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

CONTENTS

Annexes

Revision history of this document

Version Number	Date	Description and reason of revision
01	21 January 2003	Initial adoption
02	8 July 2005	• The Board agreed to revise the CDM SSC PDD to reflect guidance and clarifications provided by the Board since version 01 of this document. • As a consequence, the guidelines for completing CDM SSC PDD have been revised accordingly to version 2. The latest version can be found at <http://cdm.unfccc.int/Reference/Documents>.
03	22 December 2006	• The Board agreed to revise the CDM project design document for small-scale activities (CDM-SSC-PDD), taking into account CDM-PDD and CDM-NM.

SECTION A. General description of small-scale project activity

A.1 Title of the small-scale project activity:

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Methane capture and power generation at sewage treatment plants ("project activity")

Version 01

26/11/2007

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

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Purpose of the project activity:

The project activity aims to recover the methane generated from the anaerobic digestion of wastewater sludge and utilize it for power generation in gas engines. The project activity prevents the release of biogas (methane) from the sludge digesters into the atmosphere and also displaces the GHG intensive grid electricity with renewable electricity generated using biogas generated from sewage.

Background:

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) is a quasi-governmental body constituted in August 1978 for exclusively attending to the growing needs and for planned development and appropriate regulation of water supply and sewerage services in the Chennai Metropolitan Area. Presently, the CMWSSB area of operation covers 170 square kms in the City and about 10 square kms in the adjacent urbanised area.

The city is divided into five zones for sewage collection, conveyance, treatment and disposal. Each zone is provided with a number of sewage collection systems, pumping stations, conveying mains, treatment, and disposal arrangements. Sewage generated in the premises is received in sewers laid in the streets, conveyed to a pumping station from where it is pumped to the respective treatment locations. At the treatment plants, the sewage is treated to meet the pollution control board limits and is discharged into water courses. However, with the steep growth in population and unauthorized residential localities, the sewerage system has been expanding over several decades with different technologies, making the operation and maintenance of the sewerage system a tedious task. This has resulted in untreated sewage reaching the waterways over several decades, polluting the waterways and making them as open sewers. Sandbars were formed on the mouths of the waterways (Cooum and Adyar rivers) due to strong littoral drift on the coast creating lagoon type conditions in the last few kms of the waterways with sewage stagnation. These unsanitary conditions have continuously deteriorated the city's environment.

The Chennai City River Conservation Project (CCRCP) was formulated by the Government of Tamil Nadu in February 1999 with the objective to prevent untreated sewage flows in to the city water ways and to keep them clean on a sustainable basis. Among the five components of CCRCP, CMWSSB is the implementing agency for the component on "Prevention of untreated sewage flow reaching waterways". The component consists of 16 implementation packages to remove the maladies of the present sewerage system and to augment the sewage treatment capacity to meet sewage flows expected by year 2011. The packages include the construction of additional sewage treatment plants (STPs) at four locations totalling to 264 million litres per day (mld). The summary of the existing treatment capacities and planned expansions are given below:

S.No	Location	Capacity before CCRCP (mld)	Additional capacity (mld)	
			Phase I (Implemented under CCRCP)	Phase II (To be implemented)
1	Kodungaiyur	160	110	110
2	Koyambedu	35	60	60
3	Nesapakkam	23	40	40
4	Perungudi	45[1]	54	54
5	Villivakkam[2]	5	-	-

Table A.1: Summary of treatment capacities

CMWSSB has planned the construction of additional treatment capacities in two phases of which the first phase has been implemented under CCRCP.

Project Description:

During conceptualisation of the new STPs, CMWSSB conducted a study of the various sewage treatment methods available by employing consultants in the field. An expert committee constituted by CMWSSB reviewed the results of the study and advised on the various treatment options. CMWSSB opted for the Activated Sludge Process (ASP) with sludge digesters, a technology that is well established and has been

[1] Not functioning

[2] Primary treatment only

operating successfully in their existing STPs. The existing STPs are operating under the ASP method with sludge digesters from which biogas (60% methane) was freely released into the atmosphere. During the technology selection for the new STPs, CMWSSB learnt about the potential for power generation using biogas that could significantly reduce its electricity import from the state grid. However, technological and other barriers to CMWSSB outweighed the benefit of electricity cost reduction. The GHG reduction potential of the project activity and the associated prospect of carbon credits through the CDM encouraged CMWSSB to incorporate the methane capture and power generation components into the new STPs design. All the four new STPs have now incorporated facilities for methane capture and gas based power generation and is expected to significantly reduce GHG emissions.

Project's contribution to sustainable development:

- The project activity generates electricity that would have been otherwise imported from the grid and thus contributes to improving the electricity scenario in the region
- By preventing the release of methane from the STPs and using it for power generation, the project activity prevents equivalent GHG emissions and the resulting climate change effects.
- The STPs have improved the employment scenario in the area by involving around 30 local workers in each STP for its operation and maintenance.
- The project activity improves the living conditions of the people in the vicinity of the sewage treatment plants.
- Conserves natural resources (mainly fossil fuels) that would otherwise be consumed in generating equivalent electricity in grid connected sources.

A.3. Project participants:

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Name of Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants (*) (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
India	Chennai Metropolitan Water Supply and Sewerage Board	No

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

Description of the technology used:

The physical components of the project activity comprises of the gas holder receiving biogas from the digester, alkali scrubbing unit for removal of hydrogen sulphide (H_2S) and the gas based power generation unit.

Gas holder:

The sludge digester has a limited gas holding capacity and hence a separate gas holder has been provided. The holder is floating roof type that helps maintain uniform pressure within the unit independent of the gas volume. The holder is constructed of a circular concrete tank with a suitable gas holding capacity. An inverted metal shell with a domed cover is located within the tank and provided with rollers on the outer wall that mesh with rails embedded in the concrete wall to facilitate its vertical movement within the tank. The tank is filled with water up to a specific height and acts as a seal preventing leakage of the stored gas. A pipe header from the top of the digester passes through the concrete wall and rises vertically in the holder just above the liquid level. The dome begins to lift as the gas generated in the digester passes into the holder increasing the pressure inside and comes down when the gas is released, decreasing the pressure inside. The outlet from the gas holder is through a second pipe which starts from the liquid level and exits the tank from the bottom. Condensate traps are located in the inlet and outlet lines to remove moisture from the gas. Flow of gas is monitored by a gas flow meter located in the pipe line.

Hydrogen sulphide scrubber:

Sewage contains an assortment of inorganic compounds including sulphur compounds. Under anaerobic conditions in the digester, these compounds are attacked by sulphur bacteria giving an end product of hydrogen sulphide (H_2S). Biogas H_2S concentration can reach as high as 1.5%. When fired in boiler or power generating equipment H_2S in the presence of moisture is converted to sulphurous acid which is corrosive and damages the equipment. Hence removal of this component is essential before using the gas as a fuel. H_2S scrubbing system has been installed to scrub the gas and achieve safe concentrations of less than 150 ppm.

The H_2S is scrubbed in two stages:

1. The first stage comprises of a Venturi using water as a scrubbing medium
2. The second stage comprises of a Packed tower using caustic soda solution

The scrubbing system is designed for induced draft scrubbing. The biogas collected in gas holder is drawn by a gas blower installed upstream of the scrubbing system. The biogas passed firstly through Venturi scrubber where water is re-circulated using pumps resulting in the diffusion of water and gases.

After water scrubbing it is passed through the packed tower where caustic solution is used as the scrubbing medium and is circulated using pumps. The scrubbed gas is drawn through the induced draft fan and forced into the gas engine via the flame arrester and moisture trap.

The effective removal of H_2S and limiting it within 150ppm depends on two vital factors: pH and flow rates of water and caustic solution. It is important to maintain the pH by proper neutralization and the flow rate by providing adequate make-up quantity. Any fluctuation in pH or flow rates of the fluid will have an adverse impact on the engine life.

Gas based power generation unit:

The internal combustion engine method of power generation operating under the Carnot cycle has been adopted in all four locations of the project activity. The gas based power generation units have been imported from the world's leading manufacturers of gas fuelled reciprocating engines and the only companies in the world focusing exclusively on gas engine technology. The units are of 4-stroke spark ignition engines and water cooled with intake pressure charging and exhaust turbocharger. The engines operate with high electrical efficiencies (36.7%) and employ lean combustion technology that reduce exhaust emissions. The rated capacity of engines and technical details are provided below:

Table A.2: Technical specifications of engines

Installed Power capacity	Nesapakkam	kW	475
	Koyambedu	kW	560
	Perungudi	kW	1064
	Kodungaiyur	kW	1064
General Technical specifications*:			
Exhaust gas system	Exhaust gas volume	Kg/h	3345
	Residual sound pressure level at 10 m distance	dB	75
	Nitrogen oxide	mg/Nm^3	500
	Carbon monoxide	mg/Nm^3	1200
	Non methane hydrocarbons	mg/Nm^3	150
Fuel gas system	Calorific value	kWh/Nm^3	6.4

	Fuel gas volume	Nm^3/h	246
Water circuits	Cooling water	m^3/h	20.6
Intake air	Intake air volume	Nm^3/h	2370

*For Koyambedu

The gas engine is interfaced to an alternator that converts the mechanical energy of the engine shaft into electricity. The electricity generated is at 415 V and is supplied to the internal power distribution system through the safety and power conditioning devices. A digital energy meter is installed to measure the net electricity generated by the gas engine.

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

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A.4.1.1. Host Party(ies):

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India

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

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State: Tamil Nadu

A.4.1.3. City/Town/Community etc:

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City: Chennai

Four Locations namely Kodungaiyur, Koyambedu, Nesapakkam and Perungudi

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

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The project activity is part of the four new sewage treatment plants of CMWSSB located in and around Chennai (Kodungaiyur, Koyambedu, Nesapakkam and Perungudi). Chennai is well connected by rail as well as domestic and international airports. The project sites are located within a 20 km radius in Chennai.

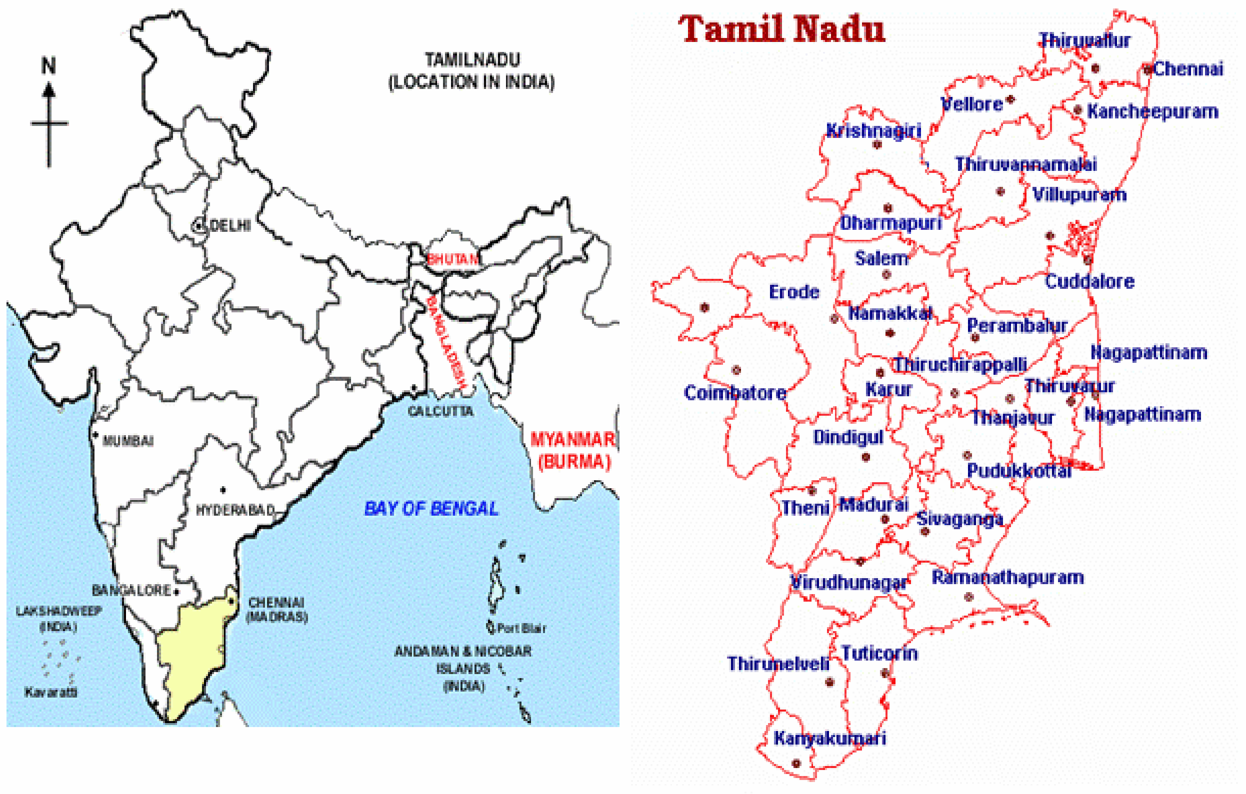

Figure A.1: Location details

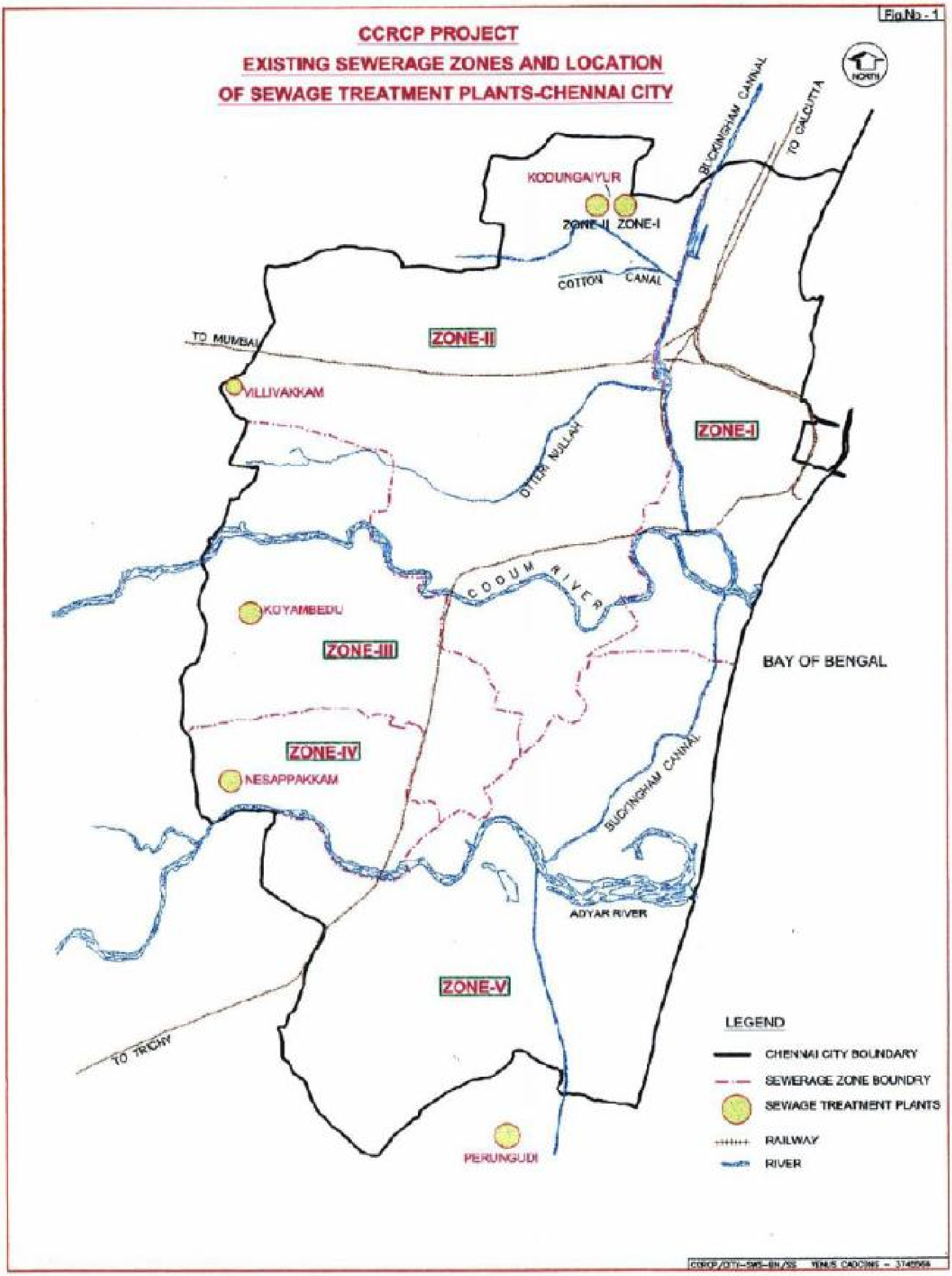

Figure A.2: Location details

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

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Type and categories of the project activity:

The project activity has two components and each of it falls under a different type and category of "Appendix B to the simplified modalities and procedures for small scale project activities".

Component	Classification	Justification
Methane capture	Type III – Other project activities	Projects involving methane recovery fall under "Other project activities"
	Category 'H' – Methane recovery	Involves the recovery of biogas from the anaerobic sludge digester that would otherwise be released into the atmosphere
Power generation	Type I – Renewable energy projects)	Project uses biogas which is a renewable fuel source
	Category 'D' – "Grid connected renewable electricity generation"	The power generated is used to displace electricity that would otherwise be imported from the state distribution grid

Eligibility as a small-scale project activity:

The table below demonstrates, following the "Simplified modalities and procedures for small-scale project activities", the eligibility of each of the project components as a small-scale project activity and confirms that they will remain under the small-scale limits over the crediting period.

Project component	Eligibility criteria	Project eligibility
Methane capture	For project activities of Type III "Provide proof that the emissions reductions every year will not go beyond the limits of 60 $ktCO_2e/y$ over the entire crediting period."	The emissions from the project activity are estimated in section E using conservative assumptions. The maximum possible emission reductions (cumulative of the four locations) from the project activity are 57,080tCO2e/year over the entire crediting period, which is within the small-scale limit.

Power generation	For project activities of Type I "Provide proof that the capacity of the proposed project activity will not increase beyond 15 MW"	The rated maximum power generation capacity of the gas engines (cumulative of all the four locations) is 3.16 MW, which falls within the threshold capacity of 15 MW.

Technology transfer to the host party:

Refer section A.4 for description of the technology employed in the project activity and how it is transferred to the host party.

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

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Year	Methane capture (tCO_2e)	Power generation (tCO_2e)	Total (tCO_2e)
2008-09	46,628	10,452	57,080
2009-10	46,628	10,452	57,080
2010-11	46,628	10,452	57,080
2011-12	46,628	10,452	57,080
2012-13	46,628	10,452	57,080
2013-14	46,628	10,452	57,080
2014-15	46,628	10,452	57,080
2015-16	46,628	10,452	57,080
2016-17	46,628	10,452	57,080
2017-18	46,628	10,452	57,080
Total	466,280	104,520	570,800

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

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CMWSSB has not used public funding for the project activity.

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

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The occurrence of de-bundling of the project activity is determined as described in the Appendix C of the Simplified Modalities and Procedures for Small-Scale CDM project activities. The project activity shall not be deemed to be a de-bundled component of a larger project activity since there is neither a registered small-scale CDM project activity nor an application to register another small-scale CDM project activity:

- With the same project participants;
- In the same project category and technology/measure; and
- Registered within the previous 2 years; and
- Whose project boundary is within 1 km of the project boundary of the proposed small-scale activity at the closest point.

Therefore, the proposed project activity is not a de-bundled component of a larger project activity.

SECTION B. Application of a baseline and monitoring methodology

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

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Since the project activity has two components (methane capture and power generation), a combination of two approved small-scale methodologies are used as recommended in the methodologies.

For the methane capture component:

Title: "AMS III.H. Methane Recovery in Wastewater Treatment", Version 08

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

For the power generation component:

Title: "AMS I.D. Grid connected renewable electricity generation", Version 13

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

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

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The justifications for the applicable type and category and as a small-scale project activity are elaborated in sections A.4.2 and A.4.5 respectively. The justification of the choice of methodologies for each of the component is separately provided below:

Methane capture component: AMS III.H. Methane Recovery in Wastewater Treatment

Applicability criteria	**Applicability to project activity**
Section 1 of the methodology states "This project category comprises measures that recover methane from biogenic organic matter in wastewater by means of one of the following options: (iii) Introduction of methane recovery and combustion to existing sludge treatment systems	The project activity is the recovery of methane from an existing anaerobic sludge treatment digester
Section 2 of the methodology states "If the recovered methane is used for heat and electricity generation the project can use a corresponding methodology under type I project activities	The power generation using recovered methane has been treated as a separate component and a corresponding methodology (AMS I.D) under type I has been used.

This category is applicable for project activities resulting in annual emission reductions lower than **60,000 tCO2e**.	The estimated annual emission reductions from the project activity are only **57,080 tCO_2e**.

All applicability conditions of the methodology (AMS III.H) are met by the project activity.

Power generation component: AMS I.D. Grid connected renewable electricity generation

Applicability criteria	**Applicability to project activity**
This category comprises renewable energy generation units that supply electricity to and/or displace electricity from an electricity distribution system that is or would have been supplied by at least one fossil fuel fired generating unit.	The project activity generates electricity from biogas, which is a renewable fuel, and displaces equivalent electricity from the South Indian Regional (SR) grid. The SR grid is dominated by fossil fuel fired power plants.
If the unit added has both renewable and non-renewable components (e.g. a wind/diesel unit), the eligibility limit of 15MW for a small-scale CDM project activity applies only to the renewable component. If the unit added co-fires fossil fuel, the capacity of the entire unit shall not exceed the limit of **15MW**.	The project activity has only a renewable energy component with a maximum rated capacity of **3.16 MW**

Thus, the project activity is applicable to use the selected methodology (AMS I.D)

B.3. Description of the project boundary:

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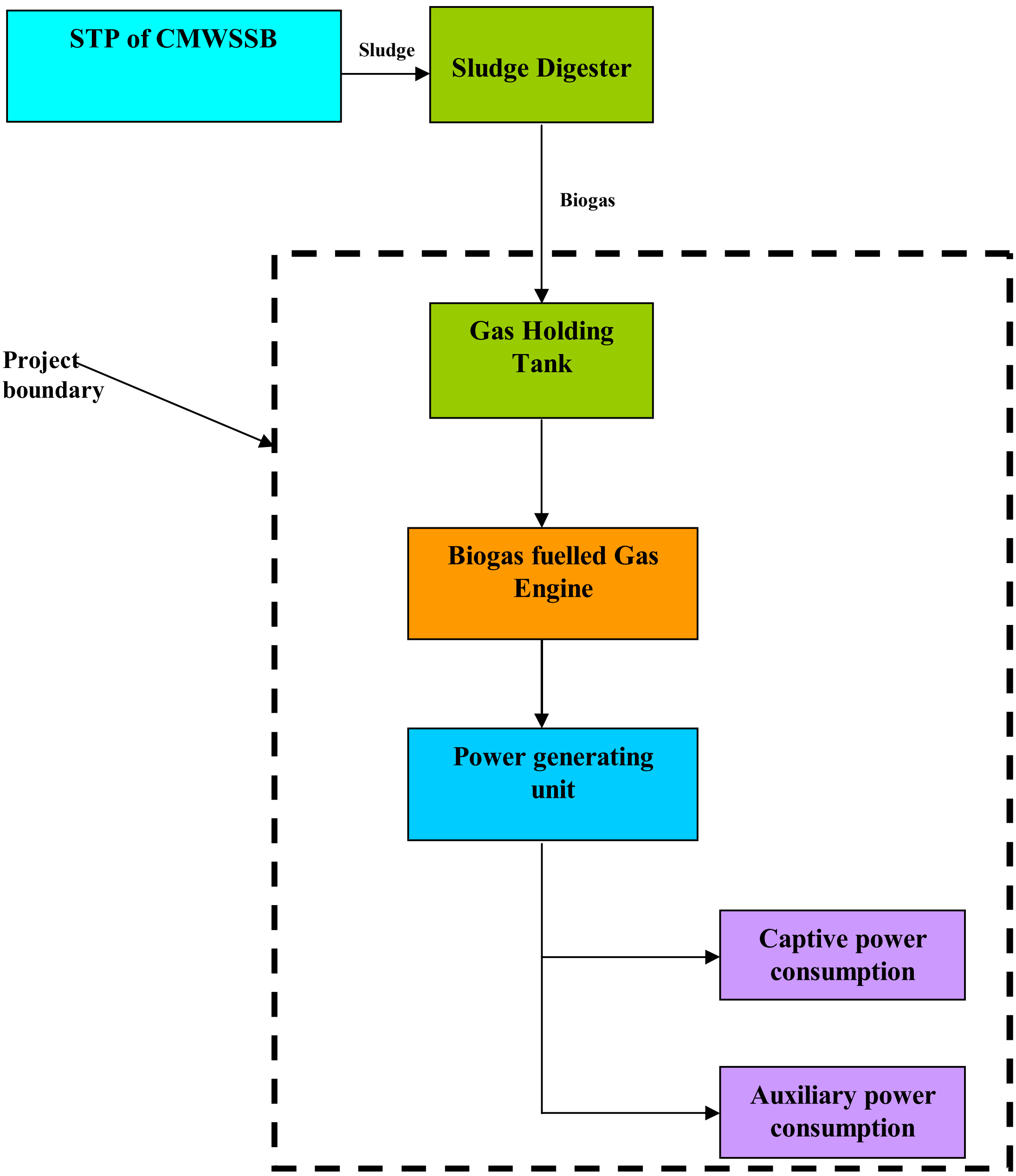
As per the Meth Panel guidelines, the Southern Regional Grid has been chosen as the reference grid. The spatial extent of the project electricity system including calculation of build margin (BM) and operating margin (OM) has been adopted from the consolidated methodology ACM0002. The quantity of electricity required for the operation of the power plant shall be subtracted while determining the net electricity generation for the project. As provided in the methodology, the transmission and distribution (T&D) losses in the electricity grid are neglected as it is not significantly affected by the project activity.

Flow chart and project boundary is illustrated in the **Figure B.1** enclosed below:



B.4. Description of baseline and its development:

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Methane recovery component:

The baseline scenario for the methane recovery component as described in AMS III.H (Section 6.iii, page 5) is "The existing sludge treatment system without methane recovery and combustion". The baseline scenario would be the unabated atmospheric release of methane into the atmosphere from the digesters without methane recovery and combustion.

Power generation component:

As per AMS I.D., the energy baseline is the kWh produced by the renewable generating unit, which will be monitored directly.

The methodology recommends the calculation of the baseline emission factor as per ACM0002. The option combined margin emission factor ("The weighted average of the operating margin and the build margin") has been applied for the project activity. The Central Electricity Authority (CEA) has published data on the emission factor of southern regional grid calculated in accordance with the modalities prescribed by ACM0002. This data (Refer Annex III for details) has been adopted for the project activity.

Though the project activity may also displace some quantity of diesel fuel that would have been used during periods of grid shutdown, as a conservative assumption, it has not been considered in the emission factor calculation.

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered small-scale CDM project activity:

Additionality:

The additionality of the project activity is demonstrated below using the attachment A to Appendix B of the simplified modalities and procedures for small-scale CDM project activities:

B.5.a. Technological barrier:

Performance uncertainties:

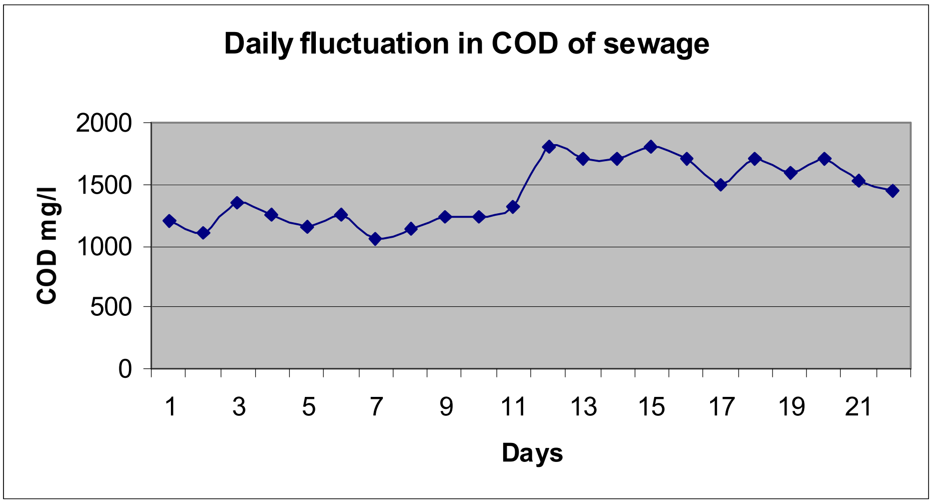
- **Importance of gas quality**

The performance, trouble free operation and life of the gas engine are primarily dependent on the characteristics of the inlet gas. The gas composition and characteristics (like ratio of methane and other gases, presence of impurities, moisture content, and calorific value) significantly influence the gas combustion and therefore the engine performance and life. The engines are designed for specific gas characteristics. Any deviation of the gas characteristics beyond permissible levels of the design condition result in lower performance, higher maintenance cost and reduced life of the engine. For the same reason, gas engine manufacturers have linked their warranties to the inlet gas characteristics and therefore it is important for a gas engine operator to maintain a consistent gas quality.

- **Biogas characteristics**

Unlike natural gas, where the gas characteristics are predominantly consistent[3], the quality and quantity of biogas are unpredictable and depend on several factors that are beyond the control of the operator. The quantity and quality of biogas depends primarily on the quantity and composition of inlet sludge (which in turn depends on inlet sewage). The quantity and characteristics of sewage inlet to the treatment plant has large fluctuations day to day (See Figures B.2 and B.3). Seasonal effects on the quantity and quality are also significant; higher quantity of diluted sewage in the wet months and lower quantity of concentrated sewage in the dry months. CMWSSB was apprehensive that such fluctuations in gas quality and quantity will have a detrimental effect on the performance[4], life and maintenance of the gas engines.

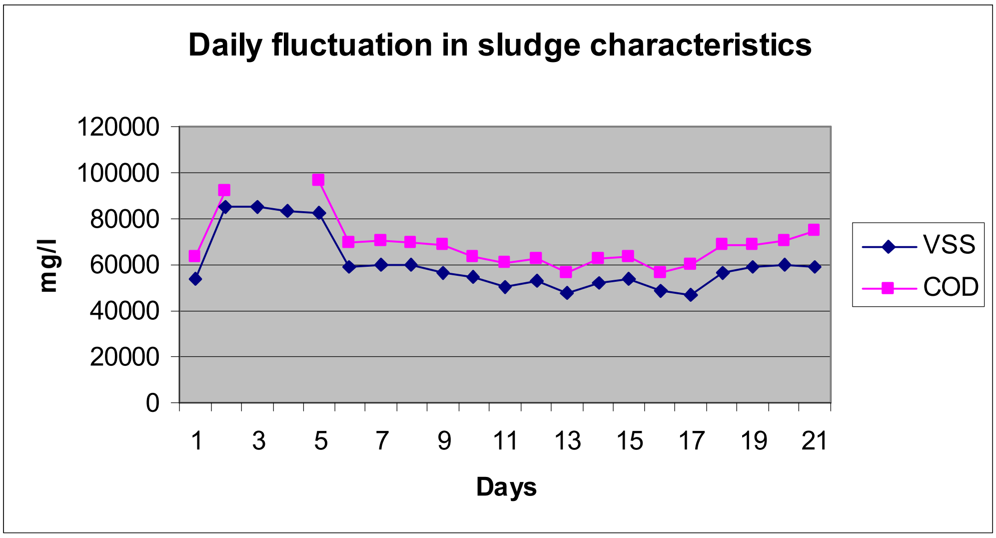
Figure B.2: Fluctuation in sewage characteristics[5]



[3] Natural gas is tapped through gas wells from a single or group of large gas reserves. Since the source of gas is fixed, the gas characteristics are consistent.

[4] It may be noted that CMWSSB's apprehension has been realised; After commissioning of the project activity, the gas quantity and actual operating hours of the engine are lower than that expected (in winter season)

Figure B.3: Fluctuation in sludge characteristics[6]



Low market share and lack of trained manpower:

- **Lack of trained manpower**

As described above, there are frequent variations in the quantity and composition of the biogas generated in the digester. In these circumstances, it is necessary that the biogas treatment and conditioning systems like the H_2S scrubber and moisture traps are maintained and operated properly to ensure trouble free operation of the gas engine. Careful monitoring and operation of the engine is required for which trained and experienced manpower is needed. Given that such sewage-biogas based power generation is attempted for the first[7] time in the region, there is a lack of manpower with necessary technical expertise or prior experience in operating such systems.

- **Lack of success stories**

Though power generation from sewage-biogas is prevalent elsewhere in the developed world, there are no successful models in the project activity region, raising apprehensions of their performance in local Indian

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[5] For the month January 2005

[6] For the month September 2006

[7] Based on information provided by major gas engine manufacturers in this market segment

conditions. The gas-based power generation system is the major component of the project activity and has been imported from one of the world's leading[8] manufacturers of gas fuelled power generation units. The performance of the sewage-biogas based power generation system in Indian conditions remained uncertain and served as a barrier to CMWSSB in implementing the project activity.

B.5.b. Other barriers:

Capacity to absorb new technologies:

In tradition CMWSSB prefers to adopt proven and well established technologies in their projects so that trouble free operation is ensured enabling the availability of technical and managerial resources for their primary purposes and not for attending to ancillary issues. Moreover, the power cost saved by the project activity is a meagre percentage of CMWSSB's annual income and it does not justify them adopting a new technology to save a meagre cash outflow (towards power cost paid to the grid supplier). Following excerpt from the tender evaluation report of various treatment technologies for the new STPs demonstrate CMWSSB's business as usual practice of adopting technologies that are well proven in India and which does not involve O&M problems against new technologies:

S.No	Name of the technology	Recommendation by consultant (Anna University)	CMWSSB expert committee	Remarks
1	Activated sludge process	Recommended	Recommended	Proven and widely used in India
2	Lamella clarifier and diffused aeration	Recommended	Not recommended	This type of clarifier is not proven in India
3	UASB reactor	Recommended	Recommended	Proven technology
4	Sedipac clarifier and	Recommended	Not	This type of sedipac clarifier

[8] In the market segment of gas fired reciprocating engines in the small industrial range of up to 3 MW. GE Jenbacher, Wartsila, Caterpillar and Deutz are the other major market players in this segment

	Biofor		recommended	is not proven in India
5	Bio Tower in lieu of ASP	Recommended	Not recommended	The problem of clogging in the filter media[9] and back washing

Similarly, the proposal to incorporate methane recovery and gas-based power generation units in their new STPs were initially viewed with scepticism considering the lack of similar successful ventures in the country.

Managerial resources barrier:

CMWSSB is engaged in the challenging job of attending to the growing needs of and for planned development and appropriate regulation of Water Supply and Sewerage Services in the Chennai Metropolitan Area. In keeping pace with the rapid growth of population in the past decades, the water and sewer systems had to be expanded with different technologies. This and the growth in unauthorized residential localities discharging sewage into the system has made it a tedious task to operate and maintain the sewerage system. Frequently and often recurrently, CMWSSB has to resolve numerous complaints relating to damaged manhole doors, unfilled tanks, street sewer blocks, leaks in public fountains, maintaining water quality etc, which has put pressure on CMWSSB's O&M staff resources. Billing & collection, collection of overdue bills and taxes and related legal disputes are another major area demanding a lot of manpower. In addition, the identification of new water sources, expansion in water supply and sewer networks have to be carried out at a rate corresponding to the hectic pace of population growth and immigration associated with the city's economic boom. A significant amount of managerial and technical manpower is required for this activity. Moreover, in recent years (2000 – 2005), the rainfall in the area has been inadequate and consequently poor storage in the reservoirs feeding the city. Year 2004 stands alone as the worst storage year in 54 years. Under these grim circumstances, CMWSSB has to strategically draft

[9] In the Kodungaiyur and Koyambedu STPs existing prior to CCRCP, high rate single stage trickling filters were constructed to treat the raw sewage. The sewage was conveyed to the filters through rotating wings consisting of four arms. Because of the high grit concentration in sewage, the arms of the wings often got stuck-up affecting the performance of the treatment plant. Subsequently, the trickling filters were replaced with aerators. With such prior experiences, CMWSSB preferred to adopt time tested and proven technology so as to avoid operational problems.

contingency plans to maintain lifeline supply of water to the city by tapping ground water sources, bring water from distant sources through tankers etc.

The managerial, technical and administrative resources of CMWSSB are continuously engulfed in effectively managing issues related to their primary services; facilitating equitable water supply, enabling proper sewage disposal throughout the year in addition to planning and execution of expansion projects. Under these circumstances, CMWSSB was sceptical about implementing the project activity, with a technology that is un-established in the country, which has performance uncertainties and is prone to O&M problems.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

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B.6.1.1 Baseline Emissions

The total baseline emissions for this project activity will be the sum of two components: methane capture and power generation.

$BE_y = BE_{y,methane} + BE_{y,power}$

B.6.1.1.a Baseline emissions for methane capture component:

The section 10 of AMS III.H states that for the project activity case, "the calculation of emission reductions shall be based on the amount of methane recovered and fuelled or flared that is monitored ex-post. Also for these cases, the project emissions and leakage will be deducted from the emission reductions calculated from the methane recovered and combusted."

The amount of methane fuelled and equivalent baseline emissions are calculated using directly measured values as described below:

$BE_{y,\ methane} = GF_y \times FM \times DM \times 21$

Where,

$BE_{y,methane}$	Baseline emissions in year y in tCO_2e
GF_y	Volume of biogas combusted in the gas engine in M^3/hr
FM	Fraction of methane in the biogas combusted
DM	Density of the methane in the biogas combusted.
21	IPCC Global warming potential for methane

B.6.1.1.b Baseline emissions from power generation component:

Section 9 of AMS I.D states "the baseline is the kWh produced by the renewable generating unit multiplied by an emission coefficient (measured in kg CO2equ/kWh) calculated in a transparent and conservative manner"

$BE_{y,power} = EG_y \times EF_y$

Where,

$BE_{y,power}$Baseline emissions in year represented in tCO_2e

EG_y	Baseline energy generation, which is equal to the electricity generated by the gas engines represented in MWh[10] per year. This data is monitored directly.
EF_y	Emission co-efficient calculated using one of the methods described under section 9 of AMS I.D and represented in tCO_2/MWh

Calculation of emission co-efficient (EF_y):

The project activity displaces electricity that would otherwise be purchased and imported from the TNEB grid. For the calculation of emission reductions, the South India Regional grid may be considered as the reference grid since the TNEB grid is interlinked with other state grids in the region and significant energy exchanges exist between them.

As described in Section B.2, the southern regional grid is considered as the baseline reference grid for the project activity and the method *"combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) according to the procedures prescribed in the approved methodology ACM0002."* as prescribed by AMS I.D has been adopted to calculate the baseline emission factor.

As prescribed by ACM0002, combined margin emission factor of the grid is calculated as follows:

$BEF_y = w_{OM}.EF_{OM,\ y} + w_{BM}.EF_{BM\ ,\ y}$

Where,

w_{OM}	Weight of the operating margin emission factor (0.5 default value as per ACM0002)
$EF_{OM,\ y}$	Operating margin emission factor calculated as per ACM0002
w_{BM}	Weight of the build margin emission factor (0.5 default value as per ACM0002)
$EF_{BM,y}$	Build margin emission factor calculated as per ACM0002
BEF_y	Combined margin baseline emission factor of the grid

Operating margin (OM):

ACM0002 provides four options for calculating OM. Option (a) "Simple OM" has been adopted here and the formula for calculating same is described below:

$$EF_{OM,y} = \sum_{i,j} F_{i,j,y}\, x\, COEF_{i,j} / \sum_{j} GEN_{j,y}$$

[10] Though the methodology states "kWh", "MWh" has been adopted here for ease of calculations

where,

$F_{i,j,y}$	Is the amount of fuel *i* (in a mass or volume unit) consumed by relevant power sources *j* in year(s) *y*
j	Refers to the power sources delivering electricity to the grid, excluding low-operating cost and must-run power plants, and including imports from the grid
$COEF_{i,j\,y}$	Is the CO_2 emission coefficient of fuel *i* (tCO_2 / mass or volume unit of the fuel), taking into account the carbon content of the fuels used by relevant power sources j and the percent oxidation of the fuel in year(s) y, and
$GEN_{j,y}$	Is the electricity (MWh) delivered to the grid by source *j*

The CO_2 emission coefficient $COEF_i$ is obtained as:

$$COEF_i = NCV_{i,} \; x \; EF_{CO2} xOXIDi$$

For calculations, local values of NCV_i and $EFCO_{2i}$ have been used. The *ex-ante* data vintage of 3-year average, based on the most recent statistics available at the time of PDD submission has been used for the calculation.

Build Margin:

The build margin is calculated as the weighted average emissions of recent capacity additions to the reference grid, based on the most recent information available on plants already built for sample group *m* at the time of PDD submission. The PDD has adopted *ex-ante* option for build margin calculation.

$$EF_{BM,y} = \sum_{i,m} F_{i,m,y} \; x \; COEF_{i,m} / \sum_{j} GEN_{m,y}$$

where,

$F_{i,m,y}$, $COEF_{i,m}$ and $GEN_{m,y}$ - Are analogous to the variables described for the OM method above for plants *m*.

The sample group *m* consists of,

- The power plants capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

Further, power plant capacity additions registered as CDM project activities have been excluded from the sample group *m* of South India Regional grid mix.

B.6.1.2 Project Emissions

The project activity doesn't result in any GHG emissions within the project boundary and therefore the same need not be estimated. $PE_y = 0$.

B.6.1.3 Leakage

Leakage need not be considered since there is no transfer of generating equipment from elsewhere to the project activity or vice-versa. $L_y = 0$.

B.6.1.4 Emission Reductions (ER_y):

The emission reductions from the project activity are equal to the baseline emissions minus project emissions and Leakage.

$ER_y = BE_y - PE_y - L_y$

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

Data / Parameter:	**EF_y**
Data unit:	tCO_2/MWh
Description:	Baseline emission factor
Source of data used:	Central Electricity Authority (CEA)
Value applied:	0.86
Justification of the choice of data or description of measurement methods and procedures actually applied :	The values are deduced from the CEA's CO_2 Baseline Database, which are best suited to the current scenario.
Any comment:	-

B.6.3 Ex-ante calculation of emission reductions:

>>

Ex-ante calculation of baseline emissions (Methane capture component)					
S.No	**Notation**	**Parameter**	**Unit**	**Value**	**Comments**
1	GFy	Biogas generated and fuelled in a year	M^3/yr	5161330	Based on expected biogas generation rate
2	FM	Fraction of methane in biogas combusted	-	0.6	Based on actual measurements
3	DM	Density of methane in biogas combusted	Kg/M^3	0.717	Density at standard temperature and pressure has been considered
4	-	Global warming potential for methane	-	21	IPCC default value
5	$BE_{y,methane}$ (1*2*3*4)/1000	Baseline methane emissions	tCO_2/yr	46628	Methodology formula
Ex-ante calculation of baseline emissions (Power generation component)					
S.No	**Notation**	**Parameter**	**Unit**	**Value**	**Comments**
6	EG_y	Energy generated in gas engines	MWh	12154.5	Based on expected biogas generation and rated engine efficiency
7	EF_y	Baseline emission co-efficient	tCO_2/yr	0.86	Based on CEA data
8	$BE_{y,power}$ (6*7)	Baseline emissions from power	-	10452	Methodology formula
9	BE_y (5+8)	Total baseline emissions	tCO_2/yr	57080	Methodology formula

Ex-ante calculation of Emission reductions					
S.No	**Notation**	**Parameter**	**Unit**	**Value**	**Comments**
1	BE_y	Total baseline emissions	tCO_2/yr	57080	Methodology formula
2	PEy	Project emissions	tCO_2/yr	0	No project emissions
3	Ly	Leakage	tCO_2/yr	0	No leakage
4	ER_y (1-2-3)	Baseline methane emissions	tCO_2/yr	57080	Methodology formula

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

>>

Total emission reductions from the project activity:

Year	Methane capture (tCO_2e)	Power generation (tCO_2e)	Total (tCO_2e)
2008-09	46,628	10,452	57,080
2009-10	46,628	10,452	57,080
2010-11	46,628	10,452	57,080
2011-12	46,628	10,452	57,080
2012-13	46,628	10,452	57,080
2013-14	46,628	10,452	57,080
2014-15	46,628	10,452	57,080
2015-16	46,628	10,452	57,080
2016-17	46,628	10,452	57,080
2017-18	46,628	10,452	57,080
Total	**466,280**	**104,520**	**570,800**

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

B.7.1 Data and parameters monitored:

Data / Parameter:	GF_y
Data unit:	M^3
Description:	Volume of biogas combusted
Source of data to be used:	CMWSSB flow meters
Value of data	5161330
Description of measurement methods and procedures to be applied:	Volume of gas would be monitored on a daily basis and recorded in log books
QA/QC procedures to be applied:	Periodic calibration of flow meters if required
Any comment:	-

Data / Parameter:	GP
Data unit:	Bar
Description:	Pressure of biogas at inlet to gas engine
Source of data to be used:	CMWSSB pressure gauges
Value of data	1.15
Description of measurement methods and procedures to be applied:	Pressure of biogas would be monitored on a daily basis
QA/QC procedures to be applied:	Periodic calibration of pressure gauges would be done to ensure accuracy of data
Any comment:	Used to calculate density of methane

Data / Parameter:	GT
Data unit:	Degree Celsius
Description:	Temperature of biogas at inlet to gas engine
Source of data to be used:	CMWSSB temperature gauges
Value of data	30
Description of measurement methods and procedures to be applied:	Temperature of biogas would be monitored on a daily basis
QA/QC procedures to	Periodic calibration of temperature gauges would be done to ensure accuracy of

be applied:	data
Any comment:	Used to calculate density of methane

Data / Parameter:	DM
Data unit:	Kg/M_3
Description:	Density of methane
Source of data to be used:	Calculated using temperature and pressure of biogas.
Value of data	0.717
Description of measurement methods and procedures to be applied:	Standard gas formula. Density = P/RT, where P – Pressure in pascals R – Specific gas constant. 518.3 for methane T – Temperature in kelvin
QA/QC procedures to be applied:	-
Any comment:	-

Data / Parameter:	FM
Data unit:	-
Description:	Fraction of methane in biogas
Source of data to be used:	Third party analysis of biogas
Value of data	0.6
Description of measurement methods and procedures to be applied:	Gas chromatography by a third party
QA/QC procedures to be applied:	CMWSSB would appoint a reputed agency for gas analysis.
Any comment:	-

Data / Parameter:	EGy
Data unit:	MWh
Description:	Energy generated by the power generation units
Source of data to be used:	CMWSSB energy meters
Value of data	12154.5
Description of measurement methods and procedures to be applied:	Energy generated would be recorded by monitoring personnel on a daily basis in log books.
QA/QC procedures to be applied:	Periodic calibration of energy meters would be undertaken if required
Any comment:	

B.7.2 Description of the monitoring plan:

>>

CMWSSB has implemented the following operational and management structure to monitor the emission reductions from the CDM project activity.

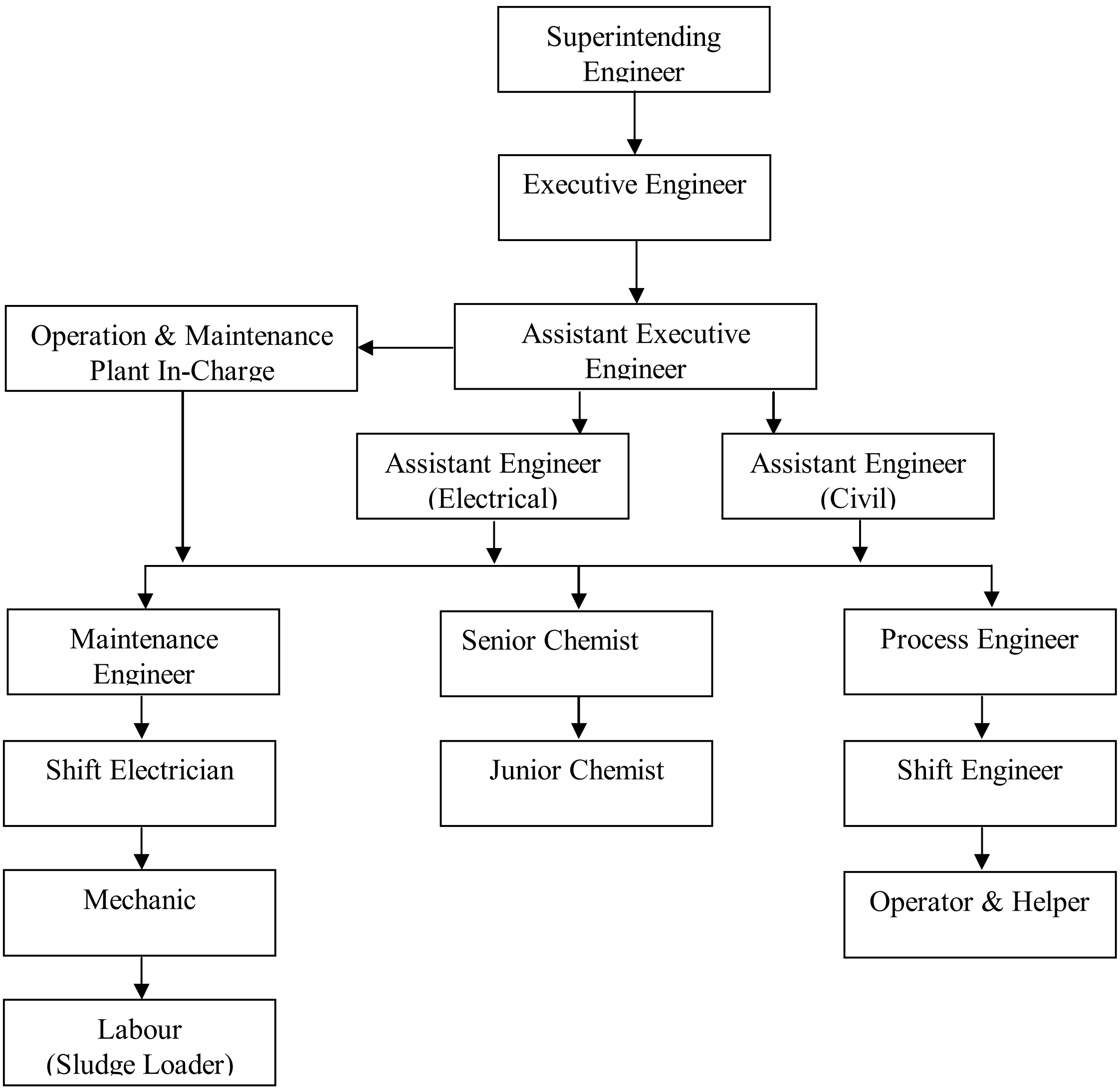

Figure B.4: Operational and Management Structure

The responsibility of monitoring the various CDM parameters have been decided and delegated to the respective departments (like maintenance, electrical and lab) in the STP. The monitored values are daily cross-checked by the respective Assistant Engineers. Further, a weekly verification of the data is conducted by the Assistant Executive Engineer (AEEs). Every month, all the recorded CDM parameters would be compiled and forwarded to the Executive Engineer (EE)/CDM Co-ordinator. Based on the monitored data received from all the four STPs, the EE will prepare a monthly report of the emission reductions and forward it to the Superintending Engineer (SE) for review.

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

>>

Date of determination of the baseline:

26/11/2007

Name of the person/entity determining the baseline:

Chennai Metropolitan Water Supply and Sewerage Board (project participant),

No.1, Pumping Station road,

Chintadripet,

Chennai – 600 002,

Tamil Nadu, India.

Refer Annex I for details.

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

>>
03/09/2003

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

>>
10 years 0 months

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

>>
CMWSSB has adopted a fixed crediting period of ten years

C.2.1. Renewable crediting period

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

>>

C.2.1.2. Length of the first crediting period:

>>

C.2.2. Fixed crediting period:

>>

C.2.2.1. Starting date:

>>
01/04/2008 or Upon Registration with UNFCCC whichever is later

C.2.2.2. Length:

>>
10 years 0 months

SECTION D. Environmental impacts

>>

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

>>

As per the National Environmental Impact Assessment (EIA) notification of the Ministry of Environment and Forests (MoEF) dated 27.01.1994 and amended as on 13.06.2002, EIA is not required to be conducted for the project activity.

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

>>

Not Applicable

SECTION E. Stakeholders' comments

>>

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

>>

CMWSSB had invited all the local stakeholders involved in the project activity and the date, time and venue of the meeting were informed well in advance. The meeting was conducted at Nesapakkam Treatment Plant conference hall on 29.10.2006 between 10.30 hrs and 13.00 hrs. The stakeholders were welcomed to the Nesapakkam Treatment Plant conference hall where the meeting was organized. The stakeholders and CMWSSB personnel introduced themselves. CMWSSB Engineer gave a presentation describing the following:

- The CMWSSB process of water and wastewater treatment
- Greenhouse effect, Global warming, Kyoto protocol and CDM
- About the innovative approach adopted by CMWSSB to mitigate Greenhouse Gases
- Power generation process, fuel used and technology employed in CMWSSB project activity
- Environmental benefits of the project activity including GHG emission reductions and sustainable development of the region

Later, the stakeholders were taken to the project activity site to get an insight of process involved and the CMWSSB personnel explained the process and also answered queries of the stakeholders.

At the end of the meeting, the stakeholders provided their responses in writing. All the received responses were positive and encouraging. There were no negative comments received from any of the stakeholders. The responses have been documented for the reference of DOE during the Validation process.

E.2. Summary of the comments received:

>>

Query 1: "*Can you brief us on the process involved in the project activity?*"

Stakeholder Name: Captain Mr. N.V. Narasimhan, Resident

CMWSSB Response: *"The project activity involves the capture methane gas generated from the sludge digestor and the captured gas will be fed to the gas combustion engine to produce electricity"*

Query 2: "*When the treated Wastewater is released into the water bodies, does it cause any harm to the water bodies?*"

Stakeholder Name: Ln Mr. Vairasekar, Representative of NGO

CMWSSB Response: *"The treated wastewater are under the prescribed limit of the pollution control board and CMWSSB takes proper care to be within the prescribed limits by regularly monitoring the treated wastewater before disposing it and the treated wastewater does not cause harm to the water bodies "*

Query 3: *"Is this project advertised or publicly availablable?"*
Stakeholder Name: Mr. H. Vembu, Resident
CMWSSB Response: *"No, after the project gets registered it would be made public"*

All the stakeholders agreed to CMWSSB's above response.

Other Comments:
Comment: *"We are happy that this environment friendly project activity has come up and we would appreciate if this project can be given more publicity"*
Stakeholder Name: Mr. H. Vembu, Resident

Comment: *"We sincerely appreciate the efforts taken by the CMWSSB to mitigate the Greenhouse Gases and would like to see the same kind of project activity being extended to other parts of the state"*
Stakeholder Name: Mr. V. Nagasundaram, Representative from NGO

Comment: *"We congratulate CMWSSB for such an innovative project and at the same we would like to thank CMWSSB for inviting us and helping us to understand the modus of operandi adopted by CMWSSB to mitigate Greenhouse Gases"*
Stakeholder Name: Mr. P. Chandrasekaran, Representative from NGO

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

>>

No negative comments were received from the stakeholders. All the stakeholders were happy in knowing that a CDM project activity in their locality is contributing to a global cause and they commended the CMWSSB management for their initiatives in the areas of climate change and sustainable development. The stakeholders lauded the project promoter for the environment friendly measures.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Chennai Metropolitan Water Supply and Sewerage Board
Street/P.O.Box:	No.1, Pumping Station Road
Building:	Chintadripet
City:	Chennai
State/Region:	Tamil Nadu
Postfix/ZIP:	600 002
Country:	India
Telephone:	+91 44 28520758
FAX:	+91 44 28419643
E-Mail:	ceccrcp@chennaimetrowater.com
URL:	www.chennaimetrowater.com
Represented by:	
Title:	Engineering Director
Salutation:	Mr.
Last Name:	D.
Middle Name:	
First Name:	Madhavamoorthy
Department:	
Mobile:	+91 98843 55553
Direct FAX:	
Direct tel:	+91 44 28525544
Personal E-Mail:	

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

The project promoter has not used public funding for the project activity.

Annex 3

BASELINE INFORMATION

The Central Electricity Authority (CEA) has published the baseline emission factors database for the various electricity grids in India. The emission factors have been calculated based on UNFCCC guidelines (ACM0002). For further details on the calculation methods and data used, please refer the following weblink:

http://www.cea.nic.in/planning/c%20and%20e/Government%20of%20India%20website.htm

In the CEA database, the simple operating margin, build margin and combined margin emission factors of the regional electricity grids have been provided separately for two cases; Including electricity imports and Excluding electricity imports from other regional grids. Since, emission factors excluding imports are lower, the same has been considered as a conservative approach. The combined margin emission factor for the southern regional grid (0.86 tCO_2/MWh) has been considered for this project activity.

CENTRAL ELECTRICITY AUTHORITY: CO2 BASELINE DATABASE

VERSION	**1.1**
DATE	**21 Dec 2006**
BASELINE METHODOLOGY	**ACM0002 / Ver 06**

EMISSION FACTORS

Simple Operating Margin (tCO2/MWh) (excl. Imports)

	2000-01	2001-02	2002-03	2003-04	2004-05
North	0.98	0.98	1.00	0.99	0.97
East	1.22	1.22	1.20	1.23	1.20
South	1.02	1.00	1.00	1.01	1.00
West	0.98	1.01	0.98	0.99	1.01
North-East	0.67	0.66	0.68	0.62	0.66
India	1.02	1.02	1.02	1.03	1.03

Build Margin (tCO2/MWh) (excl. Imports)

	2000-01	2001-02	2002-03	2003-04	2004-05
North					0.53
East					0.90
South					0.72
West					0.78
North-East					0.10
India					0.70

Combined Margin (tCO2/MWh) (excl. Imports)

	2000-01	2001-02	2002-03	2003-04	2004-05
North	0.76	0.76	0.77	0.76	0.75
East	1.06	1.06	1.05	1.07	1.05
South	0.87	0.86	0.86	0.86	0.86
West	0.88	0.89	0.88	0.88	0.90
North-East	0.39	0.38	0.39	0.36	0.38
India	0.86	0.86	0.86	0.86	0.86

Annex 4

MONITORING INFORMATION

Volume of biogas:

The volume of biogas is monitored through the gas flow meters and will be recorded daily in a log book. The accuracy of the meter will be ensured by proper calibration of the flow meters in periodic intervals as specified by the manufacturer.

Fraction of Methane in biogas:

The fraction of methane is measured through an Orsat apparatus every month and will be recorded in the log book. The accuracy of the data will be ensured by following standard sampling and testing methods and by periodic replacement of the apparatus working fluid. Moreover, gas samples will be sent to a third party for analysis of the methane content once a year. The lower value of that determined by CMWSSB in Orsat method and that determined by third party analysis will be considered for calculating emission reductions.

Pressure of biogas:

The pressure of biogas is measured through pressure gauges and will be recorded daily in a log book. The accuracy of the data will be ensured by proper calibration of the gauge in periodic intervals as specified by the manufacturer.

Temperature of biogas:

The temperature of biogas is measured through temperature gauges and will be recorded daily in a log book. The accuracy of the data will be ensured by proper calibration of the gauge in periodic intervals as specified by the manufacturer.

Electricity generated by the gas power generation units:

The net electricity generated by the project activity is monitored through energy meters and will be recorded daily in a log book. The accuracy of the meter will be ensured by proper calibration of the energy meters in periodic intervals as specified by the manufacturer.

Appendix 1

LIST OF REFERENCES

- www.unfccc.int
- CEA Monthly Power sector reports-
  http://www.cea.nic.in/power_sec_reports/executive_summary/2005_12/6.pdf
- MNES study report titled "Baselines for Renewable Energy Projects under Clean Development Mechanism": Chapter 2 - http://mnes.nic.in/baselinerpt.htm
- MNES Annual report 2004-05:
  http://www.mnes.nic.in/annualreport/2004_2005_English/ch2_pg1.htm
- Emission reduction calculations
- www.envfor.nic.in
- www.mnes.nic.in
- www.cea.nic.in
- Detailed Project Report
- Letters of consent from stakeholders

Appendix 2

ABBREVIATIONS

ASP	Activated Sludge Process
CCRCP	Chennai City River Conservation Project
CMWSSB	Chennai Metro Water Supply and Sewerage Board
CC	Climate Change
CDM	Clean Development Mechanism
CEA	Central Electricity Authority
CER	Certified Emission Reductions
CO	Carbon mono-oxide
CO_2	Carbon di-oxide
COD	Chemical Oxygen Demand
dB	Decibel
DPR	Detailed Project Report
EIA	Environmental Impact Assessment
FYP	Five Year Plan
GHG	Greenhouse Gas
GOI	Government of India
GWh	Gega Watt hour
H2S	Hydrogen Sulphide
IPCC	Intra-governmental Panel for Climate Change
IPP	Independent Power Producers
IREDA	Indian Renewable Energy Development Agency
KP	Kyoto Protocol
Km	Kilo meters
KV	Kilo Voltage
KW	Kilo Watt
KWh	Kilo Watt hour
TNEB	TamilNadu Electricity Board
TNPCB	TamilNadu Pollution Control Board
TNERC	TamilNadu Electricity Regulatory Commission
LP	Low Pressure
1 Lakh	1,00,000
MkWh	Million Kilo Watt hour
mld	Million litres per day
MU	Million units
MNES	Ministry of Non-conventional Energy Sources
MoP	Ministry of Power
MoU	Memorandum of Understanding
MSW	Municipal Solid Waste
MT	Metric Ton
MW	Mega Watt
NCE	Non Conventional Energy
Nox	Nitrogen Oxides

NM3	Normal Cubic Metres
NTPC	National Thermal Power Corporation
NOC	No Objection Certificate
O&M	Operation and Maintenance
p.a	Per annum
PLF	Plant Load Factor
PIN	Project Idea Note
PPM	Parts Per Million
REP	Renewable Energy Projects
SEB	State Electricity Board
SO_2	Sulphur Di-oxide
SPM	Solid Particulate Matter
STP	Sewage Treatment Plants
TJ	Trillion Joules
TPH	Tones Per Hour
TERI	Tata Energy Research Institute
UNFCCC	United Nations Framework Convention on Climate Change
VSS	Volatile Suspended Solids