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:

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Enhanced Waste Heat Recovery in Sulphuric Acid Plant for Incremental Power Generation and Thermal Applications

Version 03 dated 14 February 2008

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

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Aarti Industries Limited (AIL) is one of the leading producers of basic bulk chemicals, dye intermediates, agrochemicals & specialty chemicals in the country. Like other producers of dye intermediates, sulphonation is one of the unit operations frequently used by it. Earlier the sulphuric acid (including oleum, liquid sulfur trioxide) required for the sulphonation reaction was being procured from merchant suppliers. Aarti Industries Limited decided to produce the required sulphuric acid in captive facilities using elemental sulfur as the raw material. It has already commissioned the sulphuric acid plant. The process technology being used for the purpose is Double Contact Double Absorption (DCDA) process. DCDA is considered to be the most efficient process technology (leading to practically zero atmospheric emission of sulfur bearing gases) for producing sulphuric acid.

In the process of production of sulphuric acid (including oleum and liquid sulfur trioxide), using elemental sulfur as the raw material, hot gas and hot acid streams gets generated during various stages of the process. As a part of the process, traditionally the heat contained in hot gas streams is recovered in the form of steam in the waste heat boiler. The waste heat contained in the hot acid streams being low grade heat (heat at lower temperatures) is not traditionally recovered in the sulphuric acid plants.

The extent of recovery of heat from the hot gas streams, and hence the quantum of steam generated depends on the technical features of the process plant, the capital cost involved in the process of heat recovery and the opportunity to use the recovered heat. The steam generated in the waste heat boiler is passed through the turbo generators being operated in part extraction mode. This leads to generation of power and process steam. The process steam is used for melting sulfur and the power generated is used for captive power requirements. The present day technology[1] for sulphuric acid production and waste heat recovery contemplates generation of about 1.1 ton of steam for every ton of sulphuric acid produced (on 98% concentration basis).). The technology suppliers capital equipment suppliers and the consultants for the sulphuric acid plant of Aarti Industries Limited suggested this technology for the process and waste heat recovery for the proposed plant.

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[1] UNEP & UNIDO Technical Report N°26 – Part 1 – The Fertilizer Industry's Manufacturing Processes and Environmental Issues; Shreve's Chemical Process Industries, McGraw Hill International Editions, ISBN 0-07-066167-7; Textile Industry report prepared by GTZ and Bureau of Energy Efficiency, Project ID:85, Survey Year 2006

It was realized that it is possible to increase the level of waste heat recovery by doing some technology innovation and installing additional waste heat recovery equipment. However, such measures required significant additional capital investment. Such additional capital investment carried additional technology and investment risk in the absence of demonstration of such technology in the country in the past. Realizing that additional waste heat recovery will lead to mitigation of Green House Gases (GHG) and that some benefits will be available under Clean Development Mechanism (CDM) it was decided that such additional heat recovery be carried out in the sulphuric acid plant even if it means additional capital investment and additional investment risk.

Thus, under the proposed CDM project the extent of recovery of heat at different stages of the process has been increased. Further as a part of the CDM project low grade heat contained in the hot acid streams will also be partially recovered. The extent of heat recovery will be over and above what is being done in the industry under the present conditions in the country. Enhancement in the heat recovery has been accomplished by doing technical intervention and capital investment for introducing additional heat recovery equipments at different stages of the process. The enhanced heat recovery will lead to increase in generation of steam in the waste heat boiler and generation of hot water. Increased generation of steam in turn will lead to increase in generation of power and process steam for the same quantum of acid produced. The additional power and process steam thus produced will be used for captive purpose. The proposed interventions will also lead to recovery of low grade waste heat in the form of hot water, which will be used to meet the process requirements. The use of hot water in some of the processes will reduce the use of corresponding needs of the process steam / fuel in the heating applications.

Aarti Industries Limited carries out captive power generation in waste heat based turbo generators (using steam generated in heat recovery boilers of sulphuric acid plant) and supply of power from the state power grid and captive generation in generators using fuel oil. The need for process steam is met by way of steam generation in captive coal based process steam boilers.

Enhanced power generation due to enhanced heat recovery will lead to reduction in the need to generate power using fossil fuels in the captive power generators to the extent of additional generation of power. Additional process steam generation due to enhanced heat recovery will lead to corresponding reduction in the need to generate process steam using fossil fuels. The recovery of low grade heat in the form of hot water will reduce the need of fossil fuel to the extent of waste heat recovery.

The reduction in the use of fossil fuels for meeting the electric power needs, need of the hot water and the need of the process steam will lead to the mitigation in the emission of carbon dioxide which is a Green House Gas (GHG). The recovery of waste heat will also lead to reduction in the emission of methane and nitrous oxide associated with the use of fossil fuels. However, for the purpose of the proposed CDM project only reduction in the emission of carbon dioxide has been considered while computing the GHG emission reduction potential.

A.3. Project participants:

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The proposed CDM project has been implemented and owned by Aarti Industries Limited (Aarti Industries). Aarti Industries is a Non - Annex B (of Kyoto Protocol) country entity having its registered office and works in India. Aarti Industries Limited will be the beneficiary of the proposed 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)
Government of India (host party)	Aarti Industries Limited	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:

A brief of the technical description of the proposed small scale CDM project activity is provided in the following paragraphs. A detailed description of the same is provided as Annex 3.

The process of production of sulphuric acid using elemental sulfur leads to generation of heat during different stages of the process. In the overall process of production of sulphuric acid from elemental sulfur, heat is generated at following three stages:

- Combustion of sulfur to produce sulfur dioxide gas in the sulfur burner
- Conversion of sulfur dioxide gas to sulfur trioxide gas in the multi stage converter reactor
- Absorption of sulfur trioxide gas in water to produce sulfuric acid in absorption columns (this is a low grade heat, wherein the temperatures are low)

The heat generated at different stages of the process for producing sulphuric acid from sulfur is recovered and put to use. The extent of recovery of the waste heat varies from plant to plant, due to the following reasons:

- Process technology used
- Size of the plant
- Cost of heat recovery and the overall cost economics
- Availability of opportunity to put the recovered energy to use

Present Day Waste Heat Recovery Technology - Business as Usual (Baseline) Scenario

Over a period of time partly due to increase in the size of the sulphuric acid plants and partly due to the opportunity to put the waste heat to gainful use, it was realized that apart from the waste heat recovered in the stage of sulfur burner there is an opportunity to recover heat from the stage of conversion of sulfur dioxide to sulfur trioxide. Considering that this will lead to considerable increase in the generation of power, the present day sulphuric acid plants have provision for recovery of heat from different stages of the converter. In the present day sulphuric acid plants the steam is generated at higher pressure to optimize generation of power.

The present day plants optimally recover the heat generated due to conversion of sulfur dioxide to sulfur trioxide in the converter. In such plants the steam being generated is passed through a turbo generator. The turbo generator is being operated in part extraction mode to generate process steam required to melt sulfur. The extent of heat recovered from different stages of the converter is determined by the quantum of heat generated; need to maintain temperatures at different stages of the converter and the possibility of gainfully utilizing the waste heat being generated.

The waste heat generated at first stage of the converter is recovered in the steam super heater, and is utilized to super heat the steam generated in the waste heat boiler. This enables feeding of superheated steam in the turbo generator. The extent of heat recovery in stage I of the converter is almost complete (of the order of 80 percent). The waste heat generated in stage II and III of the converter is recovered in two separate economizers. This leads to increase in the boiler feed water temperature leading to increase in the throughput of steam. The temperature of the air used for combustion of sulfur is increased by preheating and drying the air leading to increase in the temperature of gases at the outlet of the sulfur burner. This also enables higher heat recovery from the stage of sulfur burner (heat recovery increases from 60 percent to 80 percent). The extent of heat recovery from stage II and III of the converter is about 80 percent.

Considering heat recovery of 80 percent from burner gases, 80 percent from stage I of the converter and 80 percent each from stage II & III of the converter, the extent of heat recovery in present day sulphuric acid plants is estimated to be about 778 thousand K cal per ton of acid produced. This heat leads to generation of about 1.1 ton of steam at 40 bar pressure and 420 deg C. This steam is sent through a turbo generator operated in part extraction mode. About 200 kg of steam is extracted at 7.5 bar pressure to meet the needs for melting the sulfur. Balance steam is condensed in the turbo generator. This leads to generation of about 161 kWh per ton of sulphuric acid produced. Considering the auxiliary power consumption of 8 percent in the power plant the net out put of power in the present day sulphuric acid plant is estimated to be about 148 kWh per ton of sulphuric acid produced. It is important to note that depending upon the opportunity to use the process steam or electrical power in-house, the output of process steam can be increased at the cost of power output.

The present day process for production of sulphuric acid using elemental sulfur as the starting material as described in the publicly available chemical process technology literature also states the net credit of process steam at 2000 pounds for one ton of acid produced (907 kg. per ton of acid produced). Against this the present day plants in India generates about 900 kg of net (after accounting for steam used for sulfur melting) steam for every ton of acid produced. Thus, the present day process technology being used in the country is of world class as far as waste heat recovery is concerned.

The Proposed Enhanced Heat Recovery - CDM Project

Under the proposed CDM project Aarti Industries Limited, at its sulphuric acid plant is recovering additional waste heat generated at different stages of the overall process. The hot acid is being used for preheating the air used for combustion of sulfur in the sulfur burner and for preheating the boiler feed water. Some of the waste heat in the hot acid stream is being used for producing hot water. The hot acid is being used for drying the air used for combustion and in the process; heat contained in the hot acid stream will partly get recovered in the combustion air. It is expected that up to 80 percent of the total heat generated at stage IV of the converter and 30 percent of the heat generated due to absorption of sulfur trioxide gas will get recovered. Apart from this it is proposed that the low grade heat generated due to dilution of acid (from oleum to sulphuric acid) be recovered in the form of hot water. The hot water thus generated will either be used as boiler feed water or may be used for process requirements.

This additional heat recovery is over and above the level of heat recovery with the original plant design. The enhanced heat recovery has led to increase in steam generation and the consequent higher power generation. It has also led to generation of hot water which is being used for process requirements.

With the implementation of the proposed CDM project the recovery of high grade waste heat has increased to about 830 thousand K cal per ton of acid produced from baseline figure of 778 thousand K cal per ton. In addition about 97 thousand K Cal of low grade heat per ton of acid is being recovered. The recovered high grade heat is leading to generation of 1.24 tons of high pressure steam (considering feed water temperature of 110 deg C) at 45 bar pressure and temperature of 420 deg C. Apart from this about 1390 liters of hot water per ton of acid produced ,is getting generated, due to recovery of low grade heat. Out of the total quantity of hot water generated about 1240 liters is used as boiler feed water and the balance is used for other process needs.

The steam is passed through the turbo generator operated in part extraction mode. Part of the high pressure superheated steam generated is used directly for process heating requirements of other chemical production units and the balance high pressure superheated steam is passed through the turbo generator. In order to optimally utilize the recovered heat to the extent possible process steam is extracted from the turbine. Part of the process steam extracted from the turbine is used for sulfur melting and the balance is utilized for process requirements of other units. The hot water generated can either be used as boiler feed water or is used for process requirements. Thus with implementation of the proposed CDM projects there are four different energy output streams as follows:

- High pressure superheated steam for process
- Medium pressure saturated process steam for process
- Electrical power
- Hot water

The extent of generation of these output energy streams varies from time to time, as it depends upon the operational needs. However, the planned generation of different energy output streams after implementation of the proposed CDM project is as follows:

Output stream	**Specifications**	**Quantity**	**Units**
High pressure superheated steam for process use	Superheated steam at 40 bar (g) pressure and 420 Degree C temperature	100	Kg / Ton of acid
Medium pressure saturated steam for process use**	Saturated steam at 7.5 bar (g) pressure	110	Kg / Ton of acid
Electric power*	Units of electricity	151	kWh / Ton of acid
Hot water***	Hot water at 110 Degree C temperature	150	Kg / Ton of acid

* Net generation after accounting for auxiliary power consumption for the power plant
** Net of about 200 Kg of steam utilized for sulfur melting
*** Net after accounting for use of hot water as boiler feed water

Against this in the baseline scenario (with the original design of the plant without additional waste heat recovery equipment) level of recovery of waste heat leads to generation of 148 kWh of power (power net of auxiliary consumption in the power plant per ton of sulphuric acid) and 200 kg of medium pressure saturated steam (which is used for sulfur melting and no process steam is supplied for process units) for every ton of acid produced.

The CDM project activity pertains to specific technical interventions and capital investment for increasing the recovery of waste heat generated in the process of production of sulphuric acid using elemental sulfur as the feed stock. The recovery of additional waste heat has led to generation of additional electrical power / process steam / hot water for the same quantity of sulfuric acid produced. In the absence of the CDM project activity this additional quantity of electrical power / process steam / hot water would have been generated using the existing facilities which are based on fossil fuels.

The recovery of waste heat and its gainful utilization in the baseline scenario also leads to avoidance of use of fossil fuels for generation of power and process steam. Upon implementation of the CDM project the extent of recovery of waste heat and hence avoidance of use of fossil fuels has increased. Thus, the generation of additional power / process steam / hot water using waste heat leads to mitigation of the use of fossil fuel and the consequent emission of Carbon dioxide which is a GHG, when compared to the baseline practice. The avoidance of use of fossil fuels for energy needs also leads to mitigation in the emission of other green house gases like methane and nitrous oxide. However, in order to arrive at the GHG mitigation potential in a conservative manner GHG other than carbon dioxide have not been considered.

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

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India

A.4.1.1. Host Party(ies):

>>
Aarti Industries Limited
India

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

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Gujarat State

A.4.1.3. City/Town/Community etc:

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Plot No. 801, 801/23, GIDC Estate Phase III, Vapi - 396195.

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

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Proposed CDM Project Activity site at Vapi, Gujarat

Diagram showing the location of the proposed CDM project activity at Vapi, District, Gujarat

The proposed CDM project activity is located within the existing sulphuric acid plant of Aarti Industries Limited located at Plot No. 801, 801/23, GIDC Estate Phase III, Vapi, Gujarat State, India located at 20^o 24' N latitude and 72^o54' E longitude. The nearest railway station to the project site is Vapi railway station and the nearest airport to the project site is Mumbai airport.

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

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The proposed small scale CDM project activity falls under Type III, Sectoral Scope 4 for Manufacturing Industries.

The proposed small scale CDM project activity is related to enhanced recovery of waste heat for power generation, steam and hot water for process heating applications in an industrial facility. The additional power generated displaces captive electricity generation from fossil fuels. Additional steam / hot water generation replaces the steam and hot water generated in fossil fuel based facilities.

The methodology used is the approved methodology AMS IIIQ, Version 1, applied to waste gas based energy systems. Extent of present level of waste heat recovery (given the present level of technology, present practices and economic considerations) has been considered as business as usual (baseline) scenario. The GHG mitigation due to the incremental recovery of waste heat (due to technical interventions and fresh capital investment) is the mitigation potential of the CDM project.

The proposed CDM project pertains to the category of projects that utilize waste heat as an energy source for generation of power and elemental processes. The elemental processes are defined in accordance with Approved Small Scale Baseline and monitoring methodology AMS IIIQ, Version 1.

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

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The estimated quantum of GHG emission reduction over the crediting period is given below. The details of computations are presented in section B.6.3 of this document.

Years	Estimation of annual emission reductions in tonnes of CO2 e
May 2008 – April 2009	10702
May 2009 – April 2010	10702
May 2010 – April 2011	10702
May 2011 – April 2012	10702
May 2012 – April 2013	10702
May 2013 – April 2014	10702
May 2014 – April 2015	10702
May 2015 – April 2016	10702
May 2016 – April 2017	10702
May 2017 – April 2018	10702
Total Estimated Emission Reductions (tonnes of CO2e)	107020
Total Number of crediting years	**10 years (fixed)**
Annual Average of the estimated emission reductions over the fixed crediting period of ten years (tonnes of CO2e)	**10702**

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

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The capital investment required for carrying out the technical intervention and for installing the additional capital equipment for enhanced heat recovery has been done by Aarti Industries Limited using its own resources. The technology development and detailed engineering for carrying out enhanced heat recovery for waste heat in the sulphuric acid plant has been carried out by Aarti Industries Limited using its in house expertise and by hiring the services of expert technical consultants from within the country. There is no external funding involved in the proposed CDM project. There is no public funding for carrying out the proposed CDM project activity.

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

According to paragraph 2 of Appendix C to the Simplified Modalities and Procedures for Small-Scale CDM project activities (FCCC/CP/2002/7/Add.3), a small-scale project is considered a debundled component of a large project activity if there is a registered small-scale activity or an application to register another small-scale activity:

• With the same project participants
• In the same project category and technology; and

• Registered within the previous two years; and
• Whose project boundary is within 1km of the project boundary of the proposed small scale activity

There is no other CDM project activity either registered or proposed by Aarti Industries Limited, either at the location of this proposed CDM project activity or any other location. The proposed CDM project activity is not a de-bundled component of any larger CDM project activity.

SECTION B. Application of a baseline and monitoring methodology

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

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Reference: Approved Baseline and Monitoring Small Scale Methodology AMS III Q, Version 1
Title of Methodology: Waste Gas Based Energy Systems

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

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Approved Small Scale Baseline and Monitoring CDM methodology AMS III Q is applicable for the project activities that utilize waste gas and or waste heat as an energy source for

- Co-generation
- Generation of electricity or
- Direct use as process heat or
- For generation of heat in elemental process (e.g. steam, hot water, hot oil, hot air)

The category is applicable under the following conditions as applicable to the proposed CDM project activity:

• The energy produced with the recovered waste gas/heat or waste pressure should be measurable.
• Energy generated in the project activity shall be used within the facility where the waste gas/heat or waste pressure is produced. An exception is made for the electricity generated by the project activity which may be exported to the grid.
• The waste gas/heat or waste pressure utilized in the project activity would have been flared or released into the atmosphere in the absence of the project activity. This shall be proven by one of the following options:
o By **direct measurements** of energy content and amount of the waste gas/heat or waste pressure for at least *three years* prior to the start of the project activity. Since the proposed project activity is a new activity, three years data prior to the start of the project activity is not available.
o **Energy balance** of relevant sections of the plant to prove that the waste gas/heat or waste pressure was not a source of energy before the implementation of the project activity. For the energy balance the representative process parameters are required. The energy balance must demonstrate that the waste gas/heat or waste pressure was not used and also provide conservative estimations of the energy content and amount of waste gas/heat or waste pressure released.
o **Energy bills** (electricity, fossil fuel) to demonstrate that all the energy required for the process (e.g. based on specific energy consumption specified by the manufacturer) has been procured commercially. Project participants are required to demonstrate through the financial documents (e.g. balance sheets, profit and loss statement) that no energy was generated by

waste gas/heat or waste pressure and sold to other facilities and/or the grid. The bills and financial statements should be audited by competent authorities.
o **Process plant** manufacturer's original specification/information, schemes and diagrams from the construction of the facility could be used as an estimate of quantity and energy content of waste gas/heat produced for rated plant capacity per unit of product produced.

For the purpose of this category, waste gas/heat/pressure is defined as: by-product gas/heat or pressure of machines and technical processes for which no useful application is found in the absence of the project activity and for which it can be demonstrated that it has not been used prior to, and would not be used in absence of the CDM project activity (e.g. because of low pressure, heating value or quantity available). In the project scenario, this waste gas/heat/pressure is recovered and conditioned for use.

The small scale CDM project activity pertains to generation of electricity and process steam / hot water from waste heat. As is therefore evident, the CDM project meets all the applicability criteria set out under the selected small scale methodology and hence the project category is applicable to the project.

Thus, the approved methodology AMS IIIQ can be applied for the proposed CDM project activity.

B.3. Description of the project boundary:

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In accordance with the approved baseline and monitoring methodology AMS IIIQ, the physical, geographical site of the facility where the waste gas / heat is produced and transformed into useful energy delineates the project boundary.

Accordingly the project boundary for the proposed CDM project will be the physical boundary of the process plant complex containing the sulphuric acid plant. The project is being implemented within the physical boundary of the existing process plant complex. The benefits of implementation of the proposed project by way of enhanced power generation / process steam generation / hot water generation without any emission of GHG will take place within the physical boundary of the existing process plant complex.

Other than one time capital investment, the proposed project does not use additional resources for increasing the recovery of waste heat thus there is no leakage of GHG emission outside the physical boundary of the process plant complex. There may be a minor increase in the consumables (like lubricating oil) of the turbo generators. Based on the consideration that such consumables would have been consumed in the baseline scenario as well (in captive Fuel oil based power generation), the impact on GHG emission due to consumables has not been considered.

B.4. Description of baseline and its development:

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The baseline considerations for the proposed CDM project activity entails to the extent of waste heat recovery in sulphuric acid plants in India, given the present state of technology, prevalent practices and the economic conditions. While determining the baseline for the proposed CDM project activity the state of sulphuric acid production technology presently being used in the country and the consequent extent of waste heat recovery in such sulphuric acid plants has been considered.

It has been considered that the additional waste heat based power/ elemental processes would have been generated in the fossil fuel based generators.

As explained under section A.4 (technical description of the small scale project activity) the extent of heat recovery in present day sulphuric acid plants is about 778 thousand K cal per ton of acid produced. The present practice in the sulphuric acid plants in the country is to generate high pressure (from 40 to 45 bar pressure) steam and use of the steam for power generation (in a steam turbine). As per the prevailing practice the steam turbine is operated in part extraction mode to meet the needs of the process steam for melting the sulfur. The recovered heat of about 778 K cal per ton of acid produced leads to generation of about 1.1 ton of steam at 40 bar (g) pressure and 420 deg C. This is in line with the standard sulphuric acid process technology world over.

This steam is sent through a turbo generator operated in part extraction mode. About 200 kg of steam is extracted at 7.5 bar pressure to meet the needs for melting the sulfur. Balance steam is condensed in the turbo generator leading to generation of 161 kWh of power per ton of sulphuric acid produced. Considering the auxiliary power consumption of 8 percent in the power plant the net out put of power in the present day sulphuric acid plant is estimated to be about 148 kWh per ton of sulphuric acid produced.

The present day process for production of sulphuric acid using elemental sulfur as the starting material as described in the publicly available chemical process technology literature also states the net credit of process steam at 2000 pounds for one ton of acid produced (907 kg. of steam per ton of acid produced). Against this the technology being used by the present day technology plants in India generates about 900 kg of net steam (after accounting for steam used for sulfur melting) for every ton of acid produced. Thus the present day process technology being used in the country is of world class as far as heat recovery is concerned. The present level of waste heat recovery and the consequent power generation have been considered as the baseline for the proposed CDM project activity.

The proposed CDM project activity involves specific technical interventions and capital investment for increasing the recovery of waste heat generated in the process of production of sulphuric acid using elemental sulfur as the feed stock. The recovery of additional waste heat leads to generation of additional electrical power / process steam / hot water for the same quantity of sulfuric acid produced. In the absence of the proposed CDM project activity this additional quantity of electrical power / process steam / hot water would have been generated using the existing facilities which are based on fossil fuels. Thus, the present day practice regarding waste heat recovery in a sulphuric acid plant has been considered as the baseline.

Computation of the emissions in the baseline as provided in subsequent sections of the PDD has been carried out as per the procedure provided in paragraphs 6 to 13 of AMS IC version 12.

As an introduction of element of conservativeness, this category requires that baseline emissions should be capped irrespective of planned / unplanned or actual increase in output of plant, change in operational parameters etc. Capping of the baseline emissions has been carried out based on the provisions in AMS IIIQ version 1.

Approved methodology AMS III Q specifies that the emission factor be calculated as per provisions in approved methodology AMS I C. AMS I C requires that the emission factor be computed based on the efficiency of the generation system and the emission factor of the fuel. Further, AMS IC specifies that the emission factor be determined in accordance with the provisions in AMS ID.

Paragraph 9 of AMS I D has the following provision for determination of the emission coefficient (measured in kg CO_2eq/kWh):
a) A combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) according to the procedures prescribed in the approved methodology ACM0002. Any of the four procedures to calculate the operating margin can be chosen, but the restrictions to use the Simple OM and the Average OM calculations must be considered.

OR

b) The weighted average emissions (in kg CO_2e/kWh) of the current generation mix. The data of the year in which project generation occurs must be used.

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', Version 3.0, December 2007. 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 2006-07 (April 2006 to March 2007) (adjusted for inter-regional and cross-country electricity transfers) is as follows:

Weighted Average	0.86	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	0.59	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	0.79	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.

Since the additional waste heat based power/ elemental processes which will be generated would have been generated in the fossil fuel based plants supplying power to the state power distribution grid, the weighted average emission factor of 0.86 tCO2/ MWh has been considered for the replacement of the western grid power by the waste heat based power.

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:

Under the proposed CDM project activity the extent of waste heat recovery in the sulphuric acid plant and the consequent power / process steam / hot water generation has been increased by carrying out technical interventions and additional capital investment. The generation of additional electricity / process steam / hot water from waste heat leads to reduction in the electricity generation in the fossil fuel based power generators and the use of coal for generation of process steam / hot water. The reduction in the need to generate power in fossil fuel based generators leads to reduction in the use of fossil fuel and the emission of GHG. In case of process steam / hot water the reduction in the emission of GHG due to lesser consumption of coal in process steam boilers takes place in the premises of Aarti Industries Limited.

There is no legislation in India, regarding extent of waste heat recovery from sulphuric acid plant. Thus, the extent of heat recovery is entirely governed by the technical feasibility and economic viability of such operations. In the absence of proposed CDM project activity Aarti Industries Limited, would not have gone for enhanced waste heat recovery in its sulphuric acid plant. The extent of waste heat recovery and the consequent power / process steam / hot water generation would not have increased beyond the levels being achieved by other present day sulphuric acid plants in the country. Thus, in the absence of the proposed CDM project activity Aarti Industries would have continued to draw its balance power requirements from the fossil fuel based power generators. In the absence of the proposed CDM project activity Aarti Industries would have used more coal to meet its need of process steam and hot water.

According to the Attachment A to Appendix B, project participants are to provide an explanation to show that the project activity would not have occurred anyway due to at least one of the following barriers:

(a) Investment barrier
(b) Technological barrier
(c) Barrier due to prevailing practice
(d) Other barriers: without the project activity, for another specific reason identified by the project participant, such as institutional barriers or limited information, managerial resources, organizational capacity, financial resources, or capacity to absorb new technologies, emissions would have been higher.

Barrier due to prevailing practice

The present day technology for recovery of waste heat from the sulphuric acid plants in the country is world class, which leads to generation of 1.1 ton of steam for every ton of acid produced. This level of recovery of waste heat is also specified in the publicly available literature for process technology for production of sulphuric acid using elemental sulfur.

In the absence of documented demonstaration, the initiative of increasing the recovery of waste heat is likely to be among the first in the country. The other such initiative in the country is that by Kutch Chemical Industries Limited at its sulphuric acid plant at Gandhidham, Gujarat. At the time of conceiving the proposed CDM project by Aarti Industries Limited, the enhanced waste heat recovery project of Kutch Chemicals was at the planning stage. It is important to note that Kutch Chemicals is also taking the project of enhanced waste heat recovery as a CDM project in the absence of any demonstration of the technology proposed to be used for increasing the recovery of waste heat. There are perceived risks about the technology and the uncertainty in chances of success of such an initiative.

Technological Barrier

The technology development and detailed engineering for carrying out enhanced heat recovery for waste heat in the sulphuric acid plant has been carried out by Aarti Industries Limited using its in house expertise and by hiring the services of expert technical consultants from within the country. There is no documented demonstration of a similar technical intervention in India and therefore, there is a likelihood that this technical intervention is amongst the first in the country.

In the absence of technology demonstration there were perceived technology risks with the proposed CDM project. The technical interventions under the proposed CDM project included incorporation of additional heat recovery equipments under the severe corrosive hot sulphuric condition. Performance of the materials of construction used for such additional heat recovery equipments has not been documented before. Thus there is a possibility of material failure and hence the technology failure.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

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Approved baseline and monitoring methodology AMS IIIQ stipulates that the emissions in the baseline be computed as per the procedures given in paragraphs 6 to 13 of AMS IC, version 12.

Thus, the simplified baseline is the fuel consumption of the technologies that would have been used in the absence of the project activity times an emission coefficient for the fossil fuel displaced. The options considered for baseline emission calculations is that the electricity is produced in an onsite power plant and steam / heat is produced onsite using coal.

In accordance with AMS IC, the baseline emissions for electricity produced in captive plants shall be calculated as the amount of electricity produced with the waste heat recovery technology multiplied by the CO_2 emission factor per unit of energy of the fuel that would have been used in the captive Fuel oil based generators, divided by the efficiency of the captive plant.

The efficiency of the smaller size Fuel oil based captive generators ranges from 30 percent to 45 percent. The efficiency also varies due to variation in the load factor. In order to determine the emission in the baseline in a conservative manner efficiency of the generators has been considered at 45 percent. The emission factor for the fuel in the baseline has been considered to be 74,100 Kg CO2/ TJ. This is the default emission factor for light diesel oil as provided by IPCC. Although the baseline is the use of Fuel oil, emission factor for LDO has been used to determine the emissions in baseline scenario in conservative manner.

Thus the emission factor for the power generation has been computed as follows:

Carbon Dioxide Emission Factor : Power Generation

One MWH	=	1000	kWh
	=	.003597	TJ
Power generator Efficiency		45%	
Fossil Fuel input required	=	.00799	TJ/MWh

Default Emission Factor		74100	Kg CO2 / TJ
Emissions	=	592.06	Kg CO2 / MWh
	=	0.59	Ton Co2 / MWh

In accordance with the provisions in AMS IC, for steam/heat produced using coal the baseline emissions have been calculated using the following formula:

$BEy = HGy * EF\ CO_2 / \eta_{th}$

Where:

BEy =	Baseline emissions from steam/heat displaced by the project activity during the year y in tCO2e.
HGy =	Net quantity of steam/heat supplied by the project activity during the year y in TJ.
EFCO2 =	CO2 emission factor per unit of energy of the fuel that would have been used in the baseline plant in (tCO2 / TJ),
ηth =	Efficiency of the plant using fossil fuel that would have been used in the absence of the project activity

For evaluating GHG mitigation due to generation of process steam and hot water the default carbon emission factors for the fossil fuels provided by IPCC and the thermal efficiency of the fossil fuel based steam / hot water generators have been considered.

In the absence of the proposed CDM project activity process steam and hot water will be generated in the fossil fuel based package boilers. Wide varieties of boilers are used in the process industry. The selection of a boiler configuration for a given application depends on the following factors.

- The required rate of steam / hot water generation
- The required temperature and pressure of the steam / hot water
- Quality of the boiler feed water available
- Fossil fuel available
- Space available
- Capital cost of the equipment
- Quality of steam / hot water required

Out of different types and designs of the process boilers available for generation of process steam / hot water, oil fired smoke tube boilers with multi pass for the flue gases (up to 3 pass) is considered to be the most energy efficient and is the most prevalent. The designed energy efficiency of such boilers goes up to 88 percent when saturated steam is generated at 10 to 12 bar pressure. The energy efficiency goes down with the increase in the steam pressure. Such boilers are not generally used for generation of superheated steam. For superheated steam generally water tube boilers are used. When coal is used as fuel instead of oil the designed thermal efficiency of such boilers goes down further (of the order of 75 Percent). Actual thermal efficiency achieved in the process boilers is generally lesser than the designed thermal efficiency.

Aarti Industries is presently using coal fired water tube boiler for its process steam requirements. However, in order to estimate the GHG mitigation potential for the proposed CDM project in a conservative manner, the baseline considerations have been taken as follows:

- Type of boiler : Smoke tube multi pass with thermal efficiency of 88 percent for medium pressure steam and hot water and 85 percent for high pressure superheated steam

- Fuel : Light diesel oil : Having a carbon dioxide emission factor of 74100 Kg CO2 / TJ [2]

Accordingly, carbon dioxide emission factor for different output energy streams has been determined as per following details.

Carbon Dioxide Emission Factor: High Pressure Steam

Default Emission Factor		74100	Kg CO2 / TJ
Enthalpy of Steam		3253.5	KJ / Kg
	=	3253.5	MJ / Ton
	=	3.25	GJ / Ton
Boiler Efficiency		85%	
Energy Input per ton of steam		3.83	GJ / Ton of steam
Emission per ton of steam		77.32	Kg C / Ton of Steam
	=	283.50	Kg CO2 / Ton of steam

Carbon Dioxide Emission Factor: Medium Pressure Steam

Default Emission Factor		74100	Kg CO2 / TJ
Enthalpy of Steam		2765	KJ / Kg
	=	2765	MJ / Ton
	=	2.77	GJ / Ton
Boiler Efficiency		88%	
Energy Input per ton of steam		3.14	GJ / Ton of steam
Emission per ton of steam		63.47	Kg C / Ton of Steam
	=	232.72	Kg CO2 / Ton of steam

Carbon Dioxide Emission Factor: Hot Water

Default Emission Factor		74100	Kg CO2 / TJ
Enthalpy of Hot Water		251.26	KJ / Kg
	=	251.26	MJ / Ton
	=	0.25	GJ / Ton
Boiler Efficiency		88%	
Energy Input per ton of hot water		0.29	GJ / Ton of steam
Emission per ton of hot water		5.77	Kg C / Ton of Steam
	=	21.15	Kg CO2 / Ton of steam

The baseline emissions have been calculated as the sum of emissions from production of electricity and emissions from the production of steam/heat (for each of the elemental process viz. high pressure steam, medium pressure steam, and hot water). Efficiency of the baseline units has been determined considering the highest value provided by the manufacturers of the units with similar specifications.

The baseline considerations for the proposed CDM project activity entails to the extent of waste heat recovery in sulphuric acid plants in India, given the present state of technology, the prevailing practice and the economic conditions. While determining the baseline for the proposed CDM project activity the state of sulphuric acid production technology presently being used in the country and the consequent extent of waste heat recovery in such sulphuric acid plant have been considered.

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[2] Default carbon emission factor for Light Diesel Oil as per 2006 IPCC Guidelines for National Greenhouse Gas Inventories

It has been considered that the additional waste heat based power which will be generated would have been generated in the power plants supplying power to the state grid. As explained under section A.4 (technical description of the small scale project activity) the extent of heat recovery in present day sulphuric acid plants is about 778 thousand K cal per ton of acid produced. The present practice in the sulphuric acid plants in the country is to generate high pressure (from 40 to 45 bar pressure) steam and use of the steam for power generation (in a steam turbine). As per the prevailing practice the steam turbine is operated in part extraction mode to meet the needs of the process steam for melting the sulfur. The recovered heat of about 778 K cal per ton of acid produced leads to generation of about 1.1 ton of steam at 40 bar (g) pressure and 420 deg C. This is in line with the standard sulphuric acid process technology world over.

This steam is sent through a turbo generator operated in part extraction mode. About 200 kg of steam is extracted at 7.5 bar pressure to meet the needs for melting the sulfur. Balance steam is condensed in the turbo generator leading to generation of 161 kWh of power per ton of sulphuric acid produced. Considering the auxiliary power consumption of 8 percent in the power plant the net out put of power in the present day sulphuric acid plant is estimated to be about 148 kWh per ton of sulphuric acid produced.

The present day process for production of sulphuric acid using elemental sulfur as the starting material as described in the publicly available chemical process technology literature also states the net credit of process steam at 2000 pounds for one ton of acid produced (907 kg. per ton of acid produced). Against this the technology being used by the present day technology plants in India generates about 900 kg of net steam (after accounting for steam used for sulfur melting) for every ton of acid produced. Thus the present day process technology being used in the country is of world class as far as heat recovery is concerned. The present level of waste heat recovery and the consequent power generation have been considered as the baseline for the proposed CDM project activity.

The proposed CDM project activity involves specific technical interventions and capital investment for increasing the recovery of waste heat generated in the process of production of sulphuric acid using elemental sulfur as the feed stock. The recovery of additional waste heat leads to generation of additional electrical power / process steam / hot water for the same quality of sulfuric acid produced. In the absence of the proposed CDM project activity this additional quantity of electrical power / process steam / hot water would have been generated using the existing facilities which are based on fossil fuels. Thus the present day practice regarding waste heat recovery in a sulphuric acid plant has been considered as the baseline.

Computation of the emissions in the baseline as provided in subsequent sections of the PDD has been carried out as per the procedure provided in paragraphs 6 to 13 of AMS IC version 12.

Capping of baseline emissions

As an introduction of element of conservativeness, this category of CDM projects requires that baseline emissions should be capped irrespective of planned / unplanned or actual increase in output of plant, change in operational parameters etc. Capping of the baseline emissions has been carried out based on the provisions in AMS IIIQ version 1.

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

(Copy this table for each data and parameter)

Data / Parameter:	**$q_{1,B}$ = Specific generation of power using waste heat (baseline scenario) net of auxiliary consumption**
Data unit:	Thousand kWh / Ton of acid produced (at 98% concentration)
Description:	Power generated net of auxiliary consumption for every ton of acid produced before implementation of the project
Source of data used:	Publicly available literature on process technology for sulphuric acid production for the extent of steam generation using waste heat and the specifications of the turbo generator
Value applied:	0.148
Justification of the choice of data or description of measurement methods and procedures actually applied :	The present level of technology in the country which has been considered as the baseline is world class as far as recovery of waste heat is considered. The publicly available literature specifies the quantity of waste heat recovered in the process plants world over in accordance with the prevalent practices
Any comment:	The publicly available technical literature for the process technology of sulphuric acid production from elemental sulphur specifies the net gain (net of steam used for melting of sulphur) of process steam in a sulphuric acid plant at 0.9 ton / ton of acid produced. This quantity of steam is capable of producing 0.148 thousand kWh of net electricity. The extent of recovery of waste heat can also be verified by a heat and mass balance on the prevalent technology for recovery of waste heat in the sulphuric acid plants.

Data / Parameter:	**$q_{2,B}$ = Specific generation of super heated steam in the baseline scenario**
Data unit:	Tons of steam / Ton of acid produced (at 98% concentration)
Description:	Super heated steam used for process heating applications
Source of data used:	Not generated in baseline scenario
Value applied:	0 (Zero)
Justification of the choice of data or description of measurement methods and procedures actually applied :	
Any comment:	This value in the baseline is zero.

Data / Parameter:	**q_{3B} = Generation of saturated steam using waste heat (baseline scenario)**
Data unit:	Tons of steam used for heating applications / Ton of acid produced (at 98% concentration)
Description:	
Source of data used:	Not generated in baseline scenario
Value applied:	0 (Zero)
Justification of the choice of data or	

description of measurement methods and procedures actually applied :	
Any comment:	

Data / Parameter:	**q_{4B} = Generation of hot water using waste heat (baseline scenario)**
Data unit:	Tons of hot water / Ton of acid produced (at 98% concentration)
Description:	Hot water generated using waste heat in the sulphuric acid plant
Source of data used:	Not generated in baseline scenario
Value applied:	0 (Zero)
Justification of the choice of data or description of measurement methods and procedures actually applied :	
Any comment:	

Data / Parameter:	**$q_{1,CDM}$ = Specific generation of power using waste heat (after CDM project) net of auxiliary consumption**
Data unit:	Thousand kWh / Ton of acid produced (at 98% concentration)
Description:	Power generated net of auxiliary consumption for every ton of acid produced after implementation of the project
Source of data used:	Estimated based on the technical interventions carried out
Value applied:	0.151
Justification of the choice of data or description of measurement methods and procedures actually applied :	
Any comment:	The value given is used only for computing the GHG mitigation potential. Actual GHG mitigation will be monitored by monitoring the actual power generation.

Data / Parameter:	**$q_{2,CDM}$ = Generation of superheated steam using waste heat (after implementation of the CDM project)**
Data unit:	Tons of steam / Ton of acid produced (at 98% concentration)
Description:	Super heated steam used for process heating applications
Source of data used:	Estimated based on the technical interventions carried out
Value applied:	0.100
Justification of the choice of data or description of	

measurement methods and procedures actually applied :	
Any comment:	Value given is being used only for computing GHG mitigation potential. Actual GHG mitigation will be monitored by monitoring the actual use of super heated steam for process heating applications.

Data / Parameter:	**q_{3CDM} = Generation of saturated steam using waste heat (after implementation of CDM project)**
Data unit:	Tons of steam used for heating applications / Ton of acid produced (at 98% concentration)
Description:	Process steam extracted from the turbine and put to process heating applications (other than for melting of elemental sulphur)
Source of data used:	Computed based on the technical interventions carried out
Value applied:	0.100
Justification of the choice of data or description of measurement methods and procedures actually applied :	
Any comment:	The value is being used only for estimating the GHG mitigation potential of the project. Actual GHG mitigation will be monitored by monitoring the actual use of saturated steam for process heating applications

Data / Parameter:	**q_{4CDM} = Generation of hot water using waste heat (after implementation of the CDM project)**
Data unit:	Tons of hot water / Ton of acid produced (at 98% concentration)
Description:	Hot water generated using waste heat in the sulphuric acid plant
Source of data used:	Estimated based on the technical interventions carried out
Value applied:	0.150
Justification of the choice of data or description of measurement methods and procedures actually applied :	
Any comment:	The value has been used for estimating the mitigation of GHG due to the project. Actual GHG mitigation will be monitored based on monitoring of the actual quantity of hot water generated.

Data / Parameter:	**η_1**
Data unit:	Percent
Description:	Thermal Efficiency of the power generation using internal combustion engines

	technology and light diesel oil as fuel
Source of data used:	Highest specified efficiency of the generators specified in the literature
Value applied:	45
Justification of the choice of data or description of measurement methods and procedures actually applied :	The efficiency of the generators varies across a wide range (say 20 percent to 45 percent). The best achievable efficiency as specified in the literature is 45 percent.
Any comment:	In actual practise the thermal efficiency of the generators is much lower than that specified by the manufacturers and the literature. This is partly due to the fact that the generators usually operate on part load and partly because the actual operating conditions as seldom ideal. Thus considering the efficiency levels specified in the literature leads to conservative estimates regarding emission of GHG in baseline scenario.

Data / Parameter:	η_2
Data unit:	Percent
Description:	Thermal efficiency of the process steam boilers using light diesel oil as fuel
Source of data used:	Technical literature of the manufactures of package type steam boilers.
Value applied:	88
Justification of the choice of data or description of measurement methods and procedures actually applied :	In actual practise the process steam boilers operate at thermal efficiency which is lower than the designed levels. It is not possible to achieve thermal efficiency higher than the design levels. In order to compute GHG mitigation due to the proposed CDM project in a conservative manner, the designed level of thermal efficiency has been used.
Any comment:	Smoke tube three pass boilers with wet back are considered to be most thermal efficient for generation of saturated process steam. They are the industry norm for generation of saturated steam for process heating application. The efficiency levels specified for such boilers by the manufactures has been used.

Data / Parameter:	η_3
Data unit:	Percent
Description:	Thermal efficiency of the high pressure steam boilers using light diesel oil as fuel
Source of data used:	Technical literature of the manufactures of high pressure steam boilers.
Value applied:	85
Justification of the choice of data or description of measurement methods and procedures actually applied :	In actual practise the process steam boilers operate at thermal efficiency which is lower than the designed levels. It is not possible to achieve thermal efficiency higher than the design levels. In order to compute GHG mitigation due to the proposed CDM project in a conservative manner, the designed level of thermal efficiency has been used.
Any comment:	Water tube type high pressure boilers considered to be most thermal efficient for generation of small quantities of super heated steam. They are the industry

	norm for generation of super heated steam for process heating application. The efficiency levels specified for such boilers by the manufactures has been used.

Data / Parameter:	**η_4**
Data unit:	Percent
Description:	Thermal efficiency of hot water generators / boilers using light diesel oil as fuel
Source of data used:	Technical literature of the manufactures of hot water generators / boilers
Value applied:	88
Justification of the choice of data or description of measurement methods and procedures actually applied :	In actual practise the oil fired hot water generators / boilers operate at thermal efficiency which is lower than the designed levels. It is not possible to achieve thermal efficiency higher than the design levels. In order to compute GHG mitigation due to the proposed CDM project in a conservative manner, the designed level of thermal efficiency has been used.
Any comment:	Hot water required by the industry is normally generated in the calorifier wherein the live process steam is injected in a water body to get hot water. In some of the instances oil fired heaters are used for generation of hot water. In cases where oil fired heaters are used the configuration of the equipment comprises of smoke tube three pass configuration.

Data / Parameter:	**Emission factor for light diesel oil**
Data unit:	Kg CO2 / TJ
Description:	Carbon content of light diesel oil
Source of data used:	2006 IPCC Guidelines
Value applied:	74100
Justification of the choice of data or description of measurement methods and procedures actually applied :	Carbon content of fossil fuels, when specified in terms of calorific value, takes care of any variation in the proximate analysis of the fuel. This is so due to a direct relation between calorific value and carbon content of the fuels.
Any comment:	

Data / Parameter:	**EF_1 = Default GHG emission factor for power generation in the baseline scenario**
Data unit:	Tons CO2 equivalent / MWh
Description:	Emission of GHG for generation of electrical power in the baseline scenario, the baseline considered is power generation using fossil fuel fired plants in the western grid
Source of data used:	Weighted Average Emission Rate for power generation in western grid as per CO2 Baseline Database for the Indian Power Sector, User Guide, Version 3.0, December 2007, Central Electricity Authority (CEA), Government of India
Value applied:	0.86
Justification of the choice of data or description of measurement methods and procedures actually applied :	Approved methodology AMS III Q specifies that the emission factor be calculated as per provisions in AMS I C. AMS I C requires that the emission factor be computed based on the efficiency of the generation system and the emission factor of the fuel. Further AMS IC specifies that the emission factor be determined in accordance with the provisions in AMS ID
Any comment:	

Data / Parameter:	**EF_2 = GHG Emission factor for generation of superheated steam at 40 bar pressure and 420 deg C temperature in the baseline scenario**
Data unit:	Kg CO 2 equivalent / Ton of Steam
Description:	Emission of GHG due to use of light diesel oil for generation of high pressure superheated steam
Source of data used:	Computed using emission factor for light diesel oil and efficiency of boiler (η_2.) Details of computations are provided in section B 6.1
Value applied:	272.55
Justification of the choice of data or description of measurement methods and procedures	Approved methodology AMS III Q specifies that the emissions in the baseline be computed in accordance with the procedure specified in AMS I C. Emission factor for generation of high pressure super heated steam has been computed accordingly.

actually applied :	
Any comment:	Only carbon dioxide emission has been considered. Emissions of other GHG like methane and NOx has not been considered. This leads to determination of GHG mitigation potential of the project in a conservative manner.

Data / Parameter:	**EF_3 = GHG Emission factor for generation of saturated process steam at 7.5 bar pressure in the baseline scenario**
Data unit:	Kg CO 2 equivalent / Ton of Steam
Description:	Emission of GHG due to use of light diesel oil for generation of saturated process steam
Source of data used:	Computed using emission factor for light diesel oil and efficiency of boiler (η_3.) Details of computations are provided in section B 6.1
Value applied:	222.14
Justification of the choice of data or description of measurement methods and procedures actually applied :	Approved methodology AMS III Q specifies that the emissions in the baseline be computed in accordance with the procedure specified in AMS I C. Emission factor for generation of high pressure super heated steam has been computed accordingly.
Any comment:	Only carbon dioxide emission has been considered. Emissions of other GHG like methane and NOx has not been considered. This leads to determination of GHG mitigation potential of the project in a conservative manner.

Data / Parameter:	**EF_4 = GHG Emission factor for generation of hot water at 100 deg C temperature in the baseline scenario**
Data unit:	Kg CO 2 equivalent / Ton of Steam
Description:	Emission of GHG due to use of light diesel oil for generation of hot water
Source of data used:	Computed using emission factor for light diesel oil and efficiency of boiler (η_4) Details of computations are provided in section b 6.1Annex 3
Value applied:	35.25
Justification of the choice of data or description of measurement methods and procedures actually applied :	Approved methodology AMS III Q specifies that the emissions in the baseline be computed in accordance with the procedure specified in AMS I C. Emission factor for generation of high pressure super heated steam has been computed accordingly.
Any comment:	Only carbon dioxide emission has been considered. Emissions of other GHG like methane and NOx has not been considered. This leads to determination of GHG mitigation potential of the project in a conservative manner.

B.6.3 Ex-ante calculation of emission reductions:

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	Data / Parameter	Formula Used	Unit	Value
P	Production of Sulphuric Acid		Tons / Yr.	187000
$q_{1,CDM}$	Expected specific generation of power net of auxiliary consumption after the CDM project			0.151
$q_{2.CDM}$	Expected specific generation of superheated steam after implementation of the CDM project			0.1
$q_{3,CDM}$	Expected specific generation of saturated steam after implementation of the CDM project (net of steam consumption for melting of sulfur)			0.1
$q_{4,CDM}$	Expected generation of hot water after implementation of the CDM project			0.15
Q_1	Expected generation of power in waste heat recovery based power generator net of auxiliary power consumption in turbo generator	$P * q_{1,CDM}$	Ths. kWh / Yr.	28237
Q_2	Expected generation of high pressure superheated steam for process heating applications	$P * q_{2,CDM}$	Tons / Yr.	18700
Q_3	Expected generation of medium pressure saturated steam extracted from the turbo generator net of steam used for sulfur melting	$P * q_{3,CDM}$	Tons / Yr.	18700
Q_4	Expected generation of hot water generated and used for process applications	$P * q_{4,CDM}$	Tons / Yr.	28050
$q_{1,B}$	Specific generation of power in the baseline scenario net of auxiliary power consumption in the turbo generator		Ths. kWh / ton of acid	0.148
$q_{2,B}$	Specific generation of super heated steam in the baseline scenario		Tons / ton of acid	0
$q_{3,B}$	Specific generation of medium pressure saturated steam in the baseline scenario after accounting for steam used for sulfur melting		Tons / ton of acid	0
$q_{4,B}$	Specific generation of hot water in the baseline scenario		Tons / ton of acid	0
EF_1	Default emission factor for carbon dioxide for generation of power		Tons CO2 / Ths. kWh	0.86
EF_2	Default emission factor for carbon dioxide for generation of high pressure super heated steam		Tons CO2 / Ton of steam	0.272
EF_3	Default emission factor for carbon dioxide for generation of medium pressure steam		Tons CO2 / Ton of steam	0.222
EF_4	Default emission factor for carbon dioxide for generation of hot water		Tons CO2 / Ton of hot water	0.035
$Q_{1,B}$	Generation of power which would have taken place in the baseline scenario after accounting for auxiliary power used in the turbo generator	$P * q_{1,B}$	Ths. kWh / Yr.	27676
$Q_{2,B}$	Generation of super heated steam which would have taken place in the baseline scenario	$P * q_{2,B}$	Tons / Yr.	0
$Q_{3,B}$	Generation of medium pressure saturated steam which would have taken place in the baseline scenario	$P * q_{3,B}$	Tons / Yr.	0

$Q_{4,B}$	Generation of hot water which would have taken place in the baseline scenario	$P * q_{4,B}$	Tons / Yr.	0
GHG_B	GHG Emission Mitigation which would have taken place in the Baseline Scenario	$Q_{1,B} * EF_1 + Q_{2,B} * EF_2 + Q_{3,B} * EF_3 + Q_{4,B} * EF_4$	Tons CO2 / Yr.	23801.36
GHG_{CDM}	GHG Emission mitigation after CDM project	$Q_1 * EF_1 + Q_2 * EF_2 + Q_3 * EF_3 + Q_4 * EF_4$	Tons CO2 / Yr.	34503.37
GHG	GHG Mitigation gain due to the CDM project	$GHG_{CDM} - GHG_B$	Tons CO2 / Yr.	10702.01

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

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Year	**Estimation of project activity emissions (tCO2e)**	**Estimation of baseline emissions (tCO2e)**	**Estimation of leakage (tCO2e)**	**Estimation of overall emission reductions (tCO2e)**
Fixed Crediting Period				
May 2008 – April 2009	0	10702	0	10702
May 2009 – April 2010	0	10702	0	10702
May 2010 – April 2011	0	10702	0	10702
May 2011 – April 2012	0	10702	0	10702
May 2012 – April 2013	0	10702	0	10702
May 2013 – April 2014	0	10702	0	10702
May 2014 – April 2015	0	10702	0	10702
May 2015 – April 2016	0	10702	0	10702
May 2016 – April 2017	0	10702	0	10702
May 2017 – April 2018	0	10702	0	10702
Total (tonnes of CO2e)	**0**	**107020**	**0**	**107020**

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

The proposed small scale CDM project activity pertains to generation of electricity and other useful forma of energy from waste heat. Waste heat is a zero GHG emission source of energy and the extent of mitigation of GHG will be proportional to the extent of power / process steam / hot water generation using waste heat. The output energy streams displaces generation of corresponding streams of output energy in fossil fuel based technologies. The enhanced waste heat recovery and the consequent enhanced captive power generation (using waste heat) / process steam generation is over and above the level of heat recovery and power generation / steam generation in the baseline scenario . The extent of mitigation of GHG will be proportional to the extent of output energy streams due to the CDM project. Thus monitoring of the GHG emission mitigation can be carried out by monitoring the extent of generation of different output energy streams (electric power, medium pressure saturated steam, high pressure superheated steam and hot water). The measured output energy streams will be compared with the values in the baseline scenario and the incremental generation of output energy streams will be multiplied by the corresponding GHG emission factors.

The baseline methodology applied to the proposed CDM project is AMS III Q. Accordingly the monitoring plan as given in AMS III Q will be used for the proposed project. Thus for baseline emission determination the monitoring shall consist of metering of thermal and electrical energy produced. In case of all the thermal energy produced (high pressure steam, medium pressure steam, hot water) the enthalpy of the out energy streams will also be monitored.
This will be accomplished by metering the net (net of auxiliary consumption) electricity generated by the turbo generator using the steam generated by the waste heat recovery system of the sulphuric acid plant and subtracting from it the net electricity which would have been generated in the baseline scenario. The quantum of High pressure super heated steam generated will be determined by measuring the steam flow (in a steam flow meter). Similarly the quantum of medium pressure saturated steam will be determined by using a steam flow meter. Water flow meter will be used to determine the quantum of hot water generated.

B.7.1 Data and parameters monitored:

Data / Parameter:	**Q 1 = Power generated net of auxiliary consumption in power plant**
Data unit:	kWh
Description:	Power generated net of auxiliary power consumption
Source of data to be used:	Energy meter installed at the output of the power plant
Value of data	Will vary and will be obtained by monitoring
Description of measurement methods and procedures to be applied:	Energy meter installed at the outlet of the power plant. Electronic energy meter will be used. Energy meter used will be integrator type. The reading at the beginning of the shift and at the end of the shift will be recorded. The difference of the two readings will give the electricity generated during the shift.
QA/QC procedures to be applied:	Electronic meter will be used. The use of electromagnetic meters is not suggested as they loose accuracy over a period of time. The meter will be calibrated from time to time as per the specifications of the supplier of the meter.
Any comment:	

Data / Parameter:	**Q 2 = Super heated steam used for process heating**
Data unit:	Tons of steam
Description:	Super heated steam generated and used for process heating applications
Source of data to be used:	Steam flow meter installed at the outlet of the superheated steam
Value of data	Will vary and will be obtained by monitoring
Description of measurement methods and procedures to be applied:	Mass flow meter will be used. The flow meter used will be integrator type. The reading at the start of the shift and the end of the shift will be recorded. The difference between the two readings will provide the quantity of steam used for process heating application. The corresponding temperature and pressure of the steam will also be recorded. The quantity of superheated steam used for process

	heating application during the shift will be adjusted for variation in the temperature and pressure by using the actual enthalpy of the steam (to be determined by using the steam tables for the average temperature and pressure of steam during the shift). The correction will be carried out by using the following method. Corrected value = (Recorded value * enthalpy of steam in KJ per kg) / 3253.5. 3253.5 KJ per Kg., being the enthalpy of steam used while determining the value of EF_2
QA/QC procedures to be applied:	Calibration of the steam flow meter will be carried out in accordance with the recommendation of the supplier of the steam flow meter.
Any comment:	While determining the emission factor EF_2 (emission of carbon dioxide for generation of superheated steam in baseline scenario) the enthalpy of superheated steam considered was 3253.5 KJ / Kg. As the enthalpy of the steam actually generated may vary due to variations in the temperature and pressure of the steam, it is necessary to carry out the correction in the quantity of steam.

Data / Parameter:	**Q 3 = Saturated steam used for process heating (net of quantities used for sulphur melting**
Data unit:	Tons of steam
Description:	Saturated steam at 7.5 bar pressure used for process heating applications (net of the quantities used for melting of sulphur)
Source of data to be used:	Steam flow meter installed at the outlet of header for saturated steam
Value of data	Will vary and will be obtained by monitoring
Description of measurement methods and procedures to be applied:	Mass flow meter will be used. The flow meter used will be integrator type. The reading at the start of the shift and the end of the shift will be recorded. The difference between the two readings will provide the quantity of steam used for process heating application. The corresponding pressure of the steam will also be recorded. The quantity of saturated steam used for process heating application during the shift will be adjusted for variation in the pressure by using the actual enthalpy of the steam (to be determined by using the steam tables for the average pressure of steam during the shift). The correction will be carried out by using the following method. Corrected value = (Recorded value * enthalpy of steam in KJ per kg) / 2765 2765 KJ per Kg., being the enthalpy of steam used while determining the value of EF_3
QA/QC procedures to be applied:	Calibration of the steam flow meter will be carried out in accordance with the recommendation of the supplier of the steam flow meter.
Any comment:	While determining the emission factor EF_3 (emission of carbon dioxide for generation of saturated steam in baseline scenario) the enthalpy of steam considered was 2765 KJ / Kg. As the enthalpy of the steam actually generated may vary due to variations in the pressure of the steam, it is necessary to carry out the correction in the quantity of steam.

Data / Parameter:	**Q 4 = Hot water generated and used for process applications**
Data unit:	Tons of hot water
Description:	Quantity of hot water at 100 deg. C used for process heating applications
Source of data to be used:	Water flow meter at the outlet of hot water heat exchanger
Value of data	Will vary and will be obtained by monitoring
Description of measurement methods and procedures to be applied:	Mass flow meter will be used. The flow meter used will be integrator type. The reading at the start of the shift and the end of the shift will be recorded. The difference between the two readings will provide the quantity of hot water generated and used for process heating application. The corresponding temperature of hot water will also be recorded. The quantity of hot water used for process heating application during the shift will be adjusted for variation in the temperature of the hot water. The correction will be carried out by using the following method. Corrected value = (Recorded value * Temperature of hot water in deg. C) / 100 100 deg. C being the temperature of hot water used while determining the value of EF_4
QA/QC procedures to be applied:	Calibration of the water flow meter will be carried out in accordance with the recommendation of the supplier of the water flow meter.
Any comment:	While determining the emission factor EF_4 (emission of carbon dioxide for generation of hot water in baseline scenario) the temperature of hot water considered was 100 deg. C. As the temperature of the hot water actually generated may vary, it is necessary to carry out the correction in the quantity of hot water.

Data / Parameter:	**Enthalpy of super heated steam generated**
Data unit:	KJ / Kg.
Description:	Enthalpy of superheated steam generated
Source of data to be used:	Determined from the steam tables, using the average value of temperature and pressure of the steam generated during the shift
Value of data	Will vary and will be obtained from monitoring
Description of measurement methods and procedures to be applied:	The average value of temperature and pressure required to determine the enthalpy will be obtained from the recorded value of temperature and pressure during the shift.
QA/QC procedures to be applied:	The calibration of temperature and pressure recorders will be carried out from time to time as per the recommendations of the suppliers of the recorders.
Any comment:	

Data / Parameter:	**Enthalpy of saturated steam generated**
Data unit:	KJ / Kg.
Description:	Enthalpy of saturated steam generated
Source of data to be used:	Determined from the steam tables, using the average value of pressure of the steam generated during the shift
Value of data	Will vary and will be obtained from monitoring
Description of measurement methods and procedures to be applied:	The average value of pressure required to determine the enthalpy will be obtained from the recorded value of pressure during the shift.
QA/QC procedures to be applied:	The calibration of pressure recorder will be carried out from time to time as per the recommendations of the suppliers of the recorder.
Any comment:	

Data / Parameter:	**Enthalpy of hot water generated**
Data unit:	KJ / Kg.
Description:	Enthalpy of hot water generated
Source of data to be used:	Determined from the average value of temperature of the hot water generated during the shift
Value of data	Will vary and will be obtained from monitoring
Description of measurement methods and procedures to be applied:	The average value of temperature required to determine the enthalpy will be obtained from the recorded value of temperature during the shift.
QA/QC procedures to be applied:	The calibration of temperature recorder will be carried out from time to time as per the recommendations of the suppliers of the recorder.
Any comment:	

B.7.2 Description of the monitoring plan:

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Like renewable sources of energy waste heat is a zero GHG emission source of energy. The mitigation in the emission of GHG is up to the extent of power / process steam / hot water generation using the waste heat.

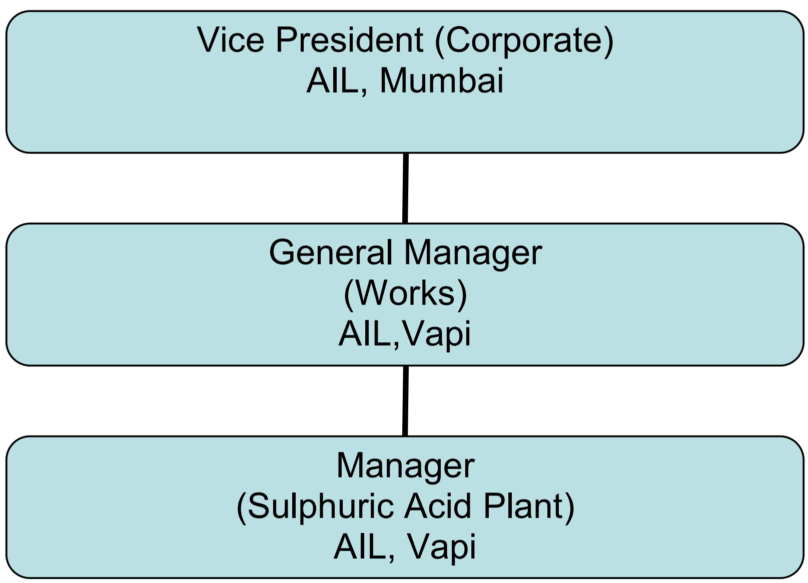
The monitoring of the GHG emission reduction will be carried out by monitoring the power / high pressure steam / medium pressure steam and hot water generated in the waste heat recovery system. The waste heat recovery system comprises of the heat exchanges, waste heat boilers and the turbo generator. The turbo generator uses the steam generated in the waste heat recovery system. The metering for the power generation will be carried out at two levels, namely at the output from the turbo generator and at the power distribution system lines from the power plant to the outside power distribution system. Least of the power generation recorded at the two places will be used for computing the incremental power generation and the consequent GHG mitigation. The meters for recording the power generation will be periodically calibrated. Calibration will be done by the outside certified parties. The steam flow meter for recording the high pressure steam super heated steam supplied for the process requirement will be installed on the pipeline supplying high pressure steam to the process units. The steam flow meter for recording the quantity of medium pressure saturated steam supplied for process use will be installed on the pipeline supplying medium pressure steam for the process use. Both the steam flow meters will be periodically calibrated. The calibration of the steam flow meters will be done by outside certified parties. Similarly the water flow meter installed on the pipeline supplying hot water for process applications will be periodically calibrated by the certified outside agencies.

As there is a direct relationship between the sulphuric acid production and the extent of waste heat recovery, waste heat recovered will be benchmarked against the amount of sulfur used and the amount of sulphuric acid produced. This will be used as an additional quality assurance tool.

In addition to the meters for recording the power generated in the turbo generator a steam flow meter at the inlet of the steam turbine will also be used.

The proposed CDM project activity will be implemented by Aarti Industries Limited at its existing sulphuric acid plant in the state of Gujarat. The CDM project will be looked after by the manager responsible for operation of the sulphuric acid plant. Day to day operations of the power generator will be carried out by the staff responsible for the operation of the waste heat based power generator within the sulphuric acid plant.

The project proponent has formulated a Project Team to ensure proper and continuous monitoring of the project activity. The same has been outlined in the organization flowchart as follows:



Organization Chart for CDM activity at AIL, Vapi, Gujarat

The meters used for recording the power / high pressure steam / medium pressure steam / hot water generated will be of integrator type. The records of the quantity of different output energy streams generation and the quantity of sulphuric acid will be recorded on a daily basis. The data will be captured and stored electronically. As a separate measure the quantity of sulphuric acid produced, power produced and the ratio of the power produced to the quantity of acid produced will be entered in the respective logbooks on a daily basis. The data shall be archived for the entire crediting period of the project.

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

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The baseline and monitoring methodology has been completed on 14 February 2008. The person responsible for completion of the baseline and monitoring methodology is as follows:

Dinesh Aggarwal
Deloitte Touche Tohmatsu India Private Limited
MCT House, One Okhla Centre, Block A
Okhla Institutional Area
New Delhi – 1100025
Phone: 91-11-66622088
Fax: 91-11-66622011
Email: daggrawal@deloitte.com

The person / entity that has determined the monitoring methodology and prepared this PDD are not the project participant listed in Annexure A. The role of the entity is limited to consulting and advisory services related to the proposed CDM project activity.

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

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Start date of the proposed small scale project activity is December 2005.

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

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The expected operational lifetime of the proposed small scale CDM project activity will be the life of the sulphuric acid plant which is about 25 years.

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

C.2.1. Renewable crediting period

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

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C.2.1.2. Length of the first crediting period:

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C.2.2. Fixed crediting period:

Fixed crediting period of 10 years.

C.2.2.1. Starting date:

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The crediting period will start from the date of registration of the project with CDM Executive Board. The expected starting date of the crediting period is 01/05/2008.

C.2.2.2. Length:

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Ten years

SECTION D. Environmental impacts

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

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Not Applicable to the proposed CDM project activity.

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

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Not Applicable to the proposed CDM project activity.

SECTION E. Stakeholders' comments

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

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The stake holders in the present context were defined as the parties and individuals who can be perceived to be affected by the proposed CDM project activity. The proposed activity pertains to enhanced heat recovery leading to incremental gains in waste heat based power and process heat generation. The proposed activity does not use additional resources and does not lead to any additional emission of local pollutants (particulate matter, acid gases, working conditions, fugitive emissions, heavy metals, waste water etc.). The proposed activity is not likely to have any adverse impact on any of 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. 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 sulphuric acid plant technology in general and the proposed CDM project in particular. The presentations were made in local language (Gujarati and Hindi). The list of the stake holders who attended the meeting is provided as Appendix to this document. The attendees included local stakeholders like vendors, employees, co-factory owners and local villagers. After the briefing / presentations, the stake holders were asked to provide there comments / suggestions for the project. After the briefing / presentations, the stake holders were asked to provide there comments / suggestions for the proposed project.

E.2. Summary of the comments received:

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Some of the stake holders pointed out the good work done by Aarti Industries for community development. It was pointed out that in-spite of production of sulphuric acid (which is generally known for fugitive emissions of sulfur gases) there is no emission of fugitive gases from the premises of Aarti Industries.

The stakeholders were happy to know about the efforts of Aarti Industries towards mitigation of GHG and participating in the global efforts for mitigating climate change. Some of the stake holders (other industries from the industrial cluster of Vapi) became interested to identify and develop CDM projects in their units and sought the help and guidance from Aarti industries. The management representative of Aarti Industries who was present during the process of stakeholders expressed their willingness to provide the required guidance / help for identification and development of the CDM projects at other industrial units located at Vapi.

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

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No adverse comments were received for the proposed CDM project.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Aarti Industries Limited
Street/P.O.Box:	71, Udyog Kshetra, 2nd Floor
Building:	Mulund Goregaon Link Road, Mulund (West)
City:	Mumbai
State/Region:	Maharashtra
Postfix/ZIP:	400080
Country:	India
Telephone:	91 - 22 – 67976666
FAX:	91 - 22 – 25904806
E-Mail:	harakh@aartigroup.com
URL:	www.aartigroup.com
Represented by:	
Title:	Vice President
Salutation:	Mr.
Last Name:	Dedhia
Middle Name:	Khimji
First Name:	Harakhchand
Department:	Corporate Planning
Mobile:	91-9967539731
Direct FAX:	91-22-67976660
Direct tel:	91-22-67976575
Personal E-Mail:	harakh@aartigroup.com

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 (Aarti Industries Limited).

Annex 3

BASELINE INFORMATION

The process of production of sulphuric acid using elemental sulfur as the starting material comprises of melting of sulfur and its subsequent combustion in atmospheric oxygen to produce sulfur dioxide gas. Sulfur dioxide gas is subsequently converted to sulfur trioxide in a multistage catalytic converter. As a next step sulfur trioxide gas is absorbed in water (in a multi-step process wherein the actual absorption is carried out in concentrated sulphuric acid which is subsequently diluted with water to the strength of the standard acid) to produce sulphuric acid. Combustion of sulfur leads to generation of heat, which is carried in the gas stream out of the sulfur burner. The process of conversion of sulfur dioxide to sulfur trioxide also leads to generation of heat (conversion reaction being an exothermic reaction). The process of absorption of sulfur trioxide in water also leads to generation of heat. The heat generated due to absorption of sulfur trioxide in water is a low grade heat (temperatures being low). In the overall process of production of sulphuric acid from elemental sulfur, heat is generated at following three stages:

- Combustion of sulfur to produce sulfur dioxide gas in the sulfur burner
- Conversion of sulfur dioxide gas to sulfur trioxide gas in the multi stage converter reactor
- Absorption of sulfur trioxide gas in water to produce sulfuric acid in absorption columns (this is a low grade heat, wherein the temperatures are low)

The extent of generation of heat at different stages of the overall process for producing one ton of sulphuric acid (100 percent concentration basis) is as given in the following Table 1

Table I
Generation of Heat at Different Stages of Production of Sulphuric Acid
(Basis: Production of One Ton of Acid at 100 Percent Concentration)

Sl No	Stage of Process		Heat generated (Ths. KCal / Ton of Acid)	
1	Burning of Sulfur			739
2	Conversion of Sulfur Dioxide to Sulfur Trioxide (Total Conversion 99.92 %)			241
	2a	Converter Stage I (74.0 % Conversion)	178.3	
	2b	Converter Stage II (18.4 % Conversion)	44.3	
	2c	Converter Stage III (4.3 % Conversion)	10.4	
	2d	Converter Stage IV (3.2% Conversion)	7.7	
3	Absorption of Sulfur Trioxide in Water to produce Sulphuric Acid			325
4	Heat of Acid dilution by moisture in Dry air tower			8.5

Source: Worked out based on the stoichiometric requirement of sulfur for acid production and heat of formation of different reactants and products at different stages of the overall process

The heat generated at different stages of the process for producing sulphuric acid from sulfur is recovered and put to use. The extent of recovery of the waste heat varies from plant to plant, due to the following reasons:

- Process technology used
- Size of the plant

- Cost of heat recovery and the overall cost economics
- Availability of opportunity to put the recovered energy to use

In the following paragraphs an outline of the status on technology in India for sulphuric acid production facilities (using sulfur) as far as recovery of waste heat is concerned is being provided. This also provides the historical perspective in India of the progress in waste heat recovery technology in sulphuric acid plants.

The Conventional Old Technology

Traditionally, in a conventional sulphuric acid plant the heat contained in the hot gases after sulfur burner are recovered in a waste heat boiler to generate steam. The hot gases after the sulfur burner are sent to waste heat boiler to generate steam because of following two reasons.

- The process parameters in the converter require that the gas be cooled before being sent to the converter (The conversion reaction being an exothermic reversible chemical reaction, it is required that an optimum temperature in the converter be maintained to ensure proper yield of sulfur trioxide)
- The recovered heat in the form of steam is utilized to melt sulfur.

Due to the two reasons mentioned above, in old traditional stand alone sulphuric acid plants the hot gases after the sulfur burner (stage 1 in Table I above) are passed through the waste heat boiler and the steam generated in the waste heat boiler is utilized for melting the sulfur. Steam left out after its utilization for melting of sulfur is vented out. This used to be the situation in the absence of any gainful utilization opportunity for the balance steam. Typically the steam used to be generated at about 10-12 bar pressure (saturated steam). The extent of heat recovery from the gases at this stage of the process used to be governed by the need to feed the gases to the converter at about 410 Deg. C. Thus, it is not possible to recover more then 60 to 65 percent of the heat generated at this stage of the process. In the absence of any gainful utilization of the recovered heat in the earlier generation of the plants there was no incentive to recover more heat out of the hot gas stream. Typically in this generation of the sulphuric acid plants the heat used to be recovered only from the stage (stage 1 in Table I above) of the sulfur burner. The process requirements to cool the fluid streams at other stages of the overall process used to be carried out using cooling water but the recovered heat used to be lost in the cooling towers.

In the absence of opportunity to gainfully utilize recovered heat the efficiency of heat recovery used to be only of the order of about 50 percent. Thus, the heat recovered in this earlier generation of sulphuric acid plants used to be of the order of about 370 Thousand K cal per tone of acid. This recovered heat when used for generation of steam leads to generation of about 590 Kg of saturated steam at 10 bar pressure (considering feed water temperature of 40 deg. C). The recovered heat used to be part utilized for melting of sulfur and the balance steam used to be vented to the atmosphere. It is estimated that the quantum of steam used for melting sulfur and maintain the temperature of molten sulfur is about 200 kg for every ton of sulphuric acid produced. Thus in this generation of sulphuric acid plants about 390 kg of steam used to be vented to the atmosphere for every ton of acid produced.

Second Generation of Technology

Realizing that the excess steam available in sulphuric acid plant can be gainfully utilized for producing power to meet the electric power needs of the plant, next generation of the sulphuric acid plants had the provision to generate power using the steam generated due to recovered heat. Thus captive steam turbines were introduced to use excess steam available. The extent of heat recovery from the gases out of the sulfur burner was also increased to about 60 percent (by introducing measures like insulation and prevention of heat loss). Thus the heat recovered in this generation of plants used to be about 443 Thousand K Cal per ton of acid. The heat generated in other stages of the process was not recovered and as before it used to be lost to the cooling towers.

As significant quantity of steam in this case used to be condensed in steam turbine the boiler feed water used to be available at a significantly higher temperature (about 70 degree C). In order to optimize power generation the pressure rating of the waste heat boiler was increased to 20 bar pressure. Thus the recovered heat of about 443 Thousand K cal per ton of acid produced, lead to generation of about 740 kg of saturated steam at 20 bar pressure (considering feed water temperature of 70 deg C). This steam used to be passed through a turbo generator operated in part extraction mode. Process steam required for melting the sulfur used to be extracted at about 7.5 bar pressure and the balance steam used to be condensed. About 200 kg of steam for every ton of sulphuric acid produced used to be extracted and about 540 kg of steam used to be condensed in the turbine. Considering that typically the heat rate of such steam turbine is about 4500 K cal per kWh, the power output in this generation of sulphuric acid plants has been estimated to be about 81 kWh for every ton of sulphuric acid produced. About 8 percent of the power generated gets used as auxiliary power consumption in the power plant (for running feed water pump, lubrication system of the power plant etc.) the net output of power in this generation of sulphuric acid plant used to be 75 kWh per ton of acid produced.

The Present Day Technology Plants

Over a period of time partly due to increase in the size of the sulphuric acid plants and partly due to the opportunity to put the waste heat to gainful use, it was realized that apart from the waste heat recovered in the stage of sulfur burner there is an opportunity to recover heat from the stage of conversion of sulfur dioxide to sulfur trioxide. Considering that this will lead to considerable increase in the generation of power the present day sulphuric acid plants has provision for recovery of heat from different stages of the converter. In the present day sulphuric acid plants the steam is generated at higher pressure to optimize generation of power.

The present day plants optimally recover the heat generated due to conversion of sulfur dioxide to sulfur trioxide in the converter. In such plants the steam being generated is passed through a turbo generator. The turbo generator is being operated in part extraction mode to generate process steam required to melt sulfur. In case of such plants the maximum possible heat recovery in the waste heat boiler is determined by the need to maintain the temperature of the gas stream feed to the converter at 412 deg C. The extent of heat recovered from different stages of the converter is determined by the quantum of heat generated; need to maintain temperatures at different stages of the converter and the possibility of gainfully extracting the waste heat being generated.

The waste heat generated at first stage of the converter is recovered in the steam super heater, and is utilized to super heat the steam generated in the waste heat boiler. This enables feeding of superheated steam in the turbo generator. The extent of heat recovery in stage I of the converter is almost complete (of the order of 80 percent). The waste heat generated in stage II and III of the converter is recovered in two separate economizers. This leads to increase in the boiler feed water temperature leading to increase in the throughput of steam. The air used for combustion of sulfur is increased by preheating and drying the air leading to increase in the temperature of gases at the outlet of the sulfur burner. By way of increasing the temperature of gases at the outlet of the sulfur burner this also enables higher heat recovery from the stage of sulfur burner (heat recovery increases from 60 percent to 80 percent). The extent of heat recovery from stage II and III of the converter is about 80 percent.

Considering heat recovery of 80 percent from burner gases, 80 percent from stage I of the converter and 80 percent each from stage II & III of the converter, the extent of heat recovery in present day sulphuric acid plants is estimated to be about 778 thousand K cal per ton of acid produced. This heat leads to generation of about 1.1 ton of steam at 40 bar pressure and 420 deg C. This steam is sent through a turbo generator operated in part extraction mode. About 200 kg of steam is extracted at 7.5 bar pressure to meet the needs for melting the sulfur. Balance steam is condensed in the turbo generator. Considering a heat rate of 4500 K cal per kWh the power out put in the present day sulphuric acid plants is about 161 kWh per ton of sulphuric acid produced. Considering the auxiliary power consumption of 8 percent in the power plant the net out put of power in the present day sulphuric acid plant is estimated to be about 148 kWh per ton of sulphuric acid produced.

It is important to note that depending upon the opportunity to use the process steam or electrical power in-house, the output of process steam can be increased at the cost of power output.

In the present day sulphuric acid plants the waste heat from stage IV of the converter and the heat generated due to absorption of sulfur trioxide gas in water do not get recovered. This is largely due to the economic reasons. The quantum of heat available at stage IV of the converter is very small and it is not considered worthwhile to recover this heat. The waste heat generated due to absorption of sulfur trioxide gas in water, in spite of its comparatively large quantum is available only as a low grade heat (at lower temperatures). Thus the cost of recovery of this heat is considered as prohibitive. The present day process for production of sulphuric acid using elemental sulfur as the starting material as described in the publicly available chemical process technology literature also states the net credit of process steam at 2000 pounds for one ton of acid produced (907 kg. per ton of acid produced). Against this the technology being used by the present day technology plants in India generates about 900 kg of net (after accounting for steam used for sulfur melting) steam for every ton of acid produced. Thus the present day process technology being used in the country is of world class as far as heat recovery is concerned.

The Proposed Enhanced Heat Recovery

Aarti Industries Limited has put up one of the most modern sulphuric acid plant in the country. Accordingly, the level of heat recovery in the sulphuric acid plant as was suggested by the technology / capital equipment suppliers and technical consultants was stated to be of the order of 1100 kg of steam for every tonne of acid produced. Like other present day sulphuric acid producers in the country, the original plant design considered by Aarti Industries Limited did not have provision for recovery of waste heat from stage IV of the converter and from the hot acid stream.

In spite of the technical risks involved and in spite of significantly higher capital cost Aarti Industries Limited expressed its desire to go for enhanced waste heat recovery. Accordingly the original design of the plant was modified and additional waste heat recovery equipments were incorporated in the design. The enhanced waste heat recovery has been considered as a CDM project by Aarti Industries Limited to part mitigate the technology and investment risks associated with the project.

Under the proposed CDM project, Aarti Industries will be partly recovering additional waste heat generated at different stages of the overall process at its sulphuric acid plant. The hot acid will be used for preheating the air used for combustion of sulfur in the sulfur burner and for preheating the boiler feed water. Some of the waste heat in the hot acid stream will also be used for producing hot water. The hot acid will be used for drying the air used for combustion and in the process; heat contained in the hot acid stream will partly get recovered in the combustion air. It is expected that up to 80 percent of the total heat generated at stage IV of the converter and 30 percent of the heat generated due to absorption of sulfur trioxide gas will get recovered. Apart from this it is proposed that the low grade heat generated due to dilution of acid be recovered in the form of hot water. The hot water thus generated will either be used as boiler feed water or may be used for process requirements.

This additional heat recovery will be over and above the level of heat recovery with the original plant design. The enhanced heat recovery will lead to increase in steam generation and the consequent higher power generation. It will also lead to generation of hot water which can then be used for process requirements.

It is estimated that with the implementation of the CDM project the recovery of high grade waste heat will increase to about 830 K cal per ton of acid produced from baseline figure. In addition about 97 K Cal of low grade heat will be recovered. The recovered high grade heat will lead to generation of 1.24 tons of high pressure steam (considering feed water temperature of 110 deg C) at 45 bar pressure and temperature of 420 deg C. Apart from this about 1390 liters of hot water per ton of acid produced ,will be generated, due to recovery of low grade heat. Out of the total quantity of hot water generated about 1240 will be used as boiler feed water and the balance will be used for other process needs.

The steam will be passed through the turbo generator operated in part extraction mode. Part of the high pressure superheated steam generated will be used directly for process heating requirements of other chemical production units and the balance high pressure superheated steam will be passed through the turbo generator. In order to optimally utilize the recovered heat to the extent possible process steam will be extracted from the turbine. Part of the process steam extracted from the turbine will be used for sulfur melting and the balance will be utilized for process requirements of other units. The hot water generated will either be used as boiler feed water or will be used for process requirements. Thus with implementation of the proposed CDM projects there will be four different energy output streams as follows:

- High pressure superheated steam for process
- Medium pressure saturated process steam for process
- Electrical power
- Hot water

The extent of generation of these output energy streams may very from time to time, as it depends upon the operational needs. However, the planned generation of different energy output streams after implementation of the CDM project is as follows:

Output stream	**Specifications**	**Quantity**	**Units**
High pressure superheated steam for process use	Superheated steam at 45 bar (g) pressure and 420 Degree C temperature	100	Kg / Ton of acid
Medium pressure saturated steam for process use**	Saturated steam at 7.5 bar (g) pressure	110	Kg / Ton of acid
Electric power*	Units of electricity	151	kWh / Ton of

			acid
Hot water***	Hot water at 110 Degree C temperature	150	Kg / Ton of acid

* Net generation after accounting for auxiliary power consumption for the power plant
** Out of this about 200 Kg of steam will get utilized for sulfur melting
*** Net after accounting for use of hot water as boiler feed water

Against this in the baseline scenario (with the original design of the plant without additional waste heat recovery equipment) level of recovery of waste heat leads to generation of 148 kWh of power (power net of auxiliary consumption in the power plant per ton of sulphuric acid) and 200 kg of medium pressure saturated steam (which is used for sulfur melting and no process steam is supplied for process units).

The CDM project activity pertains to specific technical interventions and capital investment for increasing the recovery of waste heat generated in the process of production of sulphuric acid using elemental sulfur as the feed stock. The recovery of additional waste heat will lead to generation of additional electrical power / process steam / hot water for the same quantity of sulfuric acid produced. In the absence of the CDM project activity this additional quantity of electrical power / process steam / hot water would have been generated using the existing facilities which are based on fossil fuels.

The recovery of waste heat and its gainful utilization in the baseline scenario also leads to avoidance of use of fossil fuels for generation of power and process steam. Upon implementation of the CDM project the extent of recovery of waste heat and hence avoidance of use of fossil fuels increases. Thus, the generation of additional power / process steam / hot water using waste heat leads to mitigation of the use of fossil fuel and the consequent emission of Carbon dioxide which is a GHG, when compared to the baseline practice. The avoidance of use of fossil fuels for energy needs also leads to mitigation in the emission of other green house gases like methane and nitrous oxide. However, in order to arrive at the GHG mitigation potential in a conservative manner GHG other than carbon dioxide have not been considered.

The emission factor for power generation has been worked out considering the IPCC emission factor for light diesel oil and thermal efficiency of the generators as suggested in the approved methodology AMS IC. For evaluating GHG mitigation due to generation of process steam and hot water the default carbon emission factors for the fossil fuels provided by IPCC and the thermal efficiency of the fossil fuel based steam / hot water generators have been considered.

In the absence of the proposed CDM project activity process steam and hot water will be generated in the fossil fuel based package boilers. Wide varieties of boilers are used in the process industry. The selection of a boiler configuration for a given application depends on the following factors.

- The required rate of steam / hot water generation
- The required temperature and pressure of the steam / hot water
- Quality of the boiler feed water available
- Fossil fuel available
- Space available
- Capital cost of the equipment
- Quality of steam required

Out of different types and designs of the process boilers available for generation of process steam / hot water, oil / gas fired smoke tube boilers with multi pass for the flue gases (up to 3 pass) is considered to be the most energy efficient. The designed energy efficiency of such boilers goes up to 88 percent, when saturated steam is generated at 10 to 12 bar pressure. The energy efficiency goes down with the increase in the steam pressure. Such boilers are not generally used for generation of superheated steam. For superheated steam generally water tube boilers are used. When coal is used as fuel instead of oil / gas the designed thermal efficiency of such boilers goes down further (of the order of 75 Percent). Actual thermal efficiency achieved in the process boilers is generally lesser than the designed thermal efficiency.

Aarti Industries is presently using coal fired water tube boiler for its process steam requirements. However, in order to estimate the GHG mitigation potential for the proposed CDM project in a conservative manner the baseline considerations have been taken as follows:

- Type of boiler : Smoke tube multi pass with thermal efficiency of 88 percent for medium pressure steam and hot water and 85 percent for high pressure superheated steam
- Fuel : Light diesel oil : Having a carbon dioxide emission factor of 74100 Kg CO2 / TJ [3]

Accordingly, carbon dioxide emission factor for different output energy streams has been determined as per the "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion", Annex 9, EB 32 as per following details.

Carbon Dioxide Emission Factor: High Pressure Steam

Default Emission Factor		74100	Kg CO2 / TJ
Enthalpy of Steam		3253.5	KJ / Kg
	=	3253.5	MJ / Ton
	=	3.25	GJ / Ton
Boiler Efficiency		85%	
Energy Input per ton of steam		3.83	GJ / Ton of steam
Emission per ton of steam		77.32	Kg C / Ton of Steam
	=	283.50	Kg CO2 / Ton of steam

Carbon Dioxide Emission Factor: Medium Pressure Steam

Default Emission Factor		74100	Kg CO2 / TJ
Enthalpy of Steam		2765	KJ / Kg
	=	2765	MJ / Ton
	=	2.77	GJ / Ton
Boiler Efficiency		88%	
Energy Input per ton of steam		3.14	GJ / Ton of steam
Emission per ton of steam		63.47	Kg C / Ton of Steam
	=	232.72	Kg CO2 / Ton of steam

Carbon Dioxide Emission Factor: Hot Water

Default Emission Factor		74100	Kg CO2 / TJ
Enthalpy of Hot Water		251.26	KJ / Kg

[3] Default carbon emission factor for Light Diesel Oil as per 2006 IPCC Guidelines for National Greenhouse Gas Inventories

	=	251.26	MJ / Ton
	=	0.25	GJ / Ton
Boiler Efficiency		88%	
Energy Input per ton of hot water		0.29	GJ / Ton of steam
Emission per ton of hot water		5.77	Kg C / Ton of Steam
	=	21.15	Kg CO2 / Ton of steam

Computation of the emissions in the baseline as provided in the PDD have been carried out as per the procedure provided in paragraphs 6 to 13 of AMS IC version 12.

As an introduction of element of conservativeness, this category requires that baseline emissions should be capped irrespective of planned / unplanned or actual increase in output of plant, change in operational parameters etc. Capping of the baseline emissions has been carried out based on the provisions in AMS IIIQ Version 1. Approved methodology AMS III Q specifies that the emission factor be calculated as per provisions in approved methodology AMS I C. AMS I C requires that the emission factor be computed based on the efficiency of the generation system and the emission factor of the fuel. Further, AMS IC specifies that the emission factor be determined in accordance with the provisions in AMS ID.

Paragraph 9 of AMS I D has the following provision for determination of the emission coefficient (measured in kg CO_2eq/kWh):

a) A combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) according to the procedures prescribed in the approved methodology ACM0002. Any of the four procedures to calculate the operating margin can be chosen, but the restrictions to use the Simple OM and the Average OM calculations must be considered.

OR

b) The weighted average emissions (in kg CO_2e/kWh) of the current generation mix. The data of the year in which project generation occurs must be used.

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', Version 3.0, December 2007. 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 2006-07 (April 2006 to March 2007) (adjusted for inter-regional and cross-country electricity transfers) is as follows:

Weighted Average	0.86	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	0.59	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	0.79	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.

Since the additional waste heat based power/ elemental processes which will be generated would have been generated in the fossil fuel based plants supplying power to the state power distribution grid, the weighted average emission factor of 0.86 tCO2/ MWh has been considered for the replacement of the western grid power by the waste heat based power.

Annex 4

MONITORING INFORMATION

The baseline methodology applied to the proposed CDM project is AMS III Q. Accordingly the monitoring plan as given in AMS III Q will be used for the proposed project. Thus for baseline emission determination the monitoring shall consist of metering of thermal and electrical energy produced. In case of all the thermal energy produced (high pressure steam, medium pressure steam, hot water) the enthalpy of the output energy streams will also be monitored. This will be accomplished by metering the net (net of auxiliary consumption) electricity generated by the turbo generator using the steam generated by the waste heat recovery system of the sulphuric acid plant and subtracting from it the net electricity which would have been generated in the baseline scenario. The quantum of High pressure super heated steam generated will be determined by measuring the steam flow (in a steam flow meter). Similarly the quantum of medium pressure saturated steam will be determined by using a steam flow meter. Water flow meter will be used to determine the quantum of hot water generated.

Like renewable sources of energy, waste heat is a zero GHG emission source of energy. The mitigation in the emission of GHG is up to the extent of power / process steam / hot water generation using the waste heat.

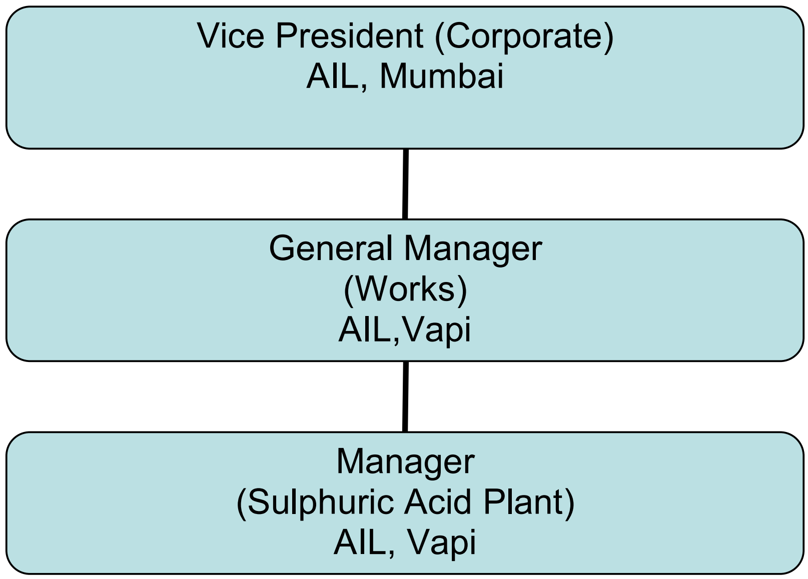
The monitoring of the GHG emission reduction will be carried out by monitoring the power / high pressure steam / medium pressure steam and hot water generated in the waste heat recovery system. The waste heat recovery system comprises of the heat exchanges, waste heat boilers and the turbo generator. The turbo generator uses the steam generated in the waste heat recovery system. The metering for the power generation will be carried out at two levels, namely at the output from the turbo generator and at the power distribution system lines from the power plant to the outside power distribution system. Least of the power generation recorded at the two places will be used for computing the incremental power generation and the consequent GHG mitigation. The meters for recording the power generation will be periodically calibrated. Calibration will be done by the outside certified parties. The steam flow meter for recording the high pressure steam super heated steam supplied for the process requirement will be installed on the pipeline supplying high pressure steam to the process units. The steam flow meter for recording the quantity of medium pressure saturated steam supplied for process use will be installed on the pipeline supplying medium pressure steam for the process use. Both the steam flow meters will be periodically calibrated. The calibration of the steam flow meters will be done by outside certified parties. Similarly the water flow meter installed on the pipeline supplying hot water for process applications will be periodically calibrated by the certified outside agencies.

As there is a direct relationship between the sulphuric acid production and the extent of waste heat recovery, waste heat recovered will be benchmarked against the amount of sulfur used and the amount of sulphuric acid produced. This will be used as an additional quality assurance tool.

In addition to the meters for recording the power generated in the turbo generator a steam flow meter at the inlet of the steam turbine will also be used.

The proposed CDM project activity will be implemented by Aarti Industries Limited at its existing sulphuric acid plant in the state of Gujarat. The CDM project will be looked after by the manager responsible for operation of the sulphuric acid plant. Day to day operations of the power generator will be carried out by the staff responsible for the operation of the waste heat based power generator within the sulphuric acid plant.

The project proponent has formulated a Project Team to ensure proper and continuous monitoring of the project activity. The same has been outlined in the organization flowchart as follows:



Organization Chart for CDM activity at AIL, Vapi, Gujarat

The meters used for recording the power / high pressure steam / medium pressure steam / hot water generated will be of integrator type. The records of the quantity of different output energy streams generation and the quantity of sulphuric acid will be recorded on a daily basis. The data will be captured and stored electronically. As a separate measure the quantity of sulphuric acid produced, power produced and the ratio of the power produced to the quantity of acid produced will be entered in the respective logbooks on a daily basis.

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Appendix

List of Stake Holders who participated in the Stakeholder Consultation Meeting

Proceedings

Meeting with Stake Holders for Corporate Social Responsibility (CSR) / Clean Development Mechanism (CDM) for Enhanced Waste Heat Recovery in Sulphuric Acid Plant at Aarti Industries Limited, Vapi, Gujarat

Venue:
Aarti Industries Limited's process plant at Vapi, Gujarat

Date:
26th July 2006

Agenda:

- To discuss general environmental and social concerns
- To discuss initiatives being undertaken by Aarti Industries 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 Aarti Industries
- Introduction to CSR initiatives – by Deloitte
- Introduction to climate change / CDM - by Deloitte
- Introduction to sulphuric acid plant technology being used by Aarti Industries Limited – by Aarti Industries
- Introduction to the proposed CDM project - by Deloitte
- Comments / suggestions / issues
- Response to questions / suggestions / issues

In Attendance:

Name	Organisation	Address	Phone Number	Signature
J. T. Modi	Bank of Baroda	III Phase, Vapi.	2420939	[illegible]
D. B. Dev	Regional Officer	GPCB, Vapi	98251 36574	[illegible]
H. R. Patel.	Notified Area - GIDC-Vapi		9879110034	[illegible]
A J Shah	EE GIDC Vapi		9879110089	[illegible]
Lalit Arora	Valson Industries Ltd	1204 III rd Phase VIA	9377680008	[illegible]
Kambhaila	Mamta Steels	2nd Phase Plot No 238 GIDC	98251 14458	[illegible]

Name	Organisation	Address	Phone Number	Signature
Babu	Aarti Industries	Phase III G.I.D.C	9925007385	[illegible]
Dinesh	Deloitte	N. Delhi	9910045759	[illegible]
J.N Sanghvi	Aarti Ind.	GIDC · VAPI	93779-60172	[illegible]
T.R. Patel	— do —	— do —	9377804589	[illegible]
Vijay Schroff	Alchemi Aarti.	III phase vapi-GIDC.	09377804587	[illegible]
Jitesh G. Bera	Alchemie Org.	III[rd] phase, GIDC	09998101990	[illegible]
H.K. Dedhia.	Aarti Industries Ltd.	Mumbai	9820077580	[illegible]
D.S. Karani	Aarti Ind. Ltd.	Mumbai	022-65397302	[illegible]
R.V. Gogri	VC & MD Aarti Ind. Ltd.	Mumbai	25688909	[illegible]
Kirit Mehta	Director Aarti Ind. Ltd.	VAPI	9824107959	[illegible]
Rajib Kr. Debnath	Manager, Deloitte.	New Delhi	9810727-686	[illegible]

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