Monitoring Report for Gujarat Alkalies and Chemicals Limited: Fuel Switch Project

Project Registration Code	:	**0494**
Project Title	:	**"Switching of fuel from Naphtha to Natural gas in the Captive Power Plant (CCP) at Dahej complex of Gujarat Alkalies and Chemicals Limited."**
Date of Registration	:	29 September 2006
Second Monitoring Period	:	01 October 2006 to 30 September 2007
Date of the 2nd monitoring report	:	30 June 2008
Monitoring Report Version	:	Version 06
Relevant project details	:	**Commencement of crediting period** : 01 January 2003 **First Monitoring period** : 01 January 2003 to 30 September 2006
Reference	:	The project is categorised under sectoral scope 4 "Manufacturing Industries" Approved baseline methodology methodologyAM0008, "Industrial fuel switching from coal and petroleum fuels to natural gas without extension of capacity and lifetime of the facility", applied to this project, has its sectoral scope 4. Project Design Document: Switching of fuel from naphtha to natural gas in the captive power plant (CPP) at Dahej complex of Gujarat Alkalies and Chemicals Limited. Version 2, dated 30/12/05.
General Project Description	:	**Project Activity:** Gujarat Alkalies and Chemicals Limited (GACL) is a Company promoted by Government of Gujarat through Gujarat Industrial Investment Corporation Ltd. GACL is the largest manufacturer of Caustic Soda and Chlorine (chlor-alkali) in the Country. It also manufactures other basic chemicals like Sodium Cyanide, Sodium Ferrocyanide, Chloromethanes, Hydrochloric Acid, Caustic Potash, Potassium Carbonate, Phosphoric Acid (85%), Hydrogen Peroxide.

The objective of project activity is to switch the fuel from Naphtha to Natural Gas (NG) in the captive power plant for generation of electricity and reduce GHG emissions into the atmosphere associated with the electricity generation due to use of less GHG intensive fossil fuel.

The total electricity generation at the power plant meets all electricity requirements of the Dahej complex, and wheels required quantity of power to GACL complex at Vadodara. The surplus electricity is sold to the Gujarat Electricity Board (GEB). Naphtha was the major fuel used for power generation till the year 2001, before the fuel switch.

Technology employed

The Captive Co- Generation Combined Cycle Power Plant (CCP) at Dahej, consists of 2 nos. of Frame–VI, Mark–V controlled, GE designed Gas Turbines equipped with dual fuel firing facility (Liquid / Natural Gas) having rated capacity of 39.2MW at ISO conditions. These Gas Turbines are provided with dedicated dual pressure waste heat recovery steam generating units designed & engineered by L&T, Hazira, having Steam Generation at 84 bar, 514^{o}C and 15 bar pressure saturated steam. The HP steam is utilized for generation of power through an extraction cum condensing sliding pressure Steam Turbine having rated capacity of 35.2MW. GACL has entered in to the contract with Gujarat State Petronet Limited (GSPL) and Gas Authority of India Limited (GAIL) for supply of NG. These NG is sourced from Gujarat State Petroleum Corporation Ltd. (GSPC)-Hazira, Petronet-RLNG, GGS-Dahej and GGS- Jolwa.

Project Location

The project activity has been carried out in the chemical complex of Gujarat Alkalies and Chemicals Limited located at Dahej. It lies on Latitude – 21^{o} 40’ N, and Longitude – 72^{o} 32’E. Dahej is at a distance of 45km from the city of Bharuch and at a distance of 108 kms from Vadodara and connected to them by road. The nearest railway station is at Bharuch and the nearest airport is at Vadodara.

Major observation made by DOE during first verification audit

1. The project generating less than 90 MW instead of installed capacity of 113 MW was verified and it was found that the project on an average produces approx 90 MW depending upon operating conditions, availability of natural gas and weather.
2. DOE had sought information regarding annual heat rate. It was explained that AM0008 mandates measurement of the heat rate once before and once after the fuel switch.
3. Information regarding calibration requirements of monitoring equipments was checked and was found to be in order.

4. Clarification on training of the project personnel was sought. Further information was provided by GACL on the reporting requirements, data management and internal auditing to the satisfaction of the DOE.
5. DOE sought clarification on monitoring requirements, monitoring information maintenance, which was shared by GACL and was found to be in order.
6. DOE verified the records relating to monthly consumption of natural gas.
7. DOE verified the information regarding NCV and total heat content of natural gas.
8. DOE verified the information regarding plant load factor measurement; reporting of load factor prior to fuel switch and disparity between load factor and natural gas consumption and was satisfied with the information provided.

Project Performance during 2nd monitoring period

During the second monitoring period no major shut down of the power plant due to any nonconformity was reported.

The power plant was shut down for major maintenance, after 6 years from commissioning, as per the maintenance and operation guidelines of the turbine manufacturer GE, for a period of 10 days in the month of January 2007. In the month of April 2007, the power plant was shut down annual maintenance for 4 days.

Further, in the month of August 2007 Natural Gas from RLNG terminal was not available; however, this did not effect the normal operation of the power plant.

QA/QC findings during the 2nd monitoring period:

No data mismatch was recorded during the monitoring period.

Adequate care was taken for continuous and correct recording the monitoring data and maintenance of necessary records.

The CDM team was enhanced and the new team members were trained for maintenance of records for the 12 year requisite period (crediting period + 2years).

Monitoring Parameters : Approved monitoring methodology AM0008/ version 01 is applied to this project. As per the requirements of AM0008 version 01, the data collected in order to monitor the GHG reduction is given in the table below:

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Comment
1. **Q_NGy**	Quantity of NG used in the unit process (i.e. power generation) as heat	Power plant records	Joules or Kcal	M	Monthly	Power Plant of GACL receives NG from 04 nos. of sources, i.e. GSPL, GAIL (RLNG), GGS-JOLWA and GGS-DAHEJ. The physical quantity is measured by individual Flow meter located at the battery limit of supplier end as mentioned below. The following volume flow measurements are carried out by following metering equipment: Source 1:Flow meter Sr No 71095 & 71096(Gas Source: GSPL:- At Dahej (GACL Premises)) Source 2: Flow meter Sr No 30611 & 30612 (Gas Source: GAIL(RLNG):-At Dahej (GACL Premises)) Source 3: Flow meter Sr No 97A-17181(Gas Source: GGS(Dahej):- At GGS-Dahej, ONGC) but part of the gas is used at the process, therefore gas used at the power plant is again measured at Flow meter Sr No 97A-17181) Source 4: Flow meter Sr No 03-1077331 (GGS (Jolwa):- At GGS-Jolwa, ONGC.) The physical quantity of NG recorded in the flow meters (source 1 , source 2 and source 4) are intimated by the control room of NG supplier to the control room engineer (executive –power plant) of GACL Power Plant at every day at 05:00 hrs by telephone. The same is recorded in the daily report of the Power Plant. Every fortnight gas supplier also supply a gas invoice as per the consumption figure recorded in the gas skid. The data in the emission reduction calculation sheet was taken from the same recorded figure. The physical quantity of the NG for source 3 is measured by the flow meter Sr no 97A-17181. *The calorific value of the NG is taken from the gas supplier*

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Comment
						invoices All these data are read by online measurement and analysis instruments. *Finally the decisive values are taken from fortnightly invoices.*
2a **$\eta_{p_}$NG**	Fuel efficiencies for NG used for combustion	Power plant records	%	C	once	Efficiency (project activity) indicated by the the Larsen & Tourbo (L&T) (EPC contractor) is a function of load factor after the fuel switch. The value taken is a calculated value provided by EPC contractor. The graphical representation is enclosed with the Monitoring report. Please refer attachment: graphs
2b **NCV_NG**	Net Calorific Value of NG	Power plant record	kCal/sm^3	M	Every Fortnight	Available in the invoice of individual NG supplier.
3. L_Factor_n	Load factor of the power plant		-	M	Once after fuel switch	
4 $Q_{\_naphtha,y}$	Quantity of Naphtha used at CPP	Records of Dahej complex	Joules or Kcal	C	Monthly.	The Records to be kept for life time of the project.
5a $\eta_{p\_}F_{naphtha,,y}$	Efficiency of Naphtha in power generation	Power plant records	%	C	Before fuel switch to NG	Efficiency (before fuel switch) indicated by the the Larsen & Tourbo (L&T) (EPC contractor) is a function of load factor. The value taken is a calculated value provided by EPC contractor. The graphical representation is enclosed with the Monitoring report. Please refer attachment: graphs
5b NCV_N	Net Calorific Value of Naphtha	Power plant record	kCal/kg	M	Before fuel switch to NG	Value of NCV of Naphtha applied is **10593 kcal/kg**. The fuel supplier (Indian Oil Corporation Limited, "IOCL") in its invoice gives the density of Naphtha at 15^0 C, which can be correlated to the NCV of naphtha using IS 1448 (Part-I) -1900 document which was provided by IOCL. It is a standard practice to estimate the NCV of Naphtha using IS 1448 standards and these correlations are also available in BIS. The invoices and the as an evidence of density of naphtha and the IS 1448 standards are enclosed with the

[1] References: IS 1448 part 1; IS 1448 part 2; Naphtha Challans shared with DOE

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Comment
						response.[1]
6 L_Factor	Load factor of operation pattern at power generation process	Power plant records	%	M	Once before fuel switch to NG	
7 $Q\_TF_{k,y}$	Quantity of Calories used for transportation mode i.e. tankers in the baseline scenario		Joules or Kcal	e	Yearly	Natural gas is being transported to Dahej Complex using pipeline. The transportation of Naphtha using Tankers in the baseline contributed to project leakage. The emissions associated with generation and transportation of naphtha as compared to that from NG has been calculated using the 1996 IPCC default values. There were two locations from which naphtha was being transported to Dahej complex, Hazira and Mumbai, out of which. 4/5th or 80% (28 tankers per day) of the naphtha was transported from Hazira and remaining 1/5 or 20% was from Mumbai (7 tankers per day). Thus the emission associated with fuel used in transporting naphtha is apportioned in the same ratio taking the distance into consideration.
8. L_Reg_y	Local regulation or constraints in using naphtha and other petroleum fuel	Legal documents or laws	-	checked	Yearly	There are/were no regulation in India and in the state of Gujarat, which constraint the facility from using naphtha or petroleum fuels. There are also no environmental regulations in India and Gujarat state preventing the use of naphtha/petroleum fuel/ coal or promoting the use of NG for power generation. The "Consent to Operate" provided by Gujarat Pollution Control Board (GPCB) allows use of petroleum fuel /NG for electricity generation at the project site.

Fuel efficiency of power plant: The fuel efficiency of the power plant has been measured as a pattern of load factors both prior (with Naphtha as fuel) and post fuel switch (with Natural Gas as fuel). Please refer the excel sheet in form of

Attachment 4 to our response to Request for review, that provides the heat rate of the power plant for naphtha and natural gas as fuel.

The summary of the fuel efficiency values are presented in the table below:

Capacity (MW)	**90**	**87.5**	**72**	**63**
% load	100	97.22%	80.00%	70.00%
Heat rate for naphtha (kCal/kWh)	1966	1979	2083	2166
Efficiency for naphtha ($\eta_{naphtha}$)	43.74%	43.46%	41.29%	39.70%
Heat rate for NG (kCal/kWh)	1956	1969	2071	2154
Efficiency for NG (η_{NG})	43.97%	43.68%	41.53%	39.93%
Ratio of efficiency of NG to naphtha	1.00503	1.00506	1.00581	1.00555

It can be seen from the above data that the key ratio of the efficiency on natural gas firing versus naphtha firing, which would determine the baseline naphtha consumption, is almost constant over the range of operating patterns tested. Further, the lower this ratio, the more conservative the baseline scenario (because lower ratio gives lower naphtha consumption in baseline scenario). It can be seen from the above data that the ratio is marginally increasing as the load decreases. Thus, a single value at the conservative end of the load pattern, i.e., at [insert load] level was selected to calculate the baseline emissions conservatively.

Further, for the monitoring period, the summary of operating pattern is as follows:

Plant Load	Operation type	No of days	$\eta_{Naphtha}$	η_{NG}
80-100%	Normal	339	0.434562911	0.436769934
70-80%	Part-load	7	0.412866059	0.415258329
< 70%	Shutdown, start-	19	0.397045245	0.399257196

The emission reduction calculations have been performed using the efficiency value during normal operating conditions (336 days) and is representative of the operating efficiency for whole monitoring period (366 days). This information has been shared with the DOE at the time of validation, initial verification and second periodic verification. All documentary evidence graphs between load and heat rate, the PG test conducted by the O&M supplier and heat rate calculations was also provided to the DOE.

Quantity of Natural gas consumed: The quantity of natural gas used in the project activity has been monitored as per the operation patterns. As mentioned in the paragraph above, the fuel efficiency of the power plant has been measured as a pattern of load factors both prior (with Naphtha as fuel) and post fuel switch (with Natural Gas as fuel).

The emission reduction calculations have been performed using the efficiency value during normal operating conditions (336 days) and is a representative of the operating efficiency for whole monitoring period (366 days).

Attached to the response for Request for Review is the revised emission reduction calculation excel sheet (refer **Attachment 5)** wherein the baseline and project emissions have been calculated based on the above identified range of fuel efficiency values.

QA/QC Measures in Monitoring :

The project is operated and managed by GACL who is also the project proponent. In order to implement a precise and representative monitoring plan GACL has established a continual registration of each monitoring parameter as part of its Quality management system.

The site has ISO 9001:2000, ISO14001:2004, OHSAS-18001:2000 Quality Management system in place. Accordingly, the monitoring plan proposed herein has become an integral part of the project Management Programmes and would be constituent of operational and management structure of this Quality Management System (QMS).

In order to monitor and control the project performance, GACL has constituted a project management team. This team is coordinated by Power Plant In-charge (Operation) who is responsible for checking the consistency of all information. The project proponent has well diversified procedure for collection of data and analysis of data at different levels and for subsequent corrective actions as when required in line with these policies.

Regular inspection is carried out and record of daily check list of critical parameters of project activity is maintained. The maintenance staff assesses the condition of all the power plant equipment and measuring equipment and take requisite action as per the monitoring plan.

The power plant engineers are responsible for managing the computer system, which are utilised to store the data. The daily data is recorded in the 5:00 hrs report. These data is then inserted to excel files manually. Every fortnight gas supplier also supply a gas invoice as per the consumption figure recorded in the gas skid. The Gas invoices are kept under the custody of Managers, Offsite & Utility. The invoices are also sent to Deputy General Manager Power Plant.

The Instrumentation and the control system for the project activity are designed with adequate instruments to control and monitoring the various operating parameters for safe and efficient operations. All the instruments are of reputed make and are calibrated at regular intervals.

Operational and Management Structure: All relevant functions and tasks are sufficiently described in the manual and the standard operating procedures of the quality management system. The operational and management structure that the project proponent is implementing to monitor emission reduction is elaborated in the PDD and followed at the site.

QC/QA procedures being undertaken for data monitored:

The QA & QC procedures are equivalent to applicable National and International Standards as well as standards given by the technology supplier and NG supplier. The QA & QC procedures are set and implemented in order to:

- Secure a good consistency through planning to implementation of the CDM project activity,
- Assign the responsibility as per the requirements and,
- Avoid any misunderstanding between people and organization involved.

Data	Uncertainty level of data (High/Medium/Low)	Explain QA/QC Procedures planned for this data,or why such procedures are not necessary.
1-6	Low	These data will be directly used for calculation of emission reductions. The measurements and data recording will be as per the procedures under ISO-9001 certified quality management system of the unit.
7	Low	These data will have minor effect on the emission, as it is used to determine the leakage, hence no QA/QC is required.

Calibration/Maintenance of Measuring and Analytical Instruments

Important measuring instruments are being calibrated as per ISO 9001 procedures. The maintenance methods and procedures have been incorporated as part of the ISO 9001 procedures and form an integral part of the systems and procedures for the organization.

The calibration records for the 2nd monitoring period are presented in the table below:

Serial No.	Gas Source	Location	Calibration frequency	Last Calibrated on
Flow meter Sr No 71095 & 71096	GSPL	At Dahej (GACL Premises))	Flow Meters:-Complete physical calibration every 06 years as per manufacturer's recommendation. Pressure	Sr.no:-71095 Dt:-02/03/2007 Sr.no:-71096 Dt:-16/04/2007

Serial No.	Gas Source	Location	Calibration frequency	Last Calibrated on
			Transmitter (PT) & Temperature Transmitter (TT) – annually.	
Flow meter Sr No 30611 & 30612	GAIL(RLNG)	At Dahej (GACL Premises))	Flow Meters:- Complete physical calibration every 06 years as per manufacturer's recommendation. Pressure Transmitter (PT) & Temperature Transmitter (TT) – annually.	Sr.no:-30611 Dt:- 26/08/2004 Sr.no:-30612 Dt:- 27/08/2007
Flow meter Sr No 97A-17181	GGS(Dahej)	At GGS-Dahej, ONGC) but part of the gas is used at the process, therefore gas used at the power plant is again measured at Flow meter Sr No 97A-17181)	Yearly	Dt:- 1/26/2007
Flow meter Sr No:- 03-1077331	GGS (Jolwa)	At GGS-Jolwa, ONGC.)	Yearly	Dt:- 5/21/2007

At source 1 (GSPL) and source 2 (GAIL-RLNG) the NG consumption is being measured by TRZ 03 make Turbine type flow meters. The gas flow meters for sources 1 and 2 are the property of gas suppliers, GSPL and GAIL-RLNG, respectively. The gas suppliers, calibrate these flow meters once in six years as per Indian Standard Organization's guideline and flow meter manufacturers' guidelines (evidence against this was provided to verifier).

GACL has in its control the Pressure and temperature transmitters for the gas flow meters, which in turn measure the pressure and of the gas and transmit the data to flow meter. The flow meter performs flow calculation based on the pressure and temperature data obtained from these transmitters. Therefore, the calibration of pressure and temperature transmitters is in fact true representation of calibration of the flow measurement system. This is the reason that GACL chose to calibrate transmitters once in a year and the calibration records are verified by the DOE

These meters measure the quantity of gas flowing through them in units of volume at prevailing pressure and temperature. Therefore, the units of volume are determined at flowing conditions. The volume of the gas flowing through is indicated by a mechanical totalizer in cubic meters at flowing conditions.

To maintain the accuracy of the monitoring system and to ensure that the quantity of fuel supplied the Pressure Transmitter (PT) and Temperature Transmitter (TT) of the flow meters in consideration are calibrated on an annual basis. This ensures that the flow meters are working within the permissible error limits. The yearly calibration records of the pressure and temperature transmitter along with the flow meter manual and other literature was shared with the DOE during the verification process.

During the six yearly calibration, these flow meter are physically checked for any deviation. The flow meters are sent to a nationally accredited laboratory where they are tested for any deviation. This is in accordance with ISO guidelines followed by gas suppliers; GSPL and GAIL (refer attachment 1 and 2). There is a provision of standby meters which record the quantity of natural gas consumed when the flow meters are sent for the purpose of calibration. These standby meters are also in custody of the Gas suppliers with GACL having no control on their operations and maintenance.

These meters have obtained following approvals

- EU approval No. D 81.7.21100.10
- German approval No. 7.211/93.06
- DVGW registration No. CE-0085BN0291

All the flow meters are property of the gas suppliers and are maintained by them in the line with manufacturers' calibration standards.

The quantity of natural gas from source 3 GGS (Dahej) and Source 4 GGS (Jolwa) is measured by Orifice type flow meters which are physically calibrated on an annual basis. The calibration records of these flow meters have been provided to the DOE at the time of verification.

Baseline Requirements **:**

The baseline for the project activity would have been to continue to generate power using naphtha at least up to the end of the crediting period without any retrofit. **Kindly refer section B.3 , B.2.1.4 of the registered PDD.**

In order to calculate the baseline emissions, the following steps have been adopted:

Step 1. Determine the equivalent amount of naphtha used corresponding to the energy generate during the monitoring period.

Step 2. The emission factors for CO_2, CH_4 and N_2O (that could be emitted from burning of fuels in the baseline scenario) that have been used for baseline calculation are default values as per 1996 IPCC guidelines that have been fixed ex-ante.

Step 3. Calculate the total equivalent CO_2 emissions.

The project emissions have been calculated for CO_2, CH_4 and N_2O for the fuel combustion using 1996 IPCC factors.

The leakages have been estimated due to generation of fuel using 1996 IPCC default factor associated with fugitive emission from use of natural gas in the project plant.

Load Factor of the power plant (L_Factor_n), as proposed under the monitoring plan, was measured once before fuel switch to natural gas for CPP at Dahej and the value was at **97%**.

Load Factor of the power plant (L_Factor_n), as proposed under the monitoring plan, was measured once after fuel switch to natural gas for the of CPP at Dahej during the first monitoring period and the value was at **97.22%**.

The baseline emission estimation for the 2nd monitoring period is presented below under GHG calculations.

GHG Calculations **:**

As suggested by the methodology (AM0008/Version 01), the GHG emission reduction, (ER_y), achieved by the project activity for a given year is

$ER_y = BE_y - PE_y - LE_y$

Baseline Emissions (BE_y)

The variables in the baseline emissions (Q_Fi,y) and the project emissions (Q_NGy) are linked with the constraint relation:

$(Q\_Ny) * \eta_{p\_F_{naphtha}} = Q\_NGy * \eta_{p\_NG}$

$BEy = Q\_Ny * (EF\_N\_CO_2 + FC\_N\_CH_4 * GWP\_CH_4 + FC\_N\_N_2O * GWP\_N_2O)$

Where,

Q_Ny, = Quantity of naphtha used in the baseline scenario during any year 'y' in the power plant, measured in energy units (e.g., Joule). **This value is 6472.83 TJ for the 2nd monitoring period. Refer Appendix 2 for details.**

The value of Quantity of Naphtha Used is derived by calculating the same from the quantity of Natural gas used, thus the quantity of naphtha used is monitored as per the methodology using the following formulae;

$$= \frac{Q\_NG \times FuelEfficiencyofNaturalGas}{FuelEfficiencyofNaphtha}$$

This value is used for calculation of baseline emission from the project activity.

$EF\_N\_CO_2$ = Equivalent emission factor per unit of energy of naphtha is 72.6 t CO_2/TJ

$EF\_N\_CO_2 = EF_{Na} \times OXID_{Na} \times 44/12 = 20.0$ tC/TJ$\times 0.99 \times 44/12 = 72.6$ tCO_2/TJ

Where

EF_{Na} = emission factor of Naphtha =20.0 tC/TJ (Source: Table 1-2, revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook)

$OXID_{Na}$ = oxidation factor = 0.99(Source: Table 1-4,revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook)}

$FC\_N\_CH_4$ = 1996 IPCC default CH_4 emission factor of Fuel i associated with fuel combustion, measured in t CH_4/TJ (CH_4 emission factors (in T/TJ) = 0.003)

$FC\_N\_N_2O$ = 1996 IPCC default N_2O emission factor of NG associated with fuel combustion, measured in t CH_4/TJ (N_2O emission factors (in T /TJ) = 0.0006)

GWP_CH_4 is the global warming potential set as 21 for the first commitment year

GWP_N_2O is the global warming potential set as 310 for the first commitment year

BE_y = 6472.831676 x (0.99*20*44/12 + 0.003*21+ 0.0006*310)

= 471539.3148 tCO2e

Project Emissions (PE_y)

Project emissions are estimated considering the different fuels and efficiencies in their use in both the baseline and project scenario. According to AM0008, the following formulae are used to estimate project emissions:

PEy= (Q_NGy)*(EF_NG + FC_NG_CH_4* GWP_CH_4 + FC_NG_N_2O* GWP_N_2O)

Where:

Q_NGy is quantity of NG used in project scenario for replacing Q_Naphtha used in the baseline scenario in power plant ,measured in energy units (e.g Joule or calories). **This value is 6439.9908 TJ for the 2nd monitoring period. Refer Appendix 1 for details of quantity of natural gas and the associated calorific values.**

EF_NG is the 1996 IPCC default CH_4 emission factor of NG associated with fuel combustion

EF_NG = $EF_{NG} \times OXID_{NG} \times 44/12 = 15.3$ tC/TJ$\times 0.995 \times 44/12 = 55.8195$ tCO_2/TJ

Where

EF_{NG}, emission factor of NG =15.3 tC/TJ (Source: Table 1-2,revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook)

$OXID_{NG}$, oxidation factor = 0.995(Source: Table 1-4,revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook)}

FC_NG_CH_4, 1996 IPCC default CH_4 emission factor of NG associated with fuel combustion, measured in t CH_4/TJ (CH_4 default emission factor (in T/TJ)=0.001)

FC_NG_N_2O = Are 1996 IPCC default N_2O emission factor of NG associated with fuel combustion, measured in t CH_4/TJ (N_2O default emission factor (in T /TJ)= 0.0001)

GWP_CH_4 is the global warming potential set as 21 for the first commitment *period.*

GWP_N_2O is the global warming potential set as 310 for the first commitment *period.*

PE_y = **6439.990819 × [55.8195 + (0.001 × 21) + (0.0001 × 310)]**

= **359811.947 t CO_2e**

Leakage Emissions (LE_y)

The leakage emission due to fuel generation and transportation is expressed as:

LEy = [Q_NGy * FE_NG_CH_4 - Q_Ny * FE_N_CH_4] * GWP_CH_4 + [Q_TFng * EF_NG_TF) - (Q_TF_N * EF_N_TF)]

where:

FE_NG_CH_4, 1996 IPCC default CH_4 fugitive emission factor of NG, measured in tCH_4/Joule. (0.096 T/TJ) + Gas transportation (0.118 T/TJ)= FE_NG_CH_4a + FE_NG_CH_4b

FE_NG_CH_4a = IPCC default CH_4 fugitive emission factor of NG , as presented in the "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories – Volume 3 – Reference Manual, Section 1.8.5, Table 1-58, Fugitive and Other Maintenance Emissions from Gas Production" (0.096 t/TJ)

FE_NG_CH_4b = IPCC default CH_4 fugitive emission factor of NG, as presented in the "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories – Volume 3 – Reference Manual, Section 1.8.5, Table 1-58, NG processing, transport and distribution" (0.118 t/TJ)

FE_N_ CH_4 = 1996 IPCC default CH_4 fugitive emission factor of naphtha, measured in tCH_4/Joule (0.005T/TJ)

EF _N_TF = 1996 IPCC default CO_2 emission factor of naphtha transportation (e.g. tankers), measured in tCO_2/Joule. (Actual calculation)

EF_NG_TF = 1996 IPCC default CO_2 emission factor of NG transportation (e.g., through pipeline), measured in tCO_2/Joule (negligible)

LEy = 28285.236+ (-2050.869) = 26234.367 tCO2e

Refer Appendix 3 for the detailed annual leakage emission calculations.

Calculation of Emission Reductions (ER_y)

ER_y = BE_y –PE_y- LE_y

= 471539.3148 – 359811.947 – 26234.367

= 85493.0008 tCO2e

= 85493 tCO2e

Refer Appendix 2 for the detailed annual baseline emissions; project emissions; and emission reduction calculations.

Appendix 1
Details Of Gas Consumption (kCal)
Period: 01 October 2006 to 30 September 2007

Date	Source 1 GSPLkcal	Source 2 RLNG kcal	Source 3 GGS Dahej kcal	Source 4 GGS JOLWA kcal	TJ
1-Oct-06	1652646903	2367546151	136,024,411.35	248,936,740.00	18.44
2-Oct-06	1679449340	2348079266	155,414,542.48	242,464,552.00	18.52
3-Oct-06	1679297155	2327208854	140,456,161.80	235,900,382.00	18.35
4-Oct-06	1673201270	2312933928	161,509,422.25	243,936,264.00	18.38
5-Oct-06	1653442860	2388512551	171,762,125.29	243,752,300.00	18.66
6-Oct-06	1696490207	2396091272	199,458,119.86	233,726,206.00	18.94
7-Oct-06	1666831002	2377646695	206,384,564.28	271,228,398.00	18.93
8-Oct-06	1680172531	2355239543	162,888,841.26	256,100,054.00	18.65
9-Oct-06	1723879704	2340733923	156,246,107.14	246,548,400.00	18.70
10-Oct-06	1696796705	2411127874	176,193,875.74	248,041,108.00	18.97
11-Oct-06	1655008389	2407032880	180,067,988.73	254,330,608.00	18.82
12-Oct-06	1652749802	2390570389	163,446,478.74	263,093,978.00	18.71
13-Oct-06	1689076828	2402408417	177,857,005.05	215,017,040.00	18.77
14-Oct-06	1713943178	2420192226	198,910,265.50	165,036,480.00	18.83
15-Oct-06	1665955956	2387769234	176,467,802.93	279,966,610.00	18.88
16-Oct-06	1620942591	2390534390	167,604,302.01	239,722,196.00	18.50
17-Oct-06	1658560005	2404472992	132,140,515.25	247,890,160.00	18.60
18-Oct-06	1630480910	2401622094	144,887,912.26	226,094,946.00	18.43
19-Oct-06	1732849226	2350931190	183,394,247.35	275,572,346.00	19.02
20-Oct-06	1642512059	2379136540	186,994,433.15	282,837,432.00	18.80
21-Oct-06	1623147904	2397316319	193,920,877.57	281,122,848.00	18.82
22-Oct-06	1681236789	2390526306	229,932,518.69	260,771,856.00	19.10
23-Oct-06	1640334653	2397059865	198,078,700.84	288,429,216.00	18.94
24-Oct-06	1622885856	2476234368	180,899,553.38	290,479,824.00	19.13
25-Oct-06	1638024934	2409943446	174,804,673.62	252,267,864.00	18.73
26-Oct-06	1747094943	2429382453	216,363,340.14	75,760,488.00	18.71
27-Oct-06	1810717625	2436082918	229,100,954.04	13,664,976.00	18.79

Date	Source 1 GSPLkcal	Source 2 RLNG kcal	Source 3 GGS Dahej kcal	Source 4 GGS JOLWA kcal	TJ
28-Oct-06	1819958838	2417827735	231,595,648.00	11,157,720.00	18.76
29-Oct-06	1806323855	2412701320	245,722,464.02	12,062,400.00	18.74
30-Oct-06	1754587457	2463282873	202,784,378.48	12,717,216.00	18.56
31-Oct-06	1716371562	2479567727	187,825,997.80	110,034,936.00	18.81
Total for October 2007	**52324971037**	**7.43E+10**	**5,669,138,229.00**	**6,528,665,544.00**	**580.99**
1-Nov-06	1693570042	2396147840	129,332,642.77	196,444,800.00	18.48
2-Nov-06	1643673140	2383657548	113,398,185.91	163,075,032.00	18.02
3-Nov-06	1771768010	2405230964	10,091,510.05	167,392,946.00	18.23
4-Nov-06	1722987723	2383151238	28,417,542.25	165,740,904.00	18.00
5-Nov-06	1765855753	2373219810	21,514,799.31	163,669,562.00	18.10
6-Nov-06	1741690039	2384144720	31,071,721.94	168,055,440.00	18.10
7-Nov-06	1672608162	2348064541	201,304,992.34	198,865,604.00	18.51
8-Nov-06	1539574828	2402732402	128,807,434.07	266,557,396.00	18.16
9-Nov-06	1730569299	2404067615	120,038,324.49	237,457,976.00	18.80
10-Nov-06	1651391636	2400512305	123,489,695.96	300,487,152.00	18.74
11-Nov-06	1612230810	2373886354	116,586,953.03	309,066,030.00	18.47
12-Nov-06	1628327482	2371638336	123,227,091.61	308,202,272.00	18.55
13-Nov-06	1800030285	2390070123	45,411,795.23	310,466,492.00	19.03
14-Nov-06	1644612037	2394801379	153,239,017.42	296,034,186.00	18.79
15-Nov-06	1574220291	1975822351	177,933,205.12	298,776,408.00	16.86
16-Nov-06	1602641521	2395129351	173,215,705.53	299,589,850.00	18.71
17-Nov-06	1696350674	2410641153	177,407,996.42	322,270,020.00	19.28
18-Nov-06	1735661932	2396754281	155,096,005.33	316,691,352.00	19.27
19-Nov-06	1709579972	2385864211	189,356,494.38	315,355,248.00	19.26
20-Nov-06	1662078474	2376967741	219,893,628.89	306,679,248.00	19.11
21-Nov-06	48270535.4	2155268620	195,199,441.18	321,541,236.00	11.39
22-Nov-06	1042172583	2112374141	160,676,347.78	329,705,352.00	15.26
23-Nov-06	1649692400	2393769308	160,141,760.35	320,881,860.00	18.94
24-Nov-06	1685970928	2395118018	154,298,813.55	313,142,868.00	19.04
25-Nov-06	1760312395	2383440992	186,167,727.26	308,188,872.00	19.42
26-Nov-06	1728168483	2375037950	226,271,163.12	323,597,448.00	19.48
27-Nov-06	1746689246	2382546541	171,293,066.53	285,804,792.00	19.20
28-Nov-06	1701504852	2399699154	101,984,275.38	325,905,264.00	18.96

Date	Source 1 GSPLkcal	Source 2 RLNG kcal	Source 3 GGS Dahej kcal	Source 4 GGS JOLWA kcal	TJ
29-Nov-06	1617513190	2394272667	208,742,322.70	327,189,312.00	19.04
30-Nov-06	1611338743	2425692111	180,681,172.08	316,084,032.00	18.98
Total for November 2007	**48191055464**	**7.08E+10**	**4,184,290,831.97**	**8,282,918,954.00**	**550.16**
1-Dec-06	1639801044	2393880963	180,131,211.76	297,881,784.00	18.89
2-Dec-06	1629897663	2390350342	163,020,351.08	316,081,208.00	18.83
3-Dec-06	1600612255	2306868120	160,887,392.17	243,738,740.00	18.05
4-Dec-06	1644898027	2381887257	189,484,142.23	203,883,032.00	18.50
5-Dec-06	1679790397	2413503383	221,280,330.66	149,544,744.00	18.69
6-Dec-06	1666427172	2407117622	163,558,309.75	281,569,528.00	18.92
7-Dec-06	1624721942	2425181610	184,406,567.46	282,793,284.00	18.91
8-Dec-06	1630988667	2417074160	160,349,433.50	257,737,100.00	18.70
9-Dec-06	1608827816	2412734561	182,802,129.34	265,810,368.00	18.71
10-Dec-06	1648488469	2439872573	173,439,761.01	258,952,052.00	18.92
11-Dec-06	1710722935	2375352798	176,658,075.12	285,874,684.00	19.04
12-Dec-06	1666828824	2406597104	212,729,619.26	287,204,088.00	19.14
13-Dec-06	1592809863	2402876948	197,496,894.97	302,338,164.00	18.82
14-Dec-06	1617446495	2208544061	166,229,227.33	265,977,644.00	17.82
15-Dec-06	1615433900	2390367723	207,925,742.76	251,283,768.00	18.69
16-Dec-06	1607926062	2396512828	175,855,856.06	274,728,820.00	18.65
17-Dec-06	1633129363	2401148000	183,868,608.80	276,172,676.00	18.81
18-Dec-06	1616021398	2438899946	173,713,459.27	256,029,124.00	18.77
19-Dec-06	1577050509	2313538618	170,542,334.51	285,390,464.00	18.19
20-Dec-06	1602198545	2421098119	193,221,539.26	249,382,104.00	18.69
21-Dec-06	1685079041	2364125338	153,138,899.82	254,990,252.00	18.66
22-Dec-06	1674999095	2376988631	170,778,281.30	263,398,072.00	18.78
23-Dec-06	1629369569	2326975334	180,933,430.82	259,401,056.00	18.40
24-Dec-06	1647421399	2354570537	169,702,363.97	258,159,692.00	18.54
25-Dec-06	1657384243	2299727407	165,700,706.53	252,419,484.00	18.31
26-Dec-06	1646350987	2334595613	194,023,758.33	228,675,096.00	18.43
27-Dec-06	1650117147	2376121251	160,623,131.77	271,441,846.00	18.66
28-Dec-06	1633188054	2318304256	184,406,567.46	261,596,582.00	18.41
29-Dec-06	1604480973	2332437204	192,155,059.81	247,689,286.00	18.32
30-Dec-06	1644254893	2333197948	182,802,129.34	250,692,780.00	18.46

Date	Source 1 GSPLkcal	Source 2 RLNG kcal	Source 3 GGS Dahej kcal	Source 4 GGS JOLWA kcal	TJ
31-Dec-06	1700647209	2428206860	183,727,040.73	277,793,074.00	19.22
Total for December 2007	**50787313956**	**7.36E+10**	**5,575,592,356.19**	**8,118,630,596.00**	**577.96**
1-Jan-07	1672223948	2427155042	215,824,110.49	242,121,204.00	19.08
2-Jan-07	1637770126	2437423172	199,570,454.03	269,350,588.00	19.02
3-Jan-07	1651619083	2436797710	193,353,573.68	290,736,498.00	19.14
4-Jan-07	1657572095	2299399810	220,665,828.37	276,968,890.00	18.65
5-Jan-07	1717941782	2286270167	216,062,853.97	193,467,310.00	18.48
6-Jan-07	1776338263	2316632687	219,309,765.37	259,762,965.00	19.14
7-Jan-07	1725082271	2323738547	226,070,980.87	236,993,650.00	18.89
8-Jan-07	1629341793	2307066714	219,854,100.52	226,475,630.00	18.35
9-Jan-07	1656918981	2268255516	205,787,334.38	248,830,650.00	18.33
10-Jan-07	1680080970	2329948262	226,338,373.57	212,753,165.00	18.62
11-Jan-07	1630594805	2317962060	243,919,443.81	281,855,880.00	18.73
12-Jan-07	1643472123	2328491579	237,702,563.46	262,874,405.00	18.72
13-Jan-07	1639878245	2333305574	244,186,836.51	254,698,420.00	18.72
14-Jan-07	1600446198	2321916995	239,860,804.56	277,873,575.00	18.59
15-Jan-07	0	1215449554	242,840,323.26	241,145,055.00	7.11
16-Jan-07	191404776.6	897238088	242,295,988.11	290,657,535.00	6.79
17-Jan-07	225879149.6	913105267	220,121,493.22	239,783,800.00	6.69
18-Jan-07	286898256.3	671120120	237,425,621.02	221,563,275.00	5.93
19-Jan-07	271472763.2	672826142	235,267,379.91	283,795,700.00	6.13
20-Jan-07	270893416.9	322226263	239,326,019.16	255,250,068.00	4.55
21-Jan-07	269342551.4	322438168	235,802,165.32	293,563,552.00	4.69
22-Jan-07	299758650.9	314767440	196,867,877.78	246,734,068.00	4.43
23-Jan-07	23593849.21	315368272	231,753,075.81	260,512,956.00	3.48
24-Jan-07	45191090.1	318617458	228,506,164.41	174,790,900.00	3.21
25-Jan-07	122833136.2	828687423	223,903,190.02	232,290,932.00	5.89
26-Jan-07	341275768.4	823056845	234,990,437.47	225,801,740.00	6.80
27-Jan-07	1687158469	813038077	233,911,316.92	205,610,304.00	12.31
28-Jan-07	1714072016	1301270482	228,773,557.12	179,491,732.00	14.33
29-Jan-07	1666644493	1301978592	229,852,677.67	232,955,180.00	14.36
30-Jan-07	1688229182	1327879960	208,222,517.92	228,339,508.00	14.45
31-Jan-07	1688544193	1336695027	218,765,430.22	224,882,012.00	14.52

Date	Source 1 GSPLkcal	Source 2 RLNG kcal	Source 3 GGS Dahej kcal	Source 4 GGS JOLWA kcal	TJ
Total for January 2007	**34112472443**	**4.64E+10**	**6,997,132,258.92**	**7,571,931,147.00**	**398.14**
1-Feb-07	1677421300	2357397833	213,936,777.98	251,647,800.00	18.84
2-Feb-07	1734429724	2358601612	212,613,457.70	189,165,908.00	18.82
3-Feb-07	1723081813	2353755971	224,035,307.18	228,978,208.00	18.96
4-Feb-07	1661586003	2357402810	214,734,524.24	296,671,892.00	18.96
5-Feb-07	1573333430	2391470620	222,439,814.65	279,639,892.00	18.70
6-Feb-07	1587138607	2408466129	208,887,513.38	294,023,416.00	18.83
7-Feb-07	1764470055	2366678350	206,231,487.58	260,887,660.00	19.25
8-Feb-07	1638215681	2368610002	213,411,203.97	253,930,088.00	18.73
9-Feb-07	1672923760	2321546573	222,974,773.91	272,701,960.00	18.80
10-Feb-07	1733706501	2370116660	228,024,038.51	254,299,480.00	19.20
11-Feb-07	1627638630	2363404316	221,642,068.38	236,575,780.00	18.62
12-Feb-07	1821890645	2358035422	227,226,292.24	291,137,960.00	19.67
13-Feb-07	1761950774	2355684953	218,986,042.58	264,213,020.00	19.26
14-Feb-07	1791154922	2364424287	213,411,203.97	106,501,420.00	18.73
15-Feb-07	1757560316	2359879487	204,635,995.04	157,594,280.00	18.75
16-Feb-07	1738227603	2357260809	185,499,469.92	148,954,500.00	18.54
17-Feb-07	1708852509	2367308354	165,039,624.51	158,231,160.00	18.42
18-Feb-07	1719967651	2367508539	213,411,203.97	165,457,464.00	18.70
19-Feb-07	1730091146	2357839719	192,407,014.05	162,010,068.00	18.60
20-Feb-07	1737880487	2365832739	167,432,863.31	171,746,988.00	18.60
21-Feb-07	1620924253	2363335539	150,417,404.72	175,343,508.00	18.04
22-Feb-07	1679435413	2355721233	164,504,665.25	165,027,636.00	18.27
23-Feb-07	1607551885	2356097934	187,123,118.20	198,150,708.00	18.20
24-Feb-07	1652624269	2362297128	230,680,064.31	208,475,352.00	18.64
25-Feb-07	1596375301	2368831316	232,012,769.83	257,309,076.00	18.65
26-Feb-07	1650089610	2349120949	222,439,814.65	248,826,552.00	18.71
27-Feb-07	1639459586	2343565319	221,116,494.37	273,054,816.00	18.74
28-Feb-07	1483587336	2273090274	207,564,193.10	244,361,604.00	17.62
Total for February 2007	**47091569209**	**6.60E+10**	**5,792,839,201.47**	**6,214,918,196.00**	**523.85**
1-Mar-07	1554063643	2349079770	221,713,758.40	217,528,056.00	18.18
2-Mar-07	1758365335	2362497601	222,775,894.01	190,124,385.00	18.98
3-Mar-07	1601459345	2291712622	224,373,797.13	213,648,675.00	18.13

Date	Source 1 GSPLkcal	Source 2 RLNG kcal	Source 3 GGS Dahej kcal	Source 4 GGS JOLWA kcal	TJ
4-Mar-07	1575306556	1912936691	223,847,429.04	249,714,060.00	16.58
5-Mar-07	1701488931	2367601114	225,708,516.21	204,145,485.00	18.83
6-Mar-07	1820745191	2364269930	224,646,380.61	167,751,210.00	19.16
7-Mar-07	1738906464	2365298671	225,172,748.70	211,519,545.00	19.01
8-Mar-07	1728758058	2358719037	224,110,613.09	200,112,255.00	18.89
9-Mar-07	1706410069	2364234356	167,413,250.42	250,449,735.00	18.79
10-Mar-07	1705576552	2356955162	173,005,911.36	281,694,285.00	18.91
11-Mar-07	1725076536	2364247660	113,648,509.96	265,128,615.00	18.70
12-Mar-07	1678638613	2362003438	222,512,709.96	225,177,135.00	18.79
13-Mar-07	1772098188	2374101879	187,913,407.58	121,481,580.00	18.65
14-Mar-07	1691659981	2397927551	206,007,310.62	184,412,085.00	18.75
15-Mar-07	1727241868	2402751585	205,208,359.06	192,963,225.00	18.95
16-Mar-07	1676652576	2354707562	224,909,564.65	225,194,445.00	18.76
17-Mar-07	1724166881	2313757631	216,656,864.98	295,343,220.00	19.05
18-Mar-07	1696301684	2360187292	219,316,903.71	245,282,700.00	18.93
19-Mar-07	1645754923	2368197458	212,135,739.08	260,705,910.00	18.78
20-Mar-07	1687615566	2371750346	216,920,049.02	242,989,125.00	18.92
21-Mar-07	1655925571	2351437256	223,274,063.81	233,295,525.00	18.69
22-Mar-07	1772985002	2350243670	219,589,487.19	198,355,290.00	19.01
23-Mar-07	1760890293	2323853157	222,512,709.96	176,986,095.00	18.77
24-Mar-07	1610692112	2361315087	231,291,777.72	276,976,271.00	18.75
25-Mar-07	1599525324	2379721499	228,631,738.99	229,714,901.00	18.58
26-Mar-07	1655303341	2354503476	200,950,417.20	236,245,243.00	18.62
27-Mar-07	1693543231	2379315090	215,322,145.90	206,251,435.00	18.81
28-Mar-07	1742649072	2338686254	223,847,429.04	244,879,024.00	19.05
29-Mar-07	1725063486	2388642944	221,976,942.44	204,684,857.00	19.01
30-Mar-07	1714876751	2386981652	202,021,952.23	223,360,579.00	18.95
31-Mar-07	1666757694	2407076008	214,260,010.29	217,833,551.00	18.86
Total for March 2007	**52514498839**	**7.28E+10**	**6,561,676,392.37**	**6,893,948,502.00**	**580.83**
1-Apr-07	1719531917	2101832497	224,088,630.28	252,210,257.00	17.99
2-Apr-07	1720005091	2098167359	221,645,594.77	277,662,749.00	18.07
3-Apr-07	1718139179	2079989236	225,439,485.21	288,901,626.00	18.05
4-Apr-07	1698825979	2113163996	208,347,817.13	232,091,171.00	17.80

Date	Source 1 GSPLkcal	Source 2 RLNG kcal	Source 3 GGS Dahej kcal	Source 4 GGS JOLWA kcal	TJ
5-Apr-07	1741624942	2109660224	191,802,239.34	237,556,592.00	17.92
6-Apr-07	1716341950	2117295265	192,348,329.64	222,302,159.00	17.78
7-Apr-07	1702183043	2113724977	198,039,165.31	260,005,408.00	17.89
8-Apr-07	1752256746	2109581149	195,605,710.32	239,512,024.00	17.99
9-Apr-07	1713474963	2059180112	161,422,374.16	218,358,415.00	17.38
10-Apr-07	1678743099	2050043933	191,533,984.46	272,030,306.00	17.55
11-Apr-07	1775549530	2079299025	192,348,329.64	199,916,130.00	17.78
12-Apr-07	1788240745	2064864965	198,853,510.48	178,973,793.00	17.71
13-Apr-07	1755345904	2100046552	146,227,651.30	192,292,732.00	17.56
14-Apr-07	1753401999	2095686348	172,813,626.04	190,135,997.00	17.63
15-Apr-07	1739322593	2101947560	211,336,942.94	208,455,040.00	17.84
16-Apr-07	1709189786	2068283433	210,522,597.77	171,464,834.00	17.41
17-Apr-07	1731562995	2064524453	224,088,630.28	168,264,800.00	17.53
18-Apr-07	1687469352	2063394279	208,079,562.25	168,440,800.00	17.28
19-Apr-07	1701638026	2112052091	218,934,304.37	163,336,800.00	17.56
20-Apr-07	1746155051	2102323952	200,760,036.24	174,926,400.00	17.68
21-Apr-07	1740833044	2109536991	216,223,013.97	185,486,400.00	17.80
22-Apr-07	1740621017	2106225068	209,708,252.60	182,626,400.00	17.75
23-Apr-07	1735638758	2055414182	193,977,019.98	172,427,200.00	17.40
24-Apr-07	0	2032492036	79,757,924.20	19,291,792.00	8.92
25-Apr-07	0	0	-	21,879,286.00	0.09
26-Apr-07	0	0	-	25,091,651.00	0.11
27-Apr-07	1150108614	0	-	25,082,850.00	4.92
28-Apr-07	1561069950	1238614394	-	27,626,339.00	11.84
29-Apr-07	1715829195	2061584158	108,806,095.52	193,903,632.00	17.08
30-Apr-07	1702449870	2058545471	60,865,116.21	194,202,866.00	16.81
Total for April 2007	**45895553338**	**5.55E+10**	**4,863,575,944.42**	**5,364,456,449.00**	**467.12**
1-May-07	1722969088	2068982271	40,850,030.81	232,733,644.00	17.02
2-May-07	1695611863	2056592854	24,886,419.61	209,587,014.00	16.69
3-May-07	1705734572	2114048831	112,805,697.80	260,580,008.00	17.55
4-May-07	1701862917	2063482415	55,189,576.23	264,522,856.00	17.10
5-May-07	1716095128	2063001349	4,060,164.43	229,230,846.00	16.80
6-May-07	1708902986	2063965504	23,806,893.54	249,657,967.00	16.94

Date	Source 1 GSPLkcal	Source 2 RLNG kcal	Source 3 GGS Dahej kcal	Source 4 GGS JOLWA kcal	TJ
7-May-07	1635094470	2063275715	3,783,117.91	253,292,780.00	16.56
8-May-07	1716049745	2065963938	85,206,133.02	242,942,804.00	17.21
9-May-07	1716935040	2066217383	79,808,502.66	274,203,956.00	17.32
10-May-07	1692778307	2115516774	76,283,324.60	268,412,898.00	17.38
11-May-07	1661661850	2110558768	85,483,179.53	265,902,598.00	17.26
12-May-07	1698978270	2112074010	77,639,897.19	268,601,456.00	17.40
13-May-07	1704366094	2109194715	38,413,932.15	271,968,520.00	17.26
14-May-07	1703130650	2063018604	68,984,581.96	257,884,126.00	17.13
15-May-07	1695494176	2070809381	173,784,590.84	265,217,036.00	17.60
16-May-07	1705466070	2196355092	202,081,548.57	258,812,672.00	18.26
17-May-07	1703395601	2239812297	172,867,471.35	251,812,862.00	18.28
18-May-07	1659575152	2253493694	194,505,759.41	250,652,836.00	18.24
19-May-07	1673458560	2251482617	209,924,830.91	268,471,882.00	18.43
20-May-07	1688732364	2257919737	208,845,304.84	259,697,550.00	18.48
21-May-07	1724218948	2246350831	216,421,094.00	252,440,846.00	18.58
22-May-07	1619296666	2244754985	219,392,179.02	267,774,122.00	18.21
23-May-07	1676021591	2256519628	174,653,943.69	268,375,940.00	18.32
24-May-07	1747885559	2255591890	126,877,750.04	239,558,452.00	18.29
25-May-07	1797762852	2244581193	-	276,077,466.00	18.08
26-May-07	1723364126	2251430875	10,823,920.70	276,155,964.00	17.84
27-May-07	1726118038	2256101485	113,350,237.50	277,464,264.00	18.31
28-May-07	1707982457	2253881702	231,840,165.49	242,419,268.00	18.57
29-May-07	1638431995	2238381585	198,021,384.14	275,109,324.00	18.21
30-May-07	1695079313	2246215560	46,257,214.49	274,228,402.00	17.84
31-May-07	1607332913	2249794978	68,172,549.08	275,292,486.00	17.58
Total for May 2007	**52569787361**	**6.71E+10**	**3,345,021,395.52**	**8,029,082,845.00**	**548.76**
1-Jun-07	1641620291	2254962844	164,361,128.87	271,154,820.00	18.13
2-Jun-07	1691061825	2245760637	132,915,893.77	273,222,226.00	18.18
3-Jun-07	1702653466	2249949247	50,363,816.41	272,496,071.00	17.90
4-Jun-07	1642572051	2177677129	11,326,381.26	269,394,962.00	17.17
5-Jun-07	1735546667	2212570095	19,423,457.85	269,292,446.00	17.74
6-Jun-07	1703723376	2226184571	22,662,288.49	270,180,918.00	17.68
7-Jun-07	1700187682	2217198469	1,352,688.09	272,282,496.00	17.54

Date	Source 1 GSPLkcal	Source 2 RLNG kcal	Source 3 GGS Dahej kcal	Source 4 GGS JOLWA kcal	TJ
8-Jun-07	1573811841	2227558317	115,178,533.05	270,437,208.00	17.53
9-Jun-07	1718370285	2226373611	128,667,310.06	248,481,698.00	18.09
10-Jun-07	1701703564	2222156533	85,238,401.60	247,157,533.00	17.82
11-Jun-07	1589227768	2313992325	67,167,631.84	262,996,255.00	17.72
12-Jun-07	1559848964	2286557577	197,454,357.21	275,768,040.00	18.08
13-Jun-07	1740676304	2222339363	203,932,018.48	264,551,081.00	18.55
14-Jun-07	1743891407	2217408295	168,590,660.65	270,334,692.00	18.42
15-Jun-07	1660725041	2215026366	162,389,252.57	258,596,610.00	17.99
16-Jun-07	1747123403	2219596792	180,726,749.57	269,719,596.00	18.49
17-Jun-07	1746304055	2226871927	173,982,361.06	263,500,292.00	18.46
18-Jun-07	1714666918	2340844802	127,314,621.97	281,611,452.00	18.69
19-Jun-07	1708388759	2371076097	39,923,350.59	280,466,690.00	18.42
20-Jun-07	1682090111	2363204409	1,076,434.89	282,030,059.00	18.12
21-Jun-07	1625317512	2369508411	4,581,992.75	289,095,120.00	17.95
22-Jun-07	1600648734	2355746000	7,011,115.73	291,999,897.00	17.81
23-Jun-07	1629584196	2362784917	-	290,968,524.00	17.93
24-Jun-07	1777274644	2359509774	-	295,640,037.00	18.55
25-Jun-07	1765699724	2358096508	-	296,758,080.00	18.50
26-Jun-07	1604951689	2352055164	-	293,499,288.00	17.79
27-Jun-07	1668128436	2350404427	2,429,122.98	292,294,575.00	18.06
28-Jun-07	1674706548	2352561300	119,227,071.34	294,097,311.00	18.59
29-Jun-07	1658617209	2358301169	209,590,446.13	293,230,611.00	18.92
30-Jun-07	1662141922	2348572006	208,514,011.24	297,572,778.00	18.91
Total for June 2007	**50371264387**	**6.86E+10**	**2,605,401,098.45**	**8,308,831,366.00**	**543.72**
1-Jul-07	1639753915	2329428646	223,879,739.94	292,424,580.00	18.78
2-Jul-07	1450294508	2496277986	240,712,579.61	304,601,715.00	18.80
3-Jul-07	1492862408	2482455783	211,534,997.01	305,364,411.00	18.80
4-Jul-07	1570470776	2496289882	217,420,051.02	296,203,392.00	19.17
5-Jul-07	1641738470	2469768883	40,402,778.22	243,239,355.00	18.40
6-Jul-07	1666061351	2504102283	-	247,208,841.00	18.49
7-Jul-07	1688481448	2499762617	104,088,177.54	273,131,838.00	19.11
8-Jul-07	1769043331	2500415433	228,367,836.68	259,125,966.00	19.91
9-Jul-07	1864231411	2402064403	221,075,917.91	167,973,005.00	19.49

Date	Source 1 GSPLkcal	Source 2 RLNG kcal	Source 3 GGS Dahej kcal	Source 4 GGS JOLWA kcal	TJ
10-Jul-07	1659804830	2388851432	224,999,287.25	276,763,536.00	19.05
11-Jul-07	1734872352	2204543566	223,879,739.94	279,783,773.00	18.60
12-Jul-07	1705785866	2203787116	223,037,602.58	284,105,989.00	18.49
13-Jul-07	1767740702	2182123353	222,472,875.17	290,465,315.00	18.68
14-Jul-07	1791982355	2158695843	223,037,602.58	289,225,335.00	18.68
15-Jul-07	1768999416	2162427801	176,462,452.89	280,164,624.00	18.37
16-Jul-07	1837709082	2134450487	-	278,720,933.00	17.79
17-Jul-07	1832525108	2157980253	65,092,264.08	253,885,905.00	18.04
18-Jul-07	1680435091	2203071909	98,470,625.98	292,688,422.00	17.89
19-Jul-07	1689535821	2194086978	115,590,783.11	282,962,560.00	17.93
20-Jul-07	1705739896	2207793846	65,924,493.94	285,920,176.00	17.85
21-Jul-07	1680487477	2203854155	70,422,498.18	282,729,064.00	17.74
22-Jul-07	1796960521	2192880327	43,484,010.20	282,296,664.00	18.07
23-Jul-07	1873293245	2160775101	11,215,288.12	227,831,560.00	17.89
24-Jul-07	1731648783	2097931648	-	283,663,048.00	17.22
25-Jul-07	1790675334	2201532504	138,863,496.70	280,013,592.00	18.46
26-Jul-07	1744581426	2188007220	187,687,648.51	280,013,592.00	18.42
27-Jul-07	1791874783	2209083774	186,568,101.20	260,780,440.00	18.62
28-Jul-07	1755010941	2202341020	219,114,233.24	281,250,256.00	18.66
29-Jul-07	1852451151	2190668573	212,941,861.77	240,267,384.00	18.82
30-Jul-07	1683570699	2199574575	214,903,546.44	244,357,888.00	18.18
31-Jul-07	1346015672	2169984335	229,437,846.50	267,871,800.00	16.80
Total for July 2007	**53004638166**	**7.04E+10**	**4,641,088,336.29**	**8,415,034,959.00**	**571.20**
1-Aug-07	1425694889	2163526808	242,751,893.76	274,582,648.00	17.19
2-Aug-07	1537598592	2154466485	226,689,478.29	237,958,368.00	17.40
3-Aug-07	1481363362	2165398881	218,219,829.54	276,623,576.00	17.34
4-Aug-07	1464217037	2172040118	206,242,652.68	193,533,592.00	16.89
5-Aug-07	1666894432	2199987999	229,320,124.37	256,672,640.00	18.22
6-Aug-07	1667910698	2205700942	240,420,419.20	279,537,952.00	18.39
7-Aug-07	1657415268	1939352909	241,875,011.74	251,501,136.00	17.12
8-Aug-07	1609010847	2192075160	227,267,188.80	278,456,952.00	18.03
9-Aug-07	1646747706	2182800424	221,139,330.87	245,462,460.00	17.98
10-Aug-07	1653072354	2146012224	228,432,926.08	260,239,200.00	17.95

Date	Source 1 GSPLkcal	Source 2 RLNG kcal	Source 3 GGS Dahej kcal	Source 4 GGS JOLWA kcal	TJ
11-Aug-07	1630900162	2130779711	237,201,746.35	280,854,640.00	17.91
12-Aug-07	1670048317	2216370083	218,797,540.05	241,037,340.00	18.19
13-Aug-07	1695159234	2193327504	227,277,505.06	273,391,640.00	18.37
14-Aug-07	1682085761	2184823519	226,689,478.29	277,386,540.00	18.30
15-Aug-07	1695104863	2198704452	229,897,834.88	281,399,000.00	18.44
16-Aug-07	1662871249	2195124182	236,324,864.32	278,053,820.00	18.30
17-Aug-07	1633837138	2205944423	241,586,156.48	283,936,420.00	18.27
18-Aug-07	1646300885	2192314486	225,523,741.00	285,929,480.00	18.21
19-Aug-07	1658557051	2165149543	222,305,068.15	288,036,680.00	18.14
20-Aug-07	1601982382	2198375160	236,036,009.07	257,543,740.00	17.97
21-Aug-07	1661175326	2173247689	236,036,009.07	250,625,100.00	18.09
22-Aug-07	1675303632	2168790165	237,201,746.35	260,801,120.00	18.18
23-Aug-07	1638276037	2190849924	236,036,009.07	256,665,740.00	18.09
24-Aug-07	1645621505	2211381847	230,485,861.65	274,743,760.00	18.07
25-Aug-07	1655586366	2171254428	236,036,009.07	273,534,902.00	18.15
26-Aug-07	1636838804	2189509183	236,624,035.84	266,845,972.00	18.12
27-Aug-07	1641757377	2169888494	216,466,065.48	276,515,286.00	18.02
28-Aug-07	1650870183	2190440437	235,159,127.04	277,294,250.00	18.22
29-Aug-07	1689046031	2187764323	238,078,628.38	249,234,612.00	18.27
30-Aug-07	1550416281	1793689638	198,649,885.95	234,010,946.00	15.81
31-Aug-07	1503685124	2193274337	242,463,038.51	275,473,845.00	17.64
Total for August 2007	50335348894	6.70E+10	7,127,235,215.36	8,197,883,357.00	555.30
1-Sep-07	1647013013	2153959334	244,404,549.72	283,585,231.00	18.12
2-Sep-07	1610042313	2157727751	241,646,620.68	269,944,894.00	17.91
3-Sep-07	1634402293	2171665353	238,409,956.78	275,270,637.00	18.08
4-Sep-07	1635191053	2192412866	252,262,045.68	290,695,509.00	18.30
5-Sep-07	1660003505	2191202627	239,294,575.53	294,823,995.00	18.36
6-Sep-07	1662351720	2193224861	241,063,813.03	278,931,915.00	18.32
7-Sep-07	1633421848	2196061381	232,519,436.63	283,267,689.00	18.19
8-Sep-07	1693876052	2200830097	219,260,562.66	240,212,244.00	18.23
9-Sep-07	1680847851	2188421857	225,744,297.74	158,653,053.00	17.81
10-Sep-07	1632554128	2195785589	237,233,934.21	244,565,292.00	18.04
11-Sep-07	1646234597	2199646315	227,211,724.13	264,378,570.00	18.16

Date	Source 1 GSPLkcal	Source 2 RLNG kcal	Source 3 GGS Dahej kcal	Source 4 GGS JOLWA kcal	TJ
12-Sep-07	1669463314	2201339291	240,772,409.21	252,079,482.00	18.27
13-Sep-07	1593173858	2188259052	232,810,840.46	285,996,981.00	18.00
14-Sep-07	1675883072	2193015153	197,446,905.01	285,150,555.00	18.22
15-Sep-07	1678814635	2194319035	226,035,701.56	261,148,332.00	18.25
16-Sep-07	1653125993	2191878647	241,657,027.96	264,853,605.00	18.22
17-Sep-07	1637357309	2208132480	193,918,837.29	279,303,306.00	18.08
18-Sep-07	1651886859	2154419308	217,782,728.98	284,010,471.00	18.03
19-Sep-07	1652964409	2118179403	236,651,126.56	238,199,823.00	17.77
20-Sep-07	1613989868	2110854588	235,162,885.60	289,253,130.00	17.79
21-Sep-07	1566704352	2181537824	210,122,971.34	270,027,168.00	17.70
22-Sep-07	1585378044	2183324398	211,298,993.91	277,770,272.00	17.82
23-Sep-07	1637237541	2188673450	238,711,767.88	288,342,100.00	18.22
24-Sep-07	1586567852	2204200358	238,711,767.88	213,248,628.00	17.76
25-Sep-07	1612012236	2131702306	210,716,186.26	274,893,292.00	17.70
26-Sep-07	1615040603	2172929590	240,179,194.28	275,966,792.00	18.02
27-Sep-07	1630018020	2167873704	205,699,877.59	277,881,916.00	17.92
28-Sep-07	1642161124	2172741486	245,195,502.96	287,792,468.00	18.20
29-Sep-07	1646582814	2194620281	215,430,683.84	278,637,660.00	18.15
30-Sep-07	1684579347	2196015837	240,481,005.38	261,118,140.00	18.34
Total for September 2007	49168879623	6.54E+10	6,877,837,930.74	8,030,003,150.00	541.97
Total for period October 2006 to September 2007					**6439.9908185**

Appendix 2

Emission Reduction Calculations
Period: 01 October 2006 to 30 September 2007

Fuel	Heat rate (kcal/kwh)	Efficiency (Percentage)
Naphtha	1979.6	43.44
Natural gas	1969.4	43.67

Operating pattern		Q_NG TJ	Fuel Efficiency of Natural Gas	Fuel efficiency of Naphtha	Energy Content of Naphtha TJ
Normal		6,216.84	0.436769934	0.434562911	6248.409642
Part-load		107.87	0.415258329	0.412866059	108.4996822
Shutdown, start-up etc		115.28	0.399257196	0.397045245	115.9223526
		6439.990819			**6472.831676**

Baseline Emission (BEy) = **Q_N** ***(EF_N_CO2+FC_N_CH4*GWP_CH4+FC_N_N2O*GWP_N2O)**
= **471539.3148** **tCO2e**

where

EF_N_CO2	=	72.6	tCO2/TJ	(Equivalent emission factor per unit of energy of naphtha)
FC_NG_CH4	=	0.003	tCH4/TJ	(IPCC default CH4 emission factor of Fuel i associated with fuel combustion)
GWP_CH4	=	21		(global warming potential set as 21 for the first commitment year)
FC_NG_N2O	=	0.0006	tCH4/TJ	(IPCC default N2O emission factor of NG associated with fuel combustion)
GWP_N2O	=	310		(global warming potential set as 310 for the first commitment year)

Project Emission (PEy)	=	**Q_NG**	***(EF_NG+FC_NG_CH4*GWP_CH4+FC_NG_N2O*GWP_N2O)**	
	=	**359811.947**	**tCO2e**	
where				
EF_NG	=	55.8195	tCO2/TJ	(IPCC default CH4 emission factor of NG associated with fuel combustion)
FC_NG_CH4	=	0.001	tCH4/TJ	(IPCC default CH4 emission factor of NG associated with fuel combustion)
GWP_CH4	=	21		(global warming potential set as 21 for the first commitment year)
FC_NG_N2O	=	0.0001	tCH4/TJ	(PCC default N2O emission factor of NG associated with fuel combustion)
GWP_N2O	=	310		(global warming potential set as 310 for the first commitment year)
Leakage Emission (LEy)	=	**[Q_NG*FE_NG_CH4-Q_Ny*FE_N_CH4]*GWP_CH4 + [(Q_TFNG*EF_NG_TF) - (Q_TFN*EF_N_TF)]**		
	=	**26234.36701**	**tCO2e**	
Emission Reduction	=	**BEy- PEy- LEy**		
	=	**85493.0008**	**tCO2e**	
Round off figure for ER during the monitoring period	=	**85493.0000**	**tCO2e**	

Appendix 3

Leakage Emission Calculations
Period: 01 October 2006 to 30 September 2007

LEAKAGE DUE TO PRODUCTION

PERIOD : FROM 01/10/2006 TO 30/09/2007

YEAR	TOTAL TJ Of N. Gas	TOTAL TJ Of Equi. Naphtha	CH4 Emission on N. Gas Prod. (in MT)	CH4 Emission on Equi. Naphtha Prodn. (in MT)	Equivalent CO2 Emission on N. Gas Prod. (in MT)	Equivalent CO2 Emission on Equi. Naphtha Prodn. (in MT)	NET LEAKAGE Emission due to Prodn.
	(Sum of 'd' of Source - 1 to Source - 4)	(Sum of 'j' of Source - 1 to Source - 4)	(a)x EF_NG_CH4	(b)x EF_N_CH4	(c)x GWP_CH4	(d) x GWP_CH4	(e - f)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Oct 06 - Sept 07	6439.991	6248.410	618.239	31.242	12983.021	656.083	12326.938

Leakage of CH4 from Pipe line.

	TOTAL TJ Of N.Gas (Sum of 'd' of Source - 1 to Source - 4) (h)	IPCC Emission Factor (i)	Leakage (j = h x i)
Oct 06 - Sept 07	6439.991	2.478	15958.297

CO2 Emission due to Transportation of Naphtha

YEAR	TOTAL TJ Of NAPTHA (Sum of 'j' of Source - 1 to Source - 4)	Equi. Qty. Of Naptha In t (h)/ NCV_Naptha	Transportation Of Naphtha Hazira (L)x 80%	Transportation Of Naphtha Mumbai (l - m)	Total No of Tankers Hazira (m)/ CP_t	Total No of Tankers Mumbai (n)/ CP_t	Total Amount of Diesel Consumed in Ltrs. (o + p) x 2 x SFC_t	Energy Consumed During Transport. in TJ (q)x NCV_Diesel	Emission Due to Transportation Q_TFng x EF_NG_TF - (q) x $IPCC_t$)

	(k)	(L)	(m)	(n)	(o)	(p)	(q)	(r)	(s)
Oct 06 - Sept 07	6248.410	140913.08	112730.461	28182.615	9394	2349	826690.050	27.689	-2050.869

CO2 Emission due to transportation of N.Gas & RLNG is considered negligible quantity as location of N.Gas Pumping station is very near to the consumer point.

YEAR	NET Fugitive Emission due to Prodn (t = g + j)	Emission Due to Transp.	NET LEAKAGE (Fuel Gen. + Fuel Transp.) LEy (v = t + u)
Oct 06 - Sept 07	28285.236	-2050.869	26234.367

***LEy* = [*Q*_NG*y* * *FE*_NG_CH4 - *Q*_N*y* * *FE*_N_CH4] * *GWP*_CH4 + [(Q_TFng * EF_NG_TF - *Q*_TF*N* * *EF*_N_TF)]**

Q_NGy : Are quantity of natural gas used in the project scenario for replacing Q_naphtha (quantity of Naptha) used in the baseline scenario in the power plant, measured in energy units (i.e. Joule or Calories).

Q_Ny, : Quantity of naptha used in the baseline scenario during any year 'y' in the power plant, measured in energy units (e.g., Joule).

FE_NG_CH4 : IPCC default CH4 fugitive emission factor of **Natural Gas is 0.096 T/Tj**

FE_N_ CH4 : IPCC default CH4 fugitive emission factor of **Naphtha is 0.005 T/Tj.**

EF _N_TF : IPCC default CO2 emission factor of naptha transportation (e.g. through pipeline), measured in tCO2/Joule.

EF_NG_TF : IPCC default CO2 emission factor of NG transportation (e.g., through pipeline), measured in tCO2/Joule.

BEy : Base Line Emission on Naphtha

PEy : Project Emission On Natural Gas

LEy : Leakage Emission due to fuel generation and transportation.

NCV_Diesel : Net Calorific Value of Natural Gas after fuel switch is 10000 Kcal/Kg.

$IPCC_t$ **: IPCC Emission factor for tanker is 20.2 tCO2 / TJ**

SFC_t **: Specific fuel consumption of tanker is 0.2 ltr./km**

CP_t **: Capacity of tanker is consider 12 MT.**

: Distance travel by tanker from Hazira to Dahej is considered 120 km.

: Distance travel by tanker from Mumbai to Dahej is considered 400 km.

80% : 80% Naphtha was transported from Hazira and remaining from Mumbai

Naphtha is transported by tankers to the Dahej complex and NG is transported by pipeline. Thus, transportation leakage due to transportation of naphtha and generation of naphtha and NG has been calculated using the IPCC figures.