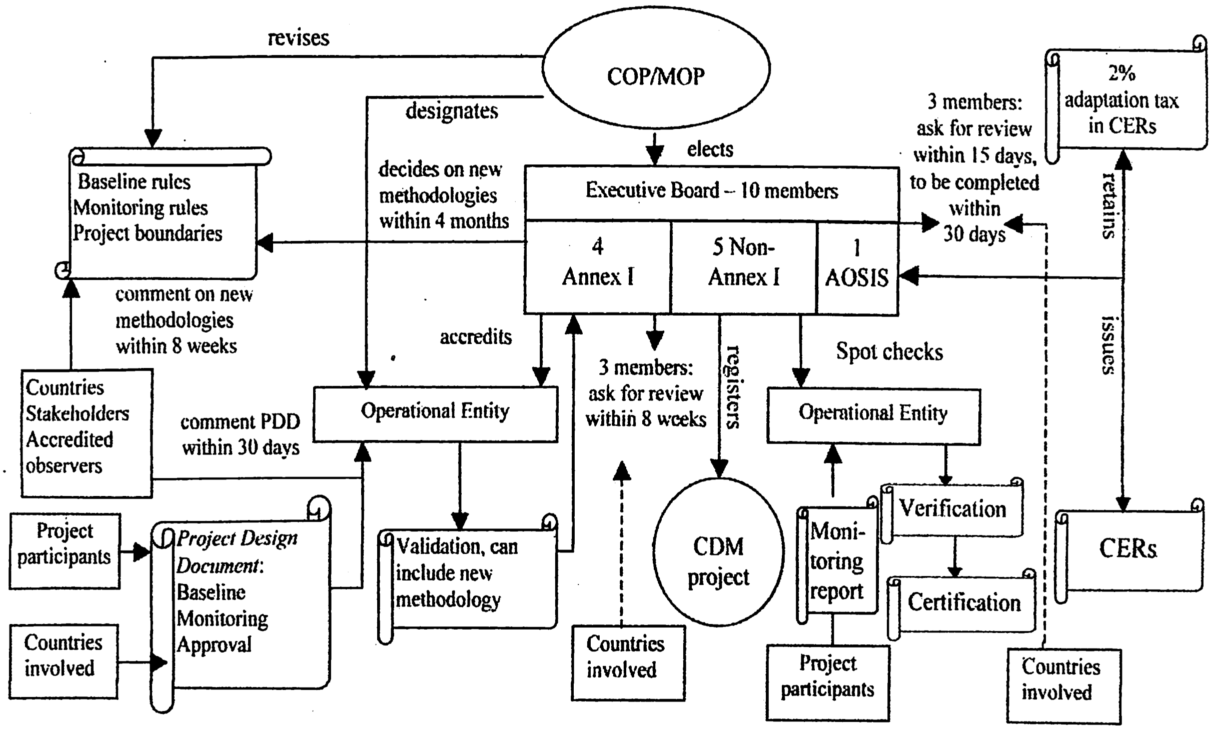
In the absence of further experience and guidelines, the following process could be applied in cases where a significant group of stakeholders outside the project participants is likely to be impacted. The project developer should:

1. Identify all local stakeholders affected or likely to be affected by the CDM project activity. These should include individuals, groups and/or communities.
2. Devise a program, which could include written and/or verbal explanation of the CDM, a description of the project and its probable impacts and an explanation of the project design document.
3. Invite the identified stakeholders for comments. This can be done by placing an advertisement in at least one local newspaper and invitation to stakeholders to provide written comments. The invitation should include the following information or state in the invitation that it is available upon request:
    - Information describing the JI/CDM mechanisms
    - The project design document
    - Information on the potential impact of the CDM project on the stakeholders
4. Record all responses. This can be accomplished either through minutes of the stakeholder meeting or in a written summary that identifies and responds to the main issues raised and includes contact information of the respondents.
5. Produce a written report on the consultation exercise for the CDM project validator. Written and verbal responses should be included in the final report. The report should present comments from the local participants including objections

or support for the project and clearly indicate the agreed measures to be undertaken by the developer to alleviate the concerns of the local participants. Contacts for participants should be provided.

In many host countries, project developers may find it difficult to define the constituency for the selected projects. Developing a knowledge base at the national level for this purpose could be a valuable asset in maintaining transparency and creating a pipeline that reflects national priorities for sustainable development.

4.7 CDM Institutions and Project Cycle as defined by the Marrakech Accords



Source: Adapted from Axel Michaelowa, 'Host Country Requirements to Make the CDM Process Nationally Efficient,' UNDP internal discussion paper, April 2003.

Figure 4.1: CDM Institutions and Project Cycle

4.8 Transparency in the CDM Process

Transparency is a critical element of the enabling environment that can be influenced by policies. Case studies of foreign direct investment suggest that investors will invest in countries if they are able to obtain reasonable clarity about the policy environment in which they will operate. A clear understanding of the procedural requirements that the developers must follow and the relationship between regulatory and support agencies is very useful. The CDM has addressed this issue by instituting a stringent process with checks and balances, including measures for public participation.

Participation of diverse stakeholders in the development of CDM project proposals is an important element in maintaining transparency as well. Throughout the project development process, parties independent from the project developer can review the proposed project. For example, local stakeholders, operational entities and international stakeholders are external assessors of proposed CDM projects.

A large number of non-governmental organizations are dedicated to ensuring that approved projects meet all of requirements of the CDM and have successfully followed the CDM project cycle. Such groups include the World Wildlife Fund, the World Resources Institute and CDM Watch. These NGOs are a crucial part of civil society and can foster due diligence throughout in the CDM process to ensure that the integrity of the Kyoto Protocol is maintained.

4.9 CDM and sustainable human development

As CDM projects are also expected to contribute to sustainable development, it is important that the CDM encourages projects and processes that advance a broader range of development goals, as well as efficient emissions reductions. Three major areas that will assist in this endeavor are:

- Emphasizing small scale projects.
- Seeking out projects that enhance human development.

- Uncovering opportunities for knowledge transfer.

The ability to achieve sustainable development will be improved through small-scale and community development projects in the CDM market.

In addition to working toward transparency in the CDM process, a growing number of organizations are working to ensure that the CDM contributes to sustainable development while reducing greenhouse gas emissions. Their major emphasis thus far has been on lobbying against projects that will negatively affect local communities and those projects that seem to fall short of meeting the additionality criteria. Examples of two such organizations are the World Wildlife Fund and CDM Watch.

4.10 UNDP's position on Carbon Trading

UNDP believes that developing countries must be empowered to negotiate effectively for fair market rules and high quality investments and technology under emerging market-based policies for addressing global climate change. Trading in carbon emission credits is a part of international agreements designed to combat climate change, thus effectively creating a new 'commodity' in international trade – one that is increasingly produced in the developing countries and consumed by more industrialized countries. International traders in this new commodity of carbon offsets should learn from the lessons gleaned from patterns of other globally traded commodities produced by the developing and less developed countries. UNDP advocates capacity development in all aspects of relevant human, institutional and system-wide issues and the creation of efficient and enabling environment and institutions for the developing countries that are producers of carbon credits. This will ensure that they have favorable terms of trade and ability to negotiate with the private sector and other buyers as equal partners.

Chapter 5: The Carbon Offset Marketplace

5.1 The Market for CERs

In the winter of 2002 the potential carbon credit demand in all Annex I countries was extensively researched and each country's position in the system of emissions trading was examined. The research concluded that demand for carbon credits exceeded supply by approximately 249.6 Mt CO_2e. The European Union 'burden sharing' agreement also places the EU in the position of a net carbon credit buyer with the approximate demand of 213.3 Mt CO_2e.

5.2 The Objectives of Buyers

A number of different buyers are entering the marketplace as well, with diverse objectives, including:

5.2.1 Purchase of low-cost emission reductions as investments

Most of the buyers are sensitive to the cost of emission reductions. Current market prices for CERs are quite low compared to prices forecast under many market studies. Current buyers may be able to sell at a much higher price in the future.

5.2.2 Minimization of future risk

This is a primary determinant of buyer behavior. Buyers are concerned about the potentially large liabilities associated with future non-compliance.

5.2.3 Risk-diversification

A number of buyers are purchasing different types of credits under all of the trading mechanisms in order to spread risk across a portfolio.

5.2.4 Learning-by-doing

Some buyers are keen to undergo early-stage learning by engaging in comprehensive project documentation, external verification and certification of CERs, in order to improve their knowledge of the market and reduce risks and transaction costs in the future.

5.2.5 Good publicity

Some buyers are purchasing credits in order to demonstrate that they are contributing to sustainable development and are concerned about the future of the global environment.

5.3 CER Transaction characteristics: Market size and Prices

The current emissions trading market is characterized by the following transaction types and prices, according to Natsource (2001) and Point Carbon (2001-2002):

- As of September 2002, over 125 transactions of greenhouse gas emission reductions are known to have occurred involving approximately 335 MtCO2e1 (more trades are likely to have gone unreported). Most of these trades have occurred in Annex I (B) countries.
- With respect to the CDM, there is price differentiation based on the perceived risks associated with different types of credits, with additional considerations given to the creditworthiness of the seller. Emission reductions with a perceived high likelihood of acceptance under the CDM are selling at a premium – between $32 -$8 per tCO2e. Other verified credits that are considered less likely to meet either host government acceptance or other verification criteria are selling at a discount, in the range of $1.75 to $3.00 per tCO2e.
- In 2002, the total market size, since 1996, involving private and publicly funded transactions of carbon credits reached between $350 million and $500 million (representing conservative and a liberal estimate, according to Natsource, October 2002). Total project volumes for 2002 are estimated at 70 Mt CO2 versus last year's volume of 12 Mt CO2.

As of late 2003, the market prices ranged between about \$3-\$10 per tCO_2e, with the majority of transactions at the lower range. Predictions about future prices are helpful in that they provide a rough sketch of market activities as they happen. However, price forecasts in this market include a high degree of uncertainty and should be treated with caution. Moreover, forecasts reflect the joint CDM/JI carbon market and not prices/volumes traded solely under the CDM. CDM projects are regarded as having higher risk than the Joint Implementation projects of Eastern Europe.

As of late 2002, the major institutional buyers include:

- The World Bank Prototype Carbon Fund
- Carboncredits.nl, the Dutch ERUPT/CERUPT
- The Netherlands Carbon Development Fund
- International Finance Corporation- Netherlands Carbon Facility
- The Asian Development Bank CDM Facility
- Community Development Carbon Fund (World Bank)
- Bio-Carbon Fund (World Bank)
- The European Bank for Reconstruction and Development
- Canada CDM fund
- Denmark JI.CDM Fund
- Development Bank of Japan
- Japan Bank for International Cooperation

Chapter 6: Case Study No. 1

6.1 Title

Flare gas recovery project at Hazira Gas Processing Complex (HGPC), Hazira plant, Oil and Natural Gas Corporation (ONGC) Limited.

6.2 Purpose

The project activity includes the **"Zero Flare" scheme** implemented at Hazira plant with an objective to reduce flaring of gas, by compressing the otherwise flared gas (which was sourced from various flare control valves, pressure safety valves, fuel gas purge points, seal purge gas released from compressors and expanders, tanks and other vessels) in order to put them back to the system and therefore recover the valuable hydrocarbons and reduce flaring to technical zero level. The intended objective was achieved which led to recovery and utilization of otherwise flared tail gas to the tune of 0.02 million standard cubic meters per day (MMSCMD) from the gas processing plant at Hazira in order to achieve technical zero flaring.

The purpose of the project is to:

- Reduce the wastage of precious natural resources.
- Reduce the impact on the environment and safety of the locality / surrounding areas.
- Achieve zero hydrocarbon emissions.
- Utilize recovered gas to produce value added product(s) in addition to gas sales to consumers.
- Reduce the emissions of greenhouse gases (GHG)'s into the atmosphere.

The scheme has therefore reduced the release of CO_2 emissions into the atmosphere and has positively contributed to the fuel requirement of the country by providing additional source of relatively cleaner fuel (gas). The project has promoted sustainable economic growth and enabled conservation of environment and natural resources such as coal/ oil and other fossil fuels.

The scheme has further resulted in enhanced production of acid gas (sulfur) and lean gas sales to consumers from the recovered gas. This has also facilitated reduced atmospheric pollution and conservation of non-renewable natural resources.

6.3 Salient features of the project

Oil and Natural Gas Corporation (ONGC) has several assets, basins and offshore platforms in the country. Hazira Plant of ONGC is an on-shore installation (gas and condensate processing plant) located near the sea-shore at an average distance of about 232 Kms from the Mumbai offshore oil field. The plant is strategically located to handle the total offshore gas and condensate produced from ONGC's Basin & Satellite (B&S) fields and Joint venture Tapti, Panna-Mukta fields (JV T-PM).

Hazira Plant of ONGC is the largest of its kind in India with an installed processing capacity of 46 MMSCMD of sour gas and 7900 MT of sour condensate everyday. It receives sour natural gas and condensate from South Basin and Satellite (B&S) and JV PMT Fields (which is a sub-sea reservoir). The gas and condensate are transported to HGPC through two (36" & 42") sub-sea pipelines. The gas and condensate are received at the gas terminal in a slug catcher where gas and slug containing HC condensate, moisture and chemicals (like corrosion inhibitors) are separated. Gas and associated condensate are sent further in separate system for processing. The various processing units are Gas Receipt Terminal, Gas Sweetening Unit (GSU), Gas Dehydration Unit (GDU), Dew Point Depression Unit (DPDU), Sulfur Recovery Unit, Sour Condensate Processing Unit, Gas Based LPG Recovery Unit and Kerosene Recovery Unit.

The HGPC is equipped with an integrated flare system consisting of three flares and integrated flare network which connects all the flare loads from process trains, cogeneration and storages spread across the complex to the flare system. The function of flare system is to safely dispose off flammable, toxic and corrosive vapours discharged by pressure relief devices of various units to less objectionable compounds by combustion. The flare network is kept continuously purged with fuel gas injected from the dead ends spread across the complex.

As described this flare network comprises two flare stacks (a) terminal flare and (b) elevated flare and (c) one box flare. Normally the elevated flare system is line. The flare system receives gas from:

- Various flare control valves of all process units at Hazira Plant.
- Pressure safety valves with their bypass valves to flare gas on all pressure vessels at Hazira Plant.
- Fuel gas purge points to keep the flare alive and to avoid air ingression at all dead ends of flare headers of all process units at Hazira Plant.
- Seal purge gas released from various compressors and expanders, tanks and other vessels.

ONGC, Hazira did not stop with just reducing the gas-flared quantity by 65% but went on to achieve the objective of "Zero flare" wherein a task force was constituted which formulated the technical specifications for the flare gas recovery compressor which was implemented in January 2006.

6.4 Project's contribution to sustainable development

The "Zero Flare" scheme has contributed to sustainable development in several ways by reducing the quantity of gas flared and recovering the same for better applications and protecting the environment.

The project helps in minimising environmental pollution due to emissions of CO_2 and other air pollutants (SPM, SO_2, NO_x) otherwise released by flaring the gas in the atmosphere. The project activity has led to increased production of acid gas and lean gas, while conserving fossil fuels and reducing the GHGs.

The project has also contributed to local skilled employment opportunities by the way of implementing the flare gas recovery compressor at their plant. the operation and maintenance (O&M) of this unit would benefit the equipment suppliers (compressors, separator, KOD, valves, etc) and technical consultants for the project. The project positively benefits the people around the plants by reduced flaring related emissions and provides better occupational health and safety (OHS) at workplace.

The engineers at ONGC had to overcome many technological challenges to implement zero gas flaring project at the processing unit of Hazira Plant. ONGC believes that their endeavor in reducing wastage of precious natural resources will bolster India's continuous thrust towards a sustainable energy security.

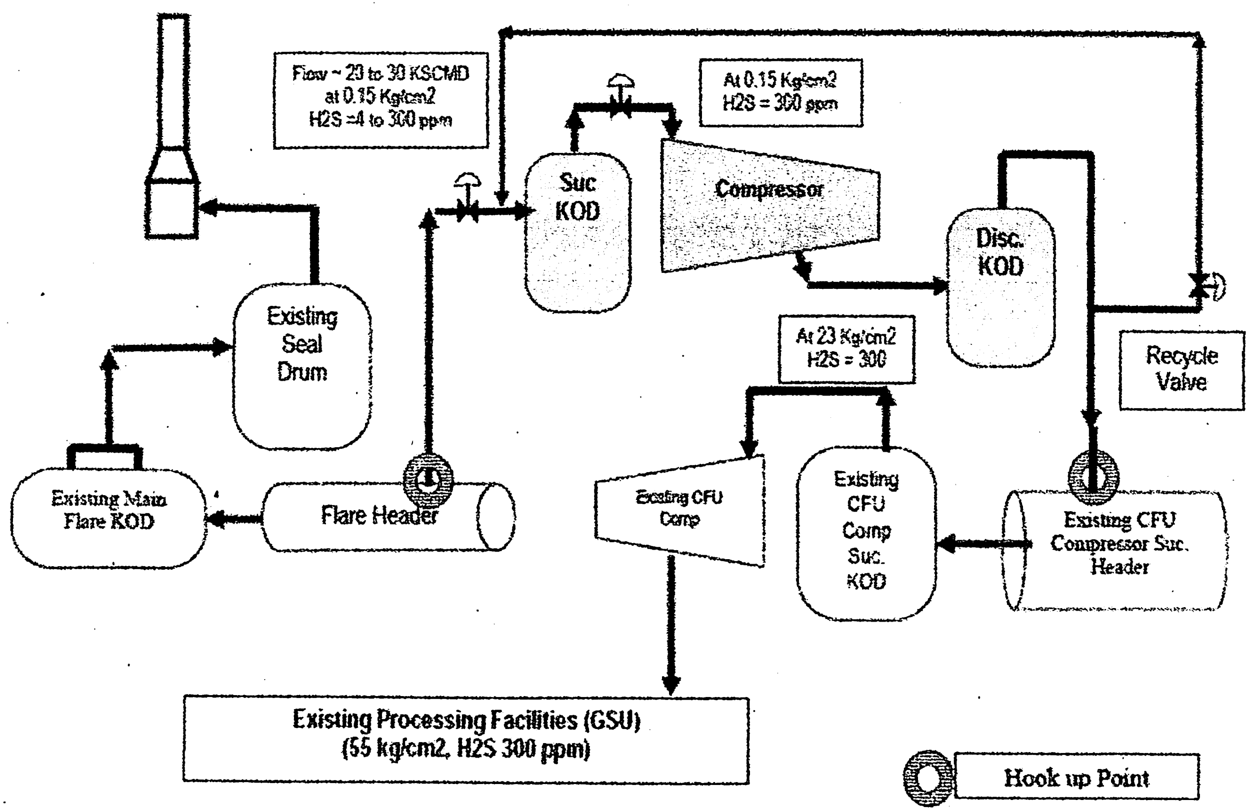
6.5 Category of the project activity

The project activity involves recovery and utilisation of associated gas from process plants and would be categorized under Sectoral Scope -5 & 10 'Fugitive emissions from fuels (solid, oil and gas)' as per the scope of the project activities enlisted in the 'Sectoral Scopes related approved methodologies and DOEs' (Version 13 Jan 07) for accreditation of operational entities.

6.6 Technology of project activity

Fuel gas header was modified in GSP to reduce the tail gas being flared. Modification was done in the Fuel gas blanketing of Amine & Methanol tanks to reduce the gas being flared. The seating of existing ANSI class-IV leakage flare control valves were replaced with soft seats, resulting in tighter shut-offs and minimizing the technical flaring. Hydrocarbon liquid being collected in suction KOD of CFU off-gas compressor has been diverted to LPG column and minimizing the technical flaring. The work also involved installing a flare gas recovery compressor (FGRC) and laying of around 0.546 km length pipeline, for drawing flared gas from the flare header to the FGRC. The compressed gas is then led to the processing facilities within the same plant for producing acid gas and lean gas.

Flare Gas Recovery Compressor (FGRC) unit consists of-one flare gas recovery reciprocating compressor - skid mounted motor driven compressor package complete with electrical motors, auxiliaries, inter coolers, after coolers, separators, scrubbers, skid piping, pressure vessels, common suction knock out drum & discharge knock out drum with all requisite instruments, level switches, instrumentation and associated instruments, instrumentation, cabling, control systems etc and electrical items, electrical safeguarding systems, cabling, termination, earthing etc.



Source: Carbon Management Group, ONGC

Figure 6.1: New layout with Flare Gas Recovery Compressor (FGRC)

6.7 Estimated amount of emission reductions over the chosen crediting period

Year	Emission Reduction (Tons of CO_2)
2007-08	8,793
2008-09	8,793
2009-10	8,793
2010-11	8,793
2011-12	8,793
2012-13	8,793
2013-14	8.793
2014-15	8,793
2015-16	8,793
2016-17	8,793
Total estimated reductions (tonnes of CO_2e)	**87,930**
Total number of crediting years	10
Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	**8,793**

Source: Carbon Management Group, ONGC

Table 6.1: Estimated amount of emission reductions

6.8 Fractional composition of tail gas

The CO2 emission reductions will depend on the carbon content of the gas that is recovered. The average fractional composition of the gas recovered from Hazira plant is described below in the following table:

No	Composition	Value in %
1	Methane	70.12
2	Ethane	6.41
3	Propane	6.91
4	I-Butane	0.99
6	N-Butane	1.29
8	I-Pentane	0.49
10	.N-Pentane	0.46
11	Hexane	0.26
12	Heptane	0.00
13	Nitrogen	0.37
14	Carbon dioxide	12.70
	Carbon content in g-C/m3	705.76

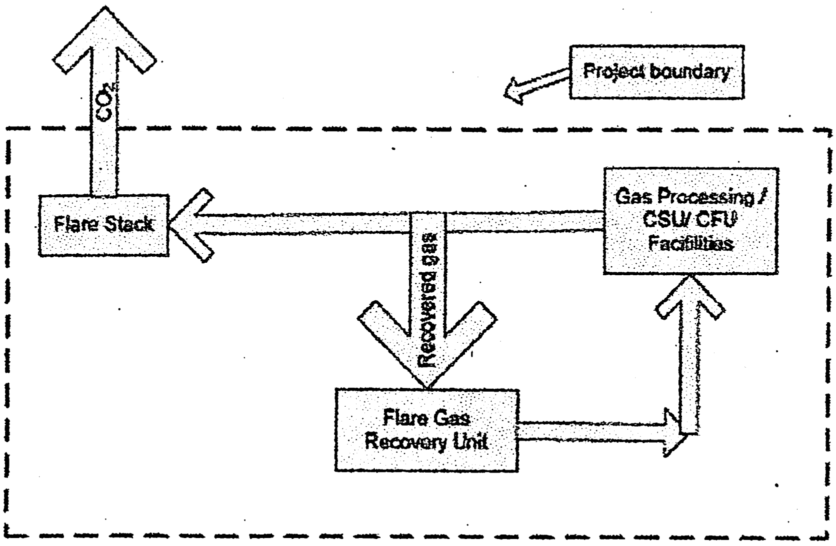
Source: Carbon Management Group, ONGC

Table 6.2: Composition of Tail Gas

6.9 Project Boundary

The project boundary as per the methodology includes the pipeline from the processing facility to the:

- The site of the original tail gas flaring site.
- The pipeline connecting the processing facility to the facilities utilizing the tail gas.
- The facility(ies) using the tail gas in the project activity.



Source: Carbon Management Group, ONGC

Figure 6.2: Project Boundary

The plausible alternative baseline scenarios for use of tail gas could include, inter alia:

a) Flaring at the oil or gas processing site;
b) On-site consumption of tail gas for energy;
c) Injection of tail gas into oil reservoir;
d) Recovery, transportation, processing and distribution of tail gas to end-users.
e) Tail gas is used as a fuel and/or feedstock at offsite facility; and
f) Another source of feedstock, other than the tail gas, is used at the end use facility where the tail gas is used in the project activity. The list of feedstock for an existing end use facility should include the existing feedstock used.
g) Project activity not being registered as a CDM project activity.

The common set of barriers identified to analyze the alternatives is listed below:

i. Technical feasibility
ii. Research & Development
iii. Lack of technological know – how

6.10 Technological Barriers

The project has faced the following technology barrier during the design phase of the project activity:

6.10.1 Gas Flaring Reduction (GFR) Schemes

ONGC – Hazira had started the initiatives for recovery of flare gas in early 2001 through in house brainstorming and deliberations. Hazira Plant had carried out studies to understand the feasibility of gas flaring reduction (GFR) in association with Institute of Oil & Gas Production Technology (IOGPT). The various schemes thought of for recovery of flare gas is as below:

6.10.1.1 Installation Gas Ejector Technology for recovery of flare gas

It was examined that for recovery of flare gas, huge quantity of high pressure motive gas would be required to recover and enhance the pressure of flare gas and the used up motive gas would call for further recompression to the same pressure. It was concluded through studies that using ejector was not an energy optimistic option and the use of gas ejector technology was dropped.

6.10.1.2 Liquid Ring Compression system

The discharge gas pressure in this system was also low and due to non-availability of LP gas consumers for any additional quantity of gas, the recovered gas has to be compressed again to high pressure for supply in HP gas consumer line. In view of above, the option for liquid ring compression system was dropped.

6.10.1.3 Compression of flare gas by suitable compressor

IOGPT carried out study and recommended for recovery of flare gas using one new Screw Compressor & existing CFU Compressor in series along with existing MDEA gas sweetening unit for removal of H2S. The new screw compressor would compress the flare gas available at 0.10 kg/cm2 g to 23 kg/cm2 g and would be sent to suction line of existing CFU compressor. The existing CFU compressor would further compress it to 57 kg/cm2 g for processing in existing in Gas sweetening unit.

In view of IOGPT recommendation, sanction of competent authority was obtained for implementation of the scheme. During the implementation phase, correspondence was made with vendors and suitability of various compressors for this specific use i.e. compression of 25000 MMSCMD gas from 0.08 kg/cm2 g to 23 kg/cm2 g was further explored by Hazira Plant.

It was observed that due to high discharge to suction ratio and low volume of gas to be compressed, screw compressor was not suitable for the specific purpose. Moreover, screw compressor had negative effect on volumetric efficiency and major repair was not possible at site
due to high precision assembly.

Reciprocating compressor, on the other hand, was suitable for low flow and high compression ratio and could easily handle variation in suction pressure and molecular weight.

In view of above, reciprocating compressor was decided to be installed and accordingly Reciprocating Compressor, Make M/s Kirloskar and Model 3EHBEG was installed and commissioned on 01.01.2006.

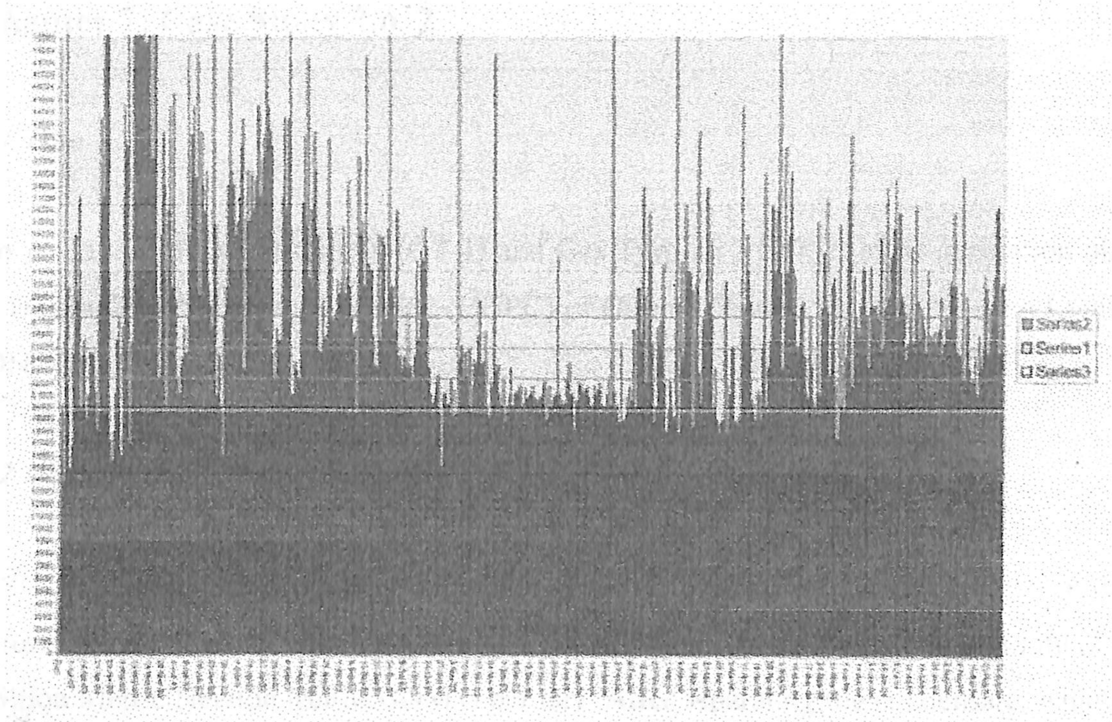
Starting from the generation of idea, preparation of the scheme, scrutiny of the safety aspect of the entire recovery system, selection of the suitable compressor for the specific use, tendering and installation & commissioning took almost 5 years for ONGC, Hazira.

6.10.2 Challenges associated with variable flow

Flare header was connected with all the processing units and product storages for safe disposal of gas released due to process upsets and abnormal scenarios such as tripping/blackout etc. along with the fixed quantity of purge gas called technical flaring for maintaining the minimum required turbulence in the header. The gas quantity varies widely in quantity as well as in quality. Based on available ultrasonic meter installed in the upstream of flare stack, the quantity of flare gas was studied on daily basis from April, 2003 to August, 2004. It was observed that flare gas quantity varied from merely 14,000 SCMD to high of 73,000 SCMD.

Such wide variation was a challenge for designing the capacity of the compressor particularly in the context of safety aspects of the plant. Selection of capacity of the compressor on the lowest flow could have led to the flare of maximum gas and similarly on the basis of the highest flow, the compressor could have starved for the maximum time. In both the extreme cases of flow, design of the compressor could have drastically changed and purpose for achieving zero gas flaring could not be achieved.

Looking into all these aspects, compressor capacity was designed based on the maximum amount of gas available for the maximum period. The graph shows the optimum flare gas quantity to be 27000 SCMD.



Source: Carbon Management Group, ONGC

Figure 6.3: Figure showing optimum gas flare quantity

Taking into consideration of minimum technical flare in the flare stack for safety reason, capacity of the compressor was selected to be 25000 SCMD.

6.10.3 Selection of discharge location

In order to recover the flare gas, options for various discharge location, which were technically feasible, were considered are as below:

1. Existing fuel gas header.
2. Existing LP Gas header.
3. Existing CFU Off-gas Compressor Suction.

Chapter 7: Case Study No. 2

7.1 Title

Up-gradation of Gas Turbine 1 (GT 1) and Gas Turbine 2 (GT 2) at co-generation plant of Hazira Gas Processing Complex (HGPC) of Oil and Natural Gas Corporation Limited (ONGC).

7.2 Description of Project Activity

ONGC's Hazira Gas-Processing Complex (HGPC) consists of facilities for receiving natural gas (NG) along with associated condensate from an off-shore field at a rate of 20 Million Metric Newton M3(MMNM3) per day. After separating the condensate, which is processed in condensate fractionation units, the gas is processed through various steps to recover liquefied petroleum gas (LPG) and there is a reduction in its dew point to less than 5 degrees centigrade in order to make it suitable for transportation over long distances. Prior to gas processing, the gas is sent to gas sweetening unit where the acid gas is recovered and further processed to obtain sulfur. The major products manufactured at HGPC are lean sweet gas, LPG, natural gas liquids (NGL) and sulfur.

The HGPC receives economical, quality and uninterrupted supply of electrical power and steam from the cogeneration plant at ONGC, Hazira which was set up in the financial year (FY) 1987 - 1988. The cogeneration plant consists of three nos. of Gas Turbine Generators (GTG) to cater the power demand of Hazira Plant. GT-1 & GT 2, which are of General Electric (GE) make were commissioned in 1988 and fitted with standard technology components. GT-3 is of Bharat Heavy Electricals Limited (BHEL) make was commissioned in 1997 and fitted with up-rated parts.

Gas turbines are high-tech capital equipments and are vital for operations hence Original Equipment Manufacturers (OEM) continuously strive to augment the gas turbine's performance by improving the design/ material of its components through research and development (R&D). Such developments are extensively tested and offered to customers in the form of new components commonly called up-rated parts. Aim of these up-rated parts, is to satisfy varied requirement of gas turbine owners, such as improvement in output, efficiency or reduction in maintenance intervals and related. New machines are traditionally supplied with up-rated parts. For older machines, these up-rated parts are available as retrofit and usually suggested for installation at the time of scheduled inspections, so that separate outage of gas turbine is not required for fitment of up-rated parts.

As the existing GT 1 and GT 2 will be completing their expected life time, ONGC is required to replace the entire hot gas path (HGP) components fitted in the gas turbine machines as at present ONGC does not have spare HGP components in stock. Under such circumstances ONGC has the option either to:

a) Procure new HGP components of standard technology (Old Design)
b) Opt for up-rated components, which offer higher efficiency and output.

A comparative analysis was made to assess both scenarios (a) and (b) described above by considering one, major inspection cycle (i.e. of 6 years, which is the normal life span of the components). Accordingly maintenance costs (including cost of spares, component repairs and services) have been compared for two scenarios.

It was assessed that the purchase of up-rated spares in place of old technology spares requires an incremental cost of Rs 4.78 Crores / gas turbine and further, the IRR of the project is below the hurdle rate of 10 % for ONGC. Despite unfavourable financial indicators (like higher incremental costs and lower IRR of scenario (b)), ONGC has decided to go for the up-rated components in order to achieve their objective of continuous thrust towards energy conservation and therefore reduction in greenhouse gas (GHG) emissions. The purpose of undertaking the project is to reduce the fossil fuel consumption (NG), and therefore reduce the CO_2 emissions that would otherwise have been released by burning of natural gas (NG) in the GTG. The project would result in reduction of heat rate by 3.3% which would result in saving of 3,926,673 Standard Cubic

Meter (SCM) of NG annually. In absence of the project activity, equivalent quantity of NG would have been burnt, thereby resulting in 7802 tonCO2 emission annually.

7.3 Project's contribution to sustainable development

The project would contribute to sustainable development of the host country India in the following ways:

- The project activity saves NG for better applications and contributes to environmental protection.
- The project activity would help in minimizing environmental pollution by reducing emissions of CO_2 and other air pollutants (SPM, SO_2, and NO_x). The project is based on the noble principle that 'energy saved is energy generated'. The project would contribute to enhancement of skills in employees and workers, and would provide benefits to equipment suppliers and technical consultants.

7.4 Category of the project activity

The project activity is a small scale potential CDM project. The project activity aims at up-gradation of GT1 and GT2 at HGPC, ONGC Hazira plant. The upgradation will result in a reduction of 3.3% heat rate. This would result in reduction of fuel consumption to the tune of 3,926,673 SCM of NG annually. In the absence of the project activity equivalent quantity of NG would be burnt in the gas turbine, which would result in annual emissions of 7802 tons of CO_2. Thus, the project activity would enable reduce GHG emissions through the energy conservation measures proposed..

- The project activity is an energy efficiency project implemented at a single industrial facility.
- The energy efficiency measures of retrofitting existing equipments of Gas Turbines at HGPC aimed primarily for improving the energy-efficiency of the facility.
- The maximum thermal energy saving in the project activity is 38.5 GWh thermal which is below the limit of 180 GWh thermal as specified in the methodology.

7.5 Technical description of the Project Activity

The technology adopted for the project activity is the MS5001 P N/T turbine model which incorporates the latest gas turbine technology that has been adapted to the MS5001 turbines. It is the maximum hot gas path up rate for MS5001P turbines.

The new technology hardware includes the hot gas path hardware from the combustion liners through to the second stage bucket. The P N/T package improves output power significantly due to improved aerodynamics, primarily due to an increase in firing temperature. Output is further improved with the recommended options of reduced camber Inlet Guide Vane (IGV's) and advanced seals. Fuel efficiency is also improved.

Several of these improvements can be purchased individually with the prime consideration being increase in component life; however, the full New Technology (N/T) package has been proposed in order to facilitate the increase in firing temperature, which accounts for the major part of the output and heat-rate performance improvement. This new-technology includes all the necessary parts for the extension of inspection intervals.

The net reduction in heat rate would be 3.3% after implementation of the project activity.

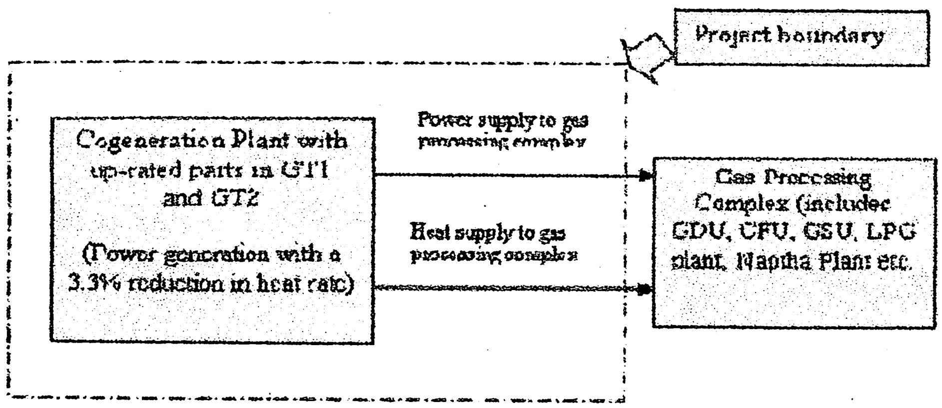
7.6 Estimated amount of emission reductions over the chosen crediting period

Years	Annual estimation of emission reductions in tones of CO2eq
2007-08	7802
2008-09	7802
2009-10	7802
2010-11	7802
2011-12	7802
2012-13	7802
2013-14	7802
2014-15	7802
2015-16	7802
2016-17	7802
Total estimated reductions (tCO2e)	**78020**
Total no of crediting years	**10**
Annual average over the crediting period of estimated reductions (tones of CO2 e)	**7802**

Source: Carbon Management Group, ONGC

Table 7.1: Estimation of Emission reductions

7.7 Project Boundary



Source: Carbon Management Group, ONGC

Figure 7.1: Project Boundary

7.8 Technological Barriers

Gas turbines are high-tech capital equipment and are vital for operations. In general, continuous augmentation of components is required to sustain its performance by improving components' design, which is done by OEMs through R&D. These developments are required to overcome technological barriers for consistent performance of such equipments and in turn requires investments on ONGC's part.

The above section describes the significant investment barriers faced by ONGC towards the project activity. It is apparent that option (1) is the baseline or business as usual (BAU) scenario for the project activity, which did not face such barriers.

The financial barrier faced by ONGC demonstrates that the project activity is over and above BAU scenario and is additional.

Chapter 8: Case Study No. 3

8.1 Title

Waste heat recovery from Process Gas Compressors (PGCs), Mumbai high south (offshore platform) and using the recovered heat to heat process heating oil.

8.2 Project Description

The WHRU is designed to extract heat from exhaust flue gases of process gas compressors and heat the well fluid and glycol reboiler in the glycol regeneration system. In the project activity the exhaust flue gases from PGC, which are at a very high temperature (approximate 450-500 deg C), is brought into contact with circulating process oil through a WHRU. The waste heat of exhaust flue gases of PGC is gained by the process oil, which is being circulated from discharge of hot oil pump to the WHRU, through heat transfer. The hot process oil is then circulated through two glycol re-boilers in the glycol regeneration system to heat glycol solution.

8.3 Project's contribution to Sustainable development

The project has contributed to sustainable development in several ways by reducing fossil fuel consumption for oil production activities. The indicators for sustainable development as stipulated by Designated National Authority (DNA) of India in the interim approval guidelines for Indian CDM projects have been studied in the context of project activity to ensure that project activity contributes to the sustainable development.

8.3.1 Social Well Being

The project activity has created direct and indirect employment opportunities for skilled/semi-skilled manpower, during the construction and operational phase of the project. Indirect employment has been generated for the equipment supplier, contractors

& technical consultants. The project activity has also resulted in providing better Occupational Health and Safety (OH&S) conditions at the work place.

8.3.2 Economic Well Being

The project activity reduces consumption of fossil fuels for the oil production activities, thereby reducing expenditure on production of petroleum products. The project activity helps in reducing the operating costs. The project activity has also created business opportunities for various stakeholders like suppliers/manufacturers, contractors etc.

8.3.3 Environmental Well Being

The project activity promotes the recovery of waste heat, which otherwise would have been discharged to the atmosphere. This recovered heat is utilized in heating the process oil which is further used to heat various process streams, thereby reducing the consumption of fossil fuels for oil production activities. Reduction in use of fossil fuels for oil production reduces the net GHG emissions to the atmosphere. The project activity also addresses the problem of depletion of fossil fuels to a certain extent.

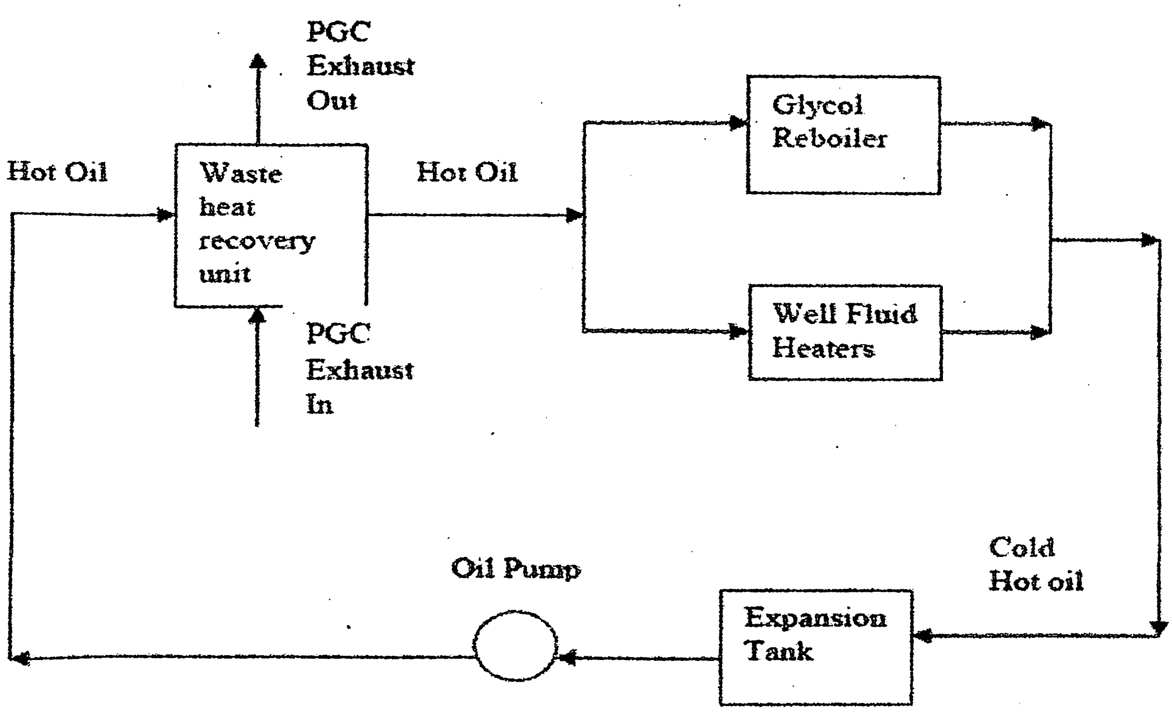
8.3.4 Technological Well Being

The project activity has resulted in reducing the fossil fuel consumption for the oil production activities by using waste heat recovery principle. The technology used can also be applied to other similar projects in oil and gas installations in the country, resulting in reductions in the use of fossil fuels for oil production.

Hence, the project activity contributes to sustainable development.

8.4 Technology of project activity

The waste heat recovery unit is designed to extract heat from the exhaust flue gases of process gas compressors and further used to heat well fluid and glycol re-boiler in the glycol regeneration system. The system includes hot process oil expansion tank, hot process oil circulation pumps, hot process oil filters, hot process oil dump coolers and well fluid heaters. The recirculation of hot process oil takes place from the discharge of the hot process oil pump to the waste heat recovery units for picking up the heat from the exhaust flue gases. The hot process oil after picking up heat in the WHRU is available at 2300C. Hot process oil is then circulated through (a) two glycol re-boilers in the glycol regeneration system to heat the glycol solution and (b) well fluid heaters to heat the well fluid. The outlet hot process oil from the heaters and re-boilers is collected back in the header, which is connected to hot process oil expansion tank. The cold hot process oil from this expansion tank is in continuous recirculation. The flow diagram is shown below:



Source: Carbon Management Group, ONGC

Figure 8.1: Flow diagram of Waste heat recovery process

The project proposes to recover and use the waste heat from PGC exhaust flue gases, through WHRU, which otherwise would have been discharged into the atmosphere. The waste heat recovered by the project activity replaces the use of energy, derived from fossil fuels, which would have been used in the absence of project activity. In the absence of project activity, all the energy required for heating the process oil (used for other process heating applications), would have been derived from fossil fuels (associated gas/ natural gas) only. The use of fossil fuels for heating purposes results in CO2 emissions into the atmosphere. Due to the project activity, the energy required for the heating of process oil is supplied through WHRU, this results in net decrease in consumption of fossil fuel for the heating of process oil, thereby reducing the net GHG emissions to the atmosphere. So the project activity leads to reduction in net GHG emissions to the atmosphere. The project activity would result in net GHG emission reductions of 53,200 tCO2 over the 10 years crediting period.

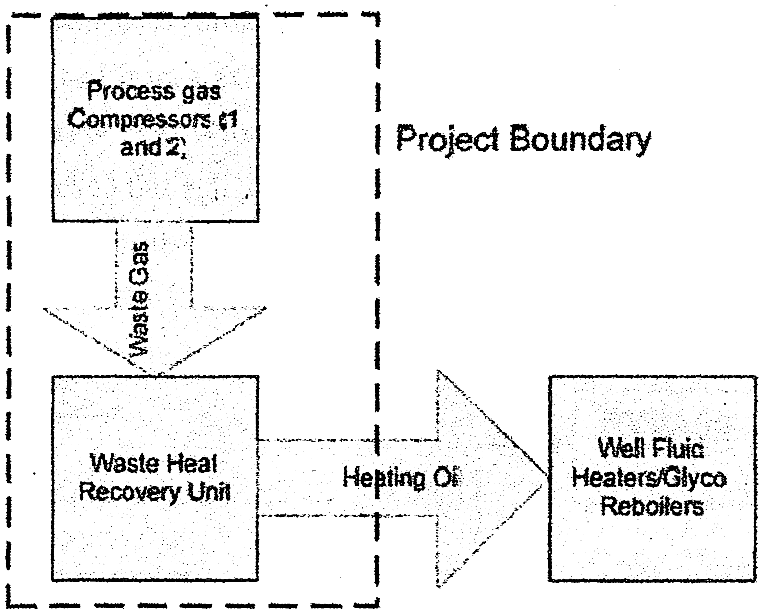
8.5 Estimated amount of emission reductions over the chosen crediting period

Year	Estimated Emission Reductions tCO2e
2006 (1st November to 31st December)	444
2007	5320
2008	5320
2009	5320
2010	5320
2011	5320
2012	5320
2013	5320
2014	5320
2015	5320
2007 (1st January to 31th October)	4876
Total tCO2e	53,200
Crediting Period	10 Years
Average Emission reduction per year over the crediting period	5,320

Source: Carbon Management Group, ONGC

Table8.1: Estimated emission reductions

8.6 Project Boundary



Source: Carbon Management Group, ONGC

Figure 8.2: Project boundary

8.7 Parameters used to determine baseline for the project activity

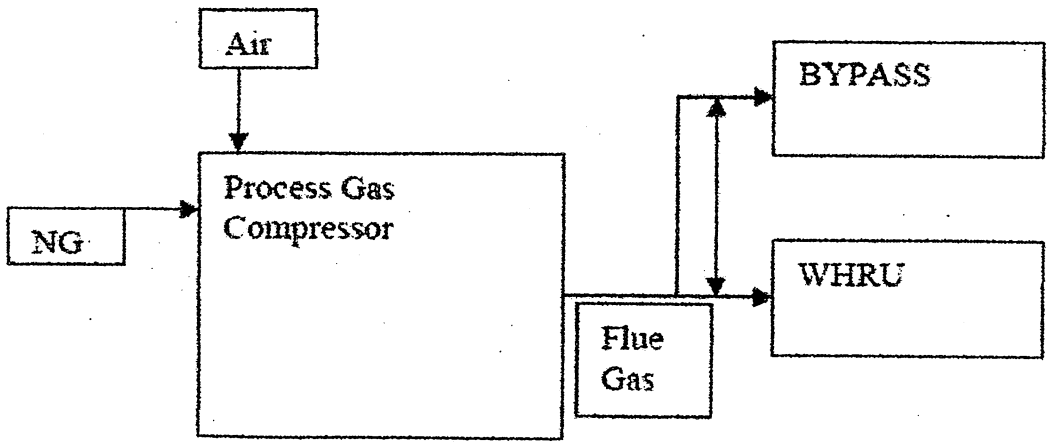
Sl No	Parameters used to determine baseline	Unit	Remarks
1	Q_{oil} (Flow rate of heating oil)	Tonne/hr	Monitored continuously and recorded daily
2	$T_{oil,in}$ (inlet temp. of heating Oil)	^0C	Monitored continuously and recorded daily
3	$T_{oil,out}$ (Outlet temp. of heating Oil)	^0C	Monitored continuously and recorded daily
4	H (Running Hours per day)	Hours	Monitored continuously and recorded daily
5	D (working days per year)	Days	Monitored continuously and recorded daily
6	Specific gravity of heating oil	Kg/litre	Standard value of the Heating Oil
7	Specific Heat of Heating oil	Kcal/kg/°C	Standard value of the Heating Oil

Source: Carbon Management Group, ONGC

Table 8.2: Baseline parameters

8.8 Technological Barriers

Generally PGC installed at offshore platforms are not equipped with WHRU and therefore the exhaust of from a PGC is released into the atmosphere. However for PGCs with WHRU, exhaust of PGC is routed through WHRU and Bypass. Openings of WHRU & Bypass are interlinked through control & instrumentation, so that hot oil temperature at the outlet of WHRU meets the process requirement.



Source: Carbon Management Group, ONGC

Figure 8.3: WHRU flow diagram

However in case of problem in WHRU, PGC has to be stopped in order to avoid overheating of hot oil. Overheating of hot oil results in coke formation in the WHRU heat exchanger therefore creates operational problems in the WHRU and increases the maintenance as well.

Alternative of the project activity does not face any of the barriers faced by the project activity. There are no barriers associated with the alternative The alternatives do not pose any investment barrier in terms of capital investment and transaction costs. So, the identified barriers to the project activity do not prevent the implementation of alternative.

The barriers faced by ONGC demonstrate that the project activity is over and above business as usual scenario and is additional.

Chapter 9: Conclusion

CDM can:

1) Increase the profitability of cleaner, more efficient technologies in the Oil & Gas industry.
2) Improve the financial viability of a project by increasing the quality of the cash flows.
3) Implementing CDM can increase the IRR of any oil & gas project on an average by 5 %.

- Right now, the transaction costs of the projects are very high and the focus is mainly on co-generation projects and power plants.
- There is immense potential in large scale projects like flare gas recovery.
- As the technology used is improvised, the skill and the knowledge of the people working on these projects would improve.
- The main purpose of CDM is to enable sustainable development and fight climate change.
- Oil and Gas industry is one of the biggest sources of Green House Gas emissions in the world.
- So, it is the responsibility of this industry to become more energy efficient and greener.
- CDM shows the way to achieve this goal.

CASE STUDY NO.1

Details of Purge gas from process unit area in service at Hazira Plant as on 20.02.2007

Sr. No.	Location	Tag No.	Line Size	Orifice Size d (in mm)	Upstream pressure (kg/sqcm A)	Downstream pressure (kg/sqcm A)	ΔP (kg/sqcm)	Purge gas (Cu Meter/Day)	Remarks
1	GSP-I	N.A.	1.5"	5.8	4.5	1.3	3.2	960	
2	GSP-II	30RO 2501	1"	5.21	4.5	1.3	3.2	775	
3	GSP-III	N.A.	1"	5.21	4.5	1.3	3.2	775	
4	GSP-IIIA	N.A.	1"	5.1	4.5	1.3	3.2	742	
5	LPG-II	10RO 1301	1"	5.74	4.5	1.3	3.2		Blocked
6	LPG - III	10RO 1302	1"	5.74	4.5	1.3	3.2	940	
7	DPD -I	N.A.	1/2"	1.67	4.5	1.3	3.2		Blocked
8	DPD-II	50RO1301	1"	1.67	4.5	1.3	3.2	80	
9	DPD-III	50RO 1401	1"	1.53	4.5	1.3	3.2	67	
10	CFU - I	N.A.	3/4"	4	4.5	1.3	3.2	457	
11	CFU - II	70RO 1601	1"	5.35	4.5	1.3	3.2	816	
12	CFU - III	70RO 1701	1"	5.08	4.5	1.3	3.2		Blocked
13	CFU - IIIA	N.A.	1"	8.61	4.5	1.3	3.2	2116	
14	KRU - I	90FE 1403	2"	11.28	4.5	1.3	3.2		Blocked
15	KRU - II	90FE 1406	2"	12.2	4.5	1.3	3.2	4248	
16	LPG Sphere - I	20RO 601	3/4"	0.81	4.5	1.3	3.2	19	
17	LPG Sphere - II	21RO 601	3/4"	2.79	4.5	1.3	3.2	222	
18	Propane Sphere	20RO 801	3/4"	1.6	4.5	1.3	3.2	73	
19	CWU - I	N.A.	3/4"	4.5	4.5	1.3	3.2		Blocked
20	CWU - IIIA	23RO 1902	3/4"	4.5	4.5	1.3	3.2		Blocked
21	Gas Terminal	N.A.	1"	1.5	4.5	1.3	3.2	64	

Total purge gas from process unit area "In-Service" 12354 NM3/Day

Total purge gas from process unit area "In-Service" 13034 SM3/Day

CASE STUDY NO. 1

% of gas processed that goes back to flare header (2006-2007)						
Month	Gas Processed (MMSCM)	Quantity of flared gas recovered by screw compressor (MMSCM)	Gas Flared (MMSCM)	Total quantity of gas going towards flare header before recovery by screw compressor (MMSCM)	% gas flared i,e	% flare gas generated out of the total gas processed
January	1221.66	0.89	0.25	1.14	0.02%	0.09%
February	1101.34	0.92	0.26	1.18	0.02%	0.11%
March	1230.10	0.87	0.33	1.20	0.03%	0.10%
April	1191.80	0.93	0.28	1.21	0.02%	0.10%
May	1198.10	0.62	0.45	1.07	0.04%	0.09%
June	1196.53	0.91	0.26	1.17	0.02%	0.10%
July	1236.25	0.84	0.35	1.19	0.03%	0.10%
August	452.94	0.00	0.88	0.88	0.19%	0.19%
September	1108.34	0.46	0.82	1.29	0.07%	0.12%
October	1260.45	1.16	0.20	1.37	0.02%	0.11%
November	1243.19	0.31	0.57	0.88	0.05%	0.07%
December	1238.48	1.16	0.20	1.36	0.02%	0.11%
TOTAL	13679.18	9.07	4.85	13.93	0.04%	0.10%

Enclosure I: CER calculations
Baseline emissions for GFR project (in SCM)

Month-Wise gas compressed by Flare Gas Compressor & Gas flared in the year

Month	Gas Compressed (MMSCM)	Gas Compressed (m^3)
January	0.894134	894134
February	0.920312	920312
March	0.874641	874641
April	0.926567	926567
May	0.619609	619609
June	0.910477	910477
July	0.8371	837100
August	0	0
September	0.462685	462685
October	1.162898	1162898
November	0.307689	307689
December	1.156901	1156901
Total		9073013

Estimation of avoided tail gas flaring per day

Average gas recovered/compressed per day	Quantity of purge gas sent to flare stack per day	quantity of gas that goes back to flare header per day	Net avoided flaring per day of the tail gas per day
24858	13034	25	11798

0.02

CASE STUDY NO. 1

Table 1.2 Project Emissions

542.16

2759400

		2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2014 -15	2015-16	2016-17
		Hazira	Hazira	Hazira	Hazira	Hazira	Hazira	Hazira	Hazira	Hazira	Hazira	Hazira
Actual Gas Recovered(m3)		4306385	4306385	4306385	4306385	4306385	4306385	4306385	4306385	4306385	4306385	4306385
Project emissions		2351.11	2351.11	2351.11	2351.11	2351.11	2351.11	2351.11	2351.11	2351.11	2351.11	2351.11
$PE_{CO2,otherfuels,y}$	tCO_2	1999.8	1999.8	1999.8	1999.8	1999.8	1999.8	1999.8	1999.8	1999.8	1999.8	1999.8
Rating of Compressor	KW	315	315	315	315	315	315	315	315	315	315	315
No. of HRS of operation	Hrs	24	24	24	24	24	24	24	24	24	24	24
days of operation	Days	365	365	365	365	365	365	365	365	365	365	365
Average emission factor of the captive generation unit	(ton CO2/MWh)	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725
$PE_{CH4,pipeline,y}$	tCO_2	33.01	33.01	33.01	33.01	33.01	33.01	33.01	33.01	33.01	33.01	33.01
GWP		21	21	21	21	21	21	21	21	21	21	21
kg to ton		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
CH4 emission factor	Gg/year/km	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029
Length of pipeline	Km	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542
$PE_{CH4,recovery,y}$	tCO_2	262.26	262.26	262.26	262.26	262.26	262.26	262.26	262.26	262.26	262.26	262.26
GWP		21	21	21	21	21	21	21	21	21	21	21
Coefficient for fugitive CH4 emission	$Gg/10^6$ gas production	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029
Fugitive methane emission along the transportation path FE,y	tCO_2	295.27	295.27	295.27	295.27	295.27	295.27	295.27	295.27	295.27	295.27	295.27
Fugitive emissions of CH_4 from accidents EFA,y	tCO_2	0	0	0	0	0	0	0	0	0	0	0
Emission Factor for energy used in end use facility EF,facility,y	tCO2/MWh	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725
Total gas processed	m3	14318950000	14318950000	14318950000	14318950000	14318950000	14318950000	14318950000	14318950000	14318950000	14318950000	14318950000
Total Electricity consumed for processing	MWh	257264	257264	257264	257264	257264	257264	257264	257264	257264	257264	257264
Specific Electricity consumed per m_3 of gas processed	MWh/m3	1.79667E-05	1.79667E-05	1.79667E-05	1.79667E-05	1.79667E-05	1.79667E-05	1.79667E-05	1.79667E-05	1.79667E-05	1.79667E-05	1.79667E-05
Energy consumed by end use facility for tail gas processing	MWh	77.37144138	77.37144138	77.37144138	77.37144138	77.37144138	77.37144138	77.37144138	77.37144138	77.37144138	77.37144138	77.37144138
Additional energy used by end-use facility (FFU,y)	tCO_2	56.07	56.07	56.07	56.07	56.07	56.07	56.07	56.07	56.07	56.07	56.07

CASE STUDY. NO. 1

CASE STUDY NO. 1

Table 1.3 Emission Reductions

Year	Estimated baseline flaring (m3)	Avoided CO2 emissions (tons CO2)	Project Emission (ton CO2)	Emission reductions (10 years) in tCO2
2007-08	4,306,385	11,144	2,351	8,793
2008-09	4,306,385	11,144	2,351	8,793
2009-10	4,306,385	11,144	2,351	8,793
2010-11	4,306,385	11,144	2,351	8,793
2011-12	4,306,385	11,144	2,351	8,793
2012-13	4,306,385	11,144	2,351	8,793
2013-14	4,306,385	11,144	2,351	8,793
2014-15	4,306,385	11,144	2,351	8,793
2015-16	4,306,385	11,144	2,351	8,793
2016-17	4,306,385	11,144	2,351	8,793
Total				87,930

Emission Reduction Calculations

Project Emission Calculations:

$PE = FE + EFA + FFU + PE_{EC}$

$FE = PE_{CH4, pipeline} + PE_{CH4, recovery}$

$PE_{CH4, pipeline} = GWP_{CH4}$*Emission Factor*Length of Pipeline

$= 21*0.0029*542$

$= 33.01\ tCO_2$

$PE_{CH4, recovery} = GWP_{CH4}$*Emission Factor*Volume of gas recovered

$= 21*0.0029*4306.385$

$= 262.26\ tCO_2$

Therefore, FE = 33.01 + 262.26 = 295 tCO_2

EFA = 0

$FFU = QF*EF_{facility}$

$= 0.725*77.37144$

$= 56.07\ tCO_2$

$PE_{EC} = EC_{PJ}*EF_{CP}$

$= 2758.344*0.725$

$= 1999.8\ tCO_2$

Therefore, Project Activity Emissions = 295+0+56.07+1999.8

= 2351 tCO_2

Leakage Emissions are negligible.

Baseline Emissions:

$BE = (V*W_{carbon}*44)/12$

$= (4306382.803 * 705.76 * 10^{-6} * 44)/12$

$= 11144\ tCO_2$

Emission Reductions:

Emission Reductions = BE – PE – LE

= 11144 – 2351 – 0

$= 8793\ tCO_2$

Nomenclature:

PE = Project Emissions, tCO_2

FE = Fugitive methane emissions along the transportation path to the point of flaring, tCO_2

EFA = Fugitive emissions of CH4 from accidents

FFU = Additional energy may be used by the end use facility that utilizes the tail gas

PE_{EC} = Project emissions from electricity consumption by the project activity

GWP = Global Warming Potential

CASE STUDY NO.2

Historical data for Power generation and corresponding gas consugption at GT1 and GT2 at Hazira Plant

Period	GT1		GT2	
	Energy MWh	Gas Nm3	Energy MWh	Gas Nm3
1-Apr	9254	4137902	9739	3921350
May-01	8067	3869050	6618	3051160
Jun-01	9765	4289483	3656	2283480
Jul-01	5716	2992730	9200	3847170
Aug-01	7541	3531800	10453	4173850
Sep-01	7098	3384430	13032	4852549
Oct-01	7754	3560740	13747	5055150
Nov-01	7513	3415340	14034	5095900
Dec-01	7963	3443420	14442	5224450
Jan-02	6084	2983980	11059	4297140
Feb-02	5942	2680610	9262	3724910
Mar-02	8481	3828550	7523	3358200
Total (2001-02)	**91178**	**42118035**	**122765**	**48885309**
Apr-02	7938	3697890	8784	3755280
May-02	10443	4241410	13257	4934720
Jun-02	11955	4556180	7371	2729500
Jul-02	10533	4101990	12331	4579020
Aug-02	6977	2918494	13095	4883380
Sep-02	5049	2274700	11176	4335605
Oct-02	0	0	13409	4970200
Nov-02	0	0	12797	4763900
Dec-02	7233	2899790	14539	5284810
Jan-03	13658	4790765	7116	2554621
Feb-03	13239	4761820	4796	1821122
Mar-03	10381	4075258	13067	4590780
Total (2002-03)	**97406**	**38318297**	**131738**	**49202938**
Apr-03	13209	4977780	13502	4674890
May-03	6222	2518040	14582	5130060
Jun-03	11948	4612200	8710	3270448
Jul-03	11182	4471139	10170	3927100

91178 42118035 122765 48885309

97406 38318297 131738 49202938

CASE STUDY NO. 2

Period	GT1 Energy MWh	GT1 Gas Nm3	GT2 Energy MWh	GT2 Gas Nm3
2003	124365	49740669	145075	51758333
2004	165751	60545339	145075	51758333
2005	177023	64899666	153678	54566590

Total NG Consumption by 2 GT's	333268930
Total Electricity Generation by 2 GT's	910967
Average NG Consumption	111089643
Average Electricity Generation	303655.67

Baseline (2003-2006)

	Unit	
Annual AverageGeneration GT1	Kwh	155713000
Annual Average Generation GT2	Kwh	148161667
Total Generation	Kwh	303874667
Average Annual Fuel Consumption GT1	SCM/year	58395224.67
Average Annual Fuel Consumption GT2	SCM/year	53221697.33
Total Fuel Consumption	SCM/year	111616922
Calorific Value	Kcal/SCM	8990
Specific Fuel Consumption	SCM/Kwh	0.367312363
Total Heat Energy	Kcal	1.00344E+12
Heat Rate	Kcal/Kwh	3302.138147

Baseline	Unit	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Annual Generation	Kwh	303874667	303874667	303874667	303874667	303874667	303874667	303874667	303874667	303874667	303874667
Fuel Consumption	SCM	111616922	111616922	111616922	111616922	111616922	111616922	111616922	111616922	111616922	111616922
CalorificValue	Kcal/SCM	8990	8990	8990	8990	8990	8990	8990	8990	8990	8990
Total Heat Energy	Kcal	1.00344E+12	1.00344E+12	1.00344E+12	1.00344E+12	1.00344E+12	1.00344E+12	1.00344E+12	1.00344E+12	1.00344E+12	1.00344E+12
Heat Rate	Kcal/Kwh	3302.138147	3302.138147	3302.138147	3302.138147	3302.138147	3302.138147	3302.138147	3302.138147	3302.138147	3302.138147
Emission Factor	tCO_2/TJ	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1
Baseline Emissions	tCO_2	236429.6207	236429.6207	236429.6207	236429.6207	236429.6207	236429.6207	236429.6207	236429.6207	236429.6207	236429.6207
Project Activity											
Reduced Heat Rate	Kcal/Kwh	3193.167588	3193.167588	3193.167588	3193.167588	3193.167588	3193.167588	3193.167588	3193.167588	3193.167588	3193.167588
Annual Generation	Kwh	303874667	303874667	303874667	303874667	303874667	303874667	303874667	303874667	303874667	303874667
CalorificValue	Kcal/SCM	8990	8990	8990	8990	8990	8990	8990	8990	8990	8990
Fuel Consumption	SCM	107933563.6	107933563.6	107933563.6	107933563.6	107933563.6	107933563.6	107933563.6	107933563.6	107933563.6	107933563.6
Reduced Energy Input	Kcal	9.70323E+11	9.70323E+11	9.70323E+11	9.70323E+11	9.70323E+11	9.70323E+11	9.70323E+11	9.70323E+11	9.70323E+11	9.70323E+11
Emission Factor	tCO_2/TJ	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1
Project Emissions	tCO_2	228627.4432	228627.4432	228627.4432	228627.4432	228627.4432	228627.4432	228627.4432	228627.4432	228627.4432	228627.4432
Emission Reductions	[illegible]	7802.177482	7802.177482	7802.177482	7802.177482	7802.177482	7802.177482	7802.177482	7802.177482	7802.177482	7802.177482

CASE STUDY No.2

Emission Reduction Calculations

Project Activity:

Heat Rate $_{project}$ = (Q $_{project}$ * NCV $_{project}$)/EG $_{gen\ project}$

= (107933563.6*8990)/303874667

= 3193.167586 K Cal/K Wh

Reduced Energy Input = Heat Rate $_{project}$*EG $_{gen\ project}$*4.186/10^9

= 3193.167586*303874667*4.186/10^9

= 4061.7709 TJ

Project Emission = REI*EF

= 4061.7709*56.1

= 228627.4432 tCO_2

Baseline Emissions:

Heat Rate $_{pre\ project}$ = Q $_{baseline}$*NCV $_{baseline}$/EG $_{gen\ baseline}$

= 111616922*8990/303874667

= 3302.138147 K Cal/K Wh

Total Energy Content of Fuel = Heat Rate $_{pre\ project}$*EG $_{gen}$*4.186/10^9

= 3302.138147*303874667*4.186/10^9

= 4200.3836 TJ

Baseline Emissions = TEC*EF

= 4200.3836*56.1

= 236429.6207 tCO_2

Emission Reduction:

ER = BE – PE

= 236429.6207 – 228627.4432

= **7802.177482 tCO_2**

Nomenclature:

Heat Rate = Reduced Heat Rate in K Cal/K Wh

Q = Quantity of fuel consumed in SCM

NCV = Net Calorific Value of the fuel in K Cal/SCM

REI = Reduced Energy Input in TJ

EG = Gross electrical energy generated in K Wh

EF = IPCC emission factor of the gas in tCO2/TJ

CASE STUDY NO. 3

Annexure 3

Baseline Information

PROPERTIES OF ESSO THERM 500 (HOT OIL)		
Temp, (°C)	Sp. Gravity (kg/litre)	Sp.Heat (Kcal/kg/°C)
100	0.775	0.53
125	0.755	0.559
150	0.72	0.57
175	0.69	0.6
200	0.66	0.625
225	0.64	0.65
250	0.625	0.665

Emission reduction Calculations(Train A)	**Value**	**Units**
Operating Range of WHRU	195-218	^0C
Flow Rate of Oil	127	m3/hr.
Density at 195° C	0.67	ton/m3
Density at 218° C	0.65	ton/m3
Average Density	0.66	ton/m3
Flow Rate of Oil	84.06	ton/hr
Specific heat of Oil 195° C	2.604	kJ/kg/^{0}C
Specific heat of Oil 218° C	2.702	kJ/kg/^{0}C
Average Specific Heat	2.653	kJ/kg/^{0}C
Inlet Temprature of Oil	195	^0C
Outlet Temprature of Oil	218	no
No. of Units	1	no
Emission factor	0.056	tCO_2/GJ
Calculations for One unit		
Heat Gained by Oil	5106.5439	MJ/ hr
Working Hours Per day	24	hours
Working Days Per year	365	days
Energy saved per year (GJ/year)	44733.325	GJ/year
Total Energy saved per year for one unit	44733.325	GJ/year
Emission Reduction	2505	tCO_2/year

CASE STUDY NO. 3

Emission reduction Calculations(Train B)	Value	Units
Operating Range of WHRU	195-217	^0C
Flow Rate of Oil	149	m3/hr
Density at 195° C	0.67	ton/m3
Density at 217° C	0.65	ton/m3
Average Density	0.66	ton/m3
Flow Rate of Oil	97.70	ton/hr
Specific heat of Oil 195° C	2.604	kJ/kg/^0C
Specific heat of Oil 217° C	2.698	kJ/kg/^0C
Average Specific Heat	2.651	kJ/kg/^0C
Inlet Temprature of Oil	195	^0C
Outlet Temprature of Oil	217	No
No. of Units	1	No
Emission factor	0.056	tCO_2/GJ
Calculations for One unit		
Heat Gained by Oil	5737.5585	MJ/ hr
Working Hours Per day	24	hours
Working Days Per year	365	days
Energy saved per year (GJ/year)	50261.012	GJ/year
Total Energy saved per year for one unit	50261.012	GJ/year
Emission Reduction	2815	tCO_2/year

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