UNFCCC CDM Project Monitoring Report

Demand side energy efficiency programmes for specific technologies at ITC Bhadrachalam pulp and paper making facility in India.

(Project 0806)

Version 03

CDM registration number- 0806

Monitoring period - 01/01/2007 up to 31/12/2008

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I T C Limited

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Project background

The CDM project with Title – "***Demand side energy efficiency programmes for specific technologies at ITC Bhadrachalam pulp and paper making facility in India"*** has been registered as CDM project by the UNFCCC on 19th February 2007 under reference number (***Project 0806***). Further background on this project can be found in the PDD and associated documents, which are available on the UNFCCC website: http://cdm.unfccc.int/Projects/DB/DNV-CUK1166082720.69/view.html

Parties involved are India (Host Country) and the United Kingdom of Great Britain and Northern Ireland [other Parties]. Private entities involved are ITC Limited – Paperboards & Specialty Paper Division Unit Bhadrachalam, India and ABN AMRO BANK N.V., UK. Contact details of the entities have been provided in pervious page.

Project Location - All measures under the energy conservation programme have been implemented within the manufacturing complex of Paperboards & Specialty Papers (PSPD) Division of ITC at Bhadrachalam located at Sarapaka Village, near Bhadrachalam town, at Khamamm District of state of Andhra Pradesh in India. The site is at a distance of 300 km from Hyderabad, the nearest metropolitan city with well connected roadways, rail route and national and international airport facility.

Project Description - The project involves implementing and maintaining energy conservative measures identified under a mill-wide power conservation programme leading to emission reduction due reduction in fossil fuel combusted to generate electricity. It's a uphill responsibility on ITC Bhadrachalam unit maintain the performances of the energy conservation measures throughout the 10years crediting period under the CDM protocol with known and unknown variability within the manufacturing process paperboards and specialty paper.

Current Status of the Project

Project Description			Job Completion date/ Date from which the Project is operational
Description	**Earlier Specification**	**Project specification**	
Paper Machine: 1			
Replacement of 12 nos. of vacuum fans connected to 4 nos. of formers (3 fans at each) by 4 nos. of energy efficient fans (1 fan at each former).	HBBB-10-3-H2 14 m3/min, 1100 mmwc	CEMTEK SINGLE FAN 42m3/min, 700 mmwc	26-09-2003
Replacement of low efficient Vacuum Pump - No. 3 at by energy efficient alternative Vacuum Pump	12E, 105m3/h, 500 mmhg	K202M, 105m3/h, 500 mmhg	16-02-2005
Replacement of double disc refiner by tri-disc refiner to reduce energy consumption in stock preparation by increasing the consecutive refining stage and improving the quality of the stock.	1 SDM,4.5T/h, 150m3/h	21TDR,4.5T/h 150m3/h	04-12-2003
Paper Machine:2			
Replacement of Unrefined chest pump with reduction in pump head of optimum requirement and reduce pumping energy	133m3/h @ 33m head	133m3/h @ 29m head	23-11-2004
Replacement of Refined chest pump with reduction in pump head of optimum requirement and reduce pumping energy	183m3/h @ 17.5m head	183m3/h @ 15m head	14-12-2004
Replacement of Mixing chest pump with reduction in pump head of optimum requirement and reduce pumping energy	181m3/h @ 14m head	181m3/h @ 10m head	14-12-2004
Replacement of Intermediate chest pump with reduction in pump head of optimum requirement and reduce pumping energy	181m3/h @ 14m head	181m3/h @ 10m head	23-11-2004
Replacement of Machine chest pump with reduction in pump head of optimum requirement and reduce pumping energy	200m3/h @ 24m head	200m3/h @ 20m head	14-02-2005

Project Description			Job Completion date/ Date from which the Project is operational
Description	**Earlier Specification**	**Project specification**	
Paper Machine:3			
Replacement of Mixing chest pump with reduction in pump head and flow of optimum requirement and reduce pumping energy	56m3/h @ 29m head	200m3/h @ 21.5m head	14-12-2004
Replacement of Intermediate chest pump with reduction in pump head of optimum requirement and reduce pumping energy	50m3/h @ 12m head	50m3/h @ 10m head	25-04-2005
Replacement of PCC pump with reduction in pump head and flow of optimum requirement and reduce pumping energy	480m3/h @ 40m head.	260m3/h @ 30m head	14-12-2004
Replacement of SCC pump with reduction in pump head and flow of optimum requirement and reduce pumping energy	168m3/h @ 32.5m head.	140m3/h @ 25m head	14-12-2004
Replacement of TCC pump with reduction in pump head and flow of optimum requirement and reduce pumping energy	90m3/h @ 27.5m head	47m3/h @ 25m head	10-09-2004
Paper Machine: 4			
Replacement of Vacuum sealing water pump with reduction in pump head and flow of optimum requirement and reduce pumping energy	144m3/h @ 31m head	125 m3/h @ 17m head	14-12-2004
Replacement of Sand filter transfer pump with reduction in pump head of optimum requirement and reduce pumping energy	175m3/h @ 40m head	175 m3/h @ 15m head	14-12-2004
Replacement of Cooling Tower pump with reduction in pump head and flow of optimum requirement and reduce pumping energy	353m3/h @ 31m head	260 m3/h @ 25m head	23-03-2005
Others			
Replacement of one high flow capacity TG3 cooling water pump (CWP 1) by optimum flow capacity pump.	2500m3/h at 27.5m head	1250m3/h at 27.5m head	05-01-2001

Project Description			Job Completion date/ Date from which the Project is operational
Description	**Earlier Specification**	**Project specification**	
Replacement of higher capacity evaporator cooling water pump by lower capacity pump	1500m3/h at 65m head	1800m3/h at 35m head	24-05-2005
Compressors			
Replacement of 9 nos. reciprocating compressors with HOC dryers by single centrifugal compressor with refrigerant dryer.	Compressor No:1,5,7,8,9,10 CFB4:1 CFB5:1	1 x 95Nm3/m	14-03-2003
Fluorescent Lamps (FL)			
Replacement 3025nos of 2x40W FL tubes with copper choke by 2x22W FL tubes with electronic ballast	2 x 40 W with Copper Choke	2 x 22 W with Electronic ballast	23-11-2004
High Pressure Mercury Vapour Lamps (HPMV)			
Replacement of 100nos of HPMV lamps by metal halide lamps.	1 x 400W HPMV	1 x 250W Metal Halide	05-06-2004
Distribution			
Installation of capacitor banks at NFL to improve power factor and reduce distribution losses	600 Kvar	(7 x 50)Kvar 950 Kvar	28-12-2004
Harmonic Filters			
Installation of harmonic filters at PM2 to reduce	Not available	450Kvar, Siemens make	20-03-2004
Variable Frequency Drives			
Installation 2 nos. of 200kw VFD for CFB4 FD fans	Not available	2 x 250Kva, ABB make	23-12-2004
Installation of 22kw VFD for PM1 horizontal chest pump.	NA	22 kw Eurotherm	30-11-2003
Drives			
Change of drives from DC to AC during machine rebuilt & Installation of Harmonic filter	Siemens make DC drives	ABB make AC drives	January,2001
Controls			

Project Description			Job Completion date/ Date from which the Project is operational
Description	**Earlier Specification**	**Project specification**	
Installation of electronic governor for 7.5MW unit to reduce bandwidth of frequency variation.	Model SR4 ,BHEL make Hydraulic governor	TS320 Trison make electronic governor	23-08-2005

Reporting Period

Monitoring Period Covered

This is the second monitoring report of the project. It provides details on the performance of the CDM project towards greenhouse gases emission reduction for the period of 01/01/2007 to 31/12/2008 (both days including).

Monitoring and Verification Protocol

Monitoring Plan as per Revised Monitoring Plan

ID number	Monitoring Protocol Followed
$\sum$**Equ$_i$** Numbers of devices replaced/ retrofitted of group "i" where "i" refers to pumps, lamps, compressors., etc	Recorded once prior to the implementation of the project measures
For measure involve replacement of lamps across the mill	
$\sum$**P$_{ibase,}$** (kW) Rated Power of the device replaced/ retrofitted at the baseline	Recorded once during the project implementation. Reference - Third party report by MKRC
$\sum$**P$_{j,Prj}$** (kW) Rated Power of the device installed as the project measures	Recorded once during the project implementation. Reference - Third party report by MKRC
O$_{hrs}$ (hrs) Operating/ running hours of the replaced device	Burning hours of the lamps replaced is measured daily through Running Hour (RH) meter and monthly final integrator reading is recorded.
For measures involve replacement of equipments that are operated without significant change of connected load	
$\sum$**P$_{p,base}$** (kW) Actual energy consumed by the equipments at the baseline	Baseline energy consumption were recorded based on a month of observation on continuous basis through installed energy meters.
$\sum$ **Energy$_{project}$** (kWh) Actual energy consumed by the equipments after the implementation of the project measure	Project energy consumption is measured through dedicated energy meters and monthly integrated consumption are recorded in IMIS Report
O-hrs$_{, actual}$ (hrs) Operating/ running hours of the equipments based on operating hours of the parent machine or equipment (such as pumps connected to paper machine, VFDs connected to fans, and the Compressors that are included in the project boundary)	Monthly operating hours of the equipment is derived based on operating hours of the parent machine or equipment as given below O-hrs$_{, actual}$ = 24hours * days in month – machine/ equipment downtime reported in IMIS monthly reports
For the measures that involves installation of power correction equipments operated at variable connected load	
Energy$_{base}$ (kWh) Actual energy consumed by the load connected to the common line without equipment 'i' (in	As the baseline is dynamic, it is established through measurement during project period. Baseline energy is measured for 3

ID number	Monitoring Protocol Followed
switched off mode) for any 3 consecutive days of continuous operation in a month	consecutive days in every month keeping the project equipment in the switched of mode. Actual consumption by the load at the baseline scenario is then derived by subtracting the initial level of reading, when the equipment is taken-off from the load, from the final reading, when equipment is again connected to the line.
O-hrs$_{corresponding,3}$ (hrs) Corresponding operating hours for the 3 consecutive days for baseline monitoring when the equipment 'i' is not connected to the load	During the recording of baseline energy consumption, hours for which the project equipment was taken-off during the month is recorded and reported and O-hrs$_{corresponding,3}$
Energy$_{project}$ (kWh) Actual energy consumed by the load connected to the common line with equipment 'i'	Energy consumed by the project measure during the time when the project equipment was on-line is measured by subtracting the energy consumed during 3 days when the project equipment was taken off-line from the total integrated energy reading at the dedicated energy meter.
O-hrs$_{actual}$ (hrs) Operating/ running hours of the equipments based on operating hours of the parent machine or equipment (such as Capacitor banks connected to NFL fibre lines, harmonic filter connected to paper machine, and electronic governor connected to the generator)	Determined based on the operating hours of the parent equipment/ machine as given below O-hrs$_{, actual}$ = 24hours * days in month – machine/ equipment downtime reported in IMIS monthly reports
O-hrs$_{corresponding,}$ (hrs) Corresponding operating hours for the month when the equipment 'i' is switched on	Operating hours by the project measure during the time when the project equipment was on-line is measured by subtracting the 3 days corresponding operating hours when the project equipment was taken off-line from the actual operating hours of the load determined based on operating hours of the parent equipment
F$_{base}$ (Hz) Frequency at which the TG2 was being operated in absence of the electronic governor	The frequency at which the TG2 was operated prior to the implementation of the project measure has been recorded and reported in the approval for capital investment (Capex 744/24) for the project measure.
F$_{project}$ (Hz) Frequency at which the TG2 is operated inline with the electronic governor	The frequency at which the TG2 is operated is recorded on daily basis and monthly average is derived from the daily

ID number	Monitoring Protocol Followed
	measurement.
Others	
E_{grid} & $E_{inhouse}$ (GWh) Electricity imported from the grid and generated in-house	This is recorded from on daily basis from the dedicated energy meter and monthly consumption is reported in IMIS report.
EFy (tCO_2/GWh) CO_2 emission factor of current generation mix of the grid	This has been computed once during PDD and value stands as $941tCO_2/GWh$
FF_i (MT) Annual quantity of coal utilized by the project	Coal consumed by the plant for generation of electricity is recorded on daily basis and reported in IMIS report on monthly basis
$NCV_{FF,i}$ (kcal/kg) Average gross calorific value of coal	Net calorific value of the coal used for generation of electricity has be derived basis on proximate analysis of coal at in-house laboratory

Operational Control Procedure Followed for Data Assurance

ITC Bhadrachalam unit has a specific operational control procedure for proper management and review of the CDM project (***Ref - Doc. No. EPM 4.4.6.29 CLEAN DEVELOPMENT MECHANISM, ENVIRONMENTAL OPERATION CONTROL PROCEDURE***).

The primary object of the procedure is to "establish system for monitoring, measuring, recording, reporting, reviewing and communicating on the performance of the Clean Development Project registered at UNFCCC under Reference No. #0806". The OCP is the integral part of the Environment Management System certified under ISO 14001:2004. The operational control procedure takes care of all quality control and quality assurance on the monitoring system and uncertainty analysis on the monitored data.

The procedure clearly delineates roles and responsibility for all activities that are required to be performed for reporting on the performance of the CDM project on the periodic basis to the management of the ITC PSPD (Project Participant). The instruments and tools identified for measurement of parameters have been listed in the critical category of instruments and are periodically calibrated as per set calibration schedule. In the event of malfunctioning of any instruments, tools, equipments, emission reduction is accounted for as per the registered Monitoring Plan.

Emission Reductions

Formulas Applied

For measure involve replacement of lamps across the mill

$$EB_y = \Sigma_i ((P_{base,i} - P_{project,i}) * O_{hrs,\ actual}) \quad (1)$$

Where,
EB_y = Annual energy saved by the project (GWh/yr)
Σ_i = the sum over the group of "i" devices replaced (lamps), for which the replacement is operating during the year, implemented as part of the project.
$P_{base,i}$ = power used by the devices/ equipment of the group of "i" devices replaced (lamps) **(at the baseline)** (kW).
$P_{project,i}$ = power used by the devices/ equipment of the group of "i" devices (lamps)newly installed **(at the project scenario)** (kW).
$O_{hrs,\ actual}$ = the actual annual burning hours of the devices of the group of "i" devices (lamps) replaced or retrofitted. (Hours)

For measures involve replacement of equipments that are operated without significant change of connected load

$$EB_y = \Sigma_i ((P_{base,i} - P_{project,i}) * O_{hrs,\ actual}) \quad (2)$$

$$P_{project,i} = Energy_{project}/O_{hrs,\ actual} \quad (2a)$$

Where,
EB_y = Annual energy saved by the project (GWh/yr)
Σ_i = the sum over the group of "i" devices retrofited (pumps, fans, etc), for which the replacement is operating during the year, implemented as part of the project.
$P_{base,i}$ = power used by the devices/ equipment of the group of "i" devices retrofitted (pumps, fans, etc) **(at the baseline)** (kW), recorded based on a period of one month monitoring prior to the implementation of the project (ex-ante baseline fixation).
$P_{project,i}$ = average hourly power used by the devices/ equipment of the group of "i" devices newly installed **(at the project scenario)** (kW).
$Energy_{project}$ = monthly electricity consumed by the devices/ equipment of the group of "i" for the project monitoring period (kWh)
$O_{hrs,\ actual}$ = the actual monthly operating hours of the devices of the group of "i" devices replaced or retrofitted. (Hours)

For the measures that involves installation of power correction equipments operated at variable connected load

$$EBy = \Sigma_i (P_{base,i} - P_{project,i}) * O_{hrs,\ actual} \quad (3)$$

Where: -

$P_{base,i}$ = power used by the devices/ equipment of the group of "i" devices retrofitted (pumps, fans, etc) **(at the baseline)** (kW) and calculated as $(Energy_{base} / O\text{-}hrs_{corresponding,3})$ **(3a)**

$Energy_{base}$ - Total electricity consumed during the three consecutive days of continuous operation in a month without the harmonic filter/ capacitor bank (in switched off mode) (kWh).

$O\text{-}hrs_{corresponding,3}$ - Corresponding operating hours for the 3 consecutive days of continuous operation for baseline establishment

$O\text{-}hrs_{actual}$ – Actual operating hours in the given month.

$$P_{project} = (Energy_{project} / O_{hrs,\ corresponding}) \quad (3,b)$$

Where:

$P_{project}$ = Energy consumed at project ($Energy_{project}$, kWh) and is the monthly recording of the metered energy consumed by the equipment with harmonic filter/ capacitor bank (less 3 days of the month for baseline energy measurement) and recording the corresponding operating hours of the equipment during the month (kW).

$O_{hrs,\ corresponding}$ - Corresponding operating hours for the month less 3 consecutive days of baseline monitoring

Only for Electronic Governor

$$P_{base} = P_{project} * (F_{base} / F_{project})^3 \quad (3,c)$$

Where

P_{base} = Power generated at baseline (kWh)

$P_{project}$ = (kWh) is the recorded monthly generation by the TG with electronic governor at a frequency of $F_{project}$ (Hz) (recorded monthly average).

F_{base} = (Hz) is recorded before installation of electronic governor based on monitoring for a period of month (49.89). Note - Power is proportional to cube of frequency.

Leakage is calculated as the sum of devices of group "i" replaced or retrofitted of power "p_i" multiplied by average annual operation hours "o_i" of the devices.

$$EL_y = \Sigma_i (Equi_i * O_{hrs}) \quad (4)$$

Where,
ELy = Annual leakage (kWh/yr)
Σ_i = the sum over the group of "i" devices retained and used, for which the replacement is not operating during the period, implemented as part of the project.
$\mathbf{Equ_i}$ = the rated power of devices of the group of "i" devices replaced or retrofitted for which the replacement is not operating during the period (kW).
$\mathbf{O_{hrs}}$ = the average annual operating hours of the devices of the group of "i" devices replaced or retrofitted. (Hours)

ERy = (EB,y – EL,y) * EFy (5)

Where:
$\mathbf{ER_y}$ = Emission Reduction from the project (tCO2 equ)
EBy = Annual energy saved by the project in kWh per year
ELy = Annual leakage from the project in kWh per year
$\mathbf{EF_y}$= Emission Factor of the electricity mix of the unit (tCO_2/GWh)
Where:

EFy = (EFgrid *Egrid + EFin-house * Ein-house) / (Egrid + Ein-house) (6)

Where:
$\mathbf{EF_y}$= Emission Factor of the electricity mix of the unit (tCO_2/GWh)
$\mathbf{EF_{grid}}$ = Emission Factor for the grid electricity used (tCO_2/GWh)
$\mathbf{E_{grid}}$ = Total grid electricity imported in the year 'y' (GWh)
$\mathbf{E_{in\text{-}house}}$ = Total in-house electricity generated in the year 'y' (GWh)
$\mathbf{EF_{in\text{-}house}}$ = Emission Factor for the grid electricity used (tCO_2/GWh)
Where:

$\mathbf{EF_{in\text{-}house} = FF_{i,y} * COEF_{FF,i} / E_{in\text{-}house}}$ **(7)**

Where:
$FF_{i,y}$ = Amount of fossil fuel by type 'i' required to generate electricity in the year 'y' (MT)
The CO_2 emission coefficient COEFi is obtained as

COEFFF,i = NCVFF,i * EFCO2, FF,i * OXIDFF,i (8)

Where:
$NCV_{FF,i}$ = Net calorific value (kcal per mass or volume unit) of the fossil fuel
$OXID_{FF,i}$ = Oxidation factor of the fossil fuel
$EFCO_{2,\,FF,i}$ = CO_2 emission factor per unit of energy of the fossil fuel (IPCC default)

Summary Energy Savings and Emission Reduction Achieved

For measure involve replacement of lamps across the mill

S. No.	Power consumed at baseline (measured prior to the project implementation)	Annual Operating Hours in the year 'y' at project	Power consumed at project	Energy Saved in the year 'y'	Emission Factor of the electricity mix used in the unit	Emission Reduction	Leakage Energy (if any)
Unit	**kW**	**hrs**	**kW**	**GWh**	**tCO2/GWh**	**tCO2**	**kwh**
Symbol	**P_{base}**	**$O_{hrs, actual}$**	**$P_{project}$**	**EB_y**	**EF_y**	**ER**	
Fluorescent Lamps (FL)							
Replacement 3025nos of 2x40W FL tubes with copper choke by 2x22W FL tubes with electronic ballast	284.41	8408.16	121.03	1.37	1874.64	2575.34	0
High Pressure Mercury Vapour Lamps (HPMV)							
Replacement of 100nos of HPMV lamps by metal halide lamps (PM-1 48 x 0.4 KW) . (PM-4 52 x 0.4 KW)	19.20	8433.00	12.00	0.06	1874.64	113.82	0
	20.80	8433.00	13.00	0.066		123.31	0
Sub Total				**1.50**		**2812.48**	

ITC Limited

For measures involve replacement of equipments that are operated without significant change of connected load

S. No.	Power consumed at baseline (measured prior to the project implementation)	Annual Operating Hours in the year 'y' at project	Project Energy (measure on continuous basis)	Power consumed at project	Energy Saved in the year 'y'	Emission Factor of the electricity mix used in the unit	Emission Reduction	Leakage Energy (if any)
Unit	**kW**	**hrs**	**kWh**	**kW**	**GWh**	**tCO2/GWh**	**tCO2**	**kwh**
Symbol	**P_{base}**	**$O_{hrs, actual}$**	**$Energy_{project}$**	**$P_{project}$**	**EB_y**	**EF_y**	**ER**	
Paper Machine: 1								
Replacement of 12 nos of vacuum fans connected to 4 nos. of formers (3 fans at each) by 4 nos of energy efficient fans (1 fan at each former).	35.68	14610.41	172161.00	11.78	0.35	1874.64	654.51	0
Replacement of low efficient Vacuum Pump -No. 3 at by energy efficient alternative Vacuum Pump	150.50	14610.41	1733386.00	118.64	0.47	1874.64	872.61	0

S. No.	Power consumed at baseline (measured prior to the project implementation)	Annual Operating Hours in the year 'y' at project	Project Energy (measure on continuous basis)	Power consumed at project	Energy Saved in the year 'y'	Emission Factor of the electricity mix used in the unit	Emission Reduction	Leakage Energy (if any)
Replacement of double disk refiner by tridisc refiner to reduce energy consumption in stock preparation by increasing the consecutive refining stage and improving the quality of the stock.	380.00	10904.00	1925464.00	176.58	2.22	1874.64	4158.05	0
Paper Machine:2								
Replacement of Unrefined chest pump with reduction in pump head of optimum requirement and reduce pumping energy	17.30	14681.73	229701.00	15.65	0.02	1874.64	45.54	0
Replacement of Refined chest pump with reduction in pump head of optimum requirement and reduce pumping energy	13.80	14681.73	101152.00	6.89	0.10	1874.64	190.19	0

S. No.	Power consumed at baseline (measured prior to the project implementation)	Annual Operating Hours in the year 'y' at project	Project Energy (measure on continuous basis)	Power consumed at project	Energy Saved in the year 'y'	Emission Factor of the electricity mix used in the unit	Emission Reduction	Leakage Energy (if any)
Replacement of Mixing chest pump with reduction in pump head of optimum requirement and reduce pumping energy	12.70	14681.73	101070.00	6.88	0.09	1874.64	160.07	0
Replacement of Intermediate chest pump with reduction in pump head of optimum requirement and reduce pumping energy	15.00	14681.73	100868.00	6.87	0.12	1874.64	223.75	0
Replacement of Machine chest pump with reduction in pump head of optimum requirement and reduce pumping energy	22.70	14681.73	254016.00	17.30	0.08	1874.64	148.58	0
Paper Machine:3								

S. No.	Power consumed at baseline (measured prior to the project implementation)	Annual Operating Hours in the year 'y' at project	Project Energy (measure on continuous basis)	Power consumed at project	Energy Saved in the year 'y'	Emission Factor of the electricity mix used in the unit	Emission Reduction	Leakage Energy (if any)
Replacement of Mixing chest pump with reduction in pump head and flow of optimum requirement and reduce pumping energy	15.50	15168.91	118031.00	7.78	0.12	1874.64	219.50	0
Replacement of Intermediate chest pump with reduction in pump head of optimum requirement and reduce pumping energy	12.10	15168.91	130175.00	8.58	0.05	1874.64	100.05	0
Replacement of PCC pump with reduction in pump head and flow of optimum requirement and reduce pumping energy	78.00	15168.91	611976.00	40.34	0.57	1874.64	1070.79	0
Replacement of SCC pump with reduction in pump head and flow of optimum requirement and reduce pumping energy	32.90	15168.91	238895.00	15.75	0.26	1874.64	487.71	0

S. No.	Power consumed at baseline (measured prior to the project implementation)	Annual Operating Hours in the year 'y' at project	Project Energy (measure on continuous basis)	Power consumed at project	Energy Saved in the year 'y'	Emission Factor of the electricity mix used in the unit	Emission Reduction	Leakage Energy (if any)
Replacement of TCC pump with reduction in pump head and flow of optimum requirement and reduce pumping energy	15.00	15168.91	88923.00	5.86	0.14	1874.64	259.84	0
Paper Machine: 4								
Replacement of Vacuum sealing water pump with reduction in pump head and flow of optimum requirement and reduce pumping energy	20.10	15602.52	187129.00	11.99	0.13	1874.64	237.11	0
Replacement of Sand filter transfer pump with reduction in pump head of optimum requirement and reduce pumping energy	21.60	15602.52	131608.49	8.44	0.21	1874.64	385.06	0
Replacement of Cooling Tower pump with reduction in pump head and flow of optimum requirement and reduce pumping energy	44.30	15602.52	384444.00	24.64	0.31	1874.64	575.04	0
Others								

S. No.	Power consumed at baseline (measured prior to the project implementation)	Annual Operating Hours in the year 'y' at project	Project Energy (measure on continuous basis)	Power consumed at project	Energy Saved in the year 'y'	Emission Factor of the electricity mix used in the unit	Emission Reduction	Leakage Energy (if any)
Replacement of one high flow capacity TG3 cooling water pump (CWP 1) by optimum flow capacity pump.	230.00	4840.00	457061.00	94.43	0.66	1874.64	1230.02	0
Replacement of higher capacity evaporator cooling water pump by lower capacity pump	304.60	11496.00	2514667.50	218.74	0.99	1874.64	1850.30	0
Compressors								
Replacement of 9 nos. reciprocating compressors with HOC dryers by single centrifugal compressor with refrigerant dryer.	721.00	17544.00	8959970.00	510.71	3.69	1396.86	5153.37	0
Variable Frequency Drives								
Installation 2 nos of 200kw VFD for CFB4 FD fans	273.90	15792.00	3082224.00	191.08	1.31	1874.64	2451.83	0
Installation of 22kw VFD for PM1 vertical chest pump.	15.50	14610.41	94201.00	6.45	0.13	1874.64	247.94	0

S. No.	Power consumed at baseline (measured prior to the project implementation)	Annual Operating Hours in the year 'y' at project	Project Energy (measure on continuous basis)	Power consumed at project	Energy Saved in the year 'y'	Emission Factor of the electricity mix used in the unit	Emission Reduction	Leakage Energy (if any)
Drives								
Change of drives from DC to AC during machine rebuilt & Installation of Harmonic filter.	772.46	14610.41	6680875.00	457.27	4.61	1874.64	8632.97	0
Sub Total					**16.60**		**29354.84**	**0**

For the measures that involves installation of power correction equipments operated at variable connected load

S. No.	Total electricity consumed during the three consecutive days of continuous operation in in switched off mode	Corresponding operating hours for the 3 consecutive days of continuous operation for baseline establishment	Power consumed at baseline (measured prior to the project implementation)	Annual Operating Hours in the year 'y' at project	Project Energy (measure on continuous basis)	Corresponding operating hours for the month less 3 consecutive days of baseline monitoring	Power consumed at project	Energy Saved in the year 'y'	Emission Factor of the electricity mix used in the unit	Emission Reduction
Unit	**kWh**	**hrs**	**kW**	**hrs**	**kWh**	**hrs**	**kW**	**GWh**	**tCO2/GWh**	**tCO2**
Symbol	**$Energy_{base}$**	**$O_{-hrscorresponding,3}$**	**P_{base}**	**$O_{hrs,\ actual}$**	**$Energy_{project}$**	**$O_{-hrscorresponding}$**	**$P_{project}$**	**EB_y**	**EF_y**	**ER**
Distribution										
Installation of capacitor banks at NFL to improve power factor and reduce distribution losses	7715870.14	1728	4465.20	15121.00	57848745.86	13393.00	4319.33	2.21	1874.64	4135.05
Harmonic Filters										
Installation of harmonic filters at PM2 to reduce	1647821	1728	953.60	14664.00	11874844.78	12936.00	917.97	0.52	1874.64	979.50
Sub Total								**2.73**		**5114.55**

For Electronic Governor

Controls	$P_{project}$	Fbase	Fproject	P_{base}	EB_y	EF_y	ER
	kWh	Hz	Hz	kWh	GWh	tCO2/GWh	tCO2
Installation of electronic governor for 7.5MW unit to reduce bandwidth of frequency variation.	79325193	49.84	48.85	84254048.32	4.93	1874.64	**9239.82**
					4.93		**9239.82**

Leakage due to running of Reciprocating Compressors

Total GWh of electricity consumed by the reciprocating compressors	Emission Factor of the electricity used in-house EF_y tCO2/GWh	Emission due to leakage effect **Ely** tCO2
0.881109	1875	1651.761359

Year	Baseline Emission (tCO_2e)	Total Electricity saved (GWh)	Project Emission (tCO2e)	Leakage (tCO2e)	Total Emission Reduction (tCO2e)
01/01/2007 - 31/12/2008	**46522**	**25.8**	**0**	**1652**	**44870**

ITC Limited