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

CONTENTS

Annexes

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:

Utilisation of Waste Heat for Chilled Water & Fuel Switch to Natural Gas (NG) for power generation at Panoli Intermediates (India) Private Limited
Version 02, August 9, 2007

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

Panoli Intermediates (India) Private Limited is one of the leading producers of chemicals and chemical intermediates in the country. As part of its manufacturing process it uses chilled water for process cooling applications. Like other users of chilled water in industry, the chilled water was being generated using vapour compression chillers. The electric power needed for the operations was being taken from the electricity grid of the western region of the country.

In order to meet its electricity needs in a more sustainable manner Panoli Intermediates installed a captive Natural Gas (NG) fired internal combustion engine based generator. The rated capacity of the gas based power plant installed by it is 1.4 MW. Prior to this the power requirements were being met by way of supplies from electricity grid of the western region. The power plants supplying power to the western region electricity grid are primarily based on coal / lignite. Power generation using coal / lignite as fuel leads to emission of more carbon dioxide when compared to power generation using natural gas as fuel. Thus establishment of gas based captive power generation facilities leads to reduction in emission of GHG. Establishment of captive power plant required significant capital investment. Further to this the cost of power generation using natural gas is higher when compared to the cost of procurement of power from the state electricity grid. The situation gets further complicated due to uncertainties regarding future price of natural gas. Realising that due to mitigation in the emission of GHG some benefits will be available under CDM a decision to go for captive generation of power was taken in-spite of significant capital investment and consequent higher cost of power generation.

As a normal practise in India, hot exhaust gases from the engine of the power generator is vented to the atmosphere. Panoli Intermediates realised that there is a potential to recover the waste heat contained in the exhaust of the engine. However, the heat contained in the exhaust of the engine is of low grade (having lower temperatures). In addition to this the energy intensity (energy content of the gases is low due to lower specific heat of the gases) of the flue gases is quite low. Further to this the cost of recovery of waste heat in a gas stream is comparatively higher (due to lower heat transfer coefficient and lower specific heat, when compared to liquids at same temperatures). The problem gets further complicated due to dirt (including particulate matter) in the exhaust gas stream. Due to its low grade there is not much potential use of this heat in the processes being used by Panoli Intermediates. One of the options was to use the waste heat contained in the exhaust of the IC engine for generation of chilled water, but this required scrapping of the existing chillers and installation of new chillers based on vapour absorption technology. The system for generation of chilled water based on vapour absorption technology is capital intensive when compared to the capital cost of conventional chillers based on vapour compression technology. The capital cost of chillers based on vapour absorption technology was acting as a barrier towards recovery of the waste heat contained in the exhaust of the engine and putting the recovered heat to gainful use. Shifting from vapour compression technology to vapour absorption technology leads to reduction in the consumption of electricity for generation of chilled water and this in turn leads to mitigation of emission of Green House Gases (GHG). Keeping this in mind, it was realised that some monetary benefits will be available for the project under Clean Development Mechanism (CDM). These monetary benefits were expected to overcome to some extent the barrier of high capital cost of vapour absorption chillers. Thus it was decided to undertake the activity of replacing existing chillers with vapour absorption chillers using waste heat of the exhaust gas from the engine of the power generators as a CDM project activity. Accordingly, Panoli Intermediates has replaced its existing chillers based on vapour compression technology with new chillers based on vapour absorption technology.

As discussed in the above paragraphs Panoli Intermediates has undertaken following two specific measures as CDM project activity:

- Switching from grid power supply to captive generation of power using Natural Gas as fuel
- Switch over from vapour compression chillers to vapour absorption chillers using waste heat of the exhaust of the IC engine of the power plant. Switching from vapour compression chillers to vapour absorption chillers will lead to reduction in consumption of energy. Reduction in the consumption of energy in turn leads to reduction in emission of GHG.

The two initiatives mentioned above lead to reduction in the emission of GHG. These initiatives were taken up as CDM project activity as the capital investment involved and the perceived risks with these initiatives were prohibitive. In the absence of the proposed CDM project activity, Panoli Intermediates would have continued to:

- Draw power from state electricity grid
- Use vapour compression chillers (VCC) for meeting its chilled water requirements

A.3. Project participants:

The proposed CDM project has been implemented and is owned by Panoli Intermediates India Private Limited (Panoli Intermediates). Panoli Intermediates is a Non - Annex B (of Kyoto Protocol) country entity having its registered office and works in India. Panoli Intermediates will be the beneficiary of the proposed small scale CDM project activity. There is no Annex B country entity participating in the project for the time being.

Name of Party involved (*) ((host) indicates a host party)	Private and/or public entity (ies) Project participants (*) (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/ No)
Panoli Intermediates (India) Private Limited (host party)	Private entity	Yes

(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party (ies) involved is required.

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

The technical description of the proposed CDM project is attached as Appendix-I.

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

India

A.4.1.1. Host Party(ies):

Panoli Intermediates (India) Private Limited, India

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

Gujarat

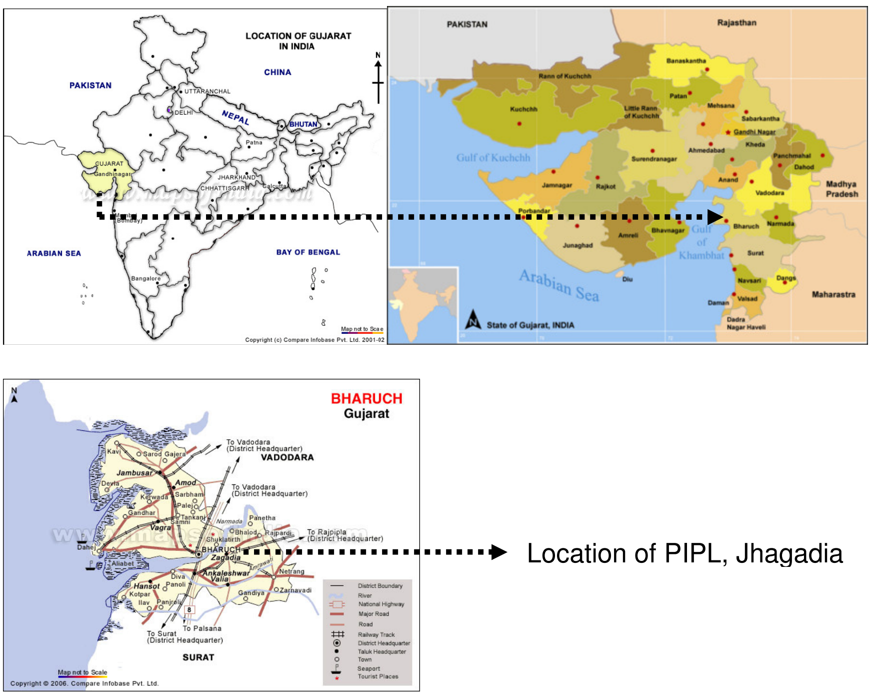
A.4.1.3. City/Town/Community etc:

Jhagadia, Dist. Bharuch

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

Plot no. 778/1 and 756/1, GIDC Industrial Area, Jhagadia, Dist. Bharuch, Gujarat, India

The project site is located at Latitude 21° 30’ N and Longitude 72° 54’ E.



Location of PIPL, Jhagadia in Gujarat, India

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

The proposed CDM project has the following two specific components:

a) Fuel switch from more carbon intensive fossil fuel generated grid electricity to captive natural gas run power plant
b) Energy efficiency due to technology shift from vapour compression chillers to vapour absorption chillers system

The type and categories for the two proposed CDM project components are as follows:

Proposed CDM Project Component	Type	Category
Shifting from more carbon intensive fossil fuel generated grid electricity to Natural gas run captive power plant	IIIB	Switching fossil fuels
Technology shift from vapour compression chiller to vapour absorption chiller system	IID	Energy efficiency and fuel switching measures for industrial facilities

There is no import of technology or technical know how for implementing the fuel switch and energy efficiency measures in the proposed CDM project. The technical know how has been indigenously developed by the equipment manufacturer and the project proponent.

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

Years	**Estimation of annual emission reductions in tonnes of CO2e**
November 2007 – October 2008	4845.89
November 2008 – October 2009	4845.89
November 2009 – October 2010	4845.89
November 2010 – October 2011	4845.89
November 2011 – October 2012	4845.89
November 2012 – October 2013	4845.89
November 2013 – October 2014	4845.89
November 2014 – October 2015	4845.89
November 2015 – October 2016	4845.89

November 2016 – October 2017	4845.89
Total estimated reductions (in tonnes of carbon dioxide equivalent)	**48458.92**
Total number of crediting years	**10**
Annual average of the estimated reductions over the crediting period (tCO2e)	**4845.89**

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

The project has been implemented using internal cash accruals. There is no external funding for the project. No public funding is sought for the project activity. No official development assistance/ public funds have been utilised for the proposed CDM project.

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

In accordance with 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 de-bundled 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

None of the above conditions is applicable in case of the proposed CDM project being promoted by Panoli Intermediates (India) Private Limited. Thus the proposed CDM project is not a de-bundled component of a larger CDM project.

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:

Type II D: Energy efficiency and fuel switching measures for industrial facilities
Reference: AMS IID, Version 10, Valid from 10 August 2007

Type IIIB: Switching fossil fuels
Reference: AMS IIIB, Version 11, Valid from 10 August 2007

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

The proposed CDM project is an outcome of specific energy conservation programmes initiated at production facilities of Panoli Intermediates, located at Jhagadia with the objective of reducing demand side energy consumption. In accordance with Appendix B of the simplified modalities and procedures for small – scale CDM project activities / version 07, the project activity is categorized as Type II D: Energy efficiency and fuel switching measures for industrial facilities for the GHG mitigation component of energy efficiency. For the switching of fossil fuels for the GHG mitigation component of fuel switching, the project is categorized as Type IIIB.

Category II D is applicable to the projects which comprise of any energy efficiency and fuel switching measure implemented at a single industrial facility. This category covers project activities aimed primarily at energy efficiency.

Category IIIB is applicable to projects which comprise fossil fuel switching in existing industrial, residential, commercial, institutional or electricity generation applications. Fuel switching may change efficiency as well. If the project activity primarily aims at reducing emissions through fuel switching, it falls into this category.

The proposed CDM project is leading to reduction in the emission of GHG due to switching of fuel for power generation (substitution of grid power which is primarily generated in coal based power plant with power generated in captive gas based power plants) and improvement of energy efficiency due to replacement of vapour compression chillers with vapour absorption chillers. Establishment of captive facilities for generation of power using gas as fuel is providing the opportunity for using waste heat in the exhaust of the power plant and effective utilisation of this waste heat in vapour absorption chillers is leading to improvement in energy efficiency.

The applicability criteria for applying Type IID in the context of the proposed CDM project are as follows:

- Project involves energy efficiency measure through installation of vapour absorption chillers at single site i.e. Production facilities of Panoli Intermediates located at Jhagadia
- The project activity is an energy efficiency measure
- The project involves installation of new equipments (Vapour Absorption Chillers and captive power plant) for energy efficiency
- The aggregate energy saving achieved by this programme is less than 60 GWh of electricity per annum.

The applicability criteria for applying Type IIIB in the context of the proposed CDM project are as follows:

- The project activity involves switch from fossil fuel generated electricity from grid in existing industrial applications to natural gas run captive power plant.
- The total emission reductions achieved through this technical measure are less than 60 kt CO2 equivalent annually.

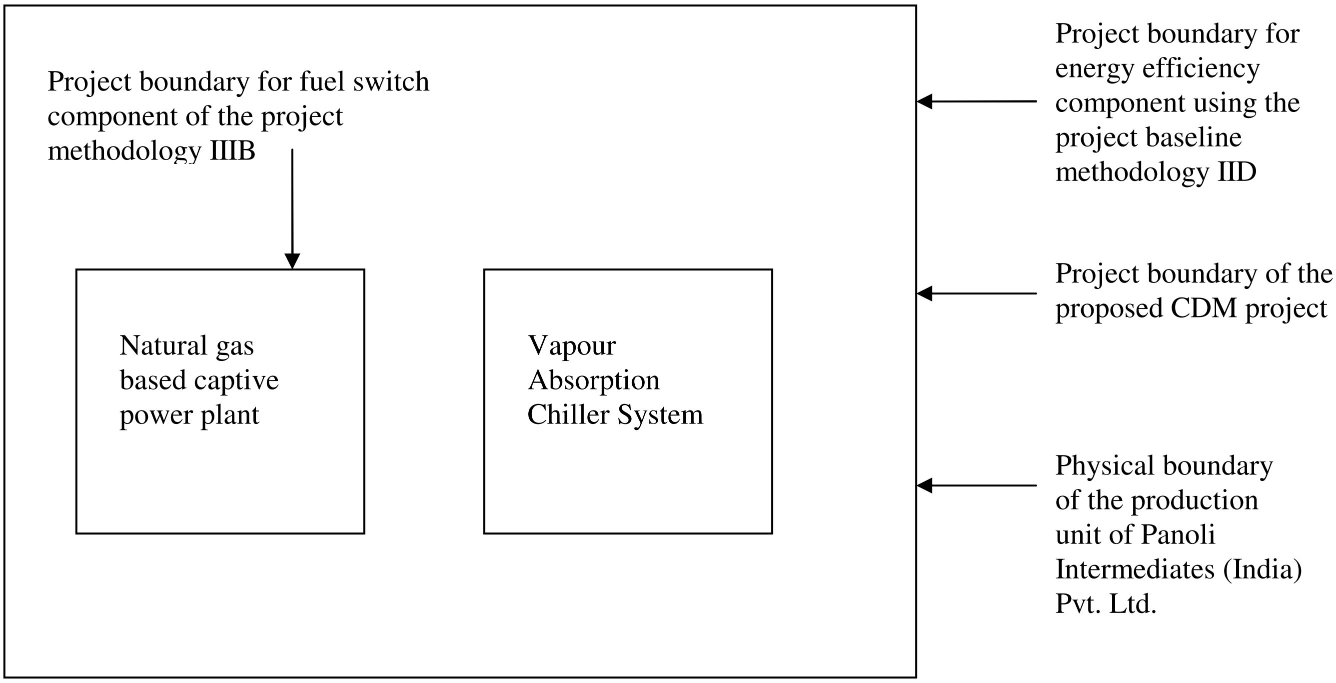
As is evident the proposed CDM project meets all the applicability criteria set out under the selected small-scale methodologies and hence the project categories Type IID and Type IIIB are applicable to the respective components of the proposed CDM project.

B.3. Description of the project boundary:

In accordance with the approved small scale baseline methodology II D, the boundary of the proposed CDM project will be the physical boundary of the production unit of Panoli Intermediates located at Jhagadia.

In accordance with the approved small scale baseline methodology III B, the boundary of the proposed CDM project pertaining to fuel switch will be the physical boundary of the captive power plant where the fuel combustion affected by the fuel switching measure occurs.

As the boundary of the fuel switch components of the proposed CDM project lies within the boundaries of the other component of the project (energy efficiency component), the boundary of the project is considered to be the physical boundary of the production unit.



Depiction of boundary of proposed CDM project

B.4. Description of baseline and its development:

The project categories applicable to the proposed CDM project are II D and IIIB. Accordingly, for the energy efficiency component of the proposed CDM project, the energy baseline being considered consists of the energy use of the vapour compression technology based chillers, being replaced by the vapour compression based chillers.

The applicable project category for the fuel switch component of the proposed CDM project is IIIB. This category mainly applies to the fuel switch from the more carbon intensive fossil fuel based grid electricity supply to the project proponent's new captive power generation facility based on natural gas; the baseline has been therefore considered as the power supply from the state electricity grid.

As earlier mentioned, in absence of the proposed CDM measures being applied, the project proponent would have continued to draw power from the state electricity grid.

The baseline scenario considers the fuel switch from fossil fuel based grid electricity supply to the project proponent's captive power generation in natural gas based generators.

The approved small scale methodology II D stipulates that for the electricity displaced, the emission coefficient be calculated in accordance with provisions in paragraphs 6 or 7 for category I.D projects.

Approved small scale methodology IIIB stipulates that the emission baseline is the current emissions of the facility expressed as emissions per unit of output (eg., kg CO2e/ kWh). Emission coefficients for the fuel used by the generating unit before and after the fuel switch are also needed for which IPCC default values may be used as per this approved methodology.

Paragraphs 6 & 7 for category I D projects have the following provision for determination of the emission coefficient (measured in kg CO_2eq/kWh) in the baseline scenario:

(a) The average of the "approximate operating margin" and the "build margin", where:
   (i) The "approximate operating margin" is the weighted average emissions (in kg CO_2eq/kWh) of all generating sources serving the system, excluding hydro, geothermal, wind, low-cost biomass, nuclear and solar generation;
   (ii) The "build margin" is the weighted average emissions (in kg CO_2eq/kWh) of recent capacity additions to the system, which capacity additions are defined as the greater (in MWh) of most recent 20% of existing plants or the 5 most recent plants.";

OR

(b) The weighted average emissions (in kg CO_2eq/kWh) of the current generation mix.

With the purpose of providing a ready reference for the emission coefficients to be used in CDM projects, Central Electricity Authority (CEA), Government of India, has published, 'CO_2 Baseline

Database for the Indian Power Sector[1]'. This database is an official publication of the Government of India for the purpose of CDM baselines. It is based on the most recent data available to the Central Electricity Authority. As per the data base the weighted average emission factor of Western Regional Grid for the financial year 2005-06 (April 2005 to March 2006) (adjusted for inter-regional and cross-country electricity transfers) is as follows:

Average	0.88	tCO2/MWh	The weighted average emission factor describes the average CO2 emitted per unit of electricity generated in the grid. It is calculated by dividing the absolute CO2 emissions of all power stations in the region by the region's total net generation. Net generation from so-called low-cost/must-run sources (hydro and nuclear) is included in the denominator.
Simple OM	0.99	tCO2/MWh	The operating margin describes the average CO2 intensity of existing stations in the grid which are most likely to reduce their output if a CDM project supplies electricity to the grid (or reduces consumption of grid electricity). "Simple" denotes one out of four possible variants listed in ACM0002 for calculating the operating margin. The simple operating margin is obtained by dividing the region's total CO2 emissions by the net generation of the stations serving the region excluding low-cost/must-run sources. In other words, the total emissions are divided by the total net generation of all thermal power stations. Hydro and nuclear qualify as low-cost/must-run sources, and their net generation is therefore excluded from the denominator.
BM	0.63	tCO2/MWh	The build margin reflects the average CO2 intensity of newly built power stations that will be (partially) replaced by a CDM project. In accordance with ACM0002, the build margin is calculated in this database as the average emissions intensity of the 20% most recent capacity additions in the grid based on net generation.
CM	0.81	tCO2/MWh	The combined margin is a weighted average of the simple operating margin and the build margin. By default, both margins have equal weights (50%). The combined margins shown in the database are calculated based on equal weights.

In accordance with the provision in paragraphs 6 & 7 of approved small scale methodology ID average of the emission factor (considering the emission due to current generation mix) has been considered for determining the emission in the baseline. Accordingly the emission factor considered is 0.88 tCO2/MWh (0.88 Kg CO2/kWh). In order to determine GHG mitigation in a conservative manner no transmission and distribution losses has been considered. In order to determine the emission in the baseline scenario, the emission factor is multiplied by the net power generated in captive natural gas based power plant. The emission in the CDM project is determined using IPCC default values for emission due to combustion of natural gas. Accordingly, the emission factor considered to determine emission of GHG due to the CDM project has been considered at 15.3 Kg C / GJ[2]. Thus emission of carbon dioxide for generation of one unit of power in the CDM project has been estimated to be 0.49 Kg[3].

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[1] 'CO2 Baseline Database for the Indian Power Sector', User Guide, Version 2.0, CEA, Government of India, June 2007

[2] Revised IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual

[3] Energy input = 2.42 kWh of natural gas = 0.008715 GJ * Carbon intensity of natural Gas (15.3 Kg C / GJ) *44/12

In case of vapour absorption chillers component of the CDM project the project proponent would have continued to use vapour compression technology based chillers (using reciprocating type compressors). Thus the energy baseline is the displaced fossil fuel, which would have been used to generate power needed by the vapour compression based chillers. The power consumption in the baseline scenario to generate equal amount of refrigeration can be estimated either based on the designed power consumption of vapour compression technology based chillers or based on the figures provided in standard reference literature. For vapour compression based refrigeration cycle (operating at above zero degree C temperatures) using reciprocating compressors the standard literature[4] provides the energy to TR ratio in the range of 0.7 to 0.9 kW/TR. In order to estimate the GHG mitigation due to the project in a conservative manner, the specific power consumption in the baseline scenario has been considered as 0.7 kWh /TR.

The baseline power consumption is specific power consumption (kWh/TR) of the vapour compression based chillers multiplied by refrigeration generation (TR/yr). The GHG emission in the baseline scenario is calculated based on emission coefficient for the western grid (discussed in the above paragraphs) multiplied by the power which would have been consumed in vapour compression based chillers. The GHG emission after implementation of the CDM project is the actual power consumption multiplied by the emission coefficient of natural gas based captive power plant.

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:

The new capital equipment installed in the proposed CDM projects not only reduces the consumption of energy but also substitutes the existing more carbon intensive fuel with a lesser carbon intensive fuel. A combination of these two reasons is leading to the reduction in the emission of GHG. The proposed CDM project was not considered as a lucrative business proposition in the absence of CDM. It is so as from business prospective it is more lucrative to have a reliable technology, which will give a smooth and safe operation scenario with less manpower & trouble free maintenance even if it consumes marginally more energy. It should be noted that the monetary savings achieved due to energy savings gets negated due to production loss due to equipment down time.

The incentive of CDM in terms of additional revenue as well as the recognition which Panoli Intermediates will get when the proposed project activity is registered as a CDM project played a major role in going ahead with the project.

The proposed CDM project has following two specific components:

- Energy efficiency measure by switch over from vapour compression chillers to vapour absorption chillers using waste heat
- Fossil fuel switching from grid power supply to captive generation of power using much lesser carbon intensive Natural Gas as fuel

In the absence of implementation of the CDM project Panoli Intermediates would have continued to draw power from the grid and would have continued to use vapour compression technology for meeting its chilled water requirements. Thus the higher level of emission of GHG would have continued.

[4] Bureau of Energy Efficiency, Government of India

There were a number of barriers towards implementation of the proposed CDM project. Implementation of the project as CDM project helped in overcoming these barriers. An outline of the barriers towards implementation of these two components of the project which has been overcome by implementing them as CDM project is being provided in the following paragraphs.

Switch from Vapour Compression Chillers to Vapour Absorption Chillers

In case of the component involving replacement of vapour compression chillers with vapour absorption chillers, the most appropriate alternative to the project activity was to install more of Vapour Compression Chillers to take care of the increase in the capacity of the production plant. As Panoli Intermediates had earlier installed Vapour compression machines, it would have been comfortable to continue the same technology considering the reliability, less cost towards maintenance of inventory and availability of trained manpower to operate the chillers. Installing vapour compression chillers is a normal practice due to its established know-how, reliability, maintenance / service availability, low cost and ready availability. Thus, if this component of the proposed CDM project would not have been implemented, electrical power would have been needed for Vapour Compression Chillers.

The proposed CDM project activity has reduced the emission of GHG which would have been generated due to the need to generate more fossil fuel based power. Some of the barriers towards replacement of the vapour compression chillers with vapour absorption chillers are as follows:

- Replacement of existing chillers with the new vapour absorption chillers required that the existing chillers be scrapped and capital investment be made to buy the new chillers
- The capital cost of chillers based on vapour absorption chillers is about three times the capital cost of chillers based on vapour compression chillers
- In comparison to vapour compressor chillers, the vapour absorption chillers are less reliable and require more maintenance

Captive Power Generation with Natural Gas as Fuel

Prior to implementation of the proposed CDM project, Panoli Intermediates used to draw electrical power from the grid of the western region.

The most probable scenario for meeting the power needs of the project proponent would have been continuation of withdrawal of power from the grid. This is because of the following reasons:

- This was an existing practise and the project proponents were comfortable with this arrangement as far as operational convenience and cost of power are concerned.
- It did not involve any additional capital investment. Non availability of capital is one of the barriers to industry in the country. The problem gets further compounded due to the high interest rate on the capital borrowed.

However, the need to establish captive facilities for power generation largely originated due to unreliable power supply from the grid. While deciding to establish captive facilities for generation of power, the choice of fuel and technology comprised of coal, diesel oil and natural gas. Due to the size of the power plant, the coal was not preferred. Thus the choice was restricted to use either diesel oil or natural gas as fuel. Panoli Intermediates would have gone for diesel oil based power generators because of the on site presence of trained manpower to run the standby diesel generator sets to take care of the unreliable power supply from the grid. This is so as the additional capital investment for setting up an augmented captive diesel generator plant would have been lesser than the capital required for installing a new natural gas based plant. Instead, the project proponent installed new captive power generators using natural gas as fuel. Some of the barriers towards such an act which has been overcome by implementing the project as CDM project are as follows:

- The cost of power generation using natural gas as fuel is much higher than the grid power
- Perceived risk of non availability of natural gas in future
- Perceived risk of rise in the price of natural gas in future
- Capital investment required to create new facilities for power generation
- Scrapping of existing emergency standby diesel oil based power generation facility which still had the residual life and was functional

In the absence of creation of natural gas based captive power generation facilities, Panoli Intermediates would have continued to either draw power from the grid or would have invested in augmentation of standby power in captive diesel oil based facilities. Thus, in the existing baseline scenario, the natural choice of the fuel for captive power generation would have been diesel oil or continuation of drawing power from the grid.

The emission of GHG for generation of power in diesel oil based power plants or coal based power plants, is higher than the emission in case of power generation in gas based power plants. This is partly due to lower carbon intensity of natural gas and partly due to higher efficiency of the power plant established by Panoli Intermediates. Thus switching from grid supplied power to the power generated in the captive power plant leads to reduction in the emission of carbon dioxide.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

The monitoring is the part of baseline methodology. As explained earlier, the baseline methodology is applicable to the project activity and hence the monitoring protocol given in the methodology is applicable to the project activity.

The baseline methodology IIIB requires monitoring of:

a) The fuel use and output for an appropriate period prior to the fuel switch being implemented
b) Monitoring fuel use and output after the fuel switch has been implemented

In case of new natural gas based power plant, the fuel use before the fuel switch to natural gas was implemented occurred due to the fossil fuel consumption taking place at the various power plants supplying power to the western grid and therefore to the project. No records are available for the same. Accordingly, the applicable emission factor for the baseline scenario has already been considered to determine the GHG emission in the baseline. After the implementation of the fuel switch, the GHG emissions saved will be determined by metering the power generated and monitoring the consumption of natural gas used. The project proponent could support the gas consumption data with the receipts of the gas purchases. The calorific value of natural gas will also be monitored to arrive at the value of emission coefficient (in terms of CO_2 equivalent / NM3, the IPCC emission coefficient is in terms of C / GJ, thus it is required to monitor the calorific value of natural gas to arrive at the emission coefficient in terms of CO_2 equivalent / NM3). No leakage calculation is required as per the guidelines of the methodology IIIB.

In the case of the energy efficiency intervention of vapour absorption chillers in a new facility, the IID methodology requires monitoring of:

(a) Metering the energy use of the equipment installed;
(b) Calculating the energy savings due to the equipment installed.

In case of replacement of vapour compression based chillers with the vapour absorption based chillers, the emission saved will be determined by monitoring the refrigeration generated and the power consumed for generation of the refrigeration. The parameters required for monitoring as per methodology are included in the monitoring plan. As per the Type IID methodology, leakage is to be considered only if the energy efficiency technology is equipment transferred from another activity or if the existing equipment is transferred to another activity. Since in the proposed CDM project, the vapour compression technology is being replaced with the vapour absorption technology, therefore, the leakage considerations are not required to be taken as per the guidelines of the approved Type IID methodology.

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

(Copy this table for each data and parameter)

Data / Parameter:	**S_B (Specific Power Consumption for chillers in Baseline Scenario)**
Data unit:	kWh/TR
Description:	Specific power consumption in the baseline scenario (in vapour compression technology based chillers)
Source of data used:	Equipment standards by ‘Bureau of Energy Efficiency’, Government of India, for vapour compression technology based chillers

Value applied:	0.7
Justification of the choice of data or description of measurement methods and procedures actually applied :	Fixed Reference value
Any comment:	

Data / Parameter:	**EF_B**
Data unit:	Kg.CO_2/kWh
Description:	Emission Coefficient for power used in chillers in baseline scenario
Source of data used:	Emission factor specified by 'Central Electricity Authority', Government of India, for the Western Grid of the country
Value applied:	0.88
Justification of the choice of data or description of measurement methods and procedures actually applied :	The Central Electricity Authority (CEA), Government of India (GOI) published, 'CO_2 Baseline Database for the Indian Power Sector' is an official database of the Government of India for the purpose of CDM baselines. As per the CDM Modalities and Procedures, project proponents are required to use the official Government data for purposes of calculation of GHG emissions. This database has been officially prepared by the CEA, GOI to specifically cater to the emission coefficient data needs for the purpose of the preparation of CDM baselines.
Any comment:	

B.6.3 Ex-ante calculation of emission reductions:

Variables	Unit	Symbol	Formula Used	Value
AVAILABLE FROM MONITORING				
Generation of Refrigeration during period under monitoring in the vapor absorption chillers (CDM Measure 1)	Ths, TR	R		2218
Actual Power Consumption for chillers after CDM project during period under monitoring	Ths. kWh / Yr.	$P_{C,CDM}$		75
Power Generation in captive natural gas based power plant during period under monitoring, (CDM Measure 2), (net of auxiliary power consumption within the power plant)	Ths kWh	P		8972
Actual Natural gas consumption in the captive power plant during period under monitoring	NM3	Q		2025
Average calorific value of natural gas during period under monitoring	K Cal / NM3	H		9200
VARIABLES WITH FIXED VALUES				
Measure 1				
Specific Power Consumption for chillers in Baseline Scenario	kWh / TR	S_B		0.7

Emission Coefficient for power used in chillers in baseline scenario	Kg CO_2 / kWh	EF_B		0.88
Measure 2				
Emission Coefficient for power drawn from grid as in baseline scenario	Kg CO_2 / kWh	EF_B		0.88
COMPUTED VARIABLES				
Power Consumption for chillers which would have taken place in Baseline Scenario	Ths. kWh / Yr.	$P_{C,B}$	R * S_B	1553
Emission Factor for Natural Gas##	Ton CO_2 / NM3	EF_{NG}	H * 0.24 / 1000	2.16
Emission Factor for power generated after CDM project	Kg CO_2 / kWh	EF_{CDM}	(Q / P) * EF_{NG}	0.49
GHG EMISSION				
Measure 1				
Emission of GHG which would have taken place in for operation of Chillers in Baseline Scenario during the period under monitoring	Ton CO_2 / Yr.	$E_{1,B}$	$P_{C,B}$ *EF_B	1366.29
Emission of GHG for operation of Chillers after CDM project during the period under monitoring	Ton CO_2 / Yr.	$E_{1,CDM}$	P_C * EF_{CDM}	36.61
GHG Mitigation due to Measure 1	**Ton CO_2 / Yr.**	**E_1**	**$E_{1,B} – E_{1,CDM}$**	**1329.68**
Measure 2				
Emission of GHG due to power usage in baseline scenario during the period under monitoring	Ton CO_2 / Yr.	$E_{2,B}$	P * EF_B	7895.36
Emission of GHG due to power usage after CDM project during the period under monitoring	Ton CO_2 / Yr.	$E_{2,CDM}$	P * EF_{CDM}	4379.15
GHG Mitigation due to Measure 2	**Ton CO_2 / Yr.**	**E_2**	**$E_{2,B} – E_{2,CDM}$**	**3516.21**
Total GHG Mitigation	**Tons CO_2 / Yr.**	**E**	**$E_1 + E_2$**	**4845.89**

IPCC Default Emission Factor for Natural Gas = 15.3 Kg C / GJ = 56.1 Kg CO2 / GJ = 0.24 Kg CO2 / K Cal (1GJ = 239 K cal)

B.6.4 Summary of the ex-ante estimation of emission reductions:

From Measure 1 as per Type IID: Energy Efficiency Improvement due to change from vapour compression chiller technology to vapour absorption chiller system

Year	Estimation of project activity emissions (tCO2e)	Estimation of baseline emissions (tCO2e)	Estimation of leakage (tCO2e)	Estimation of overall emission reductions (tCO2e)
November 2007 – October 2008	36.61	1366.29	Not applicable	1329.68
November 2008 – October 2009	36.61	1366.29	Not applicable	1329.68
November 2009 – October 2010	36.61	1366.29	Not applicable	1329.68
November 2010 – October 2011	36.61	1366.29	Not applicable	1329.68
November 2011 – October 2012	36.61	1366.29	Not applicable	1329.68

November 2012 – October 2013	36.61	1366.29	Not applicable	1329.68
November 2013 – October 2014	36.61	1366.29	Not applicable	1329.68
November 2014 – October 2015	36.61	1366.29	Not applicable	1329.68
November 2015 – October 2016	36.61	1366.29	Not applicable	1329.68
November 2016 – October 2017	36.61	1366.29	Not applicable	1329.68
Total (tonnes of CO2e)	**366.06**	**13662.88**	**Not applicable**	**13296.812**

From Measure 2 as per Type IIIB: Fuel switch from grid electricity to natural gas based captive power plant

Year	**Estimation of project activity emissions (tCO2e)**	**Estimation of baseline emissions (tCO2e)**	**Estimation of leakage (tCO2e)**	**Estimation of overall emission reductions (tCO2e)**
November 2007 – October 2008	4379.15	7895.36	Not applicable	3516.21
November 2008 – October 2009	4379.15	7895.36	Not applicable	3516.21
November 2009 – October 2010	4379.15	7895.36	Not applicable	3516.21
November 2010 – October 2011	4379.15	7895.36	Not applicable	3516.21
November 2011 – October 2012	4379.15	7895.36	Not applicable	3516.21
November 2012 – October 2013	4379.15	7895.36	Not applicable	3516.21
November 2013 – October 2014	4379.15	7895.36	Not applicable	3516.21
November 2014 – October 2015	4379.15	7895.36	Not applicable	3516.21
November 2015 – October 2016	4379.15	7895.36	Not applicable	3516.21
November 2016 – October 2017	4379.15	7895.36	Not applicable	3516.21
Total (tonnes of CO2e)	**43791.49**	**78953.6**	**Not applicable**	**35162.1**

Summarized Aggregate GHG Emission Reductions of the proposed CDM project including GHG mitigation measures I and II:

Year	**Estimation of project activity emissions (tCO2e)**	**Estimation of baseline emissions (tCO2e)**	**Estimation of leakage (tCO2e)**	**Estimation of overall emission reductions (tCO2e)**
November 2007 – October 2008	4415.76	9261.65	Not applicable	4845.89
November 2008 – October 2009	4415.76	9261.65	Not applicable	4845.89
November 2009 – October 2010	4415.76	9261.65	Not applicable	4845.89
November 2010 – October 2011	4415.76	9261.65	Not applicable	4845.89
November 2011 – October 2012	4415.76	9261.65	Not applicable	4845.89
November 2012 – October 2013	4415.76	9261.65	Not applicable	4845.89
November 2013 – October 2014	4415.76	9261.65	Not applicable	4845.89
November 2014 – October 2015	4415.76	9261.65	Not applicable	4845.89
November 2015 – October 2016	4415.76	9261.65	Not applicable	4845.89
November 2016 – October 2017	4415.76	9261.65	Not applicable	4845.89
Total (tonnes of CO2e)	**44157.56**	**92616.48**	**Not applicable**	48458.92

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

B.7.1 Data and parameters monitored:

(Copy this table for each data and parameter)

Data / Parameter:	**P (Net Power generated in natural gas based captive generator)**
Data unit:	Thousand kWh
Description:	Power generated in the captive natural gas based power plant (Net Power generated is the Gross Power less the auxiliary power consumption within the power plant)
Source of data to be used:	Electricity meter installed on the power plant and the additional electricity meter installed at the HT / LT distribution point supplying power to the manufacturing plant
Value of data:	Will vary and will be obtained from monitoring
Description of measuring methods and procedures to be	Net power generated in the power plant will be determined using an electronic energy meter installed at the outlet of the power plant. The meter used will be of integrator type. The reading of the meter will be noted in the beginning of

applied	every shift and at the end of the shift. The difference of the two readings will be taken as the power generated during the shift.
QA / QC procedures to be applied:	The measurement of power generated using an electronic meter as installed on the power plant is considered to be a reliable method for measurement of power. The additional meters at the HT / LT panel will act as a cross check. In case of difference in the two readings, the least of the two values will be used. Calibration of the energy meters being used will be carried out regularly as per the standard practice.
Any comment:	

Data / Parameter:	**Q (Quantity if natural gas used in captive power plant)**
Data unit:	NM_3
Description:	Natural Gas used in the captive Natural gas based power plant for generating power
Source of data to be used:	Gas flow meter installed at the fuel supply inlet of the power plant
Value of data:	Will vary and will be obtained from monitoring
Description of measuring methods and procedures to be applied	The gas flow meter used will be integrator type, wherein the gas used for every shift of operation will be determined. The reading of the meter at the beginning of the shift and at the end of the shift will be noted. The difference between the two readings will be determined using the difference between the two readings.
QA / QC procedures to be applied:	The gas flow meter will be calibrated from time to time as per the standard procedure and the recommendations of the supplier of the flow meter.
Any comment:	The use of mass flow meter is not suggested as the density of the gas may vary from time to time and the data of the calorific value from the gas supplier is available in volume terms. The values available from volumetric flow meter will be available as volume under ambient temperature and pressure. These will be normalised using the ambient temperature and pressure prevailing during the day

Data / Parameter:	**H (Calorific Value of Natural Gas)**
Data unit:	K Cal / NM_3
Description:	Calorific value of the natural gas supplied to the power plant
Source of data to be used:	Value specified by the supplier of the gas
Value of data:	Will vary and will be obtained from monitoring
Description of measuring methods and procedures to be applied	The billing for the gas supplied is done on the basis of the calorific value of the gas and the volume of gas supplied. Generally, the facilities for determination of the calorific value of gaseous fuels are not available with the production units. Further the use of calorific value as provided by the gas supplier will be independent and is expected to be more reliable.
QA / QC procedures to be applied:	Based on the calorific value of the gas as specified by the gas supplier, the quantum of power generated and the quantity of gas actually used the thermal efficiency of the power plant will be evaluated from time to time. Any significant variation in the thermal efficiency of the power plant will point out towards discrepancies in the calorific value or technical problems with the

	power plant. In such a case, the matter will be investigated and sorted out.
Any comment:	The volume of gas used combined with the calorific value of the gas supplied makes it possible to account for any variation which may take place in the thermal efficiency of the power plant. It is because of this reason that instead of using the default emission factor and the specified efficiency levels of the power plant, the present method of monitoring is being recommended

Data / Parameter:	**R (Refrigeration generation from vapour absorption chillers)**
Data unit:	Thousand TR (Tons of refrigeration generated)
Description:	TR (Tons of refrigeration generated) in the vapour absorption type chillers
Source of data to be used:	Integrator type volume flow meter and temperature recorder installed on the chilled water outlet of the chiller plant and a similar instrument installed at the inlet of the chilled water inlet of the chiller plant.
Value of data:	Will vary and will be obtained from monitoring
Description of measuring methods and procedures to be applied	Determination of the refrigeration generated requires determination of the temperature lost by the water and the volumetric flow rate of the water cooled. This will be done by directly measuring these two values. The use of an integrator type instrument is suggested as both these parameters are independent and may vary from time to time. Integrator type of flow meter will be used for volumetric flow rate, whereas for temperature measurement and indicator / recorder type of instrument will be used. The readings of the volume flow meter will be taken at the start of the shift and at the end of the shift. Average temperature at the inlet and out let of the chilling plant during the shift will be used to compute the refrigeration generated during the shift
QA / QC procedures to be applied:	Calibration of the volume flow meter for water and the temperature recorders will be carried out from time to time as per the standard procedure.
Any comment:	

Data / Parameter:	$P_{C,CDM}$ (Power Consumption in vapour absorption chillers after the CDM project)
Data unit:	Thousand kWh
Description:	Actual power used for generation of chilled water after implementation of the CDM project
Source of data to be used:	Dedicated meter on the line supplying power to the vapour absorption chillers
Value of data:	Will vary and will be obtained from monitoring
Description of measuring methods and procedures to be applied	Direct measurement of the power consumed by the vapour absorption chillers By using a dedicated meter purpose. An electronic energy meter will be used for the purpose.
QA / QC procedures to be applied:	Calibration of the energy meter will be carried out from time to time as per the recommendations of the supplier of the meter.
Any comment:	The proposed method of direct measurement of power consumption by the vapour absorption chillers will take into account any variation which may take place in actual practice in the efficiency of the chilling units. It is because of this reason that instead of using the designed specific energy consumption in

	the chillers, a method to directly measure the power consumption has been proposed. Variation in the efficiency of the chillers in actual practice can take place due to a variety of reasons which include the chillers operating on part load and the quality of power supply to the chillers. The use of electronic energy meter instead of an electro mechanical type of meter is being suggested as with time the accuracy level of electro mechanical meters goes down.

Data / Parameter:	EF_{NG}
Data unit:	Ton CO_2 / NM_3
Description:	Emission Factor for Natural Gas
Source of data to be used:	Computed based on the calorific value of natural gas
Value of data:	Varies depending upon the monitored value of calorific value of natural gas
Description of measuring methods and procedures to be applied	Will be computed using the following formula: EF_{NG} = H * 0.24 / 1000
QA / QC procedures to be applied:	As this is a computed value its QC / QA measures are inbuilt in the QA / QC procedures being used for the parameters used for computation
Any comment:	Emission factor for natural gas may vary with the calorific value of natural gas, there is a direct relationship between the two. The value will be determined using IPCC Default Emission Factor for Natural Gas considering 100 percent oxidization level. IPCC Default Emission Factor = 15.3 Kg C / GJ = 56.1 Kg CO_2 / GJ = 0.24 Kg CO_2 / K Cal

Data / Parameter:	EF_{CDM}
Data unit:	Kg. CO_2/ kWh
Description:	GHG Emission Coefficient due to use of natural gas for generation of power after implementation of the CDM project
Source of data to be used:	Computed based on the consumption of natural gas, the corresponding power generation and the carbon emission coefficient of the natural gas
Value of data:	Varies depending upon the monitored value of natural gas consumption, corresponding power generation and the corresponding emission coefficient of the natural gas
Description of measuring methods and procedures to be applied	Will be computed using the following formula: $EF_{CDM} = (Q / P) * EF_{NG}$
QA / QC procedures to be applied:	As this is a computed value its QC / QA measures are inbuilt in the QA / QC procedures being used for the parameters used for computation
Any comment:	

Data / Parameter:	S_B
Data unit:	kWh/TR
Description:	Specific power consumption in the baseline scenario (in vapour compression technology based chillers)
Source of data to be used:	Equipment standards by 'Bureau of Energy Efficiency', Government of India, for vapour compression technology based chillers
Value of data:	0.7
Description of measuring methods and procedures to be applied	Not Applicable, as fixed reference value is being used
QA / QC procedures to be applied:	Not applicable
Any comment:	

Data / Parameter:	EF_B
Data unit:	Kg. CO_2/ kWh
Description:	Emission Factor for power generation in baseline
Source of data to be used:	Emission factor specified by 'Central Electricity Authority', Government of India, for the Western Grid of the country
Value of data:	0.88
Description of measuring methods and procedures to be applied	Not Applicable, as fixed reference value is being used
QA / QC procedures to be applied:	Not applicable
Any comment:	

B.7.2 Description of the monitoring plan:

The proposed CDM project leads to mitigation of GHG due to following two specific measures:

- Replacement of fossil fuel mix generated grid power with power generated in captive natural gas based power generator
- Replacement of vapour compression based chilled water generation facilities with the chilled water generation facilities based on vapour absorption technology.

The monitoring of the emission reduction will be carried out by measuring the actual power generation and actual refrigeration generation and the corresponding natural gas / power consumption. For determining the refrigeration generated flow rate of the chilled water and the temperature loss across the chilling unit is measured. There will be fluctuations both in the volumetric flow rate of water and temperature loss across the chilling unit. In order to take care of the fluctuations online recorders with integrators will be used.

The fuel consumption for power generation can vary either because of variation in the efficiency of the power plant or because of the variation in the calorific value of the natural gas. Variation in the calorific value of the natural gas does not lead to variation in the emission coefficient (in terms of GHG emission per unit of power generated). However variation in the thermal efficiency of the power plant leads to variation in the emission coefficient. To account for the variations in the GHG emissions due to variation in thermal efficiency of the power plant, combination of the natural gas consumption and the computed value of emission coefficient of natural gas will be used. The value of the emission coefficient (in terms of emissions per NM_3) will be determined using emission coefficient for natural gas and the actual calorific value of natural gas.

The proposed CDM project activity has been implemented by Panoli Intermediates (India) Private Limited at its existing production facilities located at Jhagadia, in the state of Gujarat. The CDM project will be looked after by the manager responsible for operation of the production facilities. Day to day operations of the power generator will be carried out by the staff responsible for the operation of the captive power plant within the production facilities. The water flow rate and the inlet and outlet temperature of the chilled water will be measured just outside the battery limited of the chilling unit. The equipment supplier has already conducted demonstration for operation and maintenance activities and the existing staff force of PIPL is already well versed with the system. Thus, no additional training is required to be provided to the daily staff workers operating the equipments as they are already comfortable with the operation and maintenance activities related to the vapour absorption chiller system and the natural gas based captive power plant.

The meters used for recording the power generation and chilled water flow rate will be of integrator type. The records of the quantity of power generated and the refrigeration produced will be recorded on a daily basis. The data will be captured and stored electronically. As a separate measure, the quantity of power produced, natural gas consumed and the ratio of the power produced to the quantity of natural gas consumed will be entered in the logbook on every shift basis.

Measuring instruments of all the parameters covered under monitoring plan which are required to be monitored regularly will be calibrated as per maintenance schedule by authorised calibrating agencies. Calibration certificates of the equipments will be maintained by the management of Panoli Intermediates (India) Private Limited and shall be available for cross checking.

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 completion of the application of the baseline and monitoring methodology: August 9, 2007

Name of responsible person (s)/entity (ies) for application of the above:
Dinesh Aggarwal
Manager
Deloitte Touche Tohmatsu India Private Limited
MCT House, One Okhla Centre, Block A
Okhla Institutional Area
New Delhi – 1100025
Phone: 91-11-66622087
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Email: daggrawal@deloitte.com

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

The duration of the proposed small scale CDM project activity is 10 years

C.1.1. Starting date of the project activity:

Start date of the proposed small scale CDM project activity is January 9th, 2006.

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

15 years

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

Fixed crediting period is chosen

C.2.1. Renewable crediting period

Not Applicable.

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

C.2.1.2. Length of the first crediting period:

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

The crediting period will start from the date of registration of the project with CDM Executive Board. The expected start date of the crediting period is 01/11/2007.

C.2.2.2. Length:

Ten 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:

Not applicable

SECTION E. Stakeholders' comments

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

The stake holders in the present context were defined as the parties and individuals who are either affected or are perceived to be affected by the proposed CDM project activity. The proposed activity pertains to replacement of vapour compression chillers with vapour absorption technology based chillers and creation of captive facilities for generation of power using natural gas as fuel. The proposed activity is not likely to have any adverse impact on any of the stake holders.

A list of stake holders was prepared and for inviting the comments by the stake holders, a joint meeting of the stake holders was organised. All the stakeholders were informed about the stakeholder consultation meeting through verbal communication by Panoli Intermediates. Presentation regarding climate change, Kyoto Protocol and CDM was made to the stake holders in order to familiarise them regarding the concept. Information regarding other global environmental issues like ozone depletion and Montreal Protocol was also provided during the meeting. This was followed by a presentation on the proposed CDM project. The presentations were made in local language (Gujarati and Hindi). The list of the stake holders who attended the meeting is provided as Appendix-II to this document. After the briefing / presentations, the stake holders were asked to provide their comments / suggestions for the proposed project.

E.2. Summary of the comments received:

The stake holders present during the meeting appreciated the initiatives taken by Panoli Intermediates to address the local and global environmental issues. Some of the representatives on the neighbouring industries present during the meeting expressed interest in taking up similar initiatives in their units as well and asked for the guidance and support from Panoli Intermediates.

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

The management representatives of Panoli Intermediates promised to provide the required support and guidance to the neighbouring industries to undertake CDM project activities. Apart from this there are no comments for which any action is required to be taken by the project proponent.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Panoli Intermediates India Private. Limited
Street/P.O.Box:	20/21 Hari Nagar Cooperative Society
Building:	Gotri Raod
City:	Vadodra (Baroda)
State/Region:	Gujarat
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E-Mail:	knmehta@kcil.co.in
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Represented by:	
Title:	President
Salutation:	Mr.
Last Name:	Mehta
Middle Name:	Navin Chandra
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Department:	Commercial
Mobile:	91-9377726677
Direct FAX:	91-265-2397245
Direct tel:	91-265-2396751
Personal E-Mail:	knmehta@kcil.co.in

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No public funding of the project is involved. The entire cost of the project will be borne by the project proponent (Panoli Intermediates (India) Private Limited).

Annex 3

BASELINE INFORMATION

The proposed small scale CDM project activity has following two specific components:

- Switching from grid power supply to captive generation of power using Natural Gas as fuel
- Switch over from vapour compression chillers to vapour absorption chillers using waste heat

Explanation of how the above two components of the proposed project lead to reduction of emission of GHG and the baseline consideration for the two components of the proposed CDM project is being provided in the following paragraphs.

Captive Power Generation with Natural Gas as Fuel

Earlier, the power requirements for operation of the plant for producing dye intermediates and other chemicals in the production facilities of Panoli Intermediates located at Jhagadia were met by way of supplies from the power distribution grid of the western region. The power distribution grid of the western region is subdivided into power distribution grids of different state of the region. The power to the western grid in turn is supplied by the power plants of the states which are part of the western grid. The power to the western grid is also supplied by central sector power plants connected to the western grid. Some of the power plants in private sector in the western region also feed power to the western grid.

As in other parts of the country, the technology used by the coal / lignite based thermal power plants of the western region is sub critical (with the designed thermal efficiency of 35% and auxiliary power consumption level of 8%) though thermal efficiency of some of the older power plants is lesser than 35%. A typical sub-critical single reheat steam plant (operating at 180bar, 540°C/540°C cycle, and single reheat) currently exhibits a net efficiency of 32.5% (after accounting for auxiliary power consumption). However, many of the coal / lignite based thermal power plants of the state are quite old and operate at lower thermal efficiency than the designed levels. Further the auxiliary power consumption in such thermal power plants is much higher than 8%. As a consequence, the coal consumption and hence emission of carbon dioxide in such power plants is much higher than the design levels.

The power to the western grid is also supplied by a number of gas turbines. Such gas turbines use either Naphtha or Natural Gas as fuel. Some of these gas turbine based power plants operate in combined cycle while the rest of them operate in open cycle.

As an alternative to drawing power from the state electricity grid, Panoli Intermediates has established its captive power generation facilities. The need to establish captive facilities for power generation largely originated due to unreliable power supply from the grid.

While deciding to establish captive facilities for generation of power, the choice of fuel and technology comprised of coal, diesel oil and natural gas. Due to the size of the power plant coal was not preferred. Thus the choice was restricted to use either diesel oil or natural gas as fuel. The cost of power generation using natural gas as fuel is much higher due to higher cost of natural gas. However, considering that the benefits available under CDM will partly take care of the higher cost of fuel in case of selection of natural gas as fuel, it was decided to go for natural gas based captive power generation. The new captive generation facilities created comprises of an internal combustion engine (using natural gas as fuel) coupled with a generator.

In the absence of creation of natural gas based captive power generation facilities, Panoli Intermediates would have continued to either draw power from the grid or would have augmented the power generation through captive diesel oil based facilities. Thus the two possible baseline scenarios in this case are as follows:

- Withdrawal of power from the power distribution grid of the state
- Captive generation of power using diesel oil as fuel

This is largely due to the fact, that there are no regulations in the country regarding use of type of fossil fuel for generation of power in captive power plants. In the absence of the regulations the natural choice of the fuel for captive power generation would have been diesel oil due to the following reasons:

- Diesel oil is the most widely available fossil fuel. Standby captive power generation facilities based on diesel oil were already available with Panoli Intermediates and it would have continued to use these facilities.
- It is possible to store diesel oil at site to take care of fluctuations in the availability of fuel due to disturbances along the supply chain
- The cost of power generation using diesel oil is comparatively lower
- There is higher perceived risk regarding fluctuations in the prices and availability of natural gas in future

Of the two possible baseline scenarios discussed above the most probable scenario would have been withdrawal of power from the grid. This is because of the following reasons:

- This was an existing practise and the project proponents were comfortable with this arrangement as far as operational convenience and cost of power are concerned.
- It did not involve any additional capital investment. Non availability of capital is one of the barriers to industry in the country. The problem gets further compounded due to the high interest rate on the capital borrowed.

Thus in order to determine GHG mitigation due to the proposed CDM project the baseline considered is the withdrawal of power from the grid. The GHG emission in the baseline scenario has been estimated accordingly.

The electricity grid of the western region is supplied with the power generated in a number of power plants. These power plants are based on different technologies / fuels and each one of them operates at different levels of efficiency. Based on the contribution of each of the power plants, the type of fuel used in such plants and actual efficiency of such power plants, the emission of carbon dioxide for every unit of power supplied to the grid will vary from time to time. In this context it is important to note that generation mix of the western region largely comprises of thermal power. These thermal power plants use coal / lignite as fuel. The carbon dioxide emission for generation of one unit of power in a conventional coal based power plant (sub-critical technology single reheating and 510 degree C temperature) is estimated to be 1.10 Kg (considering 33 percent net efficiency, carbon intensity of coal as 27.6 kg C/ GJ). It is important to note that in the process of transmission of power from the power plants to the premises of the user there will be transmission and distribution losses. Due to transmission and distribution losses the carbon dioxide emission for every unit of power (generated in a conventional coal based thermal power plant) delivered will be higher than 1.10 Kg. Further to this the thermal power plants in actual practise operate at the efficiency levels which are lower than the design levels.

The proposed project uses the approved small scale methodology II D. Approved small scale methodology II D stipulates that for the electricity displaced, the emission coefficient be calculated in accordance with provisions in paragraphs 6 or 7 for category I.D projects. Paragraphs 6 & 7 for category I D projects have the following provision for determination of the emission coefficient (measured in kg CO2equ/kWh) in the baseline scenario:

(c) The average of the "approximate operating margin" and the "build margin", where:
  (i) The "approximate operating margin" is the weighted average emissions (in kg CO2equ/kWh) of all generating sources serving the system, excluding hydro, geothermal, wind, low-cost biomass, nuclear and solar generation;
  (ii) The "build margin" is the weighted average emissions (in kg CO2equ/kWh) of recent capacity additions to the system, which capacity additions are defined as the greater (in MWh) of most recent 20% of existing plants or the 5 most recent plants.";

OR

(d) The weighted average emissions (in kg CO2equ/kWh) of the current generation mix.

With the purpose of providing a ready reference for the emission coefficients to be used in CDM projects, Central Electricity Authority (CEA), Government of India, has published, 'CO2 Baseline Database for the Indian Power Sector[5]'. This database is an official publication of the Government of India for the purpose of CDM baselines. It is based on the most recent data available to the Central Electricity Authority. As per this data base the weighted average emission factor of Western Regional Grid for the financial year 2005-06 (April 2005 to March 2006) (adjusted for inter-regional and cross-country electricity transfers) is as follows:

Particulars	Value	Unit	Description
Average	0.88	tCO2/MWh	The weighted average emission factor describes the average CO2 emitted per unit of electricity generated in the grid. It is calculated by dividing the absolute CO2 emissions of all power stations in the region by the region's total net generation. Net generation from so-called low-cost/must-run sources (hydro and nuclear) is included in the denominator.
Simple OM	0.99	tCO2/MWh	The operating margin describes the average CO2 intensity of existing stations in the grid which are most likely to reduce their output if a CDM project supplies electricity to the grid (or reduces consumption of grid electricity). "Simple" denotes one out of four possible variants listed in ACM0002 for calculating the operating margin. The simple operating margin is obtained by dividing the region's total CO2 emissions by the net generation of the stations serving the region excluding low-cost/must-run sources. In other words, the total emissions are divided by the total net generation of all thermal power

5 'CO2 Baseline Database for the Indian Power Sector', User Guide, Version 2.0, CEA, Government of India, June 2007

			stations. Hydro and nuclear qualify as low-cost/must-run sources, and their net generation is therefore excluded from the denominator.
BM	0.63	tCO2/MWh	The build margin reflects the average CO2 intensity of newly built power stations that will be (partially) replaced by a CDM project. In accordance with ACM0002, the build margin is calculated in this database as the average emissions intensity of the 20% most recent capacity additions in the grid based on net generation.
CM	0.81	tCO2/MWh	The combined margin is a weighted average of the simple operating margin and the build margin. By default, both margins have equal weights (50%). The combined margins shown in the database are calculated based on equal weights.

In accordance with the provision in paragraphs 6 & 7 of approved small scale methodology ID average of the emission factor (considering the emission due to current generation mix) has been considered for determining the emission in the baseline. Accordingly, the emission factor considered is 0.88 tCO2/MWh (0.88 Kg CO2/kWh). In order to determine GHG mitigation in a conservative manner, no transmission and distribution losses have been considered.

Vapour Absorption Chillers

Panoli Intermediates uses chilled water for process cooling applications. Till recently, the chilled water needed for the cooling application was produced using chillers based on vapour compression technology. With the establishment of captive power generation facilities as discussed in the above paragraphs, additional waste heat streams (exhaust of the engine and hot water used for cooling of the engine) became available. In order to gainfully utilise this additional waste heat, Panoli Intermediates replaced its existing vapour compression based chillers with the chillers based on vapour absorption technology. This required that the existing chilled water generation facilities based on vapour compression technology be scrapped and new facilities based on vapour absorption technology be established. High capital cost of vapour absorption based system was acting as a barrier towards such an act. Realising that shifting from vapour compression technology to vapour absorption technology will lead to mitigation in the emission of GHG and some benefits will be available under CDM, Panoli Intermediates replaced the existing chilled water generation system with the energy efficient vapour absorption system. In the absence of the proposed CDM project, Panoli Intermediates would have continued to use the existing vapour compression based chillers. In order to increase the availability of chilled water to match the increase in demand for chilled water, due to increase in the production capacity, Panoli Intermediates would have added more chillers based on vapour compression technology. The selection of technology for generation of chilled water would have been the vapour compression technology because of following specific reasons:

- The vapour compression technology which uses the compressors run by electrical motors is the predominantly used technology for condensing the vapours of the refrigerant in a refrigeration / air conditioning cycle. Against this, in the vapour absorption cycle a low grade heat source is used as the external energy source for running the refrigeration cycle (against electrical energy used in case of vapour compression cycle). In this case, this low grade heat source is the exhaust from the engine of the power generator.
- Due to its very nature (presence of particulate matter etc.) there are risks associated with the use of engine exhaust as the source of heat. Such risks include higher maintenance cost, lower operational performance of the equipment (due to higher dirt factor), reduced life of the tubes of heat exchangers (due to deposition of particulate matter and creation of hot spots)

- The selection of a technology for a given refrigeration / air conditioning application is governed by the initial capital cost, the operating cost and other external factors (like availability of power / low grade heat source). Out of these two technologies for refrigeration, vapour absorption technology is comparatively newer and is characterised by high initial capital cost.
- The vapour absorption based systems are required to be customised to a large extent based on the quality, type and quantity of low grade heat source. Due to the need for customisation in case of vapour absorption based refrigeration systems and due to comparatively higher initial investment, the risk involved while adopting a vapour absorption based system are significantly higher
- There is no statutory policy or programme that would have prevented Panoli Intermediates, to establish more chillers based on vapour compression technology. The project is the outcome of the voluntary initiative of the management, would not have been possible in the absence of management decision of Panoli Intermediates to save energy and reduce GHG emissions associated with the saving of electric power.

Thus the baseline considered for this component of the proposed CDM project is the chilled water generation using vapour compression technology. The energy baseline is the displaced fossil fuel, which would have been used to generate power needed by the vapour compression based chillers. The power consumption in the baseline scenario to generate equal amount of refrigeration can be estimated either based on the designed power consumption of vapour compression technology based chillers or based on the figures provided in standard reference literature.

For vapour compression based refrigeration cycle (operating at above zero degree C temperatures) using reciprocating compressors, the standard literature[6] provides the energy to TR ratio in the range of 0.7 to 0.9 kW/TR. In order to estimate the GHG mitigation due to the project in a conservative manner, the specific power consumption in the baseline scenario has been considered as 0.7 kWh /TR.

The baseline power consumption is specific power consumption (kWh/TR) of the vapour compression based chillers multiplied by refrigeration generation (TR/yr). The GHG emission in the baseline scenario is calculated based on emission coefficient for the western grid (discussed in the above paragraphs) multiplied by the power which would have been consumed in vapour compression based chillers.

[6] Bureau of Energy Efficiency, Government of India

Annex 4

MONITORING INFORMATION

The proposed CDM project leads to mitigation of GHG due to following two specific measures:

- Replacement of grid power with captive power generated in captive natural gas based power generator
- Replacement of vapour compression based chilled water generation facilities with the chilled water generation facilities based on vapour absorption technology.

The monitoring of the emission reduction will be carried out by measuring the actual power generation, actual refrigeration generation and the corresponding consumption of natural gas / power. Thus both the sources of emission of GHG and the energy out put streams will be monitored. All these parameters will be monitored by direct on line measurements using high accuracy measuring instruments. As measurement of refrigeration apart from measurement of volumetric flow rate requires measurement of temperatures as well, separate temperature measuring instruments will be used. The temperature measuring instruments used will have the facility to record the temperatures. The measuring instruments used will be integrator type.

The CDM project will be looked after by the manager responsible for operation of the production facilities. Day to day operations of the power generator will be carried out by the staff responsible for the operation of the captive power plant within the production facilities. The water flow rate and the inlet and outlet temperature of the chilled water will be measured just outside the battery limits of the chilling unit.

The meters used for recording the power generation and chilled water flow rate will be of integrator type. The records of the quantity of power generated and the refrigeration produced will be recorded on a daily basis. The data will be captured and stored electronically. As a separate measure, the quantity of power produced, natural gas consumed and the ratio of the power produced to the quantity of natural gas consumed will be entered in the logbook on per shift basis. Measuring instruments of all the parameters covered under monitoring plan which are required to be monitored regularly will be calibrated as per maintenance schedule.

The monitoring methodology being used is the part of baseline methodology. The baseline methodology II D is applicable to the project activity and hence the monitoring protocol given in the methodology is applicable to the project activity.

In the case of a new facility, the monitoring methodology requires monitoring of:

(a) Metering the energy use of the equipment installed;
(b) Calculating the energy savings due to the equipment installed.

In case of new natural gas based power plant, the emission saved will be determined by metering the power generated and monitoring the consumption of natural gas used. In case of replacement of vapour compression based chillers with the vapour absorption based chillers the emission saved will be determined by monitoring the refrigeration generated and the power consumed for generation of the refrigeration. The parameters required for monitoring as per methodology are included in the monitoring plan.

Appendix – I – Technical Description of the proposed CDM Project

The proposed small scale CDM project activity has following two specific components:

- Switching from grid power supply to captive generation of power using Natural Gas as fuel
- Switch over from vapour compression chillers to vapour absorption chillers using waste heat contained in the exhaust of the engine of the captive power generator

A brief description of these two components of the proposed small scale CDM project activity is provided in the following paragraphs.

Captive Power Generation with Natural Gas as Fuel

Panoli Intermediates is one of the leading producers of dye intermediates and chemicals in the country. The power requirements for operation of the plant for producing dye intermediates and other chemicals were earlier met by way of supplies from the power distribution grid of the western region. The power distribution grid of the western region is subdivided into power distribution grids of different states of the region. Power distribution grid of the western region caters to the needs of the states of Maharashtra, Madhya Pradesh, Chhattisgarh, Daman & Diu, Dadar & Nagar Haveli, and Goa apart from that of Gujarat. The power to the western grid in turn is supplied by the power plants of the states which are part of the western grid. The power to the western grid is also supplied by central sector power plants connected to the western grid. Some of the power plants in private sector in the western region also feed power to the western grid.

As in other parts of the country the technology used by the coal / lignite based thermal power plants of the western region is sub critical (with the designed thermal efficiency of 35% and auxiliary power consumption level of 8%), though thermal efficiency of some of the older power plants is lesser then 35%. A typical sub-critical single reheating of steam based power plant (operating at 180bar, 540°C/540°C cycle, and single reheat) currently exhibits a net efficiency of 32.5% (after accounting for auxiliary power consumption). However, many of the coal / lignite based thermal power plants of the state are quite old and operate at lower thermal efficiency than the designed levels. Further the auxiliary power consumption in such thermal power plants is much higher than 8%. As a consequence the coal consumption and hence emission of carbon dioxide in such power plants is much higher than the design levels.

The power to the western grid is also supplied by a number of gas turbines. Such gas turbines use either Naphtha or Natural Gas as fuel. Some of these plants operate in combined cycle while the rest of them operate in open cycle.

As an alternative to drawing power from the state electricity grid, Panoli Intermediates has established its captive power generation facilities. The need to establish captive facilities for power generation largely originated due to unreliable power supply from the grid. The new captive generation facilities created comprises of an internal combustion engine (using natural gas as fuel) coupled with a generator. The rated capacity of the power plant is 1.416 MW. The waste heat contained in the exhaust of the engine will be utilised to run a vapour absorption technology based chillers (details of the chiller system is provided in subsequent paragraphs). Technical specifications and the operating parameters of the captive power generation system are given in Table 1 below.

Table 1
Technical Specifications and Operating Parameters of Captive Power Generator

	Unit	**At Full Load**	**At 75% Load**	**At 50% Load**
Fuel		Natural Gas	Natural Gas	Natural Gas
Fuel Gas LHV	**kWh / Nm3**	**9.5**	**9.5**	**9.5**
Energy Input	kW	3334	2573	1811
Gas volume	Nm3/ h	351	271	191
Mechanical output	kW	1451	1088	726
Electrical out put	**kW**	**1416**	1062	706
Recoverable thermal output				
Intercooler 1st stage	kW	210	117	32
Lube oil	kW	158	136	120
Jacket water	kW	380	345	290
Total recoverable thermal output	**kW**	**748**	**598**	**442**
Specific fuel consumption of engine	kWh / kWh of mechanical output	2.30	2.36	2.49
Specific fuel consumption	kWh / kWh of electrical output	2.35	2.42	2.57
Lube oil consumption	Kg / h	0.44	0.44	0.44
Electrical Efficiency		**42.5%**	**41.3%**	**39.0%**
Thermal Efficiency		**22.4%**	**23.2%**	**24.4%**
Total Efficiency		**64.9%**	**64.5%**	**63.4%**

Switching from grid supplied power to the power generated in the captive power plant leads to reduction in the emission of carbon dioxide due to following two reasons:

- The efficiency of the system installed is higher than the efficiency of the fossil fuel based power plants supplying power to the western grid. The designed efficiency of the sub-critical technology based power plant using coal / lignite is considered to be about 35 to 36 percent. On top of it the auxiliary power consumption in such power plants is 8 percent, thereby reducing the designed net efficiency levels to about 33 Percent. It is important to note that in actual practise the coal / lignite based power plants operate at efficiency levels which are much lower than the designed levels. Against this the energy efficiency of the captive power plant (considering only the power as output) installed by Panoli Intermediates is 42.5 percent.

- Lower carbon intensity of natural gas when compared to that of coal / lignite. The carbon emission intensity of coal is considered to be 27.6 Kg C / GJ[7]. Against this the carbon emission intensity of Natural Gas is considered to be 15.3 Kg C / GJ.

[7] Revised IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual

Apart from the two reasons mentioned above the emission of carbon dioxide also reduces due to recovery of waste heat contained in the exhaust of the engine. This waste heat recovered is used for running a vapour absorption technology based chiller unit. Mitigation due to recovery of waste heat in the exhaust of the engine has been accounted for separately.

As can be seen from Table 1, the input energy in the form of fossil fuel (natural gas) used for generation of one unit of power is 2.35 kWh (at full load). In actual practise the power generator is not expected to run at full load at all times. Average load on the power generator is expected to be about 75 Percent of the full load. Keeping this in mind and in order to determine GHG mitigation potential due to the proposed CDM project in a conservative manner the fossil fuel energy input for generation of one unit of power (one kWh of power) has been considered at 2.42 kWh. Accordingly emission of carbon dioxide for generation of one unit of power has been estimated to be 0.49 Kg[8]. Against this the carbon dioxide emission for generation of one unit of power in a conventional coal based power plant (sub-critical technology single reheating and 510 degree C temperature) is estimated to be 1.10 Kg (considering 33 percent net efficiency, carbon intensity of coal as 27.6 kg C/ GJ). It is important to note that in the process of transmission of power from the power plants to the premises of the user there will be transmission and distribution losses. Due to transmission and distribution losses the carbon dioxide emission for every unit of power (generated in a conventional coal based thermal power plant) delivered will be higher than 1.10 Kg. Further to this the thermal power plants in actual practise operates at the efficiency levels which is lower than the design levels.

The electricity grid of the western region is supplied with the power generated in a number of power plants. These power plants are based on different technologies / fuels and each one of them operates at different levels of efficiency. Based on the contribution of each of the power plants, the type of fuel used in such plants and actual efficiency of such power plants, the emission of carbon dioxide for every unit of power supplied to the grid will vary from time to time. More details regarding emission of carbon dioxide due to generation of power for supplying to the western grid are provided in subsequent sections.

Vapour Absorption Chillers

Panoli Intermediates uses chilled water for process cooling applications. Till recently the chilled water needed for the cooling application was produced using a heat pump based on vapour compression technology. With the establishment of captive power generation facilities as discussed in the above paragraphs, additional waste heat streams (exhaust of the engine and hot water used for cooling of the engine) became available. One of the ways to put the waste heat to gainful utilisation was to generate chilled water in a heat pump using the vapour absorption technology. However, this required that the existing chilled water generation facilities based on vapour compression technology be scrapped and new facilities based on vapour absorption technology be established. High capital cost of vapour absorption based system was acting as a barrier towards such an act. Realising that shifting from vapour compression technology to vapour absorption technology will lead to mitigation in the emission of GHG and some benefits will be available under CDM, Panoli Intermediates replaced the existing chilled water generation system with the energy efficient vapour absorption system.

Heat pumps transfer the heat from a colder location to the location at a relatively higher temperature. Heat pumps are commonly used for the cooling applications. Heat pumps are based on repetitive

[8] Energy input = 2.42 kWh of natural gas = 0.008715 GJ * Carbon intensity of natural Gas (15.3 Kg C / GJ) *44/12

condensation and evaporation cycle of a liquid (refrigerant) carried out in a controlled manner for generation of cooling effect at one end and the heating effect at the other end. The cooling in turn is used for cooling an enclosed space either for air conditioning or refrigeration. Vapour compression using compressors run by electrical motors is the predominantly used technology for condensing the vapours of the refrigerant in a refrigeration / air conditioning cycle.

One of the other technology options to generate cooling effect for refrigeration / air conditioning cycle is the vapour absorption cycle. In the vapour absorption cycle a low grade heat source is used as the external energy source for running the refrigeration cycle (against electrical energy used in case of vapour compression cycle). The selection of a technology for a given refrigeration / air conditioning application is governed by the initial capital cost, the operating cost and other external factors (like availability of power / low grade heat source). Out of these two technologies for refrigeration, vapour absorption technology is comparatively newer and is characterised by high initial capital cost. The capital cost of a vapour absorption system is significantly higher (about four to five times) when compared to the system based on vapour compression. The vapour absorption based systems are required to be customised to a large extent based on the quality, type and quantity of low grade heat source. Due to the need for customisation in case of vapour absorption based refrigeration systems and due to comparatively higher initial investment, the risks involved while adopting a vapour absorption based system are significantly higher.

Like in most parts of the world, vapour compression systems are predominantly used in India as well for refrigeration/ air conditioning and chilled water requirements. A comparatively lower initial cost, reliable and easy-to-use technology and availability in the wide range of sizes makes vapour compression based refrigeration systems a natural choice in most of the cases. Majority of chillers around the world also use vapour compression systems for cooling needs. Due to the widespread use, and hence standardization, of this technology, users can choose from a wide variety of sizes and manufacturers. The three most common types of compressors used in vapour compression chillers are centrifugal, reciprocating and screw compressors. Out of the three types of compressors the most commonly used the world over and in India is the reciprocating type, again primarily due to its lower capital cost and wide range of sizes.

As stipulated before the refrigeration systems are based on the physical property of a liquid wherein the liquid absorbs heat from its surrounding while boiling (latent heat of vaporization). Conversely, it gives up heat when it condenses. In a commercial refrigeration system the boiling of a liquid (refrigerant) and its condensing is carried out in a manner that the heat is pumped from an area required to be cooled to an area at comparatively higher temperature.

In vapour compression chillers, the refrigerant evaporates at low pressure, creating the cooling effect. The vapour is compressed to a high pressure and gives up all of the heat collected during evaporation while condensing. When compared to the conventional vapour compression systems, in vapour absorption chillers, the condenser and evaporator are exactly the same, while an absorber and generator replace the compressor in raising the refrigerant pressure.

Vapour compression chiller machines use electricity for running of the refrigeration cycle, wherein compressors are used to convert refrigerant vapours to liquid and dissipate the heat gained by the vapours in the earlier operation of the process. Further to this, vapour compression refrigeration technology use CFC (Chloro Fluoro Carbons) based refrigerant (Freon R-11, R-12, R-123 etc.) as refrigerants. CFCs cause harm to the environment, owing to ozone layer depletion.

The chillers based on vapour absorption technology use heat, instead of mechanical energy, to provide cooling. The refrigerant vapour from the evaporator is absorbed by a solution mixture in the absorber. This solution is then pumped to the generator where the refrigerant is re-vaporized using a waste heat source. The refrigerant-depleted solution is then returned to the absorber. The rich refrigerant solution will then pass through the evaporator where refrigerants evaporate by exchanging heat, return chilled water and refrigerate vapour goes to absorber.

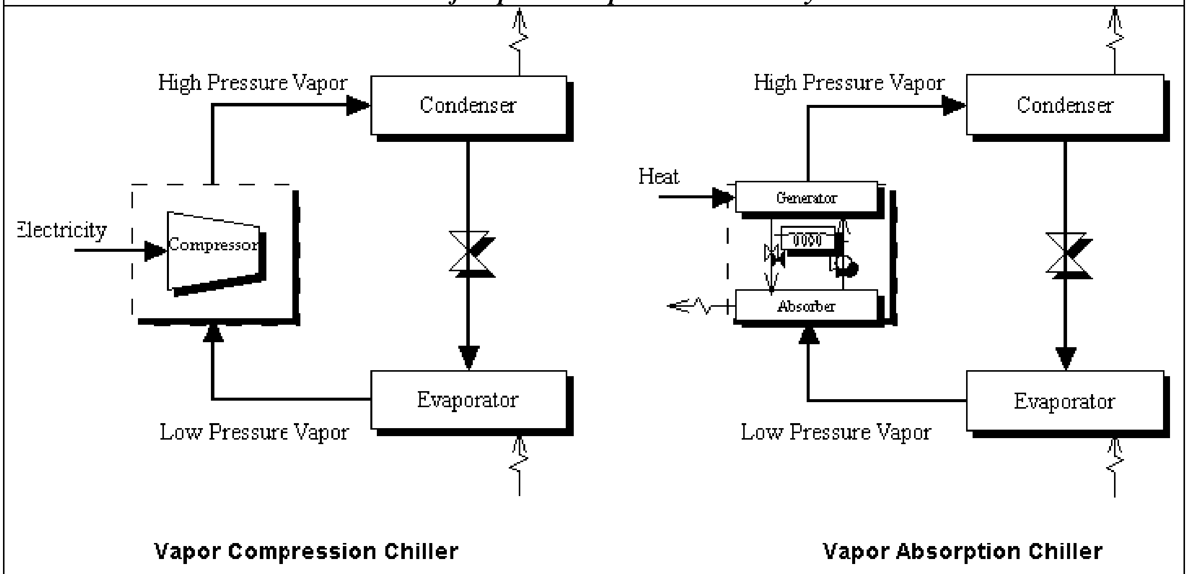
Vapour absorption chillers use strong affinity for each other in some pairs of chemicals. This affinity allows rapid dissolution in one another and is the critical factor in absorption cooling. Lithium bromide-water (Li-Br) and ammonia-water are the two most widely used chemical pairs in absorption cooling. In water-ammonia systems, ammonia (refrigerant) is drawn from a conventional evaporator into the absorber that contains water. This weak solution is pumped into a generator where high-pressure ammonia is released to a conventional condenser by applying heat. Li-Br (in solution) and water (refrigerant) systems also work in a similar fashion.

Absorption plants are divided into different categories based on the type of heat supply, the number of effects and the chemicals used. Heat may be supplied in the form of hot water, steam, direct firing or direct exhaust from an engine or turbine. To improve efficiency, some of the heat may be recycled internally by dividing the generator into high and low temperature sections. The refrigerant vapour from the high temperature generator gives up heat in the low temperature/pressure generator. This double effect arrangement reduces the heat requirement to half for the same cooling effect. High temperatures are required for this arrangement (140°C or above).

As water is the refrigerant in the Li-Br-H2O combination, the attainable cooling effect is restricted to 5°C and above. On the other hand, ammonia chillers can maintain +5°C to –40°C using normal cooling water as a coolant. Better cooling can be achieved using chilled coolant water.

The working of a vapour absorption based chilling system as against that based on vapour compression system is depicted schematically in the following figure:

Figure 1
Schematic of Vapour Compression Chiller System



Like other industries in the country, Panoli Intermediates was using a vapour compression refrigeration system for generating chilled water for process cooling needs. The system which was being used by it used anhydrous ammonia as the refrigerant. Two chillers were being used by it. The two chillers were connected to a common chilled water circulation system. Specifications of the chillers based on vapour compression technology which was being used by it are as detailed in Table 2 as follows:

Table 2
Specifications of Old Chilled Water System

	Chilled water System I	Chilled water System II
Make	Kirloskar	Kirloskar
Serial Number	KC 6	KC 3
Refrigeration Capacity	52.2 Tons of ice equivalent	26.1 Tons of ice equivalent
Compressor motor rating	111.7 kW	58.2 kW
Chilled water temperature	2 to 5 degree C	2 to 5 degree C
Number of compressors	One	One
Type of compressor	Reciprocating	Reciprocating

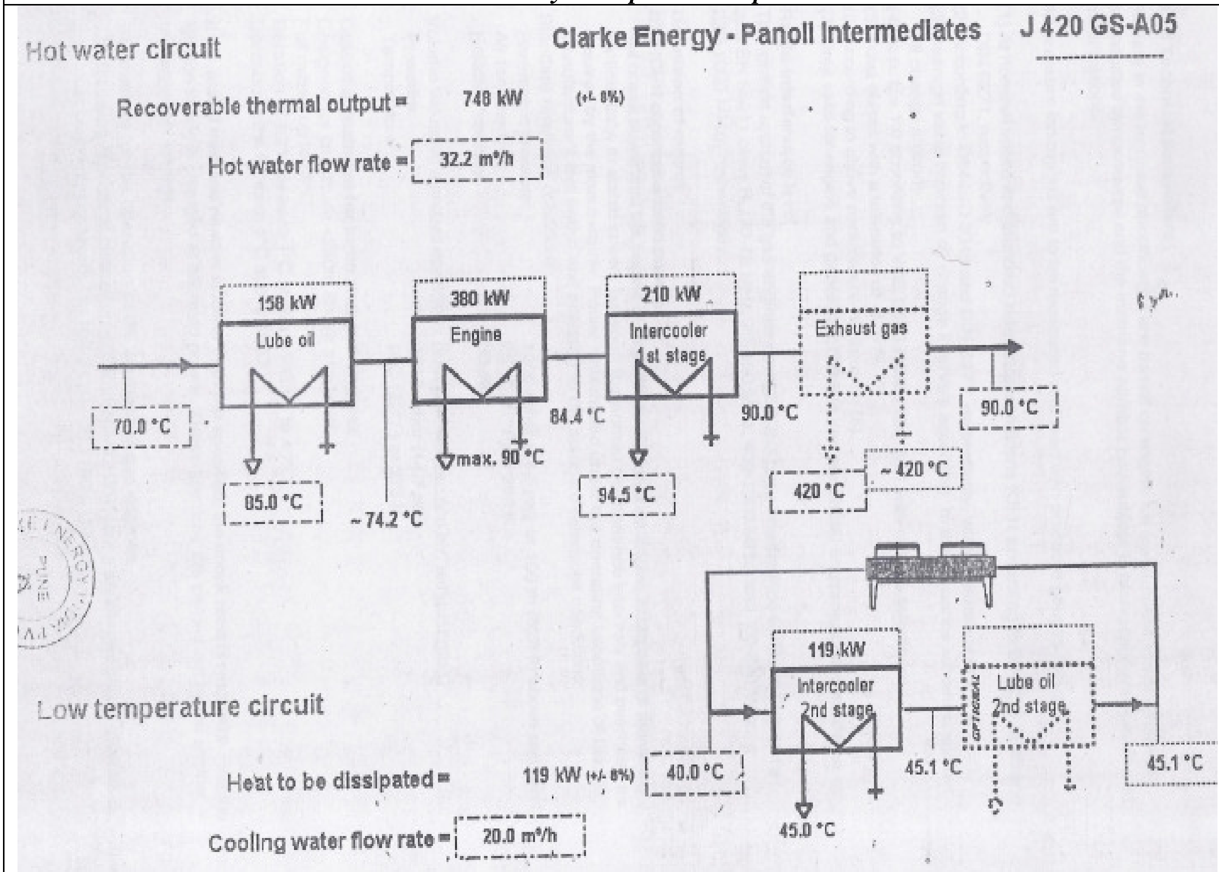
Specifications of Chilled water circulation and cooling tower system

Chilled water circulation pump rating	20 HP X 2
Chilled water flow rate	70 Cu meter / hr.
Capacity of the cooling tower	55 TR
Rating of cooling tower pump	12.5 HP
Flow rate of cooling water	40 Cu Meter
Heat of cooling water pump	30 Meter

For generation of chilled water, Panoli Intermediates has installed environment friendly Vapour Absorption Refrigeration (VAR) system in place of Vapour Compression Refrigeration (VCR) machine. The aggregate capacity of the earlier vapour compression based system was 78.3 TR. The earlier system comprised of two compressors of 52.2 and 26.1 TR capacities respectively. Against this the capacity of the vapour absorption based system installed now is a single unit of 280 TR. The increased capacity of the chillers will take care of the expansion of production capacity for chemicals. For circulation of the chilled water the old circulation system is being used.

Waste heat contained in the exhaust of the engine and the cooling water of the engine of the captive gas based power generator is used as a heat source for operation of the vapour absorption chilling system. Details of the recoverable waste heat from the exhaust, hot water and lubricating oil have already been provided in Table 1. Overall heat balance of the system is given in Figure 2 below:

Figure 2
Waste Heat Recovery in Vapour Absorption Chillers



Technical Specifications of the Vapour Absorption Chillers are provided in Table 3 below:

Table 3
Technical Specifications and Operating Parameters of Vapour Absorption Chillers

		Unit	Value
A.	**Chilled Water Circuit**		
1	Capacity	TR	280
2	Chilled water flow	Cum / hr.	169
3	Chilled water temperature		
	Inlet	Deg C	10
	Outlet	Deg C	5
B	**Cooling / Hot Water Circuit**		
1	Cooling / Hot water flow rate	Cum / hr.	280
2	Cooling water temperature		
	Inlet	Deg C	32.0
	Outlet	Deg C	37.7
C	**Heat input circuits**		
C1	**Engine Exhaust**		
1	Flue gas flow	Kg / hr.	7627
2	Flue gas inlet temperature	Deg C	420
3	Flue gas outlet temperature	Deg C	180
4	Pressure drop in VAM	Mm WC	660
C2	**Engine hot jacket water**		
1	Hot water flow	Cum / hr.	32.2
2	Hot water inlet temperature	Deg C	90
3	Hot water outlet temperature	Deg C	80
D	**Electrical circuit**		
1	Power supply		3 ph, 415V, 50 Hz
2	Control supply		110 V & 230 V, 1 ph
3	Absorbent pump rating	kW	3.7+3
4	Refrigerant pump rating	kW	0.3
5	Vacuum pump rating	kW	0.75
6	Electrical load	KVA	11.4

As can be seen the waste heat from the water of the engine jacket and the exhaust gases from the engine is being utilised for the operation of the vapour compression based chillers. The connected load of the system is only 11.4 KVA. Based on the ratings of the pumps in the system the power consumption is estimated to be about 7 kWh (apart from power consumption for circulation of the chilled water) for generation of 280 TR of chilling. Against this specific power consumption in vapour compression technology based chillers is much more. Shifting from vapour compression technology to vapour absorption technology for generation of chilled water leads to reduction in power consumption, which in turn leads to reduction in the emission of carbon dioxide (which is a GHG) due to power generation. This intervention leads to reduction in the emission of GHG due to avoidance of the need to generate power.

Installing VAR chillers based on the waste heat from the engine exhaust is not a common practice due to following reasons:

- Perceived loss of reliability
- Prone to corrosion & leakage of Lithium Bromide (Li-Br) after few (4-5 years) years of operation
- Higher capital required.

Appendix – II

List of Stake Holders who participated in the Stakeholder Consultation Meeting

Proceedings

Meeting with Stake Holders for Clean Development Mechanism (CDM) Project for Utilisation of Waste Heat for Chilled Water & Fuel Switch to Natural Gas (NG) for Power Generation at Panoli Intermediates India Private Limited, Jhagadia, Gujarat

Venue:
Panoli Intermediates India Private Limited's process plant at Jhagadia, Dist. Bharuch, Gujarat

Date:
15th January 2007

Agenda:
- To discuss general environmental and social concerns
- To discuss initiatives being undertaken by Panoli Intermediates to address the environmental and community / employees well being
- To discuss proposed CDM project to address the issue of climate change / global warming

Meeting Schedule:
- Welcome and Introduction – by Panoli Intermediates
- Introduction to CSR initiatives – by Deloitte
- Introduction to climate change / CDM - by Deloitte
- Introduction to the Technology and Technology Interventions being done at Panoli Intermediates – by Panoli Intermediates
- Introduction to the proposed CDM project - by Deloitte
- Comments / suggestions / issues
- Response to questions / suggestions / issues

In Attendance:

Name	Organisation	Address	Phone Number	Signature
G. I. Shah	GIDC	GIDC office Jhagadia	226009	[signature]
Kanaiya Patel	Aarti Inds Ltd	GIDC Jhagadia	9377545333	[signature]
Kamli H. Patel	Chemie organic chemicals Pvt. Ltd.	758, GIDC Jhagadia	9824095673	[signature]

Proceedings of the Meeting with Stake Holders for Clean Development Mechanism (CDM)Project for Utilisation of Waste Heat for Chilled Water & Fuel Switch to Natural Gas (NG) for Power Generation at Panoli Intermediates

Appendix – II (Contd.)

List of Stake Holders who participated in the Stakeholder Consultation Meeting

Name	Organisation	Address	Phone Number	Signature
[illegible]	Villager from Neighbour village (Fulwadi)	[illegible] (Fulwadi)	226160	[illegible]
[illegible]	"	[illegible]	9426871191	[illegible]
S.M. Patil	P.I.I.P.L Jhagadia	P.I.I.P.L [illegible]	98243 68164	[illegible]
K.P. Prajapati	PIIPL Jhagadia	PIPL, Jhagadia	98251 89695	Prajapati
R.K. Navalo	KLJ	Jhagadia	98250 42991	[illegible]
Pathik Shukla	UPL	Jhagadia	98243 96318	[illegible]
Dr. Rajesh [illegible]	[illegible]	2, [illegible] Avenue GIDC Ankleshwar	255617 (02646) 98252[illegible]	[illegible]
Kamlesh Panchal	Steel fab Equipment	Plot No 5713 GIDC Ankleshwar	9824183609 02646-225273 -329968	Kamlesh
Alpesh Patel	Gujarat Marketing	A/B-3 Sardar Patel complex GIDC Ankleshwar	9825027962 (02646) 224001	[illegible]
K.T. Thakkar	PIIPL Jhagadia	778, GIDC, Jhagadia	093774 25310	[illegible]
R.V. Dabgar	Baroda office DIOL/[illegible]	Baroda 20/21 [illegible] Soc. Baroda	9328323173	[illegible]
Dinesh Aggarwal	Deloitte N. Delhi	N. Delhi	99100 45759	[illegible]

Proceedings of the Meeting with Stake Holders for Clean Development Mechanism (CDM) Project for Utilisation of Waste Heat for Chilled Water & Fuel Switch to Natural Gas (NG) for Power Generation at Panoli Intermediates

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