SECTION D. Application of a monitoring methodology and plan:

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D.1. Name and reference of approved monitoring methodology applied to the small-scale project activity:

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Title: Type II, D – Energy efficiency and fuel switching measures for industrial facilities, Version 07, 28th November, Scope 4.
This methodology also refers to AMS I, D, version 09, 19th May, for grid emission calculation.

Reference: http://cdm.unfccc.int/methodologies/SSCmethodologies

D.2. Justification of the choice of the methodology and why it is applicable to the small-scale project activity:

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As earlier proved in Section B, that the project category *Title: Type II, D – Energy efficiency and fuel switching measures for industrial facilities* is applicable to the project, as project also demonstrates demand-side energy efficiency programme implemented across PSPD Bhadrachalam pulp and paper facility. Further, the project has achieved electricity savings of 13.383 GWh in a year after completion of programme spread over a period of time. Therefore, it is justified to apply the small scale selected project category to determine the actual GhG saved.

Monitoring methodology as suggested by selected project category is as follows:
Monitoring shall consist of:
1. In the case of retrofit measures, monitoring shall consist of:
(a) Documenting the specifications of the equipment replaced;
(b) Metering the energy use of the industrial facility, processes or the equipment affected by the project activity;
(c) Calculating the energy savings using the metered energy obtained from subparagraph (b).
2. In the case of a new facility, monitoring shall consist of:
(a) Metering the energy use of the equipment installed;
(b) Calculating the energy savings due to the equipment installed.
3. Published values for technical transmission and distribution losses may be used. Alternatively, technical transmission and distribution losses for the grid that supplies the industrial facility may be monitored.

As described earlier, the project involves a number of equipment replacement and/or implementation of retrofit measures to reduce power consumption which in turn directly or indirectly reduce GhG emissions at fossil fuel fired power plant, either captive or grid. Therefore, the main parameters that are required to be monitored and archived for calculation of actual emissions saved by the project are as follows:

- Electricity consumption by the equipment that has been either replaced or retrofitted
- Electricity consumption by the new installed equipment (in case of replacement) or existing equipment undergone retrofit.
- Emission factor for the electricity used by PSPD Bhadrachalam Unit.
- Specification of the equipment replaced/ retrofitted and the new equipment.

Project proposes to apply the monitoring methodology in following way:

Project Measures	Monitoring Plan
Numbers of equipments/ devices either retrofitted or replaced in the CDM project and their unique location	N_i - the number of devices of the group of "i" such as lamps and pumps replaced and other equipments like compressors, VFDs, capacitor banks and harmonic filters installed been recorded with their unique location identified.
For the equipments/ devices with constant load – Rated power of the equipments/ devices replaced Operating/ running hours of the equipments/ devices	 P_i = the power of the devices of the group of "i" such as lamps replaced. O*i* = operating/ running hours of (average 10hours/day)
For the equipments/ devices fluctuating load but same technology applied at many places within the unit - "Metering the "energy use" of an appropriate sample of the devices installed."	 P_p = the actual energy consumed by the pumps Sampling procedure – the pumps connected to the same load type has been clubbed together.
For all other single initiatives, such as VFDs, compressors, capacitor banks, harmonic filters with variable loads "Metering the energy use of the equipment installed"	 P_o = the actual energy consumed by the connected load.

Emission co-efficient of the electricity used by the project	Electricity mix of PSPD unit
	▪ In-house generation – with
	  ▪ Coal
	  ▪ Black Liquor
	▪ Grid Electricity Imports
	▪ Transmission and distribution losses of the grid
	▪ Archive the electricity mix of the unit during the year 2004-2005;
	▪ Archive the fuel used at in-house to generate electricity;
	▪ For electricity mix at the grid refer to public domain data available from any central or local electricity despatch centre, 2004-2005;
	▪ Calculate emissions from electricity generation using formula described under Section E of this PDD.

D.3 Data to be monitored:

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ID number	Data type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data to be kept?	Comment
$\sum Equ_i$	Text/ numerical	Numbers of devices replaced/ retrofitted of group "i" where "i" refers to pumps, lamps, compressors., etc	Text/ numerical	E	Once during equipment replacement or retrofitted	100%	Electronic / paper	+2 of the selected crediting period	
For measure involve replacement of lamps across the mill									
$\sum P_{ibase,}$	Power	Rated Power of the device replaced/ retrofitted at the baseline	kW	E	-do-	100%	Electronic / paper	-do-	Only for lamps
$\sum P_{j,Prj}$	Power	Rated Power of the device installed as the project measures	kW	E	-do-	100%	Electronic / paper	-do-	Only for lamps
O_{hrs}	Operating hours	Operating/ running hours of the replaced device	hrs	M	Daily	100%	Electronic / paper	-do-	
For measures involve replacement of equipments that are operated without significant change of connected load									
$\sum P_{p,base}$	Power	Actual energy consumed by the equipments at the baseline	kW	M	Daily for a period of month prior to the implementation of the project measure	100%	Electronic / paper	-do-	Equipments – Pumps, VFDs, Drives, Compressors
$\sum Energy_{project}$	Power	Actual energy consumed by the equipments after the implementation of the project measure	kWh	M	Continuously with energy meter installed and monthly recording	100%	Electronic / paper	-do-	
$O\text{-}hrs_{actual}$	Operating hours	Operating/ running hours of the equipments based on operating hours of the parent machine or equipment (such as pumps	hrs	M	Monthly	100%	Electronic / paper	-do-	

ID number	Data type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data to be kept?	Comment
		connected to paper machine, VFDs connected to fans, and the Compressors that are included in the project boundary)							
For the measures that involves installation of power correction equipments operated at variable connected load									
$Energy_{base}$	Power	Actual energy consumed by the load connected to the common line without equipment 'i' (in switched off mode) for any 3 consecutive days of continuous operation in a month	kWh	M, C	Measured for any 3 consecutive days in a month	100%	Electronic / paper	-do-	Equipment 'i' – Capacitor bank, harmonic filter.
$O\text{-}hrs_{corresponding,3}$	Time	Corresponding operating hours for the 3 consecutive days for baseline monitoring when the equipment 'i' is not connected to the load	hours	M	Measured for any 3 consecutive days in a month corresponding to measurement of $Energy_{base}$	100%	Electronic / paper	-do-	Equipment 'i' – Capacitor bank, harmonic filter.
$Energy_{project}$	Power	Actual energy consumed by the load connected to the common line with equipment 'i'	kWh	M	Monthly (less 3 days) then extrapolated for the total hours of operation in month	100%	Electronic / paper	-do-	Equipment 'i' – Capacitor bank, (for electronic governor - all days in month), harmonic filter.
$O\text{-}hrs_{actual}$	Operating hours	Operating/ running hours of the equipments based on operating hours of the parent machine or equipment (such as Capacitor banks connected to NFL & SFT fibre lines, harmonic filter	hrs	M, C	Monthly	100%	Electronic / paper	-do-	

ID number	Data type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data to be kept?	Comment
		connected to paper machine, and electronic governor connected to the generator)							
$O\text{-}hrs_{corresponding,}$	Time	Corresponding operating hours for the month when the equipment 'i' is switched on	hours	M	Measured for days in a month corresponding to measurement of $Energy_{project}$	100%	Electronic / paper	-do-	Equipment 'i' – Capacitor bank, harmonic filter.
F_{base}	Frequency	Frequency at which the TG2 was being operated in absence of the electronic governor	Hz	M	Once for a month before installation of the electronic governor	100%	Electronic / paper	-do-	Only for electronic governor. Fixed at 49.89Hz
$F_{project}$	Frequency	Frequency at which the TG2 is operated inline with the electronic governor	Hz	M	Monthly average	100%	Electronic / paper	-do-	Only for electronic governor
Others									
E_{grid} & $E_{inhouse}$	Electricity quantity	Electricity imported from the grid and generated in-house	GWh	M	Annual	100%	Electronic	-do-	Based on actual electricity bills paid and internal management reports
PN	Plant Name/ Installed Capacity and commissioning dates	Plant identification with installed capacity and commissioning dates of the power plants at the grid	Text	E	Once during PDD	100%	Paper	-do-	Data has been collected from regional load despatch centre for the year 2004-2005 either through hard copy publication or from the website.
$\sum_k GENk,y$	Electricity quantity	Total electricity generation by the grid	GWH	E	Once during PDD	100%	Paper	-do-	-do-

ID number	Data type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data to be kept?	Comment
NHRk	Heat rate of the power plant	Net heat rate of the plants identified at the grid	Kcal/kWh	E	Once during PDD	100%	Paper	-do-	-do-
COEFi	Emission co-efficient	CO_2 emission co-efficient of each fuel (i) type	tCO_2/TJ	E	Once during PDD	100%	Paper	-do-	-do-
EFy	Emission factor	CO_2 emission factor of current generation mix of the grid	$tCO_2/$	C	Once during PDD	100%	Paper	-do-	Project has calculated emission factor of the grid according to the given formulae described in Section E in transparent manner.
$\mathbf{FF_i}$	Mass/Weight	Annual quantity of coal utilized by the project	MT	M	Monthly	100%	Electronic	+2 years of the first crediting period	The coal procured will be measured after procurement at time of storage, plus during feed charge for boiler input.
$\mathbf{NCV_{FF,i}}$	Energy	Average gross calorific value of coal	Kcal/kg	Estimated	Monthly	Sample	Paper/ electronic	+2 years of the first crediting period	The NCV will be determined based the following formula – NCV = GCV – 10.2*Moisture %

D.4. Qualitative explanation of how quality control (QC) and quality assurance (QA) procedures are undertaken:

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Quality Assurance

Monitoring systems would follow relevant procedures under the ISO 14001 certified Environmental Management System of the Unit. Reference - EPM 4.4.6.24, ENVIRONMENTAL OPERATION CONTROL PROCEDURE

D.5. Please describe briefly the operational and management structure that the project participant(s) will implement in order to monitor emission reductions and any leakage effects generated by the project activity:

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The unit has deputed two technical experts to oversee the implementation of the programs in consultation with the energy audit consultant. The senior management at the level of the plant manager reviews these programs periodically.

D.6. Name of person/entity determining the monitoring methodology:

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PricewaterhouseCoopers (P) Limited, has assisted the project proponent in determining the monitoring plan according to the selected monitoring methodology. Not a project participants.

SECTION E.: Estimation of GHG emissions by sources:

E.1. Formulae used:

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E.1.1 Selected formulae as provided in appendix B:

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NA

E.1.2 Description of formulae when not provided in appendix B:

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E.1.2.1 Describe the formulae used to estimate anthropogenic emissions by sources of GHGs due to the project activity within the project boundary:

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There is no additional amount of electricity consumed by the project activity. Hence this is not applicable to the project

E.1.2.2 Describe the formulae used to estimate leakage due to the project activity, where required, for the applicable project category in appendix B of the simplified modalities and procedures for small-scale CDM project activities

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According to the selected small scale CDM project category II D, leakage for the project activity should be calculated when - the energy efficiency technology is equipment is transferred from another activity or if the existing equipment is transferred to another activity. The project has mostly invested in new equipment. In a two instances such as:

- two numbers of variable frequency drive of 200 kw for FD fans of coal fired boiler #4 (CFB4); and
- One number of capacitor bank at secondary fibre treatment #A&B;

The project has utilised energy efficient equipment transferred from applications that have now been abandoned/ decommissioned. However in two cases -
1. Double disc refiner (which has been replaced by Tri disc refiner in project scenario)
2. Ten reciprocating compressors (which has been replaced by one centrifugal compressor)

The Unit proposes to keep them on site for standby purpose. Thus its usage as and when in the future, is likely to cause leakage. To calculate leakage, the following formula should be applied: -

The 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.

$$\mathbf{E_{L,\,y} = \Sigma_i\ (Equi_{\,i,p} * O_{hrs})} \qquad \mathbf{(1)}$$

Where,
$E_{L,y}$ = 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)

The energy baseline is multiplied by an emission coefficient (measured in kg CO_2equ/GWh) for the electricity displaced (electricity mix in the unit- both in-house and grid, as derived below- equation 3 - 6).

E.1.2.3 The sum of E.1.2.1 and E.1.2.2 represents the small-scale project activity emissions:

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Emissions from project activity is equal to $E_{L,y}$ which is presently equal to 'zero'.

E.1.2.4 Describe the formulae used to estimate the anthropogenic emissions by sources of GHGs in the baseline using the baseline methodology for the applicable project category in appendix B of the simplified modalities and procedures for small-scale CDM project activities:

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The energy baseline is calculated as difference in metered energy consumption of the sum of devices of group "i" replaced or retrofitted. Following formula expresses in details:

For measure involve replacement of lamps across the mill

$$\mathbf{EB,y = \Sigma i\ (\ (P_{base,i} - P_{project,i}) * O_{hrs,\ actual}\ )} \qquad \mathbf{(2)}$$

Where,
EB,y = Annual energy saved by the project (GWh/yr)
Σi = 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.
$\mathbf{P_{base,i}}$ = 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

$$EB,y = \Sigma i\ (\ (P_{base,i} - P_{project,i}) * O\text{-}_{hrs,\ actual}) \quad (3)$$
$$P_{project,i} = Energy_{project}/O\text{-}hrs_{,\ actual} \quad (3a)$$

Where,
EB,y = Annual energy saved by the project (GWh/yr)
Σi = 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

$$EB,y = \Sigma i\ (P_{base,i} - P_{project,i}) * O\text{-}hrs_{actual} \quad (4)$$

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 $(Energy_{base}/\ O\text{-}hrs_{corresponding,3})$ **(4a)**
$Energy_{base}$ - 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.

$$P_{project} = (Energy_{project}\ /O\text{-}hrs_{corresponding}) \quad (4,b)$$

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).
$O\text{-}hrs_{corresponding}$ - Corresponding operating hours for the month less 3 consecutive days of baseline monitoring

Only for Electronic Governor

$$P_{base} = P_{project} * (F_{base} / F_{project})^3 \quad (4,c)$$

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.

Project Category	Initiative	Total GWh saved/ year	Monitoring Plan
Replacement			Rated Capacity Equp'i' * Running Hours Direct - Cross verifiable with Sample Meter Reading
	Pumps	5.014	
	Lights	0.647	
	Compressor	1.105	
Sub Total		**6.766**	
Retrofit			
	Capacitor Banks	0.696	Rated Capacity Equp'i' * Running Hours Direct - Cross verifiable with Sample Meter Reading
	Harmonic Filters	0.966	
	Variable Frequency Drive	0.496	
	Other drives	2.083	
	Power Governor	2.376	
Sub Total		**6.6**	
Total GWh saved/ year		**13.4**	

The energy baseline is multiplied by an emission coefficient (measured in kg CO_2equ/kWh) for the electricity displaced (electricity mix in the unit- both in-house and grid).

$$EF_y = (EF_{grid} * E_{grid} + EF_{in\text{-}house} * E_{in\text{-}house}) / (E_{grid} + E_{in\text{-}house}) \quad (3)$$

Where:
EF_y = Emission Factor of the electricity mix of the unit (tCO_2/GWh)
EF_{grid} = Emission Factor for the grid electricity used (tCO_2/GWh) (determined using formula (4))
E_{grid} = Total grid electricity imported in the year 'y' (GWh)
$EF_{in\text{-}house}$ = Emission Factor for the grid electricity used (tCO_2/GWh) (determined using formula (4 & 5))
$E_{in\text{-}house}$ = Total in-house electricity generated in the year 'y' (GWh)

Electricity mix in the Unit		Emission Factor	Gross Emission
In-house generation	**GWh**	**tCO_2/GWh**	**tCO_2/GWh**
Fossil Fuel (coal)	202.96	1929.12	391527.82
Biomass (BLS)	33.41	0.00	0.00
Electricity purchased (grid)	17.615	941.07	16576.47
Total GWh (04-05)	**253.98**		**408104.28**
Total Net Emission at Baseline (tCO_2/GWh)			**1606.85**

For grid electricity emission factor calculation (calculated ex-ante and fixed for the entire crediting period):

The emission factor *EFy* of the grid is represented as weighted average emission of the operating and build margin of the electricity mix in Southern Regional grid. If we set the emission factor of associated method, the *EFy* is given by

$$\mathbf{EF_{grid} = [FFi*COEFi*44/12] / [\sum_k GENk,y]} \quad \mathbf{(4)}$$

Where, the summation over *i* and *k* is for the fuels and electricity generation of the set of plants contributing to the Southern regional grid. FF stands for fossil fuel consumed by the respective plant connected to the grid and 44/12 is conversion factor for tC/TJ to tCO_2TJ.

For detail calculation of the grid please refer to the attached excel workbook to this PDD.

For fossil fuel based in-house electricity emission factor calculation

$$\mathbf{EF_{in\text{-}house} = FF_{,i,,y} * COEF_{FF,i} / E_{in\text{-}house}} \quad \mathbf{(5)}$$

Where:
EB_y = Annual Baseline emission due fossil fuel usage (tCO_2 eqv.)
$FF_{i,y}$ = Amount of additional fossil fuel by type 'i' required at baseline to generate electricity (MT)
$COEF_{FF,i}$ = default IPCC carbon-dioxide emission factor for fossil fuel of type "i", (tC/TJ)

The CO_2 emission coefficient COEFi is obtained as

$$\mathbf{COEF_{FF,i} = NCV_{FF,i} * EFCO_{2,\,FF,i} * OXID_{FF,i}} \quad \mathbf{(6)}$$

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)

Thus

$$\mathbf{ER_y = (E_{B,y} – E_{L,y}) * EF_y} \quad \mathbf{(7)}$$

Where:
ER_y = Emission Reduction from the project (tCO2 equ)
$E_{B,y}$ = Annual energy saved by the project in kWh per year
***$E_{L,y}$* =** Annual leakage from the project in kWh per year
EF_y = Emission Factor of the electricity mix of the unit (tCO_2/GWh)

E.1.2.5 Difference between E.1.2.4 and E.1.2.3 represents the emission reductions due to the project activity during a given period:

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Refer to the table below in section E.2.

E.2 Table providing values obtained when applying formulae above:

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Year	Baseline Emission (tCO_2e/ GWh)	Total Electricity saved (GWh)	Project Emission (tCO2e)	Leakage (tCO2e)	Total Emission Reduction (tCO2e)
2006	1606.85	13.4	0	0	21505
2007	1606.85	13.4	0	0	21505
2008	1606.85	13.4	0	0	21505
2009	1606.85	13.4	0	0	21505
2010	1606.85	13.4	0	0	21505
2011	1606.85	13.4	0	0	21505
2012	1606.85	13.4	0	0	21505
2013	1606.85	13.4	0	0	21505
2014	1606.85	13.4	0	0	21505
2015	1606.85	13.4	0	0	21505
Total Emission Reduction for 10 years (tCO2e)					**215049**