Project Design Document

"Methane gas Capture and Electricity Production at Kubratovo Wastewater Treatment, Sofia Bulgaria"

Софийска вода

European Bank
for Reconstruction and Development

- Final Version -

July, 2005

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1.2 Project Abstract

Project Title	Methane gas Capture and Electricity Production at Kubratovo Wastewater Treatment Plant, Sofia, Bulgaria
Abstract	The project is both a methane emissions reduction and an electricity and heat production project, whereby methane produced on the Kubratovo wastewater treatment plant will be captured and used in CHP gas engines for electricity and heat production. The key feature of the project is to reduce the emissions of methane gas to the atmosphere from the present sludge treatment activity. The project involves digester refurbishment, provision of gas distribution to engine house; gas engine co-generation system and an excess gas flare system. The objective of the project is to capture methane emissions and to maximise generation of electricity and heat from the gas engines thereby reducing the electricity demand of the plant produced from fossil fuel and heat from burning of diesel fuel. Electricity not used for own consumption will be supplied to the grid. In addition there will be a reduction by almost 50% in the volume of sludge transported to landfill.

Figure 1 – Digesters and pumping station for raw sludge

Project location	The Kubratovo wastewater treatment plant is located some 20 km outside the centre of Sofia the capital of Bulgaria in the district of Kubratovo next to the River Iskar. Adjacent to the digestion plant are the sludge holding tanks and sludge drying beds. The sludge landfill site is located some 18km from the plant at Kremikovtzi.
Date go/no-go decision of project	August 2004

Construction starting date	September 2004
Construction finishing date	April 2006
CHP starting date	January 2007
Project operational lifetime	25 years (16 year for the CHP)
Crediting Period	April 2006 – December 2007 (inclusive): Early credits (AAUs) January 2008 – December 2012 (inclusive) Kyoto period, (ERUs)

1.3 Background and Justification

Background	Sofiyska voda is the water company of Sofia registered on 28th December 1999.The company was formed following the award of a 25-year concession to United Utilities by Municipality of Sofia to operate and maintain the water and wastewater services in Sofia the capital of Bulgaria. The company is 75% owned in partnership with EBRD with the Municipality of Sofia owning the remaining 25%. The municipality of Sofia owns the Kubratovo wastewater treatment plant being the site location of this particular project. Prior to the award of the water concession in 1999, the water company of Sofia (VIK), 100% owned by the municipality, operated and maintained the Kubratovo works. The sludge treatment project has long history. It was initiated by the Municipality of Sofia in 1993 following the decommissioning of the digesters. Unfortunately the Municipality of Sofia was not able to complete the project and only partial reconstruction and equipment delivery were undertaken due to the lack of financing. The idea of re-commencing the project came about following the award of the water and wastewater concession to an international operator in 2000. Following this award, the new concession company Sofiyska Voda AD started to seek more efficient ways to operate the system. In 2002 Sofiyska Voda AD tried to recommence the project, but once again, due to financing difficulties, the project reconstruction had to be postponed again. In the middle of 2004 Sofiyska Voda AD was approached by several Carbon trading companies, all authorised by their respective governments to negotiate transactions on their behalf. The aim of these companies is to trade with Carbon emission reductions as described in article 6 of Kyoto protocol. This potential opportunity placed Sofiyska Voda AD in new and improved position in relation to the implementation of the project for the reconstruction of the sludge plant. In the light of the Kyoto protocol, completion of the project including the installation of a combined heat and power unit will enable the project to become emission reduction generative and eligible for carbon credits under the Joint implementation mechanism of the Kyoto protocol. Following the evaluation of suitable offers a choice was made to work with the Netherlands EBRD Carbon Fund. Working in conjunction with this Fund, Sofiyska Voda AD was able to recommence the tender procedure for the project. Following the tender procedure the work commenced at the end of September 2004.

The original sludge treatment design was for thickening of surplus activated sludge followed by thermophilic digestion of primary and surplus activated sludge. Post thickening of the digested sludge was followed by conditioning of the sludge with ferric chloride and lime with mechanical dewatering by 8 no Vacuum filters housed in a large sludge dewatering building. However due to high operation and maintenance costs linked to the Bulgarian economic crisis of the early 90`s the digesters were decommissioned in 1993 and have not operated since.

This situation has remained the case to date with sludge treatment being undertaken by a low technology solution resulting in high methane emissions to atmosphere. Decomposition of organic compounds in sludge in anaerobic conditions results in production of methane (CH_4) gases. Methane is a highly potent greenhouse gas, with Global Warming Potential of approximately 21 times greater than CO_2.

This project for the refurbishment of the digestion plant and installation of CHP gas had for many years been a high priority of the municipality of Sofia but due to lack of funding, the financial situation in the original water company VIK, linked to the economic situation in Bulgaria the project was unable to proceed.

Figure 2 – Sludge Drying beds

Intervention	The project is both a methane emissions reduction and energy production project. Methane produced on the Kubratovo wastewater treatment plant will be captured and used in newly installed CHP gas engines for electricity and heat production, which will in turn reduce the works electricity demand from the national grid and on-site diesel fuel usage. Electricity not used for own consumption will be supplied to the grid. An additional benefit of the project will be the reduction of odours from the wastewater treatment plant and the existing sludge disposal site some 18km from the plant. Further the project will enable easier handling of the sludge, hence improving the environmental aspects with regard to day-to-day operation of the plant. The main purpose the project being undertaken is to transform the existing low tech sludge treatment process at Kubratovo into a modern advanced treatment process matching the best sludge treatment available in Western Europe. This transformation will have a major effect on the environment in that completion of the project will dramatically reduce the existing methane gas emissions at the plant and sludge disposal site. The project can be identified as "Methane Recovery" which falls into the category of waste management and "energy recovery", which in turn is classed within the category of energy projects. Long term strategic reductions of GHG emissions will include: ➢ reduction in open release of CH_4 from open anaerobic sludge tanks and drying beds; ➢ reduction in open release of CH_4 from landfill disposal site; ➢ reduction in CO_2 emissions due to replacement of electricity production from fossil fuels; ➢ reduction in CO_2 emissions due to replacement of heat generation from fossil fuels. Completion of this project will deliver the following key results: ➢ all primary and secondary sludge thickened and digested as per EU recommendations and guidelines; ➢ all biogas produced within the digestion process used for power and heat generation via CHP gas engines thus reducing the site electricity requirement from the National grid; ➢ reduction in site fossil fuel usage as all site-heating requirements will be met from CHP gas engines; ➢ all sludge stabilised and pathogen free.

	The overall objectives can be outlined as below: ➢ replace the traditional sludge drying beds and landfill options with mesophilic digestion of all primary and secondary sludge followed by mechanical dewatering in order to reduce GHG emissions; ➢ effectively mitigate odour problems from the existing treatment of sludge and sludge liquors through introduction of digestion and removal of sludge drying beds; ➢ production of fertiliser by mechanical dewatering of the digested stabilised sludge; ➢ production of electricity from utilisation of the biogas in CHP gas engines thereby reducing GHG emissions from electricity production from the grid. The project activity consists of several key stages: ➢ rehabilitation of 4 No 7000 m^3 digesters; ➢ provision of New Raw Sludge Pumping Station; ➢ Biogas Withdrawal System; ➢ provision of new sludge recirculation unit; ➢ provision of biogas utilisation and mixing system; ➢ refurbishment of gas holder; ➢ refurbishment of heating and boiler system; ➢ provision of CHP gas engines.
Goal	Efficient use of energy recovery from treatment of sewage leading to generation of electricity and heat to be used on-site, reducing operational costs.
Purpose	The purpose of the project is to provide a environmentally friendly sludge treatment process that reduces the current methane and Carbon dioxide emissions inherent with the existing method of treatment.
Results	Results of the project will be reduced methane emissions from drying beds and landfill. Reduced Carbon dioxide emissions will result through elimination of use of diesel oil for heating and reduced use of electricity from grid due to on-site production of electricity and heat from gas engines. Other results will be reduced operational costs such as transport, fuel, chemicals and power.
Activities	Key activities of the project will be refurbishment of digesters and ancillary equipment, commissioning of digesters, sizing of CHP gas engines, installation of gas engines and commissioning of gas engines.

2. Current situation

2.1 Status and adequacy

Figure 3 – Primary settling tank

Average flows into the Kubratovo wastewater treatment works are 480,000 m^3 per day with the treated effluent being discharged into the River Iskar. The treatment of sewage at Kubratovo WwTP can be placed into four main treatment stages;

a. preliminary treatment including oil removal, screening and grit removal;
b. primary settlement of the preliminary treated sewage;
c. biological treatment of settled effluent via fine bubble diffused air activated sludge;
d. secondary settlement of the biological treated wastewater.

At tertiary stage of treatment, disinfection of the final effluent with Chlorine is available but this stage is not in use at present.

With regard to sludge treatment primary sludge settling tanks are installed with a separate pumping station equipped with centrifugal pumps. Primary sludge is pumped from these settling tanks to the mixing chamber.
Before the primary sludge enters the mixing chamber it passes a separate screen. At the moment, digestion is unavailable so the primary sludge is pumped into a separate aeration tank for aerobic stabilization before being mixed with surplus activated sludge in the mixing chamber.

Surplus sludge from the aeration tanks flows by gravity to a separate distribution chamber and from there into 2 pre-thickening tanks. The pre thickened sludge flows into a separate collecting tank. From there the sludge flows into the mixing chamber where it is mixed with the primary raw sludge.

The mixed raw sludge is pumped for chemical conditioning followed by belt pressing with the resulting sludge cake being transported to the on-site drying beds and left for a period of 15 to 18 months to dry. The dry digested sludge cake is then transported some 18km to the landfill site, Kremikovtzi.

With a view to gather greater detail of sludge decomposition a study was initiated by SV in May 2000 It was carried out by a scientific team from the National Hygienic Centre in Bulgaria, part of Ministry of Health. The team examined various types of sludge production routes including drying beds, vacuum filters and belt filter presses. Studies examined sludge aging from 1 day to 18 months on samples taken from each production route. The samples were tested for variety of indicators including mesophilic and psihrofilic bacteria, coli forms, escherichia coli, enthero coci etc.

The study indicated that at the end of the 18th month, no matter what the production route was (drying beds, vacuum filters or belt filter presses), the process of mineralization is almost complete with the organics having been significantly reduced into harmless and simple minerals.

As a result of all sample tests the scientific team concluded that the sludge coming from the belt filter presses requires 7 to 15 months storage in order to be neutralized. The sludge transferred directly to the on-site drying beds requires 18 months to reach a satisfactory level of mineralization.

In both cases the organic compounds in the sludge are degraded during storage, mainly anaerobically. Due to the anaerobic degradation of the sludge in the on-site drying beds methane gas is produced which being a strong greenhouse gas contributes to high greenhouse gas emissions.

As has been noted earlier this existing sludge treatment system is rather low tech and indeed is not “environmentally friendly” with regard to high methane emissions from the open sludge tanks, drying beds and disposal site. It is also the case that all heating requirements on-site are met through the burning of fossil fuel in inefficient boilers.

It is as a result of this existing method of sludge treatment that a project to change the current method has been instigated. See Annex 2 or detailed description of the current situation of the WwTP.

2.2 Operation Mode

The existing delivery system for treatment and disposal of sludge from the Kubratovo site is more or less fixed with little flexibility available in the treatment and disposal operation. It is key that sludge is removed from the primary sludge tanks on a daily basis. This is to ensure there is no solids build up in the tanks that would lead to treatment problems such as floatation of the sludge with odour nuisance or possible blockages within the pipe work.

Similarly it is crucial that all surplus activated sludge from the secondary treatment stage is removed from the tanks and pumped to thickening tanks. Failure to do so will lead to an increase in solids within the process leading to extra electricity requirements and possible effluent compliance failures which are not acceptable.

The current situation in relation to sludge disposal is the following: the sludge is chemically treated with polyelectrolyte prior to being dewatered on a belt press, with the resulting sludge cake being disposed of at the on-site drying beds at Kubratovo.

Present electricity requirements of the site from the National Grid are high with usage at Krubratovo being 24 GWh in 2004. This represents over 68% of the total electricity requirements of the water company. Current usage of fossil fuel for heating requirements at Kubratovo is 700,000 kg of diesel per annum. In absence of the Project this consumption is assumed constant.

Electricity usage at Kubratovo is quite constant with the plant using some 69% of the total requirements of Sofiyska Voda AD. For 2003 and 2004 details of usage are provided in table 2.1 and 2.2 below:

Table 2.1: Consumed Electrical Energy (in %)

Description	2003	2004
Kubratovo WwTW	66.4	68.5
Bistritza, Pancharevo WTP`s	3.9	3.6
Pumping Stations	14.0	12.5
Hydrophores	8.4	8.4
Cash Offices	0.3	0.4
Reservoirs, Chlorination, Offices	6.3	5.9
Impounding Structures	0.7	0.8
	100	100

Table 2.2: Consumed Electricity at Kubratovo (in kWh)

Month	2003	2004
January	1,982,000	2,087,000
February	1,833,000	2,002,000
March	1,930,000	1,989,548
April	1,773,168	2,057,440
May	1,680,580	2,047,760
June	1,599,448	1,937,408
July	1,835,944	1,949,332
August	1,920,340	1,949,244
September	1,647,028	1,931,000
October	1,833,656	2,051,000
November	1,839,000	2,086,612
December	2,038,000	2,184,776
Total	21,912,164	24,273,120

The Pollution Indicators of 2004 are presented in table 2.3 below.

Table 2.3: Pollution Indicators 2004 (in t/month)

Month	$BOD_{red.}$	SS
January	1,112	1,062
February	979	1,174
March	813	963
April	1,410	1,364
May	1,500	1,545
June	1,208	1,573
July	991	1,006
August	1,089	1,062
September	1,027	1,093
October	1,267	984
November	1,324	1,073
December	1,595	1,103

Data provided in tables 2.1, 2.2 and 2.3 above has been obtained from site records. The site data is collected in a variety of ways including:

- on-site electricity meters;
- on-site sampling and monitoring system;
- invoicing of goods delivered;
- on-site flow meters.

Further data on-site flows is provided in Annex 5.

3. Greenhouse gas sources and project boundaries

3.1 Current delivery system

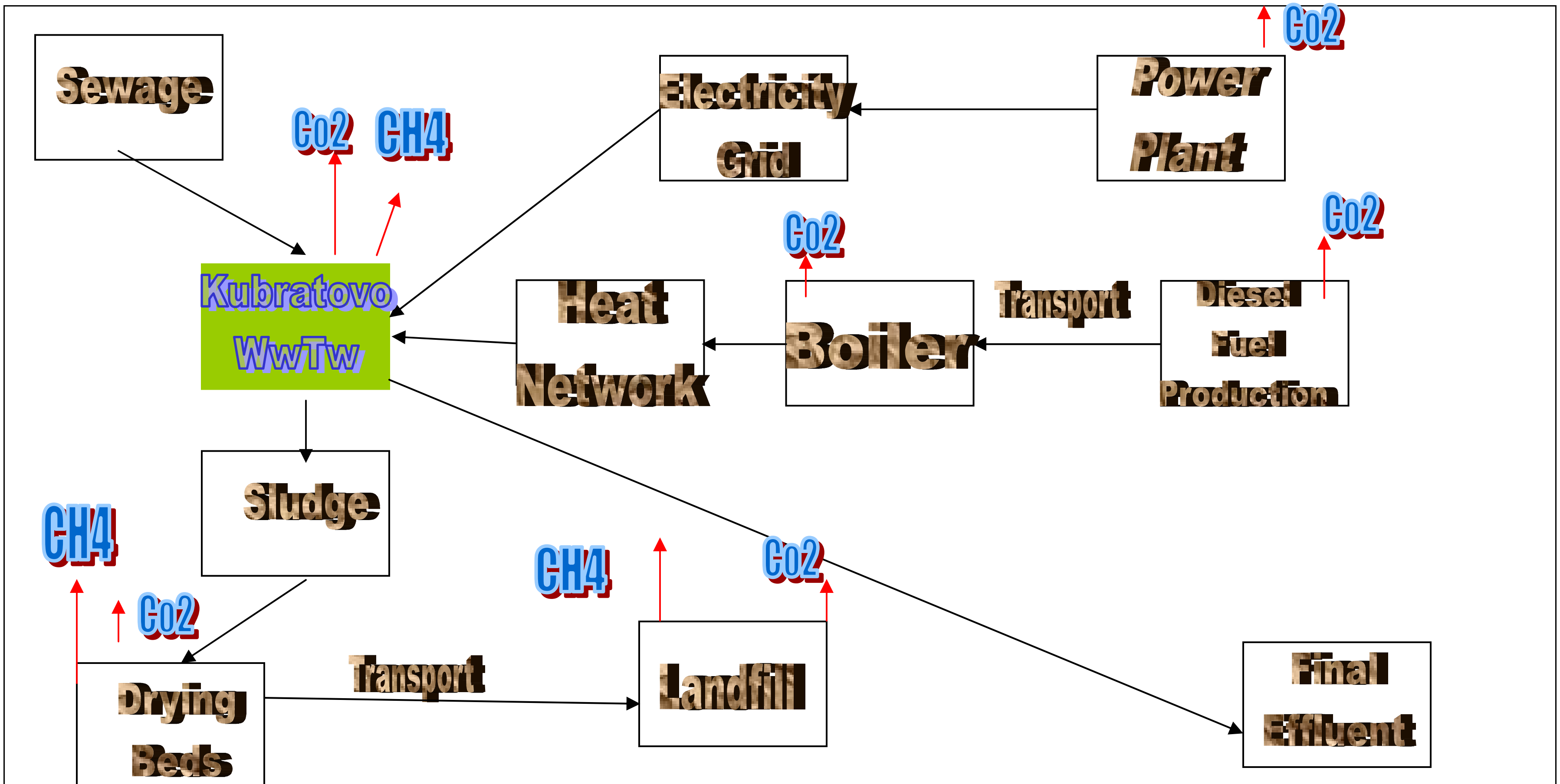

Figure 4

Below are listed the greenhouse gas emission sources and sinks in the current situation, including determination of significance	
Direct on-site emissions	• CO_2 emissions from use of on-site generation to produce heat. • CH_4 emissions from disposal of sludge on-site drying beds. • CH_4 emissions from waste water treatment (excluded as this will not be effected by the Project) • CH_4 emissions from sludge wells and pumping stations as sludge is pumped around site (excluded – less than 1% of the overall emission reductions) • Emissions from on-site transport use (excluded – less than 1% of the overall emission reductions)
Direct off-site emissions	• CH_4 emissions from disposal of sewage sludge at landfill site • Emissions from transport of sewage sludge to landfill site (excluded – less than 1% of the overall emission reductions)
Indirect on-site emissions	• CO_2 emissions from fuel utilisation in on-site transportation of sludge (excluded – less than 1% of the overall emission reductions)
Indirect off-site emissions	• CO_2 emissions from fossil fuel power stations producing electricity utilised at Kubratovo site • CO_2 emissions from fuel utilisation in off-site transportation of sludge to landfill (excluded – less than 1% of the overall emission reductions)

3.2 Project Delivery System

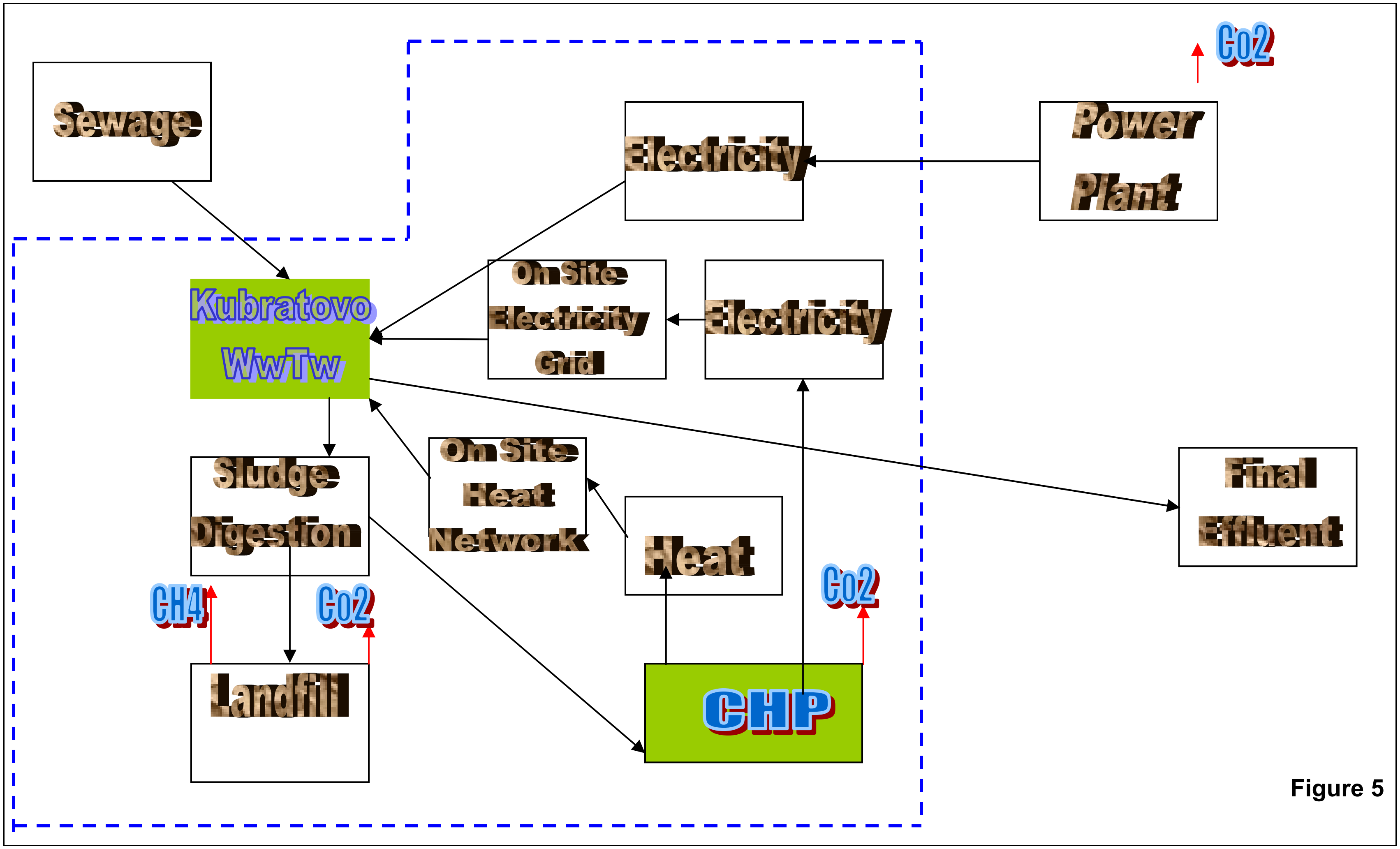

Figure 5

Listed below are the greenhouse gas emission sources in the Project , including determination of significance	
Direct on-site emissions	• CH_4 emissions from sludge wells and pumping stations (excluded – less than 1% of the overall emission reductions) • CH_4 emissions from waste water treatment (excluded as this will not be effected by the Project) • emissions from on-site transport use (excluded – less than 1% of the overall emission reductions) • CO_2 emissions from flaring of CH_4 (excluded, as the biogas used is categorised as a renewable source of biomass) • CO_2 emissions from the generation of Heat and Electricity from the biogas (excluded, as the biogas used is categorised as a renewable source of biomass)
Direct off-site emissions	• CH_4 emissions from disposal of sewage sludge at landfill site
Indirect on-site emissions	• CO_2 emissions from fuel utilisation in on-site transportation of sludge (excluded – less than 1% of the overall emission reductions);
Indirect off-site emissions	• CO_2 emissions from fuel utilisation in off-site transportation of sludge to landfill (excluded – less than 1% of the overall emission reduction)

3.2 General comments on flowchart and boundaries

Two main sources of GHG emissions are included in the boundary:

1. Direct on-site emissions related to CH_4 and CO_2 released to the atmosphere in baseline and project scenario;
2. Direct on-site emissions related to the present heat supply system;
3. Indirect emissions related to CO_2 emissions due to electricity consumption at the wastewater treatment plant.

Other sources excluded are:
1. Indirect on-site emissions and emissions due to construction and operation (insignificant) and
2. Transport of equipment and construction materials used (insignificant).
3. CO_2 emissions due to electricity generation at the plant site, as biogas is a renewable source of biomass.

Direct and indirect emissions included in the calculation of emission reductions are as follows:

1. CH_4 emissions from disposal of sludge on-site drying beds.
2. CH_4 emissions from disposal of sewage sludge at landfill site
3. CO_2 emissions from use of on-site generation to produce heat.
4. CO_2 emissions from fossil fuel power stations producing electricity utilised at Kubratovo site
5. CO_2 emissions from flaring the excess biogas

The previous flow charts indicate the existing situation and the expected project situation. The project boundary contains all anthropogenic emissions by sources of greenhouse gases under the control of the project participants that are significant and reasonably attributable to the project. Excluded from the project boundary is electricity production from the fossil fuel power station. As can be seen from the flow chart the project removes the requirement for an on-site boiler, which is replaced by a CHP gas engine. The boiler will be retained on-site as will a supply of diesel oil for standby purposes should the digestion process fail or repairs are required on the CHP unit.

The main reductions in the anthropogenic emissions following implementation of the project are CH_4 reductions at the onsite drying beds and at the landfill site, CO_2 reductions through on-site electricity production reducing requirement from grid and CO_2 reductions following the need for the oil fired boiler.

A number of insignificant emissions are excluded from the flow charts such as on-site and off-site traffic movements with regard to sludge disposal.

4. Key Factors

4.1 Summary of Key Factors

Factors that will influence the baseline development are as follows:

On-site
- Quantity of sewage received at site;
- Sewage strength with respect to BOD and SS;
- Quality and quantity of sludge produced;

Off-site
- Accession of Bulgaria to the EU;
- Connectivity to sewers and hence Kubratovo WwTW;
- Prosperity of citizens;
- Living and social conditions;
- Industrial activity as Bulgaria's economy improves;
- Fuel prices;
- Population.

4.2 Key Factor Description and Likely Trends

Figure 6– Aeration tanks

4.2.1 On-site Key Factors

In respect of the baseline development the only on-site key factors having any influence relate to the quantity and quality of the sewage that is to be treated by the plant. This in turn affects the quantity and quality of sludge production and disposal. The GHG emissions again are totally related to the quantity of sludge produced on-site.

For Kubratovo the indications are that over time there will be more of the Sofia population connected to the system producing more sewage and hence additional sludge quantities leading to greater GHG emissions. Increase in GDP leads to increase in sewage strength. Subsequent increase of sewage strength in terms of increasing BOD and SS will again lead to greater sludge production and as such additional GHG emissions.

The reverse is also true in that should the quantity and /or strength of the sewage decrease there will be a reduction in the amount of sewage sludge produced which will lead to less GHG emissions.

4.2.2 Off-site Key Factors

Economic growth and social and demographic factors

With respect to the baseline development one key external factor of influence will be the continued economic improvement of the Bulgarian economy and the likely entry of Bulgaria into the EU in 2007. As economic growth in Bulgaria continues to increase so will the social and living conditions of the people, as GDP increases and average salaries increase. With these increased salaries and improved standards of living the population is able to purchase more and better food products or white goods for use around the home.

As a consequence improved living and social conditions has a knock on effect on sewage strength with strong links between the two. In the case of Sofia the sewage is extremely weak as a result of poor social and living conditions, low level of industrial activity and a high level of infiltration water into the sewer system around Sofia. Accurate information on the quantity and quality of sewage and sludge at Kubratovo is well documented. An intensive sampling regime has been in place and will continue to enable accurate and reliable information on trends.

The 25 year concession to operate the water and wastewater services of Sofia, requires Sofiyska Voda AD to increase the connectivity to the sewerage system across the city and to reduce the high infiltration levels into the sewer system.

Figure 7 – Dewatering house

The result over time will be more people connected to sewer and less infiltration into the system hence increased sewage strength. As noted earlier sewage strength will also increase as social and living conditions continue to improve. Increased sewage strength received at Kubratovo WwTW will result in additional primary sludge quantities from increased suspended solids (SS) and additional secondary sludge from higher biochemical oxygen demand (BOD). While it is difficult at this stage to predict the actual increase in strength we have assumed that the reduced BOD quantities will increase yearly from 18,000 dry tonnes for year 2006 to 23,400 dry tonnes in 2012.

The increase in sludge quantities produced at Kubratovo will lead to increases in CH_4 emissions at on-site drying bed and the landfill site locations, given that the existing mode of operation is continued. With regard to the project implementation increased sludge quantities will lead to increased CH_4 production in turn leading to additional heat and electricity production from the CHP gas engine.

Legislation Development
With entry into the EU expected in May 2007, Bulgaria like all member countries will be subject to all EU legislation with full compliance required over time. With regard to water and wastewater services Bulgaria will have to comply with the urban wastewater directive and water framework amongst others. Bulgaria has been granted derogation in respect of compliance and for example will be able to continue sludge disposal to landfill, as is the case today. Derogation for dumping of sludge has been given till 2014[1].

Fuel Prices
As with all growing economies fuel prices will continue to rise over time. Currently Kubratovo uses some 700,000 kg of diesel oil per annum at an annual cost of 295,000 EURO. For the existing method of treatment to become financially less attractive than the proposed project fuel prices would have to rise substantially maybe ten fold, which seems extremely unlikely during the time frame in question. The expectation is the fuel prices

[1] 2004, regular Report on Bulgaria's Progress Towards Accession (EU Commission).

will continue to increase at a rate in line with average inflation and thus will not change the baseline thinking.

4.3 Summary of Risks to the Project

Provided below are key factors and risks influencing the project activity.

Key factors to the Project are as follows:
- quality and quantity of methane gas produced by digestion plant;
- overall efficiency of digestion process;
- maintenance requirements of the CHP gas engine;
- sewage strength with respect to BOD and SS;
- level of possible contaminants to digestion process contained in sewage;
- quality and quantity of sludge produced;
- efficiency and reliability of CHP gas engine.

Risks to Project are as follows:
- efficiency of digesters;
- reliability of CHP gas engine;
- skills required to operate and maintain gas engine;
- inaccurate sludge quantity forecasts;
- insufficient quantities of methane;
- digester failure due to poisoning;
- current availability of CHP technology.

4.4 Best Available Technology and Skills

The Supplier of Technology shall produce a training plan outlining all training activities and shall submit a copy of the plan to the Project Manager, for approval, prior to commencement of training.

The Supplier of Technology shall allow two training sessions for each topic to be covered, arranged to allow the phased attendance of the Sofiyska Voda AD staff working on a shift system. The training shall include, but not be limited to;

- Off-site class room training
- On-site class room training
- Hands on training
- Refresher training

Training shall include operation of overall processes and shall not be limited to individual components or systems.

Training shall at all times refer to the relevant sections of the O&M Manuals and drawings.

Operational demonstration shall be carried out in groups not exceeding 7.

The training shall include an operational demonstration of the following:-

- Plant control functions
- Plant monitoring and action on alarms
- Operation of safety systems
- Operation of set-point adjustment and controls
- Fault or failure shutdown of main elements of plant whilst in automatic mode
- Operational function from SCADA/LOI's
- Operation of the main elements of plant when the various PLC controls fail
- Access to, and removal (as necessary) of equipment
- Routine maintenance tasks
- Lifting arrangements

Combined heat and power gas engines have been on the market now for many years with the technology vastly improved from the early units which tended to be of poor reliability and high maintenance particularly in regard to corrosion problems caused by gas streams with high H_2S content. Today's CHP gas engines are state of the art with high reliability factors and minimum maintenance requirements. Most of the units today have an integral gas cleaning system, which eliminates the potential H_2S corrosion problem noted earlier.

What will be lacking at Sofiyska Voda will be the expertise in operating and maintaining the units as this will be the first CHP project in the Bulgarian water sector. This will be overcome with training and knowledge transfer particularly from United Utilities who have installed and operate many such projects in North West England, their home base.

The CHP training shall include an operational demonstration of the following:

- Managers
  - Overview of Combined Heat Power Concept
  - Overview of bio-gas process and structure
  - Energy contract format
  - Responsibility in terms of safety
    - Electricity connections of parallel generation
    - Gas, water and electrical systems
  - Financial overview
    - Reporting savings
    - Reporting performance

- Operators
  - Overview of Combined Heat Power Concept
  - Overview of bio-gas process and structure
  - Energy contract format
  - Responsibility in terms of safety
    - Electricity connections of parallel generation
    - Gas, water and electrical systems
  - Control functions
  - Taking readings
  - Scheduled Tasks

- Maintenance
  - Overview of Combined Heat Power Concept
  - Overview of bio-gas process and structure
  - Energy contract format
  - Responsibility in terms of safety
    - Electricity connections of parallel generation
    - Gas, water and electrical systems
  - Control functions
  - Scheduled Tasks and key maintenance activities
  - Familiarisation with O&M Manuals
  - Specialist skills
    - Fault finding
    - Equipment removal, overhauling, replacing
    - Testing and Commissioning

Apart from that during the process of tendering and purchase of the combined heat and power gas engine it will be requested from the potential supplier to deliver on site a training program and operation manuals, which will enable the operational stuff to use the gas engine safely and efficiently. This requirement will be part of the tender documents for CHP purchase and respectively the future bidder offers will be weighted in accordance to the training plan proposed as well.

5. Identification of the most likely baseline

5.1 Forecast baseline scenario

In order to determine the expected baseline carbon emission factors an analysis of the key factors both on-site and off-site is required. This analysis is provided in section 4.2 of this report.

In determining the baseline scenario a list of possible alternatives was initially examined. These are provide below:

Scenario	Likelihood of Scenario
Business as usual	Possible. No requirements exist. Water company lacks financial funds
Methane recovery and gas flaring	Not probable. Methane recovery and flaring is the cheapest investment option, but solution does not provide any revenue stream for company and is environmentally unacceptable
Methane recovery and electricity and heat production	Possible. Electricity and heat production will provide additional revenues/savings which makes the investment economically attractive
Land filling	Not probable. Untreated sludge is classed as hazardous and as such is not allowed to be land filled, so not a realistic option
Aerobic composting	Not probable. Aerobic composting can be a technical alternative but this solution does not provide any additional revenues. Furthermore this option will result in higher operational costs
Mineralisation	Not probable. Mineralisation is both expensive and will not provide any additional revenues for the company
Combustion	Not probable. For combustion the sludge needs to be dried. For drying the heat source needs to be relatively cheap which is not the case.

Following this analysis it was decided that the realistic baseline scenario would be based on business as usual taking into account the likely changes in the key factors. In this scenario the key factors that will have any effect on the baseline are the social and demographic factors linked to the economy, which in turn have a significant effect on the sewage strength and corresponding sludge volumes.

a) Sewage strength

The waste water collected at Kubratovo increase from 2003 to 2004 with more than 19%. The BOD reduced at Kubratovo for year 2004 is 15,000 dry tonnes. This amount has been increasing over the past two years significantly as the reconstruction programme for the treatment works has progressed and as a result of ever increasing social and living standards within the city. As we move closer to the completion of this reconstruction programme of the plant later this year, the reduction of BOD will continue to increase and will on completion be 18,000 dry tonnes per annum. The ongoing reconstruction will enable the plant to treat sewage from communities and areas throughout the city presently not connected.

Figure 8 – Inlet structure

b) Social and demographic factors
We have assumed a figure of BGN 568 for 2005 for the average monthly household income in Sofia for the purpose of calculating the increase in living standard. This figure has been determined after consideration of data from the National Statistical Institute, Regional Statistical Office of Sofia, Sofia in Figures 2003, published 2004.

According to this source the average Bulgarian household income for the year of 2002, the latest year for which data was available at the time of producing this document, is BGN 420 per month. The average household income of BGN 420 per month for the year of 2002 has been inflated to give an estimate for 2005. This was done by carrying forward the average actual increase in salary of 10.5% (as per the Bulgarian National Statistical Institute) over the period 1998 to 2002 and carrying this forward to 2005. This produces an average household income within Sofia of BGN 568 for 2005. The household income must also be projected forwards for 2012 to the remainder of the remainder of the trading period set by the Kyoto protocol in order the increase in living standard to be evaluated.

For estimates of future changes, the figures published by the Agency for Economic Analyses and Forecasts (a department of the Ministry of Finance of the Bulgarian Government), has been used. This forecasts that incomes for the whole of Bulgaria will increase at a rate of 8% per annum in real terms. It is considered that this might not be sustainable on a long-term basis, so a more conservative assumption of 7% per annum growth of household income in real terms has been used in the calculations for the sludge volumes.

Based on the Urban Development Plan the population will increase by approximately 3.8% over the remaining term of the trading period, or just under 0.5% per annum on a simple basis. Sofiyska Voda AD has used these population figures from the Urban Development Plan in the estimation of this report.

Based on the above described we have predicted that the reduced BOD will grow each year by some 5% on base year taken as 2006 or 1,000 dry tonnes per annum. This would provide a reduced BOD production of 23,400 dry tonnes at Kubratovo in 2012. Yearly figures in dry tonnes per annum are provided below in table 5.1.

Table 5.1: BOD reduced (in tonnes per annum)

year	2006	2007	2008	2009	2010	2011	2012
tonnes	18 000	18 900	19 800	20 700	21 600	22 500	23 400

5.2 Sensitivity Analysis

All data that has been used for the key factors determination, has been presented in three variants: (i) low; (ii) medium; and (iii) high. For the purpose of defining the most likely baseline scenario the medium variants have been used for all data. In order to carry out a sensitivity analysis we used both low and high variants and by doing this setting a range of the possible variation of the GHG emissions.

In case of the low scenario a lower variant of the forecasts for population, household incomes (economic growth) etc are used. We determined that in the pessimistic scenario the sewerage strength will increase by 2% per annum. In case of the optimistic scenario a higher variant from the statistical data is used. We determined an increase in the sludge volume produced by 9% annually. The totals for all three scenarios are given in table 5.2, below.

Table 5.2: total BOD reduction in three scenarios (in dry tonnes)

Year	2006	2007	2008	2009	2010	2011	2012
low scenario	18 000	18 360	18 720	19 080	19 440	19 800	20 160
Medium scenario	18 000	18 900	19 800	20 700	21 600	22 500	23 400
high scenario	18 000	19 620	21 240	22 860	24 480	26 100	27 720

5.3 Construction of the baseline scenario

The baseline scenario constructed does represent the expected greenhouse gas emissions that would occur at Kubratovo in the absence of the project. A description of the likely developments and key factors is provided in section 5.1.

This baseline scenario has also assumed that the present heating of the Kubratovo site (700,000 kg of diesel oil per annum) will be completely replaced by heat produced by the installed gas engines of the project. It is also assumed that the gas engines will also reduced the electricity demand from the national grid. The remaining Electricity produced will be supplied to the grid.

5. 4 Calculation of Baseline emissions

5.4.1 Methodology for calculating GHG emissions from sludge treatment

The methodology for estimating reductions include two types of emissions:

a) GHG emissions from sludge operations on the wastewater treatment plant;
b) GHG emissions from Electricity and Heat used on the wastewater treatment plant, which will be replaced by the Project.

The exact calculation of CO_2 equivalent ("CO_2e") emissions in the baseline and in the Project is a complicated procedure, but the difference of CO_2e emissions between the baseline and in the project is relatively easy to calculate. Therefore methodology used is based on the calculation of the difference of CO_2e production between baseline and the project.

The *IPCC Guidelines* describe a single method for calculating CH_4 emissions from domestic wastewater handling. Emissions are a function of the amount of waste generated and an emission factor that characterizes the extent to which this waste generates CH_4. The following equation describes how the annual CH_4 emissions are calculated:

Emissions = Total Organic Waste x Emission Factor

To calculate the total CH_4 emissions from sludge, the selected emission factors are multiplied by the associated organic sludge production for each handling method and then summed.

In equation form, the estimate of total CH4 emissions from sludge handling is as follows:

$$SM_j = HSR_j \times TOS \times MCF_j \times Bo$$

where:
SM_j = total methane emissions from sludge in handling system j in kg CH_4;
TSR_j = ratio of organic waste that degrades in treatment system j;
TOS = total organic waste for sludge in kg DC/yr. For domestic streams, the DC (Degradable Organic Component) is the BOD;
MCF_j = methane conversion factors for the different wastewater treatment systems. The MCF indicates the extent (expressed as a fraction) to which the methane producing potential occurs.
Bo = maximum methane producing potential of each waste type in kgCH_4/kgDC

- **Bo**

The guidelines state that if country specific data is not available (which is the case for Sofia) a default value of 0.6 kg/CH_4 BOD can be used. Comprehensive field test data (Doorn *et al*., 1997) support this default.

- **MCFs**

The MCF is an estimate of the fraction of BOD that will ultimately degrade anaerobically. In drying beds and on landfill not all the organic fraction that can be degraded anaerobically will be degraded anaerobically. A mixture of aerobic decomposition of the organic fraction (at the material surface) will occur, as well as anaerobic (in areas where no oxygen is available).

This partially aerobic respiration is not taken into account in the IPCC Good Practice Guidance, but to prevent an overestimation of the baseline emissions this extension of the IPCC methodology to take account of aerobic decomposition is included. The MCF depends on depth of the sludge pit, sludge quality, temperature and so on.

It is suggested that MCF values will be used as given in table 5.3 below.

Table 5.3: default values of MCF

	Deep > 5m	Medium depth 1 – 5 m	Small depth <1m
MCF	95%	70-95%	20-70%

The ratio of global warming from a unit of CH_4 to that of one unit of CO_2 over hundred years, defined by decision 2/CP.3 is 1 unit of CH_4 versus 21 units of CO_2. CH_4 emissions are therefore multiplied with 21 to convert in tonnes of CO_2 equivalents (tCO_2e).

5.4.2 Calculation of GHG emissions sludge treatment

BOD is captured at inlet screens and within grit removal chambers. Apart from that due to the presence of open tank surfaces, leaks, failures, etc, some part of the BOD reduced is not utilised in terms of CH_4 production. We assume that 10% of the overall BOD reduction is not responsible for production of methane and will not be changed by the Project. Yearly figures of methane generative BOD captured at the plant in dry tonnes per annum are provided in table 5.4.

Table 5.4: BOD - CH_4 generative (in tonnes per annum)

year	2006	2007	2008	2009	2010	2011	2012
tonnes	16 200	17 010	17 820	18 630	19 440	20 250	21 060

Conditions are different for waste digestion on the drying beds and the landfill. Therefore separate MCF factors are used depending on the type of sludge handling system. There are 110,000 m^2 of drying beds at the Kubratovo site. The depth of a single drying bed is 0.7 m, but as the sludge is stored there after dewatering the real depth of the disposed sludge is 1 m. Based on table 5.3 an appropriate MCF value is MCF_{DB} = 0.7.

Complete conversion of the biodegradable waste generated in a climate, such as in Bulgaria, normally takes at least two years. According to the current practice on the Kubratovo site the sludge is kept for a period of 15 – 18 months. In regards to the process kinetics of the biological anaerobic process it is considered that 85% of the BOD will be degraded on the drying beds. The remainder of the BOD will degrade on the Landfill.

The landfill that is used for dumping the dried sludge is an old abandoned mine Kremikovtzi. The depth of the sludge layer is between 2 and 3 meters. Based on table 5.3 an appropriate MCF value is MCF_L = 0.9. As this will lead to higher emissions, and the ratio is difficult to estimate, it is assumed that all of the BOD will be degraded on the drying beds.

This will also ensure a conservative calculation of the emissions. Based on that assumption the CH_4 emissions are given in table 5.5 below.

$$\mathbf{SMj = HSRj \times TOS \times MCFj \times Bo}$$

Table 5.5: overview baseline emission calculation from sludge

		2006*	2007	2008	2009	2010	2011	2012
TOS	KgBOD	16 200	17 010	17 820	18 630	19 440	20 250	21 060
HSR_{DB}		1	1	1	1	1	1	1
MCF_{DB}		0.7	0.7	0.7	0.7	0.7	0.7	0.7
B_0	$kgCH_4/kgBOD$	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Total CH_4	$KgCH_4$	5 103*	7 144	7 484	7 825	8 165	8 505	8 845
GWP		21	21	21	21	21	21	21
Total sludge emissions	tCO_2e	107 163*	150 028	157 172	164 317	171 461	178 605	185 749

*) – the biogas production will start at the beginning of April 2006

5.4.3 Calculation of GHG emissions own heat production and electricity from the grid

For the calculation of GHG emissions for heat production and electricity form and to the grid the approved baseline methodology "Simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories" was applied. Specifically for:-

(i) the renewable electricity delivered to the grid "*Type I – Renewable Energy Projects, I.D. Renewable electricity generation for a grid*" has been used;

(ii) the renewable electricity for own use and replacing electricity form the grid "*Type I – Renewable Energy Projects, I.D. Renewable electricity generation for a grid*", has also been used, but a correction is made to account for the Transmission and Distribution Losses;

(iii) the renewable thermal energy (heat) for own use and replacing own generation with diesel fuel "*Type I – Renewable Energy Projects, I.C. Thermal energy for the user*", has been used.

Calculation of the Emission Factors can be found in Annex 18.

Expected CH_4 production

It is always difficult to predict how much methane will be produced by the digesters. Based on first experience, the exact size of the CHP engine will be determined. Nevertheless, in this paragraph an estimate is made to estimate the anticipated quantity of heat and electricity this Project is likely to produce.

Although the digesters provide almost theoretically perfect conditions to the sludge digestion there is a level of degradation that cannot be exceeded. This is due to the time retention factor. The sludge will be kept within the digesters for a period of 15 day. This will be sufficient for most of the methane to be released within the fermentation tanks, not the maximum possible amount. It is considered that approximately 90% of the BOD will be digested here (further referred as Digester ratio or $HSR_{digester}$). In other words only 90% of the possible methane will be produced by the digesters, which is a conservative estimate.

Further more we assume that the CHP will utilise 90% of overall CH_4 emissions that will be produced by the digesters. 5% is a safety margin for failures of the CHP unit or in moments when the production of the biogas exceeds the capacity of the CHP unit. The rest of the biogas produced by the digesters will be flared. Another 5% are responsible for all types of biogas leakages from the gas system, which consists of Digesters, gas pipes, gasholder, gas equipment and fittings etc. As a result 10% in total will not be utilized by the gas engine.

For the determination of the quantity of CH_4 produced the same formula as given in section 5.4.1 is used. As the sludge will be digested in fermentation tanks, an ideal situation for the generation of CH_4 is created. In this calculation 0.95 is therefore taken as value for $MCF_{digester}$.

The equation below describes the CH_4 generated from the digesters:

$$\mathbf{SMj = HSRj \times TOS \times MCFj \times Bo}$$

See table 5.6 below for the calculation of the methane.

Table 5.6: overview methane production from the digester

		2006*	2007	2008	2009	2010	2011	2012
TOS	KgBOD	16 200	17 010	17 820	18 630	19 440	20 250	21 060
$HSR_{digester}$	%	90	90	90	90	90	90	90

$MCF_{digester}$	%	95	95	95	95	95	95	95
B_0	$kgCH_4/kgBOD$	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Total CH_4	tCH_4/y	6 233*	8 726	9 142	9 557	9 973	10 388	10 804

*) - the biogas production will start at the beginning of April 2006.

Expected Energy Production

90% from the CH_4 produced in the digestion tanks will be utilised by the CHP and used to replace present supply of heat and electricity. The calculations on the energy generation will be based on the 90% CH4 used. Table 5.7 shows the energy generation from the CH_4 produced by the digesters.

Table 5.7: utilised methane from the digester

CH4 utilisation in CHP		2006*	2007	2008	2009	2010	2011	2012
CH4 utilised by the CHP	t/y	-	7,854	8,227	8,601	8,975	9,349	9,723
CH4 LHV	MJ/kg	-	50	50	50	50	50	50
Energy content biogas	GJ	-	392,676	411,375	430,074	448,772	467,471	486,170
Energy (heat) used in the digester	GJ	-	20 408	20 408	20 408	20 408	20 408	20 408
Energy input available in the CHP	GJ	-	372,267	390,966	409,665	428,364	447,063	465,762
Electricity production	%	-	38%	38%	38%	38%	38%	38%
Heat production	%	-	47%	47%	47%	47%	47%	47%
Electricity production in the CHP	GJ	-	141,462	148,567	155,673	162,778	169,884	176,989
Electricity production in the CHP	MWh	-	39,295	41,269	43,242	45,216	47,190	49,164

*) the CHP will be operational at the beginning of 2007

Heat

In table 5.8 data is given for the calculation of baseline emissions for the heat replacement. Diesel oil has a CEF (Carbon Emission Factor) of 74.1 $kgCO_2$ / GJ.

Table 5.8: data CHP unit

Energy content biogas	50 MJ / tCH_4
Heat use for digester	20 408 400 MJ
Diesel Oil Carbon Emission Factor	74.10 $kgCO_2/GJ$

The plant has two main heat consumption needs – building heating and digesters heating. At present local heat supply is provided with a diesel boiler. Currently Kubratovo uses some 700,000 kg of diesel oil per annum for heat generation. Using this number as a basis and having in mind that 1 kg Diesel = 10,200 kcal. and 1 kcal. = 4.1868 kJ we assume that the plant's heating requirement are **29,893,752 MJ.** According to the detailed design by Passavant Roediger Anlagenbau for the sludge plant reconstruction the digesters will require overall heat amount of 15.5 MWh/daily. The total amount for digesters heating in MJ equals to **20,408,400 MJ.** The total heat requirements for the plant and digesters are **50,302,152 MJ.** The emissions reduction that could be claimed from the heat energy source replacement is the heat currently produced by the diesel boilers.

Table 5.9: CEF for heat generated by CHP used on-site

Year	2006*	2007	2008	2009	2010	2011	2012
GJ needed	-	29 894	29 894	29 894	29 894	29 894	29 894
$kgCO_2/MWh$	-	74.1	74.1	74.1	74.1	74.1	74.1
tCO_2e	-	2 215	2 215	2 215	2 215	2 215	2 215

*) the CHP will be operational at the beginning of 2007

Electricity
The CHP unit will not only be able to satisfy the current electricity demand of the plant, but is likely to generate more than that. The extra electricity produced by the CHP will be supplied to the National Grid. In this regard, the Bulgarian Energy law adopted by the Bulgarian Parliament on November 26, 2003, published in the State Gazette No. 107 of December 9, 2003 states in chapter 11 (eleven), section I, Article 159 (2): "The Public provider and/or public suppliers shall be obliged to buy out the electricity generated in plants using renewable energy sources, ...with total installed capacity up to 10 MW...". Furthermore, in Article 160 (1) it states: "The transmission Company and the distraction companies shall be obliged to connect by priority all power plants generating electricity from renewable energy sources ...with total installed capacity up to 10MW to the transmission network and the distribution network respectively".

Title and reference of the approved baseline methodology applied to the project activity is ASM-I.D "Renewable Electricity Generation for a grid". This choice of the methodology is deemed justified and applicable to the project activity as the chosen methodology is designed for grid-connected renewable power generation project activities. The conditions for the methodology to be applicable are respected:

- the project activity applies to electricity capacity additions from electricity generation from biogas;
- generated electricity is supplied to an electricity distribution system that is supplied by at least one fossil fuel or non-renewable biomass fired generating unit;

The eligibility limit of 15 MW/y for the Project is respected.

The chosen methodology has been applied in the context of the project through determining the emissions factor for the Bulgarian grid. The additionality questions have been answered, and the answers substantiated with documented evidence, in such a way as to clarify why the project would not occur in the absence of the JI. Operating and Build Margins have been used to calculate the emission factor for the electric grid. Considering that Bulgaria has a substantial share of its total produced electricity being provided by hydropower – a low-cost source – the Operating Margin was calculated using data from the National Electricity Company and adjusted to include the biggest hydropower plants. Then, using both of these derived "margins" to determine the Combined Margin, it was possible to estimate the emission factor of the grid and therefore know "what would happen otherwise", in terms of GHG emissions.
The baseline is the kWh produced by the renewable generating unit multiplied by an emission coefficient (measured in kg CO_2eq/kWh) calculated in a transparent and conservative manner as the average of the "approximate operating margin" and the "build margin", where:

i. The "approximate operating margin" is the weighted average emissions (in kg CO_2eq/kWh) of all generating sources serving the system, excluding hydro, geothermal, wind, low-cost biomass, nuclear and solar generation
ii. The "build margin" is the weighted average emissions (in kg CO_2eq/kWh) of recent capacity additions to the system, which capacity additions are defined as the greater (in MWh) of most recent 20% of existing plants or the 5 most recent plants."

For historical data and projections for the electricity generation, CO_2eq emissions from electricity generation and the emission factors, please look at "Historical data and projections for the electricity generation, CO_2 emissions from electricity generation and the emission factors". Calculations to determine the emission factors for one year see "Calculations to determine the emission factors for one year. Information of the study performed by the national electric company (NEK), Bulgaria. Dated 09-05-2005. Study on standard multi project baseline for Joint Implementation projects in the Bulgarian power sector.

Determination of the annual emissions of CO_2 and of other noxious gases is according to Commission decision of 21.01.2004 establishing guidelines for the monitoring and reporting of Greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council. The emissions factors elaborated by the MoEW (Methodology for calculation of emissions of noxious substances (pollutants) released into the environment based on balance methods) have been used for the CO_2 emissions assessment.

The calculation of the emissions of CO_2 and other noxious substances are made at the following premises:

- The emissions from biogas combustion are zero
- The decrease of harmful gases emissions equals the emissions form, obtained from the combustion of an alternative (substituting) fuel
- The increase of harmful gases emissions is due to transportation, which emit these gases when heavy fuel oil, petroleum, etc. are used
- The increase of harmful gases emissions is also due to electricity usage for the needs of the steam boiler.

For the electricity generated and used on-site and additional 10% for transport losses has been used (http://www.eva.ac.at/enercee/bg/supplybycarrier.en.htm). The baseline emissions, based on the electricity produced by the CHP, are given in table 5.10 below. Calculation of these factors can be found in annex 18.

Table 5.10: CEF for electricity to be replaced from and supplied to the grid

	2006*	2007	2008	2009	2010	2011	2012
MWh produced by CHP	-	39,295	41,269	43,242	45,216	47,190	49,164
MWh currently used	-	25,200	26,400	27,600	28,800	30,000	31,200
CEF electricity reduction from the grid (kgCO2/MWh)	-	1,319	1,319	1,319	1,319	1,319	1,319
tCO2e	-	33,239	34,822	36,405	37,988	39,571	41,154
Extra MWh to National grid	-	14,095	14,869	15,642	16,416	17,190	17,964
CEF electricity generation for the grid (kgCO2/MWh)	-	1,199	1,199	1,199	1,199	1,199	1,199
tCO2e	-	16,900	17,829	18,757	19,685	20,613	21,541
Total tCO2e	-	50,139	52,651	55,162	57,673	60,183	62,694

*) the CHP will be operational at the beginning of 2007

5.4.4 Total Baseline emissions

The total baseline from the emissions from the present sludge treatment, heat generation and electricity used on the plant in the period till 2012 is shown in table 5.11 below.

Table 5.11: total baseline emissions (in tCO_2e)

Year	2006	2007	2008	2009	2010	2011	2012	Total
Present sludge treatment	107 163*	150 028	157 172	164 317	171 461	178 605	185 749	1 114 495
Electricity generation by CHP	-	50,139	52,651	55,162	57,673	60,183	62,694	338,503
Heat generation by CHP	-	2 215	2 215	2 215	2 215	2 215	2 215	13 291
Total emissions	107,163	202,382	212,038	221,694	231,349	241,003	250,658	1,466,289

6. Additionality

Test 1. The project is not business as usual because an alternative exists for the project that is more economically attractive.

Currently in Bulgaria there is no legal requirement or environmental regulation in place that would cause the company to change from its present operational mode at this moment in time. Sludge is presently sent to drying, where it stays for 18 months before it is disposed at a landfill site. The landfill has sufficient operational capacity to receive the sludge from Kubratovo beyond 2012. There have been some discussions with the municipality regarding locating a waste incinerator on the Kubratovo site. If such an incinerator were installed there would be a possibility of incinerating the sludge in admixture with the domestic waste. However this decision by the municipality to build a waste incinerator is seen to be quite some time away and will certainly not be operational before end 2012.

Therefore the only viable alternative to the project implementation is the continuation of the existing sludge treatment process at Kubratovo. This existing process involves removal and thickening of the sludge followed by belt pressing of the sludge with storage on on-site drying beds and disposal to an off-site landfill. Continuation of this existing process requires no capital expenditure. Opex costs for the period 2003 to 2012 are provided below. All figures are nominal. Sludge volumes are forecast to increase from 20,000 Tonnes per annum to 26,000 tonnes per annum in 2012.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Transport	325000	325000	325000	325000	341250	357500	373750	390000	406250	422500
Electricity	1424291	1577753	1577753	1625000	1706250	1787500	1868750	1950000	2031250	2112500
Manpower	110000	110000	110000	110000	110000	110000	110000	110000	110000	110000
Maintenance	100000	100000	105000	110250	115763	121551	127628	134010	140710	147746
Chemicals	250000	250000	250000	250000	262500	275000	287500	300000	312500	325000
Disposal	10000	10000	10000	10000	10500	11000	11500	12000	12500	13000
Heating Oil	547,000	547,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000
Total	2766291	2919753	3177753	3230250	3346263	3462551	3579128	3696010	3813210	3930746
Total EURO	1418611	1497309	1629617	1656538	1716032	1775667	1835450	1895390	1955492	2015767

Table 6.1: Operational cost for business as usual (values in EUR)

Net present value of this method of treatment for the period 2003 to 2012 using a 10% discount rate is 10,383,298 EURO. The assumptions are:

- 5% increase in sludge production from 2006;
- electricity costs increase 5% per annum as a result of increased volumes;
- chemical, transport, disposal and maintenance costs also rise by 5% per annum as a result of increased sludge volumes;
- figures are all nominal.

With regard to implementation of the project the corresponding figures are detailed below.

Assumptions are:

- 5% increase in sludge production from 2006;
- digestion operation reduces sludge volumes by 30%;
- transport, chemical and disposal costs reduce by 30% per annum from 2006;

- maintenance costs increase by 5% per annum;
- CHP gas engine produces 60,000 kWh per day;
- CHP engine eliminates the need for diesel oil presently used for on-site heating.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Capital Commissioning	1950000	4875000	4100000		0	0	0	0	0	0
Transport	325000	325000	325000	214500	225225	235950	246675	257400	268125	278850
Electricity	1424291	1577753	1577753	1625000	1706250	1787500	1868750	1950000	2031250	2112500
Manpower	110000	110000	110000	72600	47916	31625	20872	13776	9092	6001
Maintenance	100000	100000	105000	110250	115763	121551	127628	134010	140710	147746
Chemicals	250000	250000	250000	165000	173250	181500	189750	198000	206250	214500
Disposal	10000	10000	10000	6600	6930	7260	7590	7920	8250	8580
Heating Oil	574000	574000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000
Savings										
Electricity	0	0	0	-698299	-733214	-768128	-803043	-837958	-872873	-907788
Heating Oil	0	0	0	-800000	-800000	-800000	-800000	-800000	-800000	-800000
Total	4743291	7821753	7277753	1495651	1542120	1597257	1658222	1723147	1790804	1860388
Total EURO	2432457	4011155	3732181	767001	790831	819106	850370	883665	918361	954045

Table 6.2:Operation cost for Project without Carbon Credits(values in EUR)

Net present value of this project for the period 2003 to 2012 using a 10% discount rate is 11,413,562 EURO. Therefore the project is not an economically attractive course of action with the preferred option being the continuation of the existing method of treatment.

Test 2. The project is not business as usual because without the sales of Carbon credits the project is not economically viable.

Presently a law would be required to ensure that this particular project is carried out. As there is not such a law the project is additional. As has been shown in test 1 the project as it stands is not economically viable. Using a 10% discount rate the NPV of the project without sales of Carbon credits is 11,413,562, EURO. With sales of Carbon credits included within the project it becomes economically viable as the NPV at 10% discount rate becomes 9,507,680 EURO. In this scenario including the sales of Carbon credits the project is not business as usual and is therefore additional. Costs revenues and savings are provided below:

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Capital Commissioning	1950000	4875000	4100000		0	0	0	0	0	0
Transport	325000	325000	325000	214500	225225	235950	246675	257400	268125	278850
Electricity	1424291	1577753	1577753	1625000	1706250	1787500	1868750	1950000	2031250	2112500
Manpower	110000	110000	110000	72600	47916	31625	20872	13776	9092	6001
Maintenance	100000	100000	105000	110250	115763	121551	127628	134010	140710	147746
Chemicals	250000	250000	250000	165000	173250	181500	189750	198000	206250	214500
Disposal	10000	10000	10000	6600	6930	7260	7590	7920	8250	8580
Heating Oil	574000	574000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000
Carbon Credits				-2913254	-1456627	-1456627				
Savings										
Electricity	0	0	0	-698299	-733214	-768128	-803043	-837958	-872873	-907788
Heating Oil	0	0	0	-800000	-800000	-800000	-800000	-800000	-800000	-800000
Total	4743291	7821753	7277753	-1417603	85493	140630	1658222	1723147	1790804	1860388
Total EURO	2432457	4011155	3732181	-726976	43843	72118	850370	883665	918361	954045

Table 6.3: Operation cost for Project with Carbon Credits (values in EUR)

Figure 9 – Inlet Channel

7. Estimation of project emissions

7.1 Emissions from the CHP

Biomass describes, in one word, all plants, trees and organic matter on the earth. Biomass is a source of renewable energy because the natural process of photosynthesis constantly produces new organic matter in the growth of trees and plants. Photosynthesis stores the sun's energy in organic matter. That energy is released when biomass is used to make heat, electricity or liquid fuels.

As the generation of electricity and heat is done from Biogas from Waste Water, which is a renewable source of biomass, no emissions from the CHP using biogas are considered.

7.2 Emissions from landfill

After the process of digestion the sludge will be dewatered and afterwards transported to the landfill. There the process of anaerobic digestion will continue and the remaining BOD (10%) will be digested at the landfill. For these emissions MCF_{LF} = 0.9 is used.

SMj = HSRj x TOS x MCFj x Bo

Table 7.1: overview methane emissions from the landfill

		2006*	2007	2008	2009	2010	2011	2012
TOS	Kg BOD	16 200	17 010	17 820	18 630	19 440	20 250	21 060
HSR_{LF}	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1
MCF_{LF}	%	0.9	0.9	0.9	0.9	0.9	0.9	0.9
B_0	kg CH_4/kg BOD	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Total CH_4	CH_4	656*	919	962	1 006	1 050	1 094	1 137
GWP		21	21	21	21	21	21	21
Total LF emissions	tCO2e	13 778*	19 289	20 208	21 126	22 045	22 964	23 882

*) - the biogas production will start at the beginning of April 2006.

7.3 Emissions from flaring and leakage from capturing system

As mentioned, it is assumed that 90% of the CH_4 produced will be used in the CHP. The remainder is flared, as the CHP might have some down time or the production of the biogas exceeds the capacity of the CHP unit. As these CO2 emissions are emitted from a renewable energy source, flaring is deemed CO2 neutral. Therefore no emissions from flaring are considered in the project emissions.

The biogas capturing system will be gas proof and certified as gastight to avoid leakage of biogas from the system. Nevertheless, to be conservative in the estimation of the Project emissions, a leakage of CH_4 from the system of 5% is assumed.

Table 7.2: overview emissions from biogas leakages

		2006	2007	2008	2009	2010	2011	2012
Leakage 5%	tCH_4/y	312	436	457	478	499	519	540
Emissions from leakages	tCO2e	6 545	9 162	9 599	10 035	10 471	10 908	11 344

7.4 Total Project emissions

The total Project emissions from the sludge treatment and electricity generation on the plant in the period till 2012 are. See table 5.10 below.

Table 7.3: total Project emissions (in tCO_2e)

Year	2006*	2007	2008	2009	2010	2011	2012	Total
Landfill emissions	13,778	19,289	20,208	21,126	22,045	22,964	23,882	143,292
Leakage from gas capture system	6,545	9,162	9,599	10,035	10,471	10,908	11,344	68,064
Total Project emissions	20,323	28,451	29,807	31,161	32,516	33,872	35,226	211,356

*) – the CHP will be operational at the beginning of 2007

8. Estimation of emission reductions

The implementation of this project is anticipated to reduce 1,254,931 tonnes of CO_2e in the period 2006 till 2012 (inclusive). The Project Activity is expected to generate 260,771 Early Credits (AAUs) in the years 2006 and 2007 and 994,160 ERUs in the period 2008 and 2012. Table 9.1, below, provides details of the estimation of emission reductions caused through the project during the crediting period 2006 to 2012.

Table 8.1: overview of emission reductions (in tCO_2e)

Year	total	2006	2007	2008	2009	2010	2011	2012
A. BASELINE EMISSIONS								
a. CH_4 emissions	1 114 495	107 163*	150 028	157 172	164 317	171 461	178 605	185 749
Drying beds	1 114 495	107 163*	150 028	157 172	164 317	171 461	178 605	185 749
Landfill	0	0	0	0	0	0	0	0
b. CO_2 from electricity	338 502	0	50 139	52 651	55 162	57 673	60 183	62 694
c. CO_2 from heat	13 290	0	2 215	2 215	2 215	2 215	2 215	2 215
Total Baseline emissions (a + b + c)	1 466 287	107163	202 382	212 038	221 694	231 349	241 003	250 658
B. PROJECT EMISSIONS								
a. Landfill emissions	143 292	13 778	19 289	20 208	21 126	22 045	22 964	23 882
b. CH4 leakage gas system	68 064	6 545	9 162	9 599	10 035	10 471	10 908	11 344
Total Project emissions (a + b)	211 356	20 323	28 451	29 807	31 161	32 516	33 872	35 226
Total reductions (A - B)	1 254 931	86 840	173 931	182 231	190 533	198 833	207 131	215 432

9. Project Monitoring Plan

For a project of this type there is no well-defined methodology for monitoring the progress and efficiency of the project. However for a wastewater project such as this it is most appropriate to accurately measure the BOD content in the sludge as this is one of the main parameter in determining emissions from sludge in the baseline survey.

The emissions reductions achieved by the Project do not have to be derived from a comparison between baseline and project emissions, as every tonne of BOD determined equals a certain amount of methane not released to atmosphere.

The effect of this is that a monitoring and emission reduction calculation method can be used that does not rely on information about baseline emissions. This is useful and convenient as the monitoring of baseline emissions from wastewater treatment plants is at best impractical and may even be impossible.

The proposed monitoring and emission reduction calculation method can also be expected to be more accurate than an attempt to derive emission reductions as the difference between monitored or estimated baseline and project emissions.

The proposed monitoring plan sets out a number of monitoring tasks in order to ensure that all aspects of projected greenhouse gas emission reductions for the project are controlled and reported. This requires ongoing monitoring of the project to ensure performance according to its design and that claimed Emission Reductions are actually achieved.

The Monitoring Plan is a working document that identifies the key project performance indicators and sets out the procedures for tracking, monitoring and calculating the impacts of the project, in particular with respect to the project's emission reductions.

This Monitoring Plan must be used by Sofiyska Voda AD staff when planning and implementing the project as well as during the project's operation. Adherence to the instructions in the Monitoring Plan is necessary for the project operator to successfully measure and track the project impacts and prepare for the periodic verification process that must be undertaken to confirm the achieved emission reductions. The Monitoring Plan is thus the basis for the generation and delivery of Emission Reduction Units (ERUs) and Assigned Amount Units (AAUs).

The Monitoring Plan assists the operator in establishing a credible, transparent, and adequate data measurement, collection, recording and management system to successfully develop and maintain the proper information required for an audit of the collected information and for the verification and certification of the achieved emission reductions. Specifically, the Sofiyska Voda AD JI project Monitoring Plan provides the requirements and instructions for establishing and maintaining the appropriate monitoring system including Worksheets for the calculation of emission reductions and the implementation of the necessary measurement and management operations.

The Monitoring Plan will be used throughout the crediting period of the project by being adopted as a key input into the detailed planning of the project; and included into the operational manuals of Sofiyska Voda AD.
The Monitoring Plan can be updated and adjusted to meet operational requirements, provided such modifications are approved by the verifier during the process of initial or periodic.

Instead of collecting data on emissions, data on emission reductions will be collected as indicated in the table provided below:

ID	Data type	Data variable	Data unit	Measured M Calculated C Estimated E	Recording frequency	Proportion of data to be monitored	Data recording	Archived data	Comments
1.	BOD	Value prior to PST	kg/O_2/l	M	Weekly	100 %	Electronic	One year after last Carbon Credit delivery (end 2013)	Data will be aggregated monthly and yearly
2.	BOD	Value after PST	kg/O_2/l	M	Weekly	100 %	Electronic	One year after last Carbon Credit delivery (end 2013)	Data will be aggregated monthly and yearly
3.	BOD	Value after SST	kg/O_2/l	M	Weekly	100 %	Electronic	One year after last Carbon Credit delivery (end 2013)	Data will be aggregated monthly and yearly
4.	BOD	Value in secondary sludge to dewatering unit	kg/O_2/l	M	Weekly	100 %	Electronic	One year after last Carbon Credit delivery (end 2013)	Data will be aggregated monthly and yearly
5.	Sludge	Flow of primary sludge to digesters	m_3/h	M	Continuous	100 %	Electronic	One year after last Carbon Credit delivery (end 2013)	Data will be aggregated monthly and yearly
6.	Sludge	Flow of secondary sludge to dewatering unit	m_3/h	M	Continuous	100 %	Electronic	One year after last Carbon Credit delivery (end 2013)	Data will be aggregated monthly and yearly
7.	Biogas	Biogas composition	%	M /E	Continuous	100 %	Electronic	One year after last Carbon Credit delivery (end 2013)	Data will be aggregated monthly and yearly
8.	Biogas	Biogas production	m^3/h	M	Continuous	100 %	Electronic	One year after last Carbon Credit delivery (end 2013)	Data will be aggregated monthly and yearly
9.	Biogas	Flow to flare	m^3/h	M	Continuous	100 %	Electronic	One year after last Carbon Credit delivery (end 2013)	Data will be aggregated monthly and yearly
10.	Boo-lean	Ignition in flare	Yes/no	M	Continuous	100 %	Electronic	One year after last Carbon Credit delivery (end 2013)	Data will be aggregated monthly and yearly
11.	Power	Electricity production imported from the Grid	kWh	M	Continuous	100 %	Electronic	One year after last Carbon Credit delivery (end 2013)	Data will be aggregated monthly and yearly
12.	Power	Electricity production at the CHP outlet	kWh	M	Continuous	100 %	Electronic	One year after last Carbon Credit delivery (end 2013)	Data will be aggregated monthly and yearly
13.	Power	Electricity production exported	kWh	M	Continuous	100 %	Electronic	One year after last Carbon Credit delivery (end 2013)	Data will be aggregated monthly and yearly
14.	Wastewater	Wastewater quantity at the plant inlet	m^3/day	M	Continuous	100 %	Electronic	One year after last Carbon Credit delivery (end 2013)	Data will be aggregated monthly and yearly
15.	Fuel	Fuel for boiler in emergency cases	kg	M	Weekly	100%	Electronic	One year after last Carbon Credit delivery (end 2013)	Data will be aggregated monthly and yearly

Table 9.1 Data collection parameters

Monitoring of most parameters will take place online. Registration of the data will be undertaken electronically and stored on a computer located on the Kubratovo. The software installed on the computer will be capable of producing reports in a wide variety of formats, ranging from on-line data to daily, weekly, monthly and annual reports as required.

Sofiyska Voda AD is primarily responsible for the management and operation of the monitoring system. The following table summarizes the monitoring responsibilities and procedures of the Sofiyska Voda AD Joint Implementation project:

Monitoring system	- Review the Monitoring Plan and suggest adjustments if necessary. - Establish and maintain the monitoring system and implement the Monitoring Plan - Prepare for initial verification and project commissioning
Data collection	- Establish and maintain data measurement and collection systems for all Monitoring Plan indicators - Check data quality and collection procedures regularly
Data computation	- Enter data in the Monitoring Plan workbook - Use the Monitoring Plan workbook to calculate emission reductions
Data storage systems	- Store and maintain records - Implement approval system for completed worksheets - Forward annual worksheet outputs
Performance monitoring and reporting	- Analyze data and compare project performance with project targets - Analyze system problems and recommend improvements (performance management) - Prepare and forward annual reports
Monitoring Plan training and capacity building	- Ensure that operational staff is trained and enabled to meet the needs of this Monitoring Plan

Quality assurance, audit and verification	- Establish and maintain an internal approval system with a view to allowing for audits and verification - Prepare for, facilitate and co-ordinate audits and verification process

The monitoring procedure will be started after commissioning of the digesters. The collection of required data, recording and reporting is in all cases the responsibility of the project operator (Sofiyska Voda AD), who will also prepare the above mentioned chapters of the annual Monitoring reports. All parameters that are to be collected and recorded are being collected and recorded since the WWTp has been commissioned in 1984. The personnel of the plant is well trained and with proper qualification and skills for implementing all the activities defined in the Monitoring Plan. In following table responsible persons for monitoring are listed:

Name of the responsible person in the project running phase	Name of Contact Person: Dobromir Simidchiev Project Manager Address: Sofiyska Voda AD Business Park Sofia, Building 2A Phone +359 2 8122 572 Fax + 359 2 974 45 14 E-mail: dsimidchiev@sofiyskavoda.bg
Name of the responsible person for business management	Name of Contact Person: David Ordman Chief Financial Officer Address: Sofiyska Voda AD Business Park Sofia, Building 2A Phone / Fax +359 2 8122 495 Fax + 359 2 974 45 14 E-mail: dordman@sofiyskavoda.bg
Name of the responsible person for on site data collecting	Name of Contact Person: Bojana Brankova Process Engineer Address: Sofiyska Voda AD WWTP Kubratovo, Benkovski quarter Phone / Fax +359 813 29 75 Fax + 359 2 936 75 08 E-mail:

	bbrankova@sofiyskavoda.bg
Name of the responsible person for final calculation of the achieved emission reductions	Name of Contact Person: Dobromir Simidchiev Project Manager Address: Sofiyska Voda AD Business Park Sofia, Building 2A Phone +359 2 8122 572 Fax + 359 2 974 45 14 E-mail: dsimidchiev@sofiyskavoda.bg
Name of the responsible person for the control of the monitoring results	Name of Contact Person: Kevin Starling Chief Executive Officer Address: Sofiyska Voda AD Business Park Sofia, Building 2A Phone / Fax +359 2 8122 520 Fax + 359 2 974 45 14 E-mail: kstarling@sofiyskavoda.bg

According to the Monitoring plan of Sofiyska Voda AD Joint Implementation Project no leakage emissions are monitored and therefore no indicators are defined as ere are no emissions to be expected. Although, as a result from the Sofiyska Voda AD JI Project and more specifically due to the reduced electricity demand from the National Grid the electricity sector will need indirectly less allowances to emit within the European Union Emission Trading System. This must be taken into consideration in the National Allocation Plan. This will be raised and discussed with the department for JI Projects within the Ministry of Environment and Water.

10. Quality Control and Quality Assurance

The quality assurance procedures to be implemented in the context of the Kubratovo sludge project will be as follows:

Monitoring records
Most data monitored for the emission reduction calculation will be registered online at predetermined interval (e.g. every 5 minutes).

The BOD measurements will be made a minimum once /week

The monitoring reports will be prepared weekly. These reports will be checked for any anomalies before being filed for future use and reference.

Parameter	**Frequency**
Gas engine The gas engine will be subject to a regular maintenance and testing regime as laid down by the manufacturer to ensure maximum engine efficiency	According to manufacturer
Gas Boiler Gas boiler will be subject to a regular maintenance and testing regime to ensure maximum efficiency	Twice per year
Gas Flare Gas boiler will be subject to a regular maintenance and testing regime to ensure maximum efficiency	Twice per year
Sludge quantities Sludge quantities are required for estimation of baseline emissions. Sludge quantities are calculated based on the actual volumes of wastewater into the plant along with the BOD content of wastewater and sludge.	Weekly
Routine reminder procedures A routine reminder procedure will be prepared to guide staff through their daily, weekly and monthly routines in general for the wastewater treatment plant and in particular for the biogas and co-generation plant	Daily
Parameter	**Frequency**
Routine reminder procedures A routine reminder procedure will be prepared to guide staff through their daily, weekly and monthly routines in general for the wastewater treatment plant and in particular for the biogas and co-generation plant	Daily

Site audits The responsible manager makes regular site visits of the digestion, biogas and dewatering plant	Monthly
Service sheets A specialist biogas company (normally manufacturer) will carry out regular service routines. Service sheets are completed for each service to ensure all aspects of the service are completed and recorded.	According to contract with gas engine supplier

In addition to the quality assurance measures noted above, operational manuals will be prepared by the manufacturer / supplier of the digestion plant, combined heat and power engine, biogas plant and flare system. These operational manuals will include procedures for training, handling of all equipment, service and maintenance plans, emergency plans and work security plans.

The table below summarises the quality control and quality assurance procedures suggested to be implemented in the context of the Kubratovo project

Table 10 –Summary of quality control and quality assurance

Data	Data variable	Uncertainty level of data	QA /QC planned	Outline explanation why Qa /QC proceedures planned or not
wastewater	Flow to WwTP	low	yes	flow meters will be subject to regular testing maintenance and calibration to maintain accuracy Expected accruracy for meters > 97%
BOD BOD	value prior/after PST and after SST value in secondary sludge to dewatering unit	low low	yes yes	BOD measurements are well known method for measurement of strength. For measurement of sludge a large sample needs to be homogenised before a small sample is analysed Weekly measurements are made by Sofiyska voda while quarterly measurements taken by independent accredited laboratory
Sludge	Flow to dewatering unit and to digesters	low	yes	flow meters will be subject to regular testing maintenance and calibration to maintain accuracy Expected accruracy for meters > 95%
Biogas	composition	low	yes	Gas analyser will be subject to a regular testing and maintenance regime to ensure accuracy
Biogas	production	low	yes	Gas flow meter will be subject to a regular testing and maintenance regime to ensure accuracy
Biogas	flow to flare	low	yes	Expected accruracy for meters > 95%
Boo-lean	ignition in flare	low	yes	Ignition in flare can be registered accurately by several methods eg temperature, ion mobility etc
Power	imported/exported from Grid and CHP	low	yes	Electricity production will be confirmed by separate production meters
Fuel	Fuel for boiler for emergency cases	low	yes	Fuel tonnage will be followed through a level meter in the gas oil reservoir on daily basis

11. Environmental

11.1 Environmental Impacts

Detailed below are the typical potential significant environmental effects from wastewater treatment plants. Also indicated are the impacts from the operation of sludge digesters and combustion of methane gas produced from the digesters in combined heat and power engines. Installation of methane combustion systems will have very few negative environmental impacts.

Indicator	Typical potential significant environmental effects from wastewater treatment plants	Effects due to methane capture and combustion
Human beings	• Health and Safety • Residential amenity • Nuisance	The risk of spreading diseases due to operation of the sludge pits is reduced or eliminated
Flora	• Obliteration by development or site drainage • Opportunities following rehabilitation	No negative or positive effects from digester plant
Fauna	• Impact on existing terrestrial and aquatic fauna • Birds rodents and insects as pests and disease vectors • Scavengers attracted • Indirect effects from surface water pollution • Hazards to farm stocks	No additional birds and scavengers will be attracted to the sludge drying beds or landfill site
Soils and geology	• Need for material capping • Deterioration of capping soils due to upward migration of contaminants	No negative or positive effects from digester plant
Water	• Contamination by uncontrolled surface run off • Contamination of groundwater by leachate • Movements of contaminated groundwater	The drainage from the sludge beds and landfill is picked up by site drainage and not discharged to river
Air	• Generation of methane with fire and explosion hazards • Odours • Dust • Noise of equipment /traffic	Reduced GHG emissions Controlled generation of methane and combustion will reduce the odours from the wastewater treatment plant The noise levels from the gas engines and generator (located in a noise insulated container), cooling system, flare stack etc in a distance of 10m from the plant has a level of 75dB (55dB at

		100m) Noise from gas flare will be substantially lower. Exhaust emissions from the gas following combustion will typically be: NOX <500mg/m^3 CO <650mg/m^3 CH_4 <0.1 mg/m^3
Climate	• Odour dispersal • Rainfall infiltration • Dispersal of flammable gases	No negative or positive effects from digestion or combustion plant
The landscape	• Visual impact and change in character due to: ➢ Perimeter Fences ➢ Bunds and signs ➢ Access roads, entrances ➢ Exposed waste ➢ Windblown litter ➢ Flares, smoke, fires ➢ Site Structures	There will be few visible features from the digesters, since the old existing digesters will be refurbished with the new combustion plant and ancillary equipment placed in existing buildings. Existing sludge tanks and pumping stations will be rebuilt
Material assets	• Diminution of amenities for residential and leisure land users • Disruption to adjacent agriculture (eg. Due to increased bird population) • Contamination of aquifers	No negative or positive effects from digestion or combustion plant
The interaction of the foregoing	• Climatic effect can concentrate or disperse airborne impacts and nuisances • Landscaping and screening can be uncharacteristic of surroundings	No negative or positive effects from digestion or combustion plant
Cultural heritage	• Degradation of the context of monuments • Loss of remains during surface obliteration caused by cell construction or capping soils acquisitions	No negative or positive effects from digestion or combustion plant

11.2 Environmental Impact Assessment

The negative environmental impacts from the anaerobic digesters and the installed combustion systems are negligible, and the impacts are considered not significant therefore an environmental impact assessment is not required. This was confirmed by the Regional Environmental Directorate following a submission and application to the Directorate by the company (Annex 11).

Although confirmation was given, the Regional Environmental Directorate gave a number of general requirements for the project. These are:

- no fly tipping of construction material or rubble by contractors engaged on the project during construction;
- compliance with all governmental legislation on noise levels during project construction;
- prior to commissioning of the project the taking of samples from the ambient air around the construction-site will be required to monitor the air pollution levels in accordance with ordinance 14;
- prior to commissioning of the project Sofiyska Voda AD will be required to obtain a permit for working with waste.(This permit is current held by the company);
- in the event of the requirement for any tree felling or removal of bushes during the project this can only be undertaken with an appropriate permit issued by the responsible state body;
- where necessary it will be require to plant trees and bushes in line with current policy on ecological regeneration in the area.

12. Stakeholder Comments

Stakeholders have been involved to the Project for the reconstruction of the digestion plant of WwTP Kubratovo from the very beginning of the process.

To obtain and gauge the necessary comments from impacted stakeholders a number of procedures were undertaken.

Sofiyska Voda AD initially submitted to the Ministry of Environment and Water of Republic of Bulgaria a Project Idea Note, describing its intention to develop a Joint Implementation Project under article 6 of Kyoto Protocol. After reviewing the submitted documents the Ministry of Environment and Water issued a Letter of Endorsement for the project. The letter is provided in Annex 16.

An informing letter to the Mayor of Serdica municipal district (provided in Annex 13) was submitted, regarding the intention of Sofiyska Voda AD to reconstruct the digestion plant of WWTP Kubratovo and to install a combined heat and power unit for further biogas utilization. Following this information letter the mayor of the municipal district provide a letter of support for the project. This letter of support is provided in Annex 14.

The company also prepared and submitted a full package of documents to the Regional Environmental Directorate, requesting an evaluation of the requirement for a Environmental Impact Assessment. Details of the response to this submitted package are provided in chapter 11 of this document. This submission is in compliance with the requirements of the Regulation for the implementation of Environmental Impact Assessments for investment projects (State Gazette No 25 / 18th of March 2003).
No additional comments were received by any other stakeholders.

Annex 1 Map of Bulgaria

Annex 2 Technical Description

The project activity consists of several activities. The main activities of the project are discussed in some detail below:

Implementation of the project will involve the following activities:

- rehabilitation of 4 No 7000m^3 digesters;
- provision of New Raw Sludge Pumping Station;
- biogas Withdrawal System;
- provision of new sludge recirculation unit;
- provision of biogas utilisation and mixing system;
- refurbishment of gas holder;
- refurbishment of heating and boiler system.

Digesters

The original digestion plant comprises 4 brick digesters each 7.000 m^3, located in a rectangular arrangement. The axial distance between the digesters is 30 m. In front of each digester there are separate buildings with two rooms. In two of these buildings the gas compressors are located. The buildings are served with several gas/sludge/steam pipelines from/to the digester. These digesters along with ancillary equipment have not operated since 1993.

The existing 4 x 7000m^3 digesters will be totally refurbished and equipped with appropriate mechanical and electromechanical equipment and devices for a mesophilic, anaerobic digestion system.

The task of the anaerobic sludge treatment plant is to stabilise the sludge anaerobically. With this procedure the organic part of the sludge will be reduced which also effects a reduction on the dry solid mass of the total sludge. This process has a positive influence on the sizing of the sludge treatment units following digestion and also on the properties of sludge regarding the ability to dewater and elimination of odour nuisance.

The refurbished digesters will be fed by with a mixed sludge from the primary settlement tanks and the secondary sludge (surplus sludge) from the biological treatment unit. Mixing of the two sludge's will occur in the sludge mixing chamber where the mixing will produce a homogenised mixed sludge, which then will be pumped into the digesters.

The anaerobic digestion of sludge is undertaken by several groups of bacteria. The two main groups of bacteria are the Acidogenic and the Methanogenic bacteria. The Acidogenic bacteria break down the major molecules into volatile organic acids, while the Methanogenic bacteria feed on the volatile organic acids and produce a mixture of CH^4 and CO^2, the biogas. Typical biogas composition is around 65% Methane and 35% Carbon dioxide.

Refurbishment of the digesters and installation of ancillary equipment has been carefully designed to ensure the maximum efficiency of the digestion process with regard to temperature, sludge heating and mixing, gas production and collection. Safety has also been paramount in the project design.

Raw Sludge Pumping Station

As part of the project 5 new raw sludge pumps will be installed in the existing raw sludge pumping station. One of the pumps will serve as standby. The raw sludge pumping station is located between the digesters area and the surplus sludge thickening tanks. The new raw sludge pumps will be of eccentric screw type in bloc design with manual variable adjustable gearbox and overpressure protection as well as thermal stator protection. The raw sludge pumps feed the digesters with raw sludge from the sludge tank (mixing chamber) located directly in front of the raw sludge pumping station. A flow meter in each separate feeding line will observe and indicate the quantity of raw sludge fed to the digester. The feeding pipelines to the digesters leave the raw sludge pumping station below the ground level. The pipelines are buried completely on their way to the new digester's service building. One digester is fed by one raw sludge pump, whereas the operation is defined manually by selecting the pump and opening/closing the corresponding knife gate valves.

The raw sludge pumping station comprises also separate rooms where the electrical power supply is located for all the facilities in this area. Transformer, main distribution board and motor control centre are installed in individual rooms. The existing transformer is further to be used. The main distribution board has to be renewed, as a connection from there to the new motor control centre for controlling of the new equipment is technically impossible. The new motor control centres will be placed in the existing MCC-Room and displace the old one's which will not be used in the future anymore.

Biogas Withdrawal System

The existing digesters will be equipped with a complete new biogas withdrawal system located on top of the tanks. The existing system has to be dismantled and removed from the top. The new system is a stainless steel gas hood (3,0 m diameter), which is a round disc bottom with flanged connection, fixed on a stainless-steel frame. This special frame is welded onto the existing mild steel construction, which is poured into the concrete. The gas hood comprises one gas dome for biogas outlet to the consumer system and to the mixing system, an observation window with double wiper construction as well as the gas pressure relief device in order to protect the digester from over and under pressure. A 2"-socket is welded into the gas hood for installation of the existing foam sensor for the existing foam traps, in order to detect foam raising up in the digester. In case of foaming the gas mixing, respectively the gas-compressors are automatically switched off. The existing foam trap is located on roof of the digester and has to be wired with an existing local control panel inside the MCC-Room.

In order to protect the digester against excess pressure (over 0,05 bar = 5 kP/m^3) and sub pressure a special combined pressure relief device will be installed s installed into the gas hood. This device is a water-seal against the atmosphere. This seal takes action when the maximal permissible excess pressure is exceeded or the maximal permissible sub pressure falls below; in case of excess pressure gas penetrates out of the digester into the atmosphere as long as normal pressure conditions are restored. In case of sub pressure air from the atmosphere can penetrate into the digester head as long as normal pressure conditions are restored. The construction of the device is made in such manner that the sealing liquid (usually water) does not run out of the device. When the original conditions are restored, the sealing liquid flows back again. Since the device is immerged in the digester roof (in the gas room) and is continuously heated by the temperature being present in this area, there is no danger of freezing.

The observation window installed in the gas hood is gas-tight and swivelling, so that it serves at the same time as access opening. The window has on both side’s wipers for removal of the condensation water drops. It is protected against damage by a tip-up cover. At the same time this cover keeps away light beams, which are not desired by the organisms in the digester. The diameter of the observation window is 600 mm.

The biogas withdrawal dome is installed in the gas hood in order to withdraw the biogas in the closed circuit of the gas injection system as well as for the withdrawal of the biogas for the gas utilization system.

At the ground connection, where the gas mixing pipelines enter into the digester, the sludge level measurement is installed in order to indicate the sludge level inside the tank. The measuring principle for this device is a hydrostatic pressure sensor via a ceramic membrane with a special assembly kit, provided for cleaning and flushing the sensor during operation.

Sludge Circulation System

For heating up the raw sludge and maintain the process temperature at mesophilic conditions (35°C), a new combined heating and sludge circulation system is provided within the basement of the new service building. 6 volute-casing pumps for dry well installation will be installed, whereas 4 pumps are in operation and 2 are standby for emergency case.

One pump circulates the sludge of one digester via a double tube heat exchanger. In front of each heat exchanger there is a seeding mixer connected. This device is the mixing point where raw sludge is added from the raw sludge pumps into the anaerobic circulation process. The raw sludge, mixed with circulating sludge in a ration of approx. 1:4, passes through the heat exchanger and is given into the tank on top of the digester.

The suction pipeline of the circulation pump is connected to the existing bottom pipeline, leading down into the digester’s ground cone, from where the circulation sludge is taken out of the system. In front of the circulation pumps there is the temperature measurement for the sludge temperature control of the digester. If this temperature is higher than 36°C (set value), the heating system will stop feeding hot water into the outer tube of the double tube heat exchanger. The sludge from the digester is then cooling down, while the sludge circulation pumps keep on running. Below a variable set point (approx. 34°C) a command is engaged to the hot water pumps and they start feeding again in order to heat up the sludge to the upper limit value.

The recirculation pumps are not allowed to be switched off during normal operation.

During the feeding process with raw sludge, digested sludge is displaced via rising-pipe lines. Digested sludge is discharged in a separate outside shaft and from there it flows to the next sludge treatment unit.

Additional to the temperature measurement the pH-value is analysed in front of the sludge circulation pumps. The electrode takes continuously the pH-value and gives it to the indication instrument. The pH-value is an indication for the operating conditions of an anaerobic process. This is only for process information - no further control with pH is foreseen. Alternating values are symptoms for a malfunction of the biological process.

Recirculation Pumps

The re-circulating sludge is taken out of the digester from the sludge removal pipe leading down to the digester cone. Then the sludge is sucked by the recirculation pumps via the suction line and is delivered via the pressure line into the seeding mixer, where it is mixed with the raw sludge that means with the primary and surplus sludge. For each digester, one sludge recirculation pump will be installed. Moreover two standby pumps are provided.

Heat Exchanger

The anaerobic digestion process will take place under mesophilic conditions, which means within a temperature range of about 33 and 37°C. The fresh incoming raw sludge has to be heated up to the required temperature conditions. Also the heat loss of the digester has to be compensated. For this purposes a double tube heat exchanger is installed for each digester.

The mixture of raw sludge and seeding sludge is transported from the seeding mixer via the heat exchanger where the sludge is indirectly heated in the counter current flow with hot water. The heated sludge mixture is transported via the feeding line back into the digester.

Biogas Utilisation and Mixing System

During the biochemical decomposition of the organic dry solid matter by anaerobic digestion, biogas is produced. This biogas will be used for digester mixing and for digester heating. For anaerobic digestion an intensive mixing of the digester volume is required, to guarantee constant and homogenous physical and chemical conditions as well as prevention of grit deposition and scum layers. For the concept of intensified sludge digestion a proprietary system for efficient and complete mixing by gas injection has been developed. As the mesophilic processes within the digesters work at about 35°C and the bacteria are sensitive against temperature fluctuation, heating of sludge is required.

The specific gas production depends on the sludge characteristics and on its composition of the solids matter. Sludge from the primary settlement has a high fat and protein content and their gas production is about 1 Nm^3 per kg volatiles degraded. Secondary sludge consists mainly of carbohydrates; their specific gas production is around 0.80 Nm^3 per kg degraded. Experience justifies assumption of a specific gas production from mixed primary/secondary sludge of around 0.9 Nm^3 per kg degraded.

Biogas Mixing System

One of the basic conditions for an intensive sludge digestion process with a high load is that the sludge in the digester is perfectly mixed. This is best achieved using gas injection. After the raw sludge has been fed or in case of continuously feeding of the digester during the feeding period, the digester’s contents will be intensively mixed in order to balance out the temperature and degree of concentration differences. This should be done until the digester’s contents have been evenly and completely mixed. With this step, equalized conditions regarding temperature, pH-value, intermediate products, and solid matter concentrations will be homogenisized, in order to create optimal ambient conditions for the bacteria.

The biogas injection effects not only an entire homogenisation of the digester contents and therefore an optimal distribution of the nutrients along with the reaction area in the substrate, it also improves the biogas exploitation from the sludge. The small gas bubbles developing at the sludge flocks are torn off and rise up. Therewith a gas gush is produced by the gas injection that means that the amount of gas increases suddenly. It has to be considered in the dimensioning and the layout of the system. This applies especially to the dimensioning of the gas pipelines and to the gas devices, as gravel filters, ceramic filters, gas withdrawal dome (in the gas hood), gas armatures etc. The pressure losses in these devices are to be kept low correspondingly.

The system installed is an unconfined gas mixing system. There are almost no friction losses. Nearly all the total compression energy is transferred into the sludge bulk as the gas bubbles rise from the gas nozzles, thus creating a strong rising sludge flow near the nozzles. Main parts of the biogas injection system are the compressor plants and the injection nozzles.

The gas will be removed from the gas dome on top of each digester, compressed and injected back into the same digester. The injection will take place using biogas nozzles, which are installed in the digester. In each digester there are fixed injection pipes with nozzles at its ends, which are arranged at low level and just above the bottom cone of the digester.

For cleaning purpose the biogas flows through a ceramic filter for filtering prior to compression in the gas compressor, which is of a special type and material to prevent erosion and corrosion. The compressed gas is then lead from the compressor via a liquid separator and pressure pipeline through a segment of nozzles back into the digester.

Heating and Boiler System

The produced biogas is used for generation of heat and will also be used for generation of electricity via installation of CHP gas engines. The heat will be used for heating up the raw sludge to the process temperature and for compensation of the heat losses of the digesters.

The boiler house is located about 250 m away from the sludge circulation building. The existing boiler plant produces steam for heating purposes. The thermal energy of the steam will be converted to the hot water system of the digester plant by means of a steam converter, capacity of 4,500 kW. The steam converter is used for heating up hot water with a heat drop of about 85/70 °C. A circulation pump will be installed within the boiler house in order to pump the hot water via a DN 200 pipeline to the sludge circulation building.

The hot water pipeline will be connected to the new hydraulic diverter. The cold-water pipeline DN 200 will be laid back from this hydraulic diverter to the steam converter in the boiler house. The hydraulic diverter is further connected by a hot and a cold-water pipeline to the heating manifold. This will distribute the hot water to the single heating circuit according to the demand of each single heat exchanger.

The main task of the hydraulic diverter is to compensate pressure differences between the hot water supply circuit (operated by the circulation pump 180 m³/h – 15m) and the heating circuits of the single heat exchangers (operated by hot water pumps 45 m³/h – 10m). Pressure differences may occur by different flow rates within the single circuits, which are connected with each other by the heating manifold and the hydraulic diverter.

Each heat exchanger gets its own heating circuit including a hot water pump, a three way mixing valve and a temperature measurement for controlling of the three way mixing valve as the main components. Each circuit is connected with a hot water and a cold water pipe to the heating manifold.

The temperature measurement will be installed into the hot water pipe (pressure pipeline of the hot water pumps). This measurement controls the hot water temperature feeding the heat exchanger by operating the actuator of the three-way mixing valve.

Low Pressure Gas Holder

The existing gasholder has a volume capacity of about 3,000 m³. During the execution of this project this gasholder will be refurbished to a low-pressure gasholder with a volume capacity of approx. 5,000 m³. This is a storage capacity of 5,000 / 25,419 = 1/5 daily biogas production. The gasholder serves for storage and pressure compensation. in the gas system. A gas pressure of about 30 mbar can be reached and maintained in the gas system.

CHP Gas Engines

Following the commissioning of the digesters it is the intention to procure, install and operate a number of CHP units which will utilise the methane gas from the digester process converting the gas into electrical power and heat. The electrical power supplied by the CHP unit will offset present electricity usage from the Grid at Kubratovo WwTW, thus reducing power costs of the plant. At the same time the heat supplied by the unit will be used to heat the sludge again reducing heating costs.

The CHP units will be mounted outside on a concrete plinth and connected to the methane gas supply by installation of new gas pipe work and other ancillary equipment. Sizing of the CHP units is not possible at this stage as detailed information on the volume and quality of gas is required. This will take some 3 months of data collection following the commissioning of the digestion plant.

The main elements of the CHP unit are as follows:
- the Co-Generation Set Package;
- the Sludge Heat Exchanger Package;
- the Digester Gas Cleaning System;
- the Digester Gas Booster Set.

Annex 3 References

1. Operational Guidelines for Project Design Documents of Joint Implementation Projects, May 2004 (Ministry of Economic Affairs Netherlands);
2. IPPC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPPC);
3. Wastewater Engineering –Treatment, Disposal and Reuse,(Metcalf & Eddy 1991);
4. 2004 Regular Report on Bulgaria's Progress Towards Accession (Commission of EU);
5. An Explanation of Joint Implementation and the Clean Development Mechanism (UK DTI);
6. Agricultural Recycling of Sewage Sludge and the Environment (S.R. Smith 1996);
7. Sewage Sludge Conditioning, Dewatering and Thermal Drying (Manuals of British Practice IWEM).

Annex 4 Glossary of Terms

Activity level	Output level per year of the proposed project
ADF	Fraction of degradation, which is done under anaerobic Conditions
AAU	Assigned Amount Unit
B_o	Maximum methane producing capacity
BGN	Bulgarian LEV
BOD	Biochemical oxygen demand
Baseline emissions	Greenhouse gas emissions per year that would occur in the absence of the project activity
Baseline study	A document which objectively and systematically estimates the greenhouse gas emission reductions by JI project.
CH_4	Methane
CHP	Combined heat and power
COD	Chemical oxygen demand
CO_2	Carbon di Oxide
EBRD	European Bank for Reconstruction and Development
EIA	Environmental Impact assessment
EU	European Union
FTA	Organic fraction that can be degraded anaerobically
GDP	Gross domestic product
GHG	Greenhouse gas
Greenhouse gas	Gaseous constituents of the atmosphere, both natural and manmade, that absorbs and re-emit infrared radiation
H_2S	Hydrogen Sulphide
IPCC	Intergovernmental Panel on Climate Change
JI	Joint implementation, one of the three flexible mechanisms for the Kyoto Protocol
Key Factor	Those factors that significantly influence the future situation within a sector/country/ project thus determining the baseline scenario
kWh	Kilo Watt hour
Kyoto Protocol	UNFCCC protocol regarding the ultimate objective of achieving its quantified emissions limitation and reducing commitments to promote sustainable development.
Leakage	The net change of anthropogenic emissions by sources of greenhouse gases which occurs outside the project boundary and which is measurable and attributable to the CDM project
MWh	Mega Watt hour
MoEW	Bulgarian Ministry of Environment and Water
Monitoring	The collection and archiving of all relevant data necessary for determining the baseline
NCV	Net calorific value
NPV	Net present value
Off-site	Not on the physical location of project
On-site	On the physical location of project
PDD	Project design document

Project activity	A project activity is a measure, operation or action that aims at reducing greenhouse gas emissions
Project Boundary	The project boundary shall encompass all anthropogenic emissions by sources of greenhouse gases under the control of the project participants that are significant and reasonable.
Scenario	An account or synopsis of a possible course of action or events.
Significant	Greenhouse gas emissions from a source are considered significant if they account to at least 1% of the total baseline emissions
Source	Any process, activity or mechanism which releases GHG, an aerosol or precursor of GHG into atmosphere.
SS	Suspended solids
tCO_2e	Tonne of CO2 equivalent
TCOD	Total amount of chemical oxygen demand
Validation	The process of independent evaluation of a JI project by a validator against the requirements of the JI guidelines
WwTW	Wastewater treatment works

Annex 5: Anticipated Future Flows to Kubratovo

Anticipated Future Flows to Kubratovo

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Average Daily Flow m3	362,894	382,861	372,381	357,168	348,363	339,567	330,781	322,005	318,114	314,234
Annual Flow m3	132,456,237	139,744,313	135,919,202	130,366,334	127,152,385	123,941,967	120,735,130	117,531,926	116,111,785	114,695,385
Domestic Flow m3	114,247	155,684	165,063	179,975	180,307	180,640	180,972	181,305	181,638	181,972
Industrial Flow m3	42,224	42,857	43,500	44,153	44,815	45,487	46,170	46,862	47,565	48,278
Infiltration m3	214,246	194,246	174,246	144,246	134,496	124,746	114,996	105,246	100,371	95,496
DWF	148,647	188,615	198,135	212,922	213,866	214,821	215,785	216,759	217,743	218,738
3 x DWF	445,942	565,844	594,405	638,765	641,599	644,462	647,354	650,277	653,229	656,213
6 x DWF	891,884	1,131,688	1,188,810	1,277,530	1,283,198	1,288,924	1,294,709	1,300,553	1,306,458	1,312,425

Annex 6: Letter from Deputy Mayor of Sofia from MoEW re sludge disposal

Annex 7: Cover letter from Ministry of Health re sludge analysis

Annex 8: Report on sewage sludge after 15 months storage in drying beds

Annex 9: Letter from Ministry of Health with accompanying report on sludge quality

Annex 10: Letter from Sofiyska Voda to Regional Environmental Directorate questioning the need for an Environmental Impact Assessment

Annex 11: Response letter from Regional Environmental Directorate

Annex 12: Environmental requirements from Regional Directorate

Annex 13: Request letter from Sofiyska Voda to Municipal District requesting support for project

Annex 14: Letter of support for project from Mayor of Municipal District

Annex 15: Cover letter from Sofiyska Voda requesting endorsement of PIN

Annex 16: Cover letter from Ministry of Environment re PIN

Annex 17: Letter of endorsement for PIN

Annex 18: Emissions reduction calculation