CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-SSC-PDD)
Version 03 - in effect as of: 22 December 2006

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Revision history of this document

Version Number	Date	Description and reason of revision
01	21 January 2003	Initial adoption
02	8 July 2005	• The Board agreed to revise the CDM SSC PDD to reflect guidance and clarifications provided by the Board since version 01 of this document. • As a consequence, the guidelines for completing CDM SSC PDD have been revised accordingly to version 2. The latest version can be found at <http://cdm.unfccc.int/Reference/Documents>.
03	22 December 2006	• The Board agreed to revise the CDM project design document for small-scale activities (CDM-SSC-PDD), taking into account CDM-PDD and CDM-NM.

SECTION A. General description of small-scale project activity

A.1 Title of the small-scale project activity:

>> **Demand side energy efficiency project at IPCL-Vadodara Complex**

Version No 8 Dated **18/08/07**[1]. Project Reference No. RIL/I/PDD/0607/006

A.2. Description of the small-scale project activity:

>> **Introduction**

Reliance Group has acquired control of Indian Petrochemicals Corporation Limited (IPCL) in the year 2002 when Government of India, as a measure of privatisation of Public Sector Undertakings (PSUs), divested its equity holding to IPCL to Reliance Group Company. IPCL is the pioneering petrochemical company in India, established on March 22, 1969. Today, IPCL is one of the leading petrochemical companies in India involved in the business of manufacturing polymers, synthetic fiber, fiber intermediates, solvents, surfactants, industrial chemicals, catalysts and adsorbents. The Company is backed by strong Research Centre, Product Application Centers, Technology Management Centers and Customer Relations Centers. The company owns and operates three petrochemical complexes - a Naphtha based complex at Vadodara, Gujarat and Gas based complexes at Nagothane near Mumbai in Maharashtra and at Dahej near Bharuch in Gujarat. The company produces over one million tonnes of merchant products and has a turnover close to USD 2bn.

Vadodara complex is the oldest complex in the IPCL & Reliance family. Its construction was started in May 1970 and whole complex was commissioned in March 1979. The Vadodara Complex houses 21 manufacturing units within the complex spread over nearly 357 hectares of land. The different products manufactured at the manufacturing sites are Linear Alkyl Benzene, Acrylic Fibres, Acrylates, Ethylene, Propylene, Ethylene Glycol, Polyvinyl chloride, Polyethylene, Polypropylene, Polybutadiene rubber, Benzene, etc. It also has a Captive Power Plant. Vadodara Manufacturing Complex is the first fully integrated Petrochemical Complex of India.

Purpose

Reliance after having taken over management control of Vadodara Manufacturing Complex, introduced the concept of CDM in energy conservation schemes that result from audit programmes with the aim of benefit to employees and neighborhood, which were carried out in-house to assess energy conservation potential at the complex by identifying possibilities to adopt new technologies/ modifications to minimize the energy losses and reduce specific energy consumption. RIL at Vadodara Manufacturing Complex is

[1] *All dates are in dd/mm/yy format*

consciously working in the field of energy conservation and management to reduce Green House Gas emission. In recognition of its effort, contribution and success, Vadodara Complex became winners of various energy conservation awards like National Energy Conservation Award in Petrochemicals Sector by Ministry of Power, Government of India, and National Award for Excellence in Energy Management by CII, Award for Excellence in Natural Gas Conservation by GAIL and also is also recipient of various awards for its work in the field of Environment protection, Pollution reduction and safety.

The purpose of undertaking this project activity was improving the efficiency of the oil heating facility by preventing loss of thermal energy in flaring of the Acetylene Wash Column overhead stream, and using the same gainfully, thereby increasing the gaseous fuel component and reducing LSHS in the fuel mix being fired for heating oil in the Hot Oil Heater, HH-2 at LAB Plant. The useful utilization of the heat component of a hydrocarbon stream that was being flared, thus improves energy efficiency by reducing additional fuel usage in the form of LSHS in the oil heating facility. The project activity also contributes towards reduction of emission of Greenhouse Gas from burning equivalent quantity of LSHS.

The Linear Alkyl Benzene (LAB) is produced from C_{10} - C_{13} linear olefins and are useful detergent intermediates that can be readily sulfonated to yield linear alkylbenzene sulfonates.

$$C_{10} - C_{13} \text{ olefins} + \text{Benzene} \xrightarrow{\text{HF ACID CATALYST}} \text{Linear alkyl benzene (LAB)}$$

$$\text{Linear Alkyl benzene(LAB)} \xrightarrow{\text{SULFONATION}} \text{LAB sulfonates}$$

These compounds constitute the “active” ingredients of many **household detergents.** They are surface active compounds (surfactants) which are combined with various builders (often inorganic salts) to make up a detergent formula.

$$\text{LAB SULFONATES + BUILDERS} \longrightarrow \text{HOUSEHOLD DETERGENTS}$$

LAB manufacturing process is a technology, patented by UOP Inc.

The LAB Plant is divided into two parts called,

a) Front End

b) Back End

In the Front End, normal paraffin (C_{10} to C_{13}) is extracted from kerosene feed and purified. The purified feedstock is fed to the Back End for conversion to Linear Alkyl Benzene (LAB). In the

Back End, fossil fuel is consumed in the Hot Oil Heater, HH-2, to maintain the reaction temperature at ~180 ^{0}C.

Since flared gases or liquids represent wastage of energy, a study was undertaken to identify sources of thermal energy being lost to flare. It was found that the non-condensable gases from Acetylene Wash Column overhead (AWC O/H) in the Butadiene plant, which contains Vinyl Acetylene (VA), as such a stream being flared. This stream was being flared as recommended by the Licensor of the Hydrogenation process in order to prevent build-up of Vinyl Acetylene in the system to dangerous levels causing in situ explosions. The VA is an unsaturated hydrocarbon with a carbon number of four and is a highly unstable, flammable, high pressure gas with a low flash point. It was thought of preventing wastage of the thermal energy available in the Acetylene Wash Column Overhead and use it in the Hot Oil Heater HH-2 of LAB Plant, thus saving energy and reducing emission of GHG from combustion of fossil fuel LSHS.

Sustainable development:

The project also contributes to sustainable development in terms of environmental, socio-economic and technological development by

- Reduction in fossil fuel consumption - a non-renewable source of limited availability.
- Reduction in GHG emission, mainly carbon dioxide.
- Prevention of air quality deterioration due to adverse effects of
  - Fossil fuel extraction,
  - Petroleum processing, and
  - Fuel transportation.
- Reduction in atmospheric vent of hydrocarbon.
- Encouraging other large facilities irrespective of sector to adopt small but effective fuel switch measures.
- Release the available primary source of energy, LSHS, for processes where it is necessary

The four criteria for sustainable development as defined by Host Government are addressed as follows:

Community Development

Vadodara Complex achieves this goal by fulfilling the role of a good neighbour to the surrounding villagers at its township and production areas at Vadodara. In order to achieve this goal in Vadodara, manufacturing Complex, works through Rural Development Cell and through Trusts constituted exclusively for this purpose. The Rural Development Cell looks after the villagers overall development in the areas of Health, Education, Employment generation and use of improved technology in agriculture and wasteland development. Our activities in the villages surrounding Vadodara Complex during the years are briefly summarized below:

Women Empowerment Programme: Employment generation through vocational training with the help of Gram Technology, an agency of Govt of Gujarat and Jan Shikshan Sansthan, an organization promoted by the Govt of India, Ministry of HRD involved in the area of providing vocational training to the village artisans and women to generate employment opportunity.

Employment and Income Generation: In order to provide gainful employment opportunities to the youths of project affected villages, Vadodara Complex has been working in association with the government sponsored agencies in providing vocational training. During the years, we have arranged training for youths in Hospital Attendant Courses and also helped them in-house to improve their fluency in spoken English.

Water Conservation and Improved methods of cultivation: Development of village means overall development of the farmer and the farm labour in the villages. Farmers were provided access to the experience of experts from PDC farm who shared their knowledge on drip irrigation, mulching, vermiculture and use of manure, etc. Farmers were also introduced to Plasticulture Development Farm.

To augment the depleting water levels in villages, work in recharging village wells has been started in one of the villages. Vadodara Complex also encourages the Gram Panchayats in the surrounding villages to plant trees and fruit bearing sapling to reclaim the available wasteland. The plants and tree saplings are donated by Vadodara Complex.

Health and Sanitation : In the area of health care, and sanitation, Vadodara Complex has been working in these villages over the years and has demonstrated the use of smokeless choolas, community and household latrines and sanitation, organised medical camps for human and animals.

Socially oriented Activities: With the active cooperation of the Collector, Vadodara, Vadodara Complex has also worked in the area of revamping the Natural Drain (Kass) between Undera and Laxmipur and also between Undera and Ankodia via Koyali Village and also Karachia and Noritalao. Vadodara Manufacturing Complex also provides financial help to various NGOs and institutions in the area of rural development, education and promotion of sports.

Environmental impact*:* The project activity has reduced consumption of fossil fuel for generation of heat energy based on LSHS, thus directly reducing emission of Greenhouse Gases (GHG) like carbon dioxide in addition to other pollutants like NOx and SOx. It has also resulted in an indirect improvement in air quality by way of reduced emissions as a result of exploration, processing and transportation of fuel. This contributes to the sustainable development of environment.

***Social impact**:* The project activity generated employment during the erection and commissioning of the project. Interaction with the Process Licensor, enhanced the skill sets of manpower.

***Economic impact*:** The project activity reduces fossil fuel consumption in the LAB heaters, thus reducing the variable cost of production. Though the quantum of savings are negligible as compared to total turnover of the site, directionally the project contributes to economic development.

Technological impact : This kind of innovative and effective energy efficiency measures serve to demonstrate the operational efficacy of such systems and encourage others to adopt similar measures leading to further conservation of fuel and protection of environment.

A.3. Project participants:

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Name of the Party involved (*) ((Host) indicates a host Party)	Private and / or Public entity(ies) project participants (*)(as applicable)	Indicate if the party involved wishes to be considered as project participant (Yes / No)
India [(Ministry of Environment and Forest (MoEF)(Host party)]	**Reliance Industries Limited** (Private entity)	**No**

Contact information of project proponent is attached as Annex-I.

A.4. Technical description of the small-scale project activity:

Vadodara Complex is an integrated Petrochemical complex using Naphtha as the main feedstock. There are downstream production units to convert the cracked products from Naphtha Cracker to value added products.

The oil heating facility in manufacturing Linear Alkyl Benzene (LAB), includes the hot oil heater HH-2, and associated equipments and sub-systems including the flare, available fuels and fuel feeding systems. The Hot Oil Heater HH-2 is equipped to burn liquid, gaseous or a combination of both fuels.

Non-condensable gases from Acetylene Wash Column overhead (AWC O/H) in the Butadiene plant which contain Vinyl Acetylene (VA) was being flared. This stream was being flared as recommended by the process licensor in order to prevent build-up of the highly unstable and flammable Vinyl Acetylene in the system to dangerous levels causing in situ explosions. This stream was considered for recovery, and subsequent to hydrogenation to n-Butane, for use in augmenting Fuel Gas supply for use in the Hot Oil Heater HH-2 at LAB Plant.

The flare forms a necessary part of the gaseous fuel handling system, the latter being a sub-system of the oil heating facility. In the absence of the project activity, this flare was utilised to burn off the Acetylene Wash Column overhead (AWC O/H). The energy content of this AWC O/H, a potential fuel for oil heating, was thus lost to the atmosphere. Hence, not only was energy wasted in the flare leading to inefficiency of the oil heating facility, a carbon intensive fuel, LSHS was consumed more leading to additional GHG emissions.

In order to improve the energy efficiency of oil heating facility it was envisaged that loss of thermal energy in the oil heating facility can be reduced by retrofitting in the fuel feeding system. As the quantity of fuels required are dictated by energy demand, energy from this AWC O/H is thus utilised effectively to augment Fuel Gas for use in the oil heating facility and reduce an energy-wise equivalent amount of LSHS. This improves the energy efficiency of the oil heating facility and at the same time reduces GHG emission.from additional energy-wise equivalent quantity of LSHS/Furnace Oil that is fired in the heater.

Due to the very low pressure of AWC O/H gas the fuel sub-system had to be first retrofitted with a recovery system. This normally calls for a process of liquefaction by compression and subsequent chilling. Such a process would require a compressor that consumes electrical energy and additional chilling streams that also calls for additional input of energy. This is the process recommended by the process licensor Search for an alternative method resulted in identifying Pyrolysis Gasoline stream as a solvent to recover the AWC O/H stream.

The AWC O/H stream had to be pressurized to keep it in the liquid phase in the Pyrolysis Gasoline stream. Hence, Pyrolysis Gasoline (PG) from the minimum flow line of the PG feed pump to Hydrogenation Reactor was identified as the driving medium to recover the AWC O/H stream from the flare header by using an eductor.

An eductor is a device in which the energy of one stream is used to pump another. The pumping gas/liquid, say compressed air, enters through the nozzle at the right and passes through the venturi nozzle and out the discharge opening at the left (See Fig 1 below). As it passes into the nozzle, it develops a vacuum at the suction port that causes the sample in the suction chamber to be entrained with the stream and be delivered through the exhaust port.

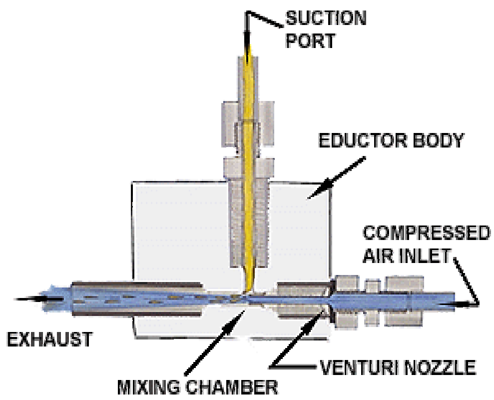

Fig 1. *Schematic of Eductor*

The eductor installed uses Pyrolysis gasoline (PG) as the motive fluid and the recovered stream gets dissolved in the PG stream and is returned to the PG Feed Drum from where it is fed to the hydrogenation reactor to be recovered as saturated C4, namely n-Butane, for augmenting the quantity of Fuel Gas available. This fuel gas is utilized in the LAB heater, HH-2, to replace an energy-wise equivalent quantity of LSHS, thus leading to energy conservation and reduction in CO_2 emission.

The PG obtained as a product of naphtha cracking is rich in aromatics and aliphatic hydrocarbons. However, this stream is unstable because of its high diolefinic components, which due to the unsaturation tend to polymerise to form gum. If the C6 cut of the raw PG were to be run in the benzene extraction unit without hydrogenation, inferior benzene would be produced since the bulk of the olefin and diolefin content of the charge would be concentrated in the aromatic fraction. To remove these unsaturated compounds the raw PG charge has to be selectively hydrogenated prior to aromatic extraction.

The hydrogenation of PG is done in two stages. In the first stage, all the diolefins are selectively hydrogenated in liquid phase over a nickel oxide catalyst. The second stage hydrogenation is carried out only with the C6 cut obtained from the first stage fractionating column. Here, the catalyst used is cobalt-molybdenum oxide and all the mono-olefins get saturated.

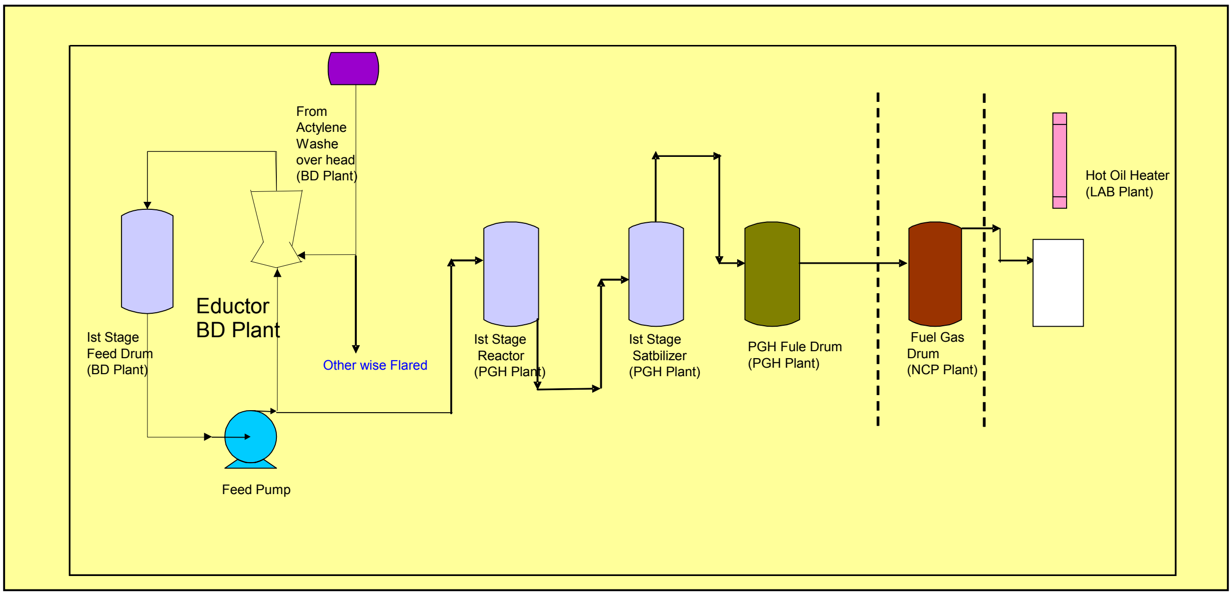

Fig 2. *Schematic of VA Recovery*

After hydrogenation the products are distilled and purified to obtain hydrocarbons containing five or more carbon atoms on the carbon-carbon backbone (referred to as C5 and above) as the product. The streams containing C4s and below are downgraded into the Fuel Gas system to augment the available Fuel Gas. The augmented Fuel Gas is then used in the Hot Oil Heater HH-2 of LAB Plant. Thus, the energy that was being wasted in the flare is recovered resulting in reduced quantity of LSHS fired and thus reduced GHG emission.

A.4.1. Location of the small-scale project activity:

>>
INDIA

A.4.1.1. Host Party(ies):

>>
INDIA

A.4.1.2. Region/State/Province etc.:

>>
GUJARAT

A.4.1.3. City/Town/Community etc:

>>
P.O. : Petrochemicals, Dist. : Vadodara - 391 346.

A.4.1.4. Details of physical location, including information allowing the unique identification of this small-scale project activity :

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The project site is located at the manufacturing premises of Vadodara Manufacturing Complex, in the state of Gujarat in the Western part of India. It is about 20 Km from Vadodara. The nearest National Highway is NH-8 and nearest railway station is at Ranoli. The site coordinates are **Latitude 22.00⁰ E** and **Longitude 72.24⁰ N.**

A.4.2. Type and category(ies) and technology/measure of the small-scale project activity:

>>

Type II D(Ver 10): Energy efficiency and fuel switching measures for industrial facilities

A.4.3 Estimated amount of emission reductions over the chosen crediting period:

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As stated above, the reduction in emission of carbon dioxide is a resultant of the project activity. The project was commissioned on 24/06/03. The estimated reduction of carbon dioxide emission from the project is given in the Table A.1 below. Details are indicated in the tables in Section E.

Emission reductions

Table A.1

Year	Annual estimation of emission reduction tonnes CO2 e
Year 1	6494
Year 2	6494
Year 3	6494
Year 4	6494
Year 5	6494
Year 6	6494
Year 7	6494
Year 8	6494
Year 9	6494
Year 10	6494
Total estimated reductions (tonnes CO2 e)	64940
Total Number of crediting years	10
Annual Average over the crediting period of estimated reductions (tonnes of CO2 e)	6494

A.4.4. Public funding of the small-scale project activity:

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No public funding has been sought for the project activity and the project proponent made the entire investment for the project from funds available with itself.

A.4.5. Confirmation that the small-scale project activity is not a debundled component of a large scale project activity:

As mentioned under Appendix C of the simplified Modalities and Procedure for Small-Scale CDM project Activities, “ A proposed small-scale project activity shall be deemed to be a debundled component of a large project activity if there is a registered small-scale CDM project activity or an application to register another small-scale CDM project activity:

- With the same project participants
- In the same project category and technology / measure and
- Registered within the previous 2 years and
- Whose boundary is within 1 km of the project boundary of the proposed small-scaled activity at the closest point.”

The project activity is not a debundled component of a large project activity as there is no small scale CDM project activity or an application registered by Vadodara Manufacturing complex, in the same project category in the last two years within 1 km of the project boundary of the proposed small-scale project activity.

SECTION B. Application of a baseline and monitoring methodology

B.1. Title and reference of the approved baseline and monitoring methodology applied to the small-scale project activity:

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Type II D (Ver 10): **Energy efficiency and fuel switching measures for industrial facilities**

Reference : Categorisation of Appendix B to the simplified modalities and procedures for small-scale CDM project activities.

B.2 Justification of the choice of the project category:

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Applicability criteria of the project as mentioned in the methodology AMS IID are as follows:

These criteria in the context of the project are point-wise addressed in the following table:

Table B.1

Category	Criteria	Project Activity	Applicability
Type II D	Energy efficiency measures implemented at a single industrial facility	The project is implemented at a single facility, i.e. the BBH Unit of Vadodara Manufacturing Complex. The project is aimed at energy efficiency through fuel switching measure.	Methodology is applicable
	The category covers project activities aimed primarily at energy efficiency	The Project activity improves energy efficiency of the system inside the project boundary by recovering the energy wasted in the flare and using it to heat oil in the heater, thus reducing the heat rate of the system.	Methodology is applicable
	The measures may replace existing equipment or be installed in a new facility	The project involves recovery of waste hydrocarbon stream by using an Eductor using Pyrolysis Gasoline as a motive fluid to trap escaping hydrocarbons.	Methodology is applicable
	The aggregate energy savings of a single project may not exceed the equivalent of 15 GWh_e per year. A total saving of 15 GWh_e per year is equivalent to a **maximum saving of 180 GWh_{th} per year** in fuel input to the generation unit.	The energy saving through this activity is **24.609 GWH_{Th}** per year.	Methodology is applicable
	In the case of replacement, modification or retrofit measures, the baseline consists of the	In the absence of the project activity, the Hot Oil Heater, HH-2 would have continued to consume LSHS equivalent to the energy obtained from	Methodology is applicable

	energy baseline of the existing facility or sub-system that is replaced, modified or retrofitted. In the case of a new facility the energy baseline consists of the facility that would otherwise be built.	the recovered hydrocarbon stream that reaches the heater as a C4 stream of n-Butane. Had the project activity not been carried out at Vadodara Complex, it would have, additionally, continued to flare the AWC O/H stream.. Hence the baseline for the project activity will be the energy equivalent quantity of LSHS used in the Hot Oil Heater, HH-2 at LAB Plant.	
	In the absence of the CDM project activity, the existing facility would continue to consume energy (ECbaseline, in GWh/year) at historical average levels (EChistorical, in GWh/year), until the time at which the industrial or mining and mineral production facility would be likely to be replaced, modified or retrofitted in the absence of the CDM project activity (DATEBaselineRetrofit).	Not applicable.	--
	If the energy efficiency technology is equipment transferred from another activity or if the existing equipment is transferred to another activity, leakage is to be considered.	No transfer equipment.	--
	In the case of a new facility, monitoring shall consist of: (a) Metering the energy use of the equipment installed; (b) Calculating the energy savings due to the equipment installed.	Relevant metering requirements have been identified under monitoring plan.	Methodology is adhered.
	In case the project activity involves fossil fuel switching measures leakage resulting from fuel extraction, processing, liquefaction, transportation, re-gasification and distribution of fossil fuels outside of the project boundary shall be	Fuel switch is attained by reduction of fossil fuel. LSHS is replaced with the recovered fuel gas. Hence the methodology requirements not applicable.	Methodology is adhered.

	considered. The guidance provided in the leakage section of ACM0009 as in annex 1 of this document shall be followed for this purpose.		
	In case the project activity involves the replacement of equipment, and the leakage effect of the use of the replaced equipment in another activity is neglected, because the replaced equipment is scrapped, an independent monitoring of scrapping of replaced equipment needs to be implemented. The monitoring should include a check if the number of project activity equipment distributed by the project and the number of scrapped equipment correspond with each other. For this purpose scrapped equipment should be stored until such correspondence has been checked. The scrapping of replaced equipment should be documented and independently verified.	No replacement of equipment.	Methodology is adhered.

From the above discussion, it can be concluded that the project meets all the applicability criteria set out under the selected small-scale methodology and hence the project category is applicable to the project.

The emission factor for LSHS has been taken from IPCC Good Practice Guidance, 2000. The calculation procedure has been provided in Annexure 3.

B.3. Description of the project boundary:

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The project boundary is the physical, geographical site of the industrial facility, process or equipment that is affected by the project activity**”.** A simple schematic diagram showing the project boundary and the equipments considered in the project activity is shown below.

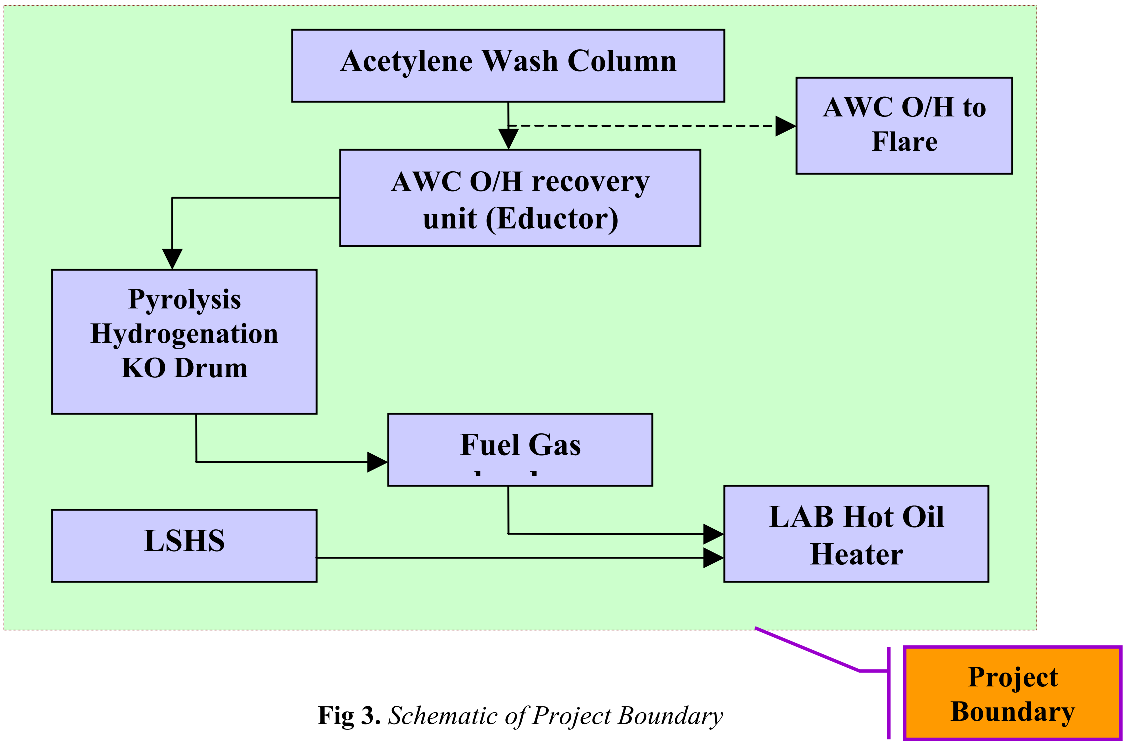

Fig 3. *Schematic of Project Boundary*

B.4. Description of baseline and its development:

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In the absence of the project activity, the Hot Oil Heater, HH-2 would have continued to consume LSHS equivalent to the energy obtained from the recovered hydrocarbon stream that reaches the heater as a C4 stream of n-Butane. Had the project activity not been carried out at Vadodara Complex, it would have, additionally, continued to flare the AWC O/H stream. Hence the baseline for the project activity will be the energy equivalent quantity of LSHS used in the Hot Oil Heater, HH-2 at LAB Plant.

In addition to the emissions arising from LSHS combustion in HH-2, CO_2 emissions occur during fossil fuel extraction, processing and transportation to the consumption site. Reduction is LSHS combustion also results in reduction due emission from these sources. In view of insufficient specific data on these activities as applicable to this project activity, the resultant reduction in emissions is not included in the project. This also provides a conservative estimate of the emission reductions.

Table B.2

Emission reduction due to recovered Acetylene Wash Overhead Stream				
1	Monthly average Acetylene Wash Column o/h, AWC (Jul'03 to Mar'06)	Kg/month	Q_{AWC}	**DCS/IP21**
2	**Composition of AWC**			
2.a	Avg 1,3-Butadiene (1,3-BD) content in AWC stream	% wt	N_{BD}	**Laboratory analysis**
2.b	Avg Ethyl acetylene (EA) content in AWC stream	% wt	N_{EA}	**Laboratory analysis**
2.c	Avg Vinyl Acetylene (VA) content in AWC stream	% wt	N_{VA}	**Laboratory analysis**
3	**Quantity of recovered hydrocarbon**			
3.a	Quantity of 1,3-BD	Kg/month	$Q_{BD} = Q_{AWC} * N_{BD}$	**Calculated**
3.b	Quantity of EA	Kg/month	$Q_{EA} = Q_{AWC} * N_{EA}$	**Calculated**
3.c	Quantity of VA	Kg/month	$Q_{VA} = Q_{AWC} * N_{VA}$	**Calculated**
4	**Molecular weight of components**			
4.a	Molecular wt of 1,3;BD		MW_{BD}	**Standard value**
4.b	Molecular wt of EA		MW_{EA}	**Standard value**
4.c	Molecular wt of VA		MW_{VA}	**Standard value**
5	**Moles of recovered components**			
5.a	Moles of 1,3-BD	Kg-moles/month	$M_{BD} = Q_{BD} / MW_{BD}$	**Calculated**
5.b	Moles of EA	Kg-moles/month	$M_{EA} = Q_{EA} / MW_{EA}$	**Calculated**
5.c	Moles of VA	Kg-moles/month	$M_{VA} = Q_{VA} / MW_{VA}$	**Calculated**
6	**Annual energy saving by recovery of eqv n-Butane**			
6.a	Moles of n-Butane from 1,3-BD	Kg-moles/month	$M_{butBD} = M_{BD}$	**Calculated**
6.b	Moles of n-Butane from VA	Kg-moles/month	$M_{butEA} = M_{EA}$	**Calculated**
6.c	Moles of n-Butane from EA	Kg-moles/month	$M_{butVA} = M_{VA}$	**Calculated**
6.d	Total moles of n-Butane recovered	Kg-moles/month	$M_{but} = M_{butBD} + M_{butEA} + M_{but\ VA}$	**Calculated**
6.e	Molecular wt of n-Butane		Mw_{but}	**Standard value**
6.f	Monthly average n-Butane recovered (Jul'03 to Mar'06)	T/month	$Q_{but} = (M_{but} * MW_{but}) /1000$	**Calculated**
6.g	Estimated annual n-Butane recovery	T/yr	$Q_{tot} = Qbut * 12$	**Calculated**
6.h	NCV of n-Butane (LPG)	TJ/T	NCV_{but}	**See Footnote**[2]
6.i	Total energy saved	TJ/yr	$En = Q_{tot} * NCV_{but}$	**Calculated**
7	**Emission reduction**			
7.a	CO2 emission factor of LSHS	tCO2/TJ	Ef_{LSHS}	**Pg 2.16, Table 2.2, 2006 IPCC Guidelines for National Greenhouse Gas Inventories**
7.b	Emission reduction due to reduced LSHS consumption equivalent to n-Butane from AWC stream	tCO2/month	$E = En * Ef_{LSHS}$	**Calculated**

[2] *'Revision of default Net Calorific Value, Carbon Content Factor and Carbon Oxidization Factor for various fuels in 2006 IPCC GHG Inventory Guideline' Kainou Kazunari, August 2005, RIETI, IAI, Government of Japan*

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered small-scale CDM project activity:

As explained above, the project initiatives qualify under Type II, D- Energy efficiency and fuel switching measures for industrial facilities of small scale CDM simplified modalities and procedure. The project additionality is analysed below.

In accordance with paragraph 28 of the simplified modalities and procedures for small scale CDM projects, a simplified baseline and monitoring methodology is listed in Appendix B may be used if the project participant can demonstrate that project activity would otherwise not be implemented due to the existence of one or more barrier (s) listed in the attachment A to Appendix B. Similarly, for the identified CDM project, following barriers have been overcome:

As per the decision 17/cp.7 Para 43, a CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity. In addition to this 'The Charter on Corporate Responsibility for Environmental Protection' does not mention any reduction of GHGs, as mentioned in the Kyoto Protocol, as a corporate task/responsibility, but only asks for plans for improved thermal efficiency of plants and upkeep of pollution control systems with adequate redundancy of power supply. Also, there are/were no regulations and programs either at the State or Municipal or Country levels that compel or constrain the facility from implementing energy efficiency projects. In the Manufacturing sector in India, energy efficiency projects are not under the purview of any legal act. Hence, Vadodara Manufacturing Complex of IPCL has taken initiative above and beyond the demands of the above mentioned Charter, national/sectoral policies or legal acts, to improve the efficiency of its operations and reduce energy consumption, thereby reducing GHG emission.

Additionality of the project is justified based on the guidelines in Attachment A to Appendix B of the simplified modalities and procedures for small-scale projects. The project activity would not have occurred anyway due to at least one of the following barriers.

Technological barrier *A less technologically advanced alternative to the project activity involves lower risks due to the performance uncertainty or low market share of the new technology adopted for the project activity and so would have led to higher emissions*;

As observed within the project boundary, in the absence of the project activity, the hydrocarbon stream from the Acetylene Wash Column overhead would have continued to burn in the flare. The thermal energy of this stream would have thus been lost to the atmosphere. In the project commissioned on

24/06/2003, this hydrocarbon stream is recovered to augment Fuel Gas that is used in the fuel mix of Hot Oil Heater HH-2 at LAB Plant. The thermal energy released during combustion of the n-Butane gas resulting from the recovered stream is utilised in the said heater to heat oil used in the manufacturing process. As a result, an energy-wise equivalent quantity of LSHS is reduced from the fuel mix of the heater. This activity, thus, leads to reduced energy consumption within the project boundary for the purpose of heating oil and also leads to reduction in GHG emission.

Table B.2

Additionality Requirements
Identification of alternatives to the project activity consistent with current laws and regulations **Sub-step 1a. Define alternatives to the project activity:** Following alternatives for the project are identified 1) Project activity without CDM benefit 2) Liquefying and cooling the recovered stream for processing as feed to hydrogenation unit 3) Product recovery of Vinyl Acetylene (VA) for use in organic synthesis 4) Continuation of existing practice The first two alternatives are ruled out because of technological and prevailing practice barrier which are elaborated below. The third alternative would have generated a by-product of very small quantity. The project proponent is not in the business of specialty chemicals like VA. Developing a dedicated marketing infrastructure for such small quantity is not viable. Continuation with the existing practice as recommended by the process licensor, i.e. flaring the Acetylene Wash Column overhead stream would have been the most plausible alternative as this alternative was not affecting business scenario. Hence, continuation with the existing practice is the baseline scenario. The project proponent has executed this project as an effort to reduce Greenhouse Gas emission.
Technological barriers: 1. Risks involved: The project activity involves recovering a stream of hydrocarbons consisting primarily of Vinyl acetylene (VA), ethyl acetylene (EA) and 1,3-Butadiene (BD). As per the recommendation of the process licensor, the AWC O/H stream is only to be flared to prevent build up of VA beyond the maximum permissible limit of 30% of the mixture. Vinyl acetylene is an extremely dangerous compound because of possible decomposition[3]. The situation is aggravated by the presence of EA and BD that lower the limit for decomposition. Rapid decomposition of VA results in rapid release of heat leading to explosion. An explosion in a

[3] *Exhibit 1: Copy from Plant Safety Manual*

Additionality Requirements
hydrocarbon stream of a Plant can result in a chain or series of explosions, resulting in loss of property and human life. 2. The performance of the eductor is dependent on the pressure of the motive fluid, in this case Pyrolysis gasoline. Any build-up of pipe corrosion products on the suction nozzle or at the throat of the eductor, will reflect immediately as a loss in eductor performance and result in upset of the recovery system. Project proponent has to train the employees as they are neither experienced nor trained to handle such issues arising out of increase in VA concentration in AWC O/H stream. The people at Vadodara Manufacturing Complex BBH unit are not trained in the aspects of handling these risks. Iimplementation of the project has resulted in additional risks which the operating personnel have to tackle on a day-to-day basis by vigilant monitoring of the system operation and VA concentration in the recovered stream, as well as in the attached systems. This calls for training and refreshers for the operating staff at regular intervals. It can be appreciated that the risks involved in devising and implementing the system of recovery were sufficient to warrant non-approval of the scheme. Further noting that the business in general of Vadodara Manufacturing Complex was not impacted by flaring of this stream as was being practiced, there was no compelling reason for Vadodara Manufacturing Complex, other than reducing GHG emission reduction, to recognize the risks and still implement the recovery scheme. The project activity crosses technological barriers as the project proponent has mitigated significant risk by installing safety instruments and automations, although project proponent had no experience to implement this project. The system becomes much more complicated which may disturb the main product quality if things go wrong.
Barrier due to prevailing practice The prevailing practice in similar sized plants elsewhere, is liquefaction of this vent stream and cooling to 5 ^{0}C. This involves employing cooling and chilling systems that consume electricity that in turn results in emission of carbon dioxide at the generation stage. Hence, the alternative results in additional GHG emissions[4]. Vadodara Manufacturing Complex has adopted a scheme that is not a common practice and does not lead to additional emission of GHG. For the Petrochemicals sector in India, energy efficiency projects are not under the purview of any legal

[4] *Documents are available for reference*

Additionality Requirements
act. However, this project activity complies with all good and safe engineering practices. Hence, there is no mandatory requirement for project proponent to implement the energy efficiency project such as this project activity. The project proponent regularly initiate energy efficiency programmes at their all manufacturing sites also have taken voluntary initiatives to realize the potential of Clean Development Mechanism under the Kyoto Protocol at by organizing workshop / Energy Conservation meet. Such initiative needs considerable investment, highly skilled & trained personnel and dedicated technical personnel to monitor the energy utilized. Awareness and systematic approach towards energy conservation and reduction of GHG emission is not a common practice in the country. It is also not a common practice in Indian industries to carry out such major modifications in the process on ground of energy conservation alone. In recognition of its effort, contribution and success, Project proponent became winners of various energy conservation awards like National Energy Conservation Award in Petrochemicals Sector by Ministry of Power, Government of India, and National Award for Excellence in Energy Management by CII, Award for Excellence in Natural Gas Conservation by GAIL and also is also recipient of various awards for its work in the field of Environment protection, Pollution reduction and safety.

Impact of CDM registration

The approval and registration of the project activity as a CDM activity would result inter alias in the following benefits:

- Reduction in GHG emissions.
- CDM fund will provide additional coverage to cover the risk due to failure of project, shut down of plant and loss of production.
- The fund will stimulate efforts in Vadodara Manufacturing Complex to find methods of mitigating risks and enhance replication of such projects to promote GHG abatement in the industry.
- Publicity of the efforts taken by the project proponent towards energy efficiency would result in sustainable development; and
- The social status of the company would be enhanced.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

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In addition to the emissions arising from LSHS/Liquid fuel combustion in, additional CO_2 emissions occur during fossil fuel extraction, processing and transportation to the consumption site. Reduction in LSHS consumption also results in reduction of GHG emissions due to these activities. In view of insufficient specific data on these activities as applicable to this project activity, the resultant emissions are not included in the project. This also provides a conservative estimate of the emission reductions.

As per the provisions of paragraph 14 of Draft Simplified Modalities and Procedures for Small Scale CDM Project Activities [FCCC/CP/2002/7/Add.3, English, Page 21] the "Project participants may use the simplified baseline and monitoring methodologies specified in appendix B for their project category" if they meet the applicability criteria of Small scale CDM project activity. As detailed in Section B.2 of this Project design Document, Category IID is applicable to the project activity. Hence, the monitoring methodology and plan has been developed in line with the guidance provided in Appendix B.

The baseline emission, i.e. CO2 emission from combustion of LSHS, is limited to the extent of the energy available from the recovered AWC O/H stream converted to n-Butane.

Within the project boundary, in the absence of the project activity, the hydrocarbon stream from the Acetylene Wash Column overhead would have continued to burn in the flare resulting in loss of thermal energy and hence lower efficiency of the oil heating facility. In the project activity, the retrofitting carried out in the fuel sub-system has resulted in this hydrocarbon stream being recovered to augment Fuel Gas that is used in the fuel mix of Hot Oil Heater HH-2 at LAB Plant. As a result, an energy-wise equivalent quantity of LSHS is reduced from the fuel mix of the heater. This activity has lead to an improvement in energy efficiency of the system within the project boundary by about 10% as shown in the sample calculation given in Table I.E of Annexure 3. The increment in energy efficiency has also resulted in reduction of GHG emission.

Hence, it is justified to apply the Small-Scale methodology AMS II.D, for this project activity.

As per the provisions set in the Category IID methodology, the following major parameters are to be measured and monitored in the project activity.

- Quantity of AWC O/H stream recovered.
- Laboratory analysis of the composition of this stream

B.6.2. Data and parameters that are available at validation:

(Copy this table for each data and parameter)

Data / Parameter:	**Q_{AWC}**
Data unit:	Kg/month

Description:	Monthly average Acetylene Wash Column O/H used
Source of data used:	Monthly Report of Plant
Value applied:	**240123.64 Kg/month**
Justification of the choice of data or description of measurement methods and procedures actually applied :	The value used is an average for a period of 33 months, Jul'03 to Mar'06, of the quantity of Acetylene Wash Column Overhead (AWC O/H) stream used as fuel in Heater HH-2.
Any comment:	This value is used in the calculation for energy used in Heater HH-2 in lieu of LSHS.

Data / Parameter:	**N_{BD}**
Data unit:	% wt
Description:	Average 1,3-Butadiene (1,3-BD) content in AWC O/H stream
Source of data used:	Laboratory Analysis records
Value applied:	**27.03 %wt**
Justification of the choice of data or description of measurement methods and procedures actually applied :	The AWC O/H stream is analysed in a Gas Chromatograph type analyser and the percentage composition of the stream is recorded in the Laboratory Information Management System (LIMS). The data is also available in the Laboratory Register maintained as record for such analysis.
Any comment:	This value is used in the calculation for energy used in Heater HH-2 in lieu of LSHS. The 95% confidence level for the average 1,3-Butadiene content in the steam is provided in Table I.F of Annexure 3.

Data / Parameter:	**N_{EA}**
Data unit:	% wt
Description:	Average Ethylacetylene (EA) content in AWC O/H stream
Source of data used:	Laboratory Analysis records
Value applied:	**6.19 %wt**
Justification of the choice of data or description of measurement methods and procedures actually applied :	The AWC O/H stream is analysed in a Gas Chromatograph type analyser and the percentage composition of the stream is recorded in the Laboratory Information Management System (LIMS). The data is also available in the Laboratory Register maintained as record for such analysis.
Any comment:	This value is used in the calculation for energy used in Heater HH-2 in lieu of LSHS. The 95% confidence level for the average Ethylacetylene content in the steam is provided in Table I.F of Annexure 3.

Data / Parameter:	**N_{VA}**
Data unit:	% wt
Description:	Average Vinylacetylene (VA) content in AWC O/H stream
Source of data used:	Laboratory Analysis records
Value applied:	**27.54 %wt**
Justification of the choice of data or description of measurement methods	The AWC O/H stream is analysed in a Gas Chromatograph type analyser and the percentage composition of the stream is recorded in the Laboratory Information Management System (LIMS). The data is also available in the Laboratory Register maintained as record for such analysis.

and procedures actually applied :	
Any comment:	This value is used in the calculation for energy used in Heater HH-2 in lieu of LSHS. The 95% confidence level for the average Vinylacetylene content in the steam is provided in Table I.F of Annexure 3.

Data / Parameter:	**MW_{BD}**
Data unit:	--
Description:	Molecular weight of 1,3-Butadiene
Source of data used:	Calculated from molecular weight of individual elements as given in a standard periodic table of elements
Value applied:	**54**
Justification of the choice of data or description of measurement methods and procedures actually applied :	Not applicable
Any comment:	This value is used in the calculation for energy used in Heater HH-2 in lieu of LSHS and will remain constant throughout the crediting period of the project.

Data / Parameter:	**MW_{EA}**
Data unit:	--
Description:	Molecular weight of Ethylacetylene
Source of data used:	Calculated from molecular weight of individual elements as given in a standard periodic table of elements
Value applied:	**54**
Justification of the choice of data or description of measurement methods and procedures actually applied :	Not applicable
Any comment:	This value is used in the calculation for energy used in Heater HH-2 in lieu of LSHS and will remain constant throughout the crediting period of the project.

Data / Parameter:	**MW_{VA}**
Data unit:	--
Description:	Molecular weight of Vinylacetylene
Source of data used:	Calculated from molecular weight of individual elements as given in a standard periodic table of elements
Value applied:	**52**
Justification of the choice of data or description of measurement methods and procedures actually applied :	Not applicable
Any comment:	This value is used in the calculation for energy used in Heater HH-2 in lieu of LSHS and will remain constant throughout the crediting period of the project.

Data / Parameter:	**MW_{but}**
Data unit:	--
Description:	Molecular weight of n-Butane
Source of data used:	Calculated from molecular weight of individual elements as given in a standard periodic table of elements
Value applied:	**58**
Justification of the choice of data or description of measurement methods and procedures actually applied :	Not applicable
Any comment:	This value is used in the calculation for energy used in Heater HH-2 in lieu of LSHS and will remain constant throughout the crediting period of the project.

Data / Parameter:	**NCV_{but}**
Data unit:	TJ/kT
Description:	Net calorific value of n-Butane
Source of data used:	*'Revision of default Net Calorific Value, Carbon Content Factor and Carbon Oxidization Factor for various fuels in 2006 IPCC GHG Inventory Guideline'* Kainou Kazunari, August 2005, RIETI, IAI, Government of Japan
Value applied:	**46.3 TJ/kT**
Justification of the choice of data or description of measurement methods and procedures actually applied :	The 1,3-Butadiene, Ethylacetylene and Vinylacetylene in the AWC O/H stream are converted into n-Butane during hydrogenation and are downgraded into the Fuel Gas system to augment the available Fuel Gas that is then used in the Hot Oil Heater HH-2 of LAB Plant. The energy from this n-Butane results in reduced quantity of LSHS fired and thus reduced GHG emission.
Any comment:	This value is used in the calculation for energy used in Heater HH-2 in lieu of LSHS and will remain constant throughout the crediting period of the project.

Data / Parameter:	**Ef_{LSHS}**
Data unit:	tCO2/TJ
Description:	CO_2 emission factor of LSHS
Source of data used:	Page 2.16, Table 2.2, Volume 2:Energy, *2006 IPCC Guidelines for National Greenhouse Gas Inventories*.
Value applied:	**73.3 tCO2/TJ**
Justification of the choice of data or description of measurement methods and procedures actually applied :	The methodology allows for use of IPCC default values of emission factors for fossil fuels.
Any comment:	This value is used in the calculation emission reduction due to reduction of energy equivalent quantity of LSHS in Heater HH-2 and will remain constant throughout the crediting period of the project.

B.6.3 Ex-ante calculation of emission reductions:

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Table B.3

Emission reduction due to recovered Acetylene Wash Overhead Stream				
1	Monthly average Acetylene Wash Column o/h, AWC (Jul'03 to Mar'06)	Kg/month	$\mathbf{Q_{AWC}}$	**240123.64**
2	**Composition of AWC**			
2.a	Avg 1,3-Butadiene (1,3-BD) content in AWC stream	% wt	$\mathbf{N_{BD}}$	27.03
2.b	Avg Ethyl acetylene (EA) content in AWC stream	% wt	$\mathbf{N_{EA}}$	6.19
2.c	Avg Vinyl Acetylene (VA) content in AWC stream	% wt	$\mathbf{N_{VA}}$	27.54
3	**Quantity of recovered hydrocarbon**			
3.a	Quantity of 1,3-BD	Kg/month	$\mathbf{Q_{BD}} = Q_{AWC} * N_{BD}$	64895.46
3.b	Quantity of EA	Kg/month	$\mathbf{Q_{EA}} = Q_{AWC} * N_{EA}$	14874.04
3.c	Quantity of VA	Kg/month	$\mathbf{Q_{VA}} = Q_{AWC} * N_{VA}$	66141.51
4	**Molecular weight of components**			
4.a	Molecular wt of 1,3;BD		$\mathbf{MW_{BD}}$	54
4.b	Molecular wt of EA		$\mathbf{MW_{EA}}$	54
4.c	Molecular wt of VA		$\mathbf{MW_{VA}}$	52
5	**Moles of recovered components**			
5.a	Moles of 1,3-BD	Kg-moles/month	$\mathbf{M_{BD}} = Q_{BD} / MW_{BD}$	1201.768
5.b	Moles of EA	Kg-moles/month	$\mathbf{M_{EA}} = Q_{EA} / MW_{EA}$	275.445
5.c	Moles of VA	Kg-moles/month	$\mathbf{M_{VA}} = Q_{VA} / MW_{VA}$	1271.952
6	**Annual energy saving by recovery of eqv n-Butane**			
6.a	Moles of n-Butane from 1,3-BD	Kg-moles/month	$\mathbf{M_{butBD}} = M_{BD}$	1201.768
6.b	Moles of n-Butane from VA	Kg-moles/month	$\mathbf{M_{butEA}} = M_{EA}$	275.445
6.c	Moles of n-Butane from EA	Kg-moles/month	$\mathbf{M_{butVA}} = M_{VA}$	1271.952
6.d	Total moles of n-Butane recovered	Kg-moles/month	$\mathbf{M_{but}} = M_{butBD} + M_{butEA} + M_{but\ VA}$	**2749.165**
6.e	Molecular wt of n-Butane		$\mathbf{Mw_{but}}$	58
6.f	Monthly average n-Butane recovered (Jul'03 to Mar'06)	T/month	$\mathbf{Q_{but}} = (M_{but} * MW_{but}) /1000$	159
6.g	Estimated annual n-Butane recovery	T/yr	$\mathbf{Q_{tot}} = Qbut * 12$	1913
6.h	NCV of n-Butane	TJ/T	$\mathbf{NCV_{but}}$	0.04630
6.i	Total energy saved	TJ/yr	$\mathbf{En} = Q_{tot} * NCV_{but}$	**88.591**
7	**Emission reduction**			
7.a	CO2 emission factor of LSHS	tCO2/TJ	$\mathbf{Ef_{LSHS}}$	73.3
7.b	Emission reduction due to reduced LSHS consumption equivalent to n-Butane from AWC stream	tCO2/month	$\mathbf{E} = En * Ef_{LSHS}$	**6494.00**

B.6.4 Summary of the ex-ante estimation of emission reductions:
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An ex-ante calculation of emission reduction shows that the net emission reduction due to the project activity is 6494 tCO2/yr and the energy saving due to the project 24.609 GWH_{th} per year.

Table B.4

Summary of Emission Reduction				
Year	**Estimation of Project activity emission**	**Estimation of baseline emissions**	**Estimation of leakage**	**Estimation of emission reduction**
	(tonnes CO_2 e)	**(tonnes CO_2 e)**	**(tonnes CO_2 e)**	**(tonnes CO_2 e)**
Year 1	0	6494	0	6494
Year 2	0	6494	0	6494
Year 3	0	6494	0	6494
Year 4	0	6494	0	6494
Year 5	0	6494	0	6494
Year 6	0	6494	0	6494
Year 7	0	6494	0	6494
Year 8	0	6494	0	6494
Year 9	0	6494	0	6494
Year 10	0	6494	0	6494
Total	**0**	**64940**	**0**	**64940**

B.7 Application of a monitoring methodology and description of the monitoring plan:

The process monitoring and control system at the Vadodara Complex is automated. All the parameters covered under monitoring plan are monitored. The Worksheet Doc No RIL/I/0607/006/PM is designed and developed in-house to monitor the project.

Central Technical Services (CTS) monitors the data on monthly basis in the form of monthly reports. Central Technical Services (CTS) Engineer will monitor and document the data on a regular basis as per the monitoring plan.

Report on emission reductions will be maintained on a monthly basis and will be available with Central Technical Services Department.

B.7.1 Data and parameters monitored:

Data / Parameter:	Q_{AWCR}
Data unit:	Kg/month
Description:	Monthly AWC O/H stream used as fuel in heater
Source of data to be used:	AWC O/H stream used as fuel is measured by flow measuring instrument Tag No. BCKR-4FI9311A (Totaliser: BCKR-4FQ9311A) that is available from DCS through IP21 automatic data retrieval and archiving system.
Value of data	Actual as obtained during monitoring of project as per the Monitoring Plan in Section B.7.2 of this PDD.
Description of measurement methods and procedures to be applied:	AWC O/H stream used as fuel is measured by orifice type flowmeter and the same is available through IP21 automatic data retrieval and archiving system.
QA/QC procedures to be applied:	The Monitoring Plan in Section B.7.2 of this PDD addresses all issues concerning the QA / QC procedures. Calibration of the monitoring equipments is also included in the ISO system practised at Vadodara Manufacturing Complex.
Any comment:	The data and values will be archived for the entire crediting period and an additional period of two years after the crediting period is over.

Data / Parameter:	Q_{AWCF}
Data unit:	Kg/month
Description:	Monthly AWC O/H stream flared.
Source of data to be used:	AWC O/H stream flared is measured by flow measuring instrument Tag No. BCKR-4FI9311B (Totaliser: BCKR-4FQ9311B) that is available from DCS through IP21 automatic data retrieval and archiving system.
Value of data	Actual as obtained during monitoring of project as per the Monitoring Plan in Section B.7.2 of this PDD.
Description of measurement methods and procedures to be applied:	AWC O/H stream flared is measured by orifice type flowmeter and the same is available through IP21 automatic data retrieval and archiving system.
QA/QC procedures to	The Monitoring Plan in Section B.7.2 of this PDD addresses all issues

be applied:	concerning the QA / QC procedures. Calibration of the monitoring equipments is also included in the ISO system practised at Vadodara Manufacturing Complex.
Any comment:	The data and values will be archived for the entire crediting period and an additional period of two years after the crediting period is over.

Data / Parameter:	N_{BD}
Data unit:	% wt
Description:	Content of 1,3-Butadiene in the AWC O/H stream
Source of data to be used:	Laboratory Analysis records
Value of data	Actual as obtained during monitoring of project as per the Monitoring Plan in Section B.7.2 of this PDD.
Description of measurement methods and procedures to be applied:	The AWC O/H stream is analysed in a Gas Chromatograph type analyser and the percentage composition of the stream is recorded in the Laboratory Information Management System (LIMS). The data is also available in the Laboratory Register maintained as record for such analysis.
QA/QC procedures to be applied:	The Monitoring Plan in Section B.7.2 of this PDD addresses all issues concerning the QA / QC procedures. Calibration of the monitoring equipments is also included in the ISO system practised at Vadodara Manufacturing Complex. The AWC O/H stream will be analysed for 1,3-Butadiene content in the Laboratory, and the actual analysis values will be used for calculating the emission reduction in the project scenario. If the actual value is higher than the CI-1 value for that component as given in Table I.F in Annexure 3, the CI-1 value will be used for that component to calculate emission reduction. Otherwise the actual value will be used.
Any comment:	The data and values will be archived for the entire crediting period and an additional period of two years after the crediting period is over.

Data / Parameter:	N_{EA}
Data unit:	% wt
Description:	Content of Ethylacetylene in the AWC O/H stream
Source of data to be used:	Laboratory Analysis records
Value of data	Actual as obtained during monitoring of project as per the Monitoring Plan in Section B.7.2 of this PDD.
Description of measurement methods and procedures to be applied:	The AWC O/H stream is analysed in a Gas Chromatograph type analyser and the percentage composition of the stream is recorded in the Laboratory Information Management System (LIMS). The data is also available in the Laboratory Register maintained as record for such analysis.
QA/QC procedures to be applied:	The Monitoring Plan in Section B.7.2 of this PDD addresses all issues concerning the QA / QC procedures. Calibration of the monitoring equipments is also included in the ISO system practised at Vadodara Manufacturing Complex. The AWC O/H stream will be analysed for Ethylacetylene content in the Laboratory, and the actual analysis values will be used for calculating the emission reduction in the project scenario. If the actual value is higher than the CI-1 value for that component as given in Table I.F in Annexure 3, the CI-1 value will be used for that component to calculate emission reduction. Otherwise the actual value will be used.
Any comment:	The data and values will be archived for the entire crediting period and an additional period of two years after the crediting period is over.

Data / Parameter:	**N_{VA}**
Data unit:	% wt
Description:	Content of Vinylacetylene in the AWC O/H stream
Source of data to be used:	Laboratory Analysis records
Value of data	Actual as obtained during monitoring of project as per the Monitoring Plan in Section B.7.2 of this PDD.
Description of measurement methods and procedures to be applied:	The AWC O/H stream is analysed in a Gas Chromatograph type analyser and the percentage composition of the stream is recorded in the Laboratory Information Management System (LIMS). The data is also available in the Laboratory Register maintained as record for such analysis.
QA/QC procedures to be applied:	The Monitoring Plan in Section B.7.2 of this PDD addresses all issues concerning the QA / QC procedures. Calibration of the monitoring equipments is also included in the ISO system practised at Vadodara Manufacturing Complex. The AWC O/H stream will be analysed for Vinylacetylene content in the Laboratory, and the actual analysis values will be used for calculating the emission reduction in the project scenario. If the actual value is higher than the CI-1 value for that component as given in Table I.F in Annexure 3, the CI-1 value will be used for that component to calculate emission reduction. Otherwise the actual value will be used.
Any comment:	The data and values will be archived for the entire crediting period and an additional period of two years after the crediting period is over.

Data / Parameter:	**MW_{BD}**
Data unit:	--
Description:	Molecular weight of 1,3-Butadiene
Source of data to be used:	Calculated from molecular weight of individual elements as given in a standard periodic table of elements
Value of data	**54**
Description of measurement methods and procedures to be applied:	Not applicable
QA/QC procedures to be applied:	Not applicable
Any comment:	The value will be remain constant for the entire crediting period.

Data / Parameter:	**MW_{EA}**
Data unit:	--
Description:	Molecular weight of Ethylacetylene
Source of data to be used:	Calculated from molecular weight of individual elements as given in a standard periodic table of elements
Value of data	**54**
Description of measurement methods and procedures to be applied:	Not applicable
QA/QC procedures to be applied:	Not applicable
Any comment:	The value will be remain constant for the entire crediting period.

Data / Parameter:	**MW_{VA}**
Data unit:	--
Description:	Molecular weight of Vinylacetylene
Source of data to be used:	Calculated from molecular weight of individual elements as given in a standard periodic table of elements
Value of data	**52**
Description of measurement methods and procedures to be applied:	Not applicable
QA/QC procedures to be applied:	Not applicable
Any comment:	The value will be remain constant for the entire crediting period.

Data / Parameter:	**MW_{but}**
Data unit:	--
Description:	Molecular weight of n-Butane
Source of data to be used:	Calculated from molecular weight of individual elements as given in a standard periodic table of elements
Value of data	**58**
Description of measurement methods and procedures to be applied:	Not applicable
QA/QC procedures to be applied:	Not applicable
Any comment:	The value will be remain constant for the entire crediting period.

Data / Parameter:	**NCV_{but}**
Data unit:	TJ/kT
Description:	Net Calorific value of n-Butane
Source of data to be used:	*'Revision of default Net Calorific Value, Carbon Content Factor and Carbon Oxidization Factor for various fuels in 2006 IPCC GHG Inventory Guideline'* Kainou Kazunari, August 2005, RIETI, IAI, Government of Japan
Value of data	**46.3 TJ/kT**
Description of measurement methods and procedures to be applied:	Not applicable
QA/QC procedures to be applied:	Not applicable
Any comment:	The value will be remain constant for the entire crediting period.

Data / Parameter:	**Ef_{LSHS}**
Data unit:	tCO2/TJ
Description:	CO_2 emission factor of LSHS
Source of data to be used:	Page 2.16, Table 2.2, Volume 2:Energy, *2006 IPCC Guidelines for National Greenhouse Gas Inventories*.
Value of data	**73.3 tCO2/TJ**
Description of	Not applicable

measurement methods and procedures to be applied:	
QA/QC procedures to be applied:	Not applicable
Any comment:	The value will be remain constant for the entire crediting period.

B.7.2 Description of the monitoring plan:

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Description of the Monitoring Plan

The Monitoring and Verification procedures define a project-specific standard against which the project's performance and conformance with all relevant criteria will be monitored and verified. It includes

- suitable data collection, collation and archiving methods consistent with good practices
- data interpretation techniques for monitoring and verification of GHG emissions.

These procedures provide for a clear, credible, and accurate set of monitoring, evaluation and verification procedures. The purpose of these procedures would be to direct and support continuous monitoring of the key performance indicators for the project, viz. Greenhouse Gas (GHG) emission reductions.

Major Parameters monitored will be as follows:

1. Quantity of hydrocarbon recovered as AWC O/H stream as measured by BCKR-4FI9311A and available as display on the DCS as 4FQ9311A.
2. Quantity of AWC O/H stream flared as measured by BCKR-4FI9311B and available as display on the DCS as 4FQ9311B
3. Laboratory analysis of the recovered stream to determine quantity of 1,3-Butadiene, Ethylacetylene and Vinylacetylene content in the stream.

All instruments will be calibrated and marked at regular intervals so that the accuracy of measurement can be ensured all the time.

Monitoring Plan

The general monitoring principles are based on:

- Frequency of monitoring
- Minimising uncertainties and increasing reliability of performance of the Project

- Reporting and archiving the data used in monitoring and accounting for the emission reduction from the Project

Frequency of monitoring

The project developer has installed all metering facilities within the plant premises. The measurements are monitored on a continuous basis, and the accumulated values of the parameters are recorded in the project monitoring worksheet, a Windows OS based spreadsheet titled *RIL_I_PM_0607_006.xls*. This worksheet is used by the CDM Coordinator at Vadodara Manufacturing Complex to calculate the reduction in GHG emission and to generate monthly reports that form a necessary component of the Management Information System.

The Manager–Energy Management Cell within Central Technical Services Department will be responsible for

- monitoring the Project on a day to day basis,
- co-ordinating with the Head of Department-NCP, Head of Department-BBH, other internal and external agencies/authorities and CDM Cell at DAKC-Mumbai for the purpose of smooth operation of the Project and accrual of emission reduction.

Uncertainties & Reliability

The amount of emission reduction units is proportional to the net energy reduction due to the CDM Project. Measurement devices having good accuracy and procured from reputed manufacturers have been installed at site for the purpose of monitoring the various parameters of the Project. Since the reliability of the monitoring system is governed by the accuracy of the measurement system and the quality of the equipment for reproducibility, all instruments must be calibrated as per the planned frequency for ensuring reliability of the system. The list of instruments used for monitoring the Project, along with the frequency of calibration is given in Table I of Annexure 4.

In the event that a particular instrument malfunctions or breaks down, all efforts will be made to repair or replace that instrument within one month's time of such eventuality. The data used in calculating the emission reduction for that particular parameter will be average value of the parameter for the three months immediately preceding the period of fault

This will ensure that the uncertainties in the parameters used for calculating the emission reductions from the project are minimal and the calculations are consistent, verifiable and reliable.

The Head of Department (HOD) – BBH will be responsible for upkeep of the instruments and calibration equipments used for minimising uncertainties and ensuring reliability of the Project.

Reporting and archiving

Registration is done on the basis of month-wise data logging in computer. Daily and monthly reports are prepared stating quantity of recovered hydrocarbon. The quantity of recovered hydrocarbon is available in the IP21 system that extracts data automatically from the DCS and locks it in the data archiving server. The analysis data for the content of Ethylacetylene, Vinyl acetylene and 1,3-Butadiene are entered into the Laboratory Information Management System (LIMS) that is also a data archiving system available in the Vadodara Manufacturing Complex.

The Manager – Energy Management Cell will be responsible for

- collection and updation of all data in the project monitoring worksheet,
- generation and distribution of monthly reports to the Management accounting for
  - the actual emission reduction achieved during the month,
  - any specific event affecting emission reduction due to the Project during the month
- Archiving all data from the sources mentioned in Section B.7.1 of this PDD for the purpose of verification for a period of twelve years from the date of registration of the Project with UNFCCC.

B.8 Date of completion of the application of the baseline and monitoring methodology and the name of the responsible person(s)/entity(ies)

>>

Date of completing of this baseline development: 28/07/06

Name of person/entity determining the baseline: Reliance Industries Limited

Contact details are given in Annexure 1.

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

>>
13/03/2003 (Date of start of procurement)

C.1.2. Expected operational lifetime of the project activity:

>>
20 years

C.2 Choice of the crediting period and related information:

Fixed crediting period has been selected

C.2.1. Renewable crediting period

Not applicable

C.2.1.1. Starting date of the first crediting period:

>>
Not applicable

C.2.1.2. Length of the first crediting period:

>>
Not applicable

C.2.2. Fixed crediting period:

Yes

C.2.2.1. Starting date:

>>
15/10/2007 **OR** date of registration of the project with UNFCCC**, whichever is later.**

C.2.2.2. Length:

>>
10 Years

SECTION D. Environmental impacts

>>

D.1. If required by the host Party, documentation on the analysis of the environmental impacts of the project activity:

>>

As per the guidelines for conducting the EIA, the project activity does not fall into any of the two categories, hence EIA is not required to be done as per the guidelines. However, the project proponent has carried out Aspect-Impact analysis as a good engineering practice.

The different Aspects considered under the Aspect impact assessment are as follows:

- **Land –** There is no degradation of land quality due to the project. The quality of the land is not negatively affected by the project activity as it is non-polluting, clean and there is no land development activity or discharge of effluents into the soil from the equipment installed in the project boundary.
- **Water –** There is no degradation of water quality due to the project. The quality of the water is not negatively affected by the project activity.
- **Air quality –** The eductor installed does not emit any contaminants into the air that can be attributed solely as a result of its operation.
- **Noise –** There is no contribution to noise level at site that can be attributed solely as a result of its operation.
- **Solid / Hazardous waste –** In the project activity there is no generation of solid or hazardous waste attributable to the project activity**.**
- **Resource Depletion –** The project activity aims at reduction in fossil fuel consumption and, thereby conserving resources rather than causing its depletion.
- **Biological Environment –** Not applicable.
- **Public Health and Safety –** The project activity does not endanger public health and safety as it reduces emission of harmful Greenhouse Gases. Moreover. In the project activity adequate safety measures have been implemented and persons involved have been trained in the operation of the recovery system.
- **Socio-economic and cultural environment –** Due to the project activity the Socio- Economic and cultural environment has improved as successful implementation of the project has improved the skill sets of the people, instilled confidence and has provided fresh impetus to the personnel to conserve energy by identifying more areas in the process where energy can be conserved and GHG emissions can be reduced.

D.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

>>

The project activity does not fall in any of the two categories specified in the guidelines for conducting a EIA. But as good Engineering practise detailed Aspect Impact analysis was carried out and it is evident from it that none of the impacts are considered to be significant by the project participants or the Host party.

SECTION E. Stakeholders' comments

>>

The people such as the plant personnel, people working in the complex on contract, the erection and commissioning people, and the people in the surrounding area of the production complex were identified as the stakeholders.

E.1. Brief description how comments by local stakeholders have been invited and compiled:

>>

The Stakeholders were explained in totality and in depth about the project activity .The related document on the project was also circulated among them.

After providing all the details of project activity, the stakeholders have filled in questionnaires given to them to assess the impact of the project on the following:

1. Air pollution
2. Water pollution
3. Water availability
4. Water allocation
5. Natural drainage pattern
6. Drainage in general
7. Solid waste generation and disposal
8. Land use / landscape
9. Plant life
10. Agriculture / horticulture
11. Habitat fragmentation
12. Employment
13. Vocational opportunities
14. Income levels
15. Stress on infrastructure

The stakeholders, after going through the project activity rated it as environment friendly and without any negative impact on the work environment. They also praised the environment friendly approach of the company. The filled in questionnaires are available with the project proponent as records and can be made available to the Validator.

E.2. Summary of the comments received:

>>

The stakeholders have indicated that there is no significant impact of the project activity in terms of any of the above parameters.

The Local Stakeholders survey included the operators, engineers and technicians working in the manufacturing facility.

In the questionnaire submitted to all the local stake holders none of them had given any negative or specific opinion about the project activity. All of them have appreciated the efforts put forward by the company for the betterment of the environment .The Stakeholders where of the opinion that because of the project activity there is no direct or indirect impact to the surrounding moreover the project activity is only going to reduce the Green house gas emissions which would have continued if this project was not commissioned.

E.3. Report on how due account was taken of any comments received:

>>

Stakeholders have appraised the project as environment friendly and have expressed their satisfaction that it reduces emissions and contributes to well-being of society. There are no negative comments received that require the project proponent to take any corrective action.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Reliance Industries Limited
Street/P.O.Box:	Thane-Belapur Road, Ghansoli
Building:	Ground Floor, C Wing, Block 2, Reliance Corporate Park (RCP)
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E-Mail:	kisor.mukherjee@ril.com
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Represented by:	
Title:	Vice President
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Last Name:	Mukherjee
Middle Name:	K
First Name:	Kisor
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Direct tel:	+ 91 22 44774131
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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

There was no public funding in procurement or implementation of the project activity. The entire investment was from funds generated internally.

Annex 3

BASELINE INFORMATION

Calculation for CO_2 emission reduction

Table I.A : AWC O/H stream recovered per month

Month	AWC O/H (MT)	Month	AWC O/H (MT)	Month	AWC O/H (MT)
Jul-03	265.44	Jul-04	273.98	Jul-05	207.4
Aug-03	280.01	Aug-04	296.28	Aug-05	93.35
Sep-03	275.95	Sep-04	284.86	Sep-05	223.17
Oct-03	261.83	Oct-04	272.96	Oct-05	186.52
Nov-03	251.54	Nov-04	283.99	Nov-05	214.86
Dec-03	192.18	Dec-04	260.51	Dec-05	215.91
Jan-04	297.74	Jan-05	278.51	Jan-06	140.24
Feb-04	348.69	Feb-05	259.48	Feb-06	154.5
Mar-04	264.14	Mar-05	274.09	Mar-06	222.14
Apr-04	219.19	Apr-05	184.97	Average	240.123
May-04	207.36	May-05	255.88		
Jun-04	236.68	Jun-05	239.73		

Table I.B : Avg composition of AWC O/H stream

DATA for the period Apr'05 to Mar'06			
Month	Avg composition of AWC O/H stream		
	1,3 Butadiene	EA	VA
	KSM3	MT	MT
Apr-05	42.84	6.33	27.90
May-05	38.63	6.46	33.30
Jun-05	43.53	5.47	26.87
Jul-05	12.68	4.23	21.81
Aug-05	13.45	5.77	21.31
Sep-05	23.75	6.53	30.76
Oct-05	29.61	6.51	27.52
Nov-05	24.11	7.03	30.01
Dec-05	15.27	6.87	29.31
Jan-06	18.89	5.89	30.93
Feb-06	40.87	5.11	23.56
Mar-06	20.68	8.13	27.26
Average	27.03	6.19	27.54

Table I.C : Calculation for emission reduction

Emission reduction due to recovered Acetylene Wash Overhead Stream				
1	Monthly average Acetylene Wash Column o/h, AWC (Jul'03 to Mar'06)	Kg/month	$Q_{AWCR} - Q_{AWCF}$	**240123.64**
2	**Composition of AWC**			
2.a	Avg 1,3-Butadiene (1,3-BD) content in AWC stream	% wt	N_{BD}	27.03
2.b	Avg Ethyl acetylene (EA) content in AWC stream	% wt	N_{EA}	6.19
2.c	Avg Vinyl Acetylene (VA) content in AWC stream	% wt	N_{VA}	27.54
3	**Quantity of recovered hydrocarbon**			
3.a	Quantity of 1,3-BD	Kg/month	$Q_{BD} = Q_{AWC} * N_{BD}$	64895.46
3.b	Quantity of EA	Kg/month	$Q_{EA} = Q_{AWC} * N_{EA}$	14874.04
3.c	Quantity of VA	Kg/month	$Q_{VA} = Q_{AWC} * N_{VA}$	66141.51
4	**Molecular weight of components**			
4.a	Molecular wt of 1,3;BD		MW_{BD}	54
4.b	Molecular wt of EA		MW_{EA}	54
4.c	Molecular wt of VA		MW_{VA}	52
5	**Moles of recovered components**			
5.a	Moles of 1,3-BD	Kg-moles/month	$M_{BD} = Q_{BD} / MW_{BD}$	1201.768
5.b	Moles of EA	Kg-moles/month	$M_{EA} = Q_{EA} / MW_{EA}$	275.445
5.c	Moles of VA	Kg-moles/month	$M_{VA} = Q_{VA} / MW_{VA}$	1271.952
6	**Annual energy saving by recovery of eqv n-Butane**			
6.a	Moles of n-Butane from 1,3-BD	Kg-moles/month	$M_{butBD} = M_{BD}$	1201.768
6.b	Moles of n-Butane from VA	Kg-moles/month	$M_{butEA} = M_{EA}$	275.445
6.c	Moles of n-Butane from EA	Kg-moles/month	$M_{butVA} = M_{VA}$	1271.952
6.d	Total moles of n-Butane recovered	Kg-moles/month	$M_{but} = M_{butBD} + M_{butEA} + M_{but\ VA}$	**2749.165**
6.e	Molecular wt of n-Butane		Mw_{but}	58
6.f	Monthly average n-Butane recovered (Jul'03 to Mar'06)	T/month	$Q_{but} = (M_{but} * MW_{but}) /1000$	159
6.g	Estimated annual n-Butane recovery	T/yr	$Q_{tot} = Qbut * 12$	1913
6.h	NCV of n-Butane	TJ/T	NCV_{but}	0.04630
6.i	**Total energy saved**	**TJ/yr**	$En = Q_{tot} * NCV_{but}$	**88.591**
7	**Emission reduction**			
7.a	CO2 emission factor of LSHS	tCO2/TJ	Ef_{LSHS}	73.3
7.b	Emission reduction due to reduced LSHS consumption equivalent to n-Butane from AWC stream	tCO2/month	$E = En * Ef_{LSHS}$	**6494.00**

Table I.D : Data table for sample calculation to demonstrate improvement in energy efficiency

DATE	HOT OIL FLOW	Inlet Oil	Outlet Oil	Heat Absorbed in Oil	Fuel Consumption		
		Inlet Temp	Outlet Temp		LSHS	Fuel Gas	Heat input to HH-2
	Kg/day	deg C	deg C	Kcal/day	Kg/day	Kg/day	Kcal/day
01-Sep-06	23500838.74	278.50	312.27	436821840.03	30216.00	18497.00	500824369.00
02-Sep-06	23689619.21	277.00	311.74	462539814.98	27456.00	24522.00	536674794.00
03-Sep-06	23654175.96	278.00	312.05	461847785.66	25872.00	25356.00	529497612.00
04-Sep-06	23651097.62	277.00	312.23	461787680.94	25608.00	25804.00	531569708.00
05-Sep-06	23652678.32	277.50	311.95	461818544.22	24888.00	26365.00	530231405.00
06-Sep-06	23706425.48	278.00	312.15	462867957.41	26064.00	25101.00	528739677.00
07-Sep-06	23652834.54	278.50	312.27	439647062.04	28176.00	20837.00	504970549.00
08-Sep-06	23690188.80	278.00	312.23	462550936.41	22176.00	29259.69	533457365.54
09-Sep-06	23626802.95	277.00	312.24	461313327.62	7824.00	43216.00	536118032.00
10-Sep-06	23633043.01	277.50	312.09	461435164.86	6576.00	44257.00	534523889.00
11-Sep-06	23646272.00	277.00	311.86	461693460.80	3960.00	46723.00	534185171.00
12-Sep-06	23646272.00	277.50	311.86	461693460.80	4800.00	45763.00	532515251.00
13-Sep-06	23670400.04	277.50	311.88	462164560.74	5400.00	44885.00	529288645.00
14-Sep-06	23673727.81	277.00	312.01	462229535.48	5904.00	44616.00	531533832.00
15-Sep-06	23640114.77	277.00	312.20	461573240.95	5400.00	45864.00	539643528.00
16-Sep-06	23670316.69	277.00	312.00	462162933.44	5520.00	44958.00	531272766.00
17-Sep-06	23699936.00	277.30	312.11	462741250.40	5160.00	45309.00	531349293.00
18-Sep-06	23684543.97	277.00	311.94	462440721.10	5280.00	45376.00	533269952.00
19-Sep-06	23705260.81	277.30	312.13	462845217.27	6480.00	43891.00	529683107.00
20-Sep-06	23749855.96	277.50	312.07	463715937.66	6720.00	43442.00	527358034.00
21-Sep-06	23707257.63	277.00	312.03	462884205.19	7680.00	42260.00	524552020.00
22-Sep-06	23659167.82	278.00	312.10	461945251.73	6240.00	43717.00	525418709.00
23-Sep-06	23659167.82	278.00	312.10	461945251.73	6240.00	43717.00	525418709.00
24-Sep-06	23756678.33	278.00	312.07	463849144.47	5520.00	44034.00	521499618.00
25-Sep-06	23733631.96	278.00	312.07	463399164.06	6360.00	44387.00	533717299.00
26-Sep-06	23722150.31	277.50	312.13	463174984.78	6240.00	44721.00	536038017.00
27-Sep-06	23673145.53	277.90	312.08	462218166.40	6600.00	43264.00	524263328.00
28-Sep-06	23722982.33	278.00	312.28	463191230.07	6960.00	42979.00	524884883.00
29-Sep-06	23705011.12	278.00	312.30	462840342.04	6840.00	43305.00	527120985.00
30-Sep-06	23703097.58	277.30	312.53	462802980.19	6960.00	42928.00	524345456.00
Total	**710286695.12**			**13824141153.47**	**345120.00**	**1169353.69**	**15853966003.54**

Table I.E : Sample calculation to demonstrate improvement in energy efficiency

Sample calculation to demonstrate improvement in energy efficiency of system				
1	Eqv Butane from the recovery *(From Item 6.f, Table I.C)*	T/month	$\mathbf{Q_{but}}$	159
2	NCV of n-Butane	TJ/T	$\mathbf{NCV_{but}}$	0.04630
3	Energy from n-Butane	Kcal/month	$\mathbf{En_{but}} = Q_{but} * NCV_{but} * 10\text{^}12 * 0.2388 / 1000$	1762966795
4	LSHS fired in heater *(Table I.D)*	Kg/month	Q_{LSHS}	345120.00
5	Fuel Gas fired in heater *(Table I.D)*	Kg/month	Q_{FG}	1169353.69
6	NCV of LSHS	Kcal/Kg	NCV_{LSHS}	10100.00
7	NCV of Fuel Gas	Kcal/Kg	NCV_{FG}	10577.00
8	Energy from fuel to HH-2 *(Table I.D)*	Kcal/month	$\mathbf{En_{fuel}} = (Q_{LSHS} * NCV_{LSHS}) + (Q_{FG} * NCV_{FG})$	15853966003.54
9	Total energy used in oil heating facility in absence of project *(Table I.D)*	Kcal/month	$\mathbf{En_{avlbl}} = En_{but} + En_{fuel}$	17616932798.24
10	Hot oil heated *(Table I.D)*	Kg/month	$\mathbf{Q_{HO}}$	710286695.12
11	Heat rate if project was not implemented	Kcal/Kg	$\mathbf{H_1} = En_{avlbl} / Q_{HO}$	24.80
12	Heat rate due to project implementation	Kcal/Kg	$\mathbf{H_2} = En_{fuel} / Q_{HO}$	22.32
13	Diff	%	**Improvement** = $(H_1 - H_2) * 100 / H_1$	**10.01**

Table I.F: 95% Confidence interval from the historical values for 1,3Butadiene, Ethylacetylene & Vinylacetylene

Confidence Interval				
Description	**Symbol**	**Value (CI for 1,3 Butadiene on % wt units)**	**Value (CI for Ethylacetylene on % wt units)**	**Value (CI for Vinylacetylene on % wt units)**
Average	x	27.82916	6.56983	28.55059
Std dev	s	14.72234	1.72829	6.25101
Sample size	n	237	237	237
Degree of freedom	n-1	236	236	236
Confidence level	%	95	95	95
	ά	0.05	0.05	0.05
	ά/2	0.025	0.025	0.025
	$t_{ά/2}$	1.972	1.972	1.972
CI-1 *(See note)*	μ_{UCL}	29.715	6.791	29.351
CI-2 *(See note)*	μ_{LCL}	25.943	6.348	27.750

Note : Confidence Interval, $CI = x \pm \{ t_{\alpha/2} * (s / \sqrt{n}) \}$

Annex 4

MONITORING INFORMATION

Table I

Sr. No	Data type	Data Unit	Tag No	Service / Location	Type Of Inst	Inst Acc%	Calib Proc No	Cal. Freq.
1	AWC/OH Stream Recovered	Kg	BCKR-4FI9311A (BCKR-4FQ9311A)	BBH Plant	Flow Transmitter	± 0.2%	GEN-SMP-11	Annual
2	AWC/OH To Flare	Kg	BCKR-4FI9311B (BCKR-4FQ9311A)	BBH Plant	Flow Transmitter	± 0.2%	GEN-SMP-11	Annual
3	AWC/OH Stream Composition	%	BQAG GC 02	Central Laboratory	Gas Chromatograph		Does not need calibration as method is simple area % method	

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