JI MONITORING REPORT

Title of the project activity	“Methane gas capture and electricity production at Kubratovo Wastewater Treatment, Sofia, Bulgaria”
Reference number of the project activity	Registered under JI Track 1, No BG 1000166
Version number of the monitoring report	1.1
Completion date of the monitoring report	27.11.2012
Registration date of the project activity	08/2007
Monitoring period number and duration of this monitoring period	4th monitoring period; 01/01/2012 – 31/10/2012
Project participant(s)	Sofiyska Voda AD; EBRD
Host Party(ies)	Bulgaria
Sectoral scope(s) and applied methodology(ies)	Sectoral scope 1,13; JI specific methodology
Estimated amount of GHG emission reductions or net anthropogenic GHG removals by sinks for this monitoring period in the registered PDD	187,475 tCO_{2e}
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved in this monitoring period	132,390 tCO_{2e}

CONTENTS

Annexes

SECTION A. Description of project activity
A.1. Purpose and general description of project activity

Methane produced on the Kubratovo wastewater treatment plant is captured in common methane tanks serving as a buffer and then supplied to the newly installed CHP gas engines for electricity and heat production, which in turn reduces both the plant's electricity purchases from the grid and diesel fuel usage. Excess electricity is supplied to the grid.

- The main purpose of the project is to transform the existing low tech sludge treatment process at Kubratovo into a modern advanced treatment process matching the best sludge treatment practise available in Western Europe. This transformation will have a major effect on the environment through dramatically reducing the existing methane gas emissions at the plant and sludge disposal site while also reducing the volume of sludge (to as much as 50%) that in the baseline needs to be transported to the landfill site. This will proportionally extend the life of the landfill site.

The overall objective of the project is to provide an environmentally friendly sludge treatment process reducing methane and carbon dioxide emissions that – under a business-as-usual scenario – would have continued. Other objectives are:

- replace the traditional sludge drying beds and landfill options with mesophilic digestion of all primary and secondary sludge followed by mechanical dewatering (see Figure 1) 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.

Completion of this project would 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 on-site electricity purchases from the national grid;
- reduction in on-site fossil fuel usage as all site-heating requirements will be met by the CHP gas engines;
- all sludge stabilised and pathogen free.

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.

Apart from the obvious advantages that the project provides for greenhouse gas emissions abatement it has direct connection to the general requirements of the European Union for advanced treatment of municipal waste waters. The legal act that governs those requirements is the Sewage Sludge Directive 86/278/EEC (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31986L0278:EN:HTML) and the Urban Waste Water Treatment Directive 91/271/EEC (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31991L0271:EN:HTML).

The Sewage Sludge Directive 86/278/EEC seeks to encourage the use of sewage sludge in agriculture and to regulate its use in such a way as to prevent harmful effects on soil, vegetation, animals and man. To this end, it prohibits the use of untreated sludge on agricultural land unless it is injected or incorporated into the soil. Treated sludge is defined as having undergone "biological, chemical or heat treatment, long-term storage or any other appropriate process so as significantly to reduce its fermentability and the health hazards resulting from its use". To provide protection against potential health risks from residual pathogens, sludge must not be applied to soil in which fruit and vegetable crops are growing or grown, or less than ten months before fruit and vegetable crops are to be harvested.

Grazing animals must not be allowed access to grassland or forage land less than three weeks after the application of sludge. The Directive also requires that sludge should be used in such a way that account is taken of the nutrient requirements of plants and that the quality of the soil and of the surface and groundwater is not impaired.

The main purpose of the project is to transform the existing low tech sludge treatment process at Kubratovo into a modern advanced treatment process matching the best sludge treatment practice available in Western Europe. This transformation will have a major effect on the environment through dramatically reducing the existing methane gas emissions at the plant and sludge disposal site while also reducing the volume of sludge (to as much as 50%) that needs to be transported to the landfill site, hence reducing GHG emissions from transportation as well (not included in GHG abatement calculations). Moreover, this will proportionally extend the life of the landfill site.

The following overall measures have been implemented by the project in order to achieve its goals, as well as to comply the European Directives for Waste Water and Sewage Sludge treatment:

- Primary settling tanks
  The refurbished digesters will be fed with a mixed sludge from the primary settlement tanks (see Figure 5) and the secondary sludge (surplus sludge) from the biological treatment unit. Mixing of the two will occur in the sludge mixing chamber where the mixing will produce a homogenised mixed sludge, which then will be pumped into the digesters.
- Digesters for anaerobic sludge treatment
  The anaerobic sludge treatment plant stabilises 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 goal of anaerobic digestion is the stabilization of the sewage sludge in order to prevent odour nuisance and improve dewatering. As degradation of the volatile solids is an asymptotic and never ending process, a criterion is needed to define the required ratio of the VSS destruction.
  After the process of digestion the sludge will be dewatered and afterwards transported to the landfill site. At the landfill site, the process of anaerobic digestion will continue as described in the PDD.
- Raw Sludge Pumping Station
  As part of the project 5 new raw sludge pumps will be installed in the existing raw sludge pumping station.
- Sludge Circulation System
  For heating up the raw sludge and maintaining 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.
- 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.

A.2. Location of project activity

Vilage of Kubratovo, Sofia region, Bulgaria

A.3. Parties and project participant(s)

Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Bulgaria	Sofiyska Voda AD (Private entity)	No
The Kingdom of the Netherlands	EBRD (Public entity)	No

A.4. Reference of applied methodology

Ji specific methodology validated by TUV-SUED with Determination Report No 743 691/2006-01-25.

A.5. Crediting period of project activity
Before Kyoto period: 01/01/2007 – 31/12/2007
During Kyoto period: 01/01/2008 – 31/12/2012

SECTION B. Implementation of project activity
B.1. Description of implemented registered project activity

The project had been implemented in two stages:
Erection of new digester system consisting of 4 digesters, 7,000 m3 each designed, supplied and erected by PASSAVANT ROEDIGER Anlagenbau.
For destroying of the methane a flaring system was implemented, consisting of 2 x DN150 flares, type ZA1-..F2-0/N0 designed and manufactured by HEGWEIN GmbH, Germany.
Erection of 3 new co-generation sets GE JMS 320 GS-B.LC with 1063 kW electric capacity each and 1088 kW thermal capacity, for generation of electric and thermal energy by combusting biogas from digesters.

The digesters have been commissioned at the end of 2006 and started generating Early credits on 01 January 2007 but due to some technical problems in the adjustment of the biological process the generation of biogas has been interrupted in the end of June 2007 and resumed during the first Kyoto crediting period on May,1st , 2008, so the first industrial quantities of biogas have been registered in May, 2008
The CHP has been commissioned and started generating electricity for plant’s needs in November, 2009.

Following is a table with major dates for implementation of the different stages:

Activity	Date
JI Approval by owner	June , 2004
JI endorsement by the Host country	February 2005
Construction start	01 January 2006
Letter of Approval	03 August 2007
Commissioning Ist stage (digesters)	December, 2006
Commissioning IInd stage (CHP)	25 Nov., 2009

Table 1: Implementation of the project

B.2. Post registration changes
B.2.1. Temporary deviations from registered monitoring plan or applied methodology

No temporary deviations or revisions to the registered monitoring plan were made.

B.2.2. Corrections

No corections to the registered project were made

B.2.3. Permanent changes from registered monitoring plan or applied methodology

No permanent deviations or revisions to the registered monitoring plan were made

B.2.4. Changes to project design of registered project activity

No changes to the project design of registered project activity were made.

B.2.5. Changes to start date of crediting period

No changes to the start date of the crediting period were made.

B.2.6. Types of changes specific to afforestation or reforestation project activity

N/A

SECTION C. Description of monitoring system

Monitoring methodology: A JI-specific monitoring approach was developed for this project in line with the "Guidance on criteria for baseline setting and monitoring". The resulting Monitoring Plan was determined as part of the determination process.

Baseline Monitoring Methodology
The emission reductions from Kubratovo WwTP JI Project are based on:
The difference in generation of methane in the "business as usual" baseline treatment of the wastewater and the sludge.
The methodology for monitoring and the calculation of the emission reductions is based on metered inlet quantity of domestic waste-water entering the plant and its Biochemical Oxygen Demand (reduced), (BOD reduced) . The baseline monitoring of the GHG emissions is based on registering of the inlet quantity of domestic waste-water to the plant and the difference in BOD content in that waste-water at the plant inlet and after the digesters before the de-watering tanks.
Power generation of electricity and heat by new co-generation nits (CHP). The electricity power generation of Kubratovo WwTP JI Project displaces power generated by other dispatched power-plants in the Bulgarian National Grid.
The heat recovery of the co-generation units displaces the heat generated by the old boilers that combusted fossil fuel (diesel fuel). The burners of those boilers are duel fuel so the diesel fuel will be used as a back-up fuel in case of emergency.
The old steam boilers have been reconstructed for production of hot water only, using the existing duel fuel burners and combusting biogas.

The methodology for the monitoring and the calculation of the emission reductions due to electricity displacement is based on metered quantities of electricity generated by the co-generation units and the EF of the Bulgarian National Grid published by Bulgarian National Electric Company (NEC) for the crediting period.

Operational and monitoring obligations

The operator (Sofiyska voda) of the JI Project must fulfill certain operational and data collection obligations in order to ensure that sufficient information is available to calculate emission reductions in a transparent manner and to allow for a successful verification of these emission reductions.
The operator must integrate the monitoring requirements and the calculation of the emission reductions into the operational procedures for the operation of the digesters and co-generation units in the JI Project. In particular, the Operator has to install the electronic workbook. In order to avoid errors based on data transfer, maximum automation of the workbook is desired. The implementation of the monitoring system and the calculation of the emission reductions is subject to review and approval at the verification.

The control and monitoring system consists of Waste-water /sludge BOD part, biogas part and electricity generation part.

Measurement of the waste-water flow and Biochemichal Oxygen Demand (BOD),(reduced)
For the purpose of monitoring the emission reductions the following parameters are to be measured:

- Measuring of the waste-water flow-rate at plant inlet prior to Primary Settling Tanks (PST)
- Measuring of the BOD concentration in the inlet waste-water prior to Primary Settling Tanks (PST)
- Measuring of the BOD concentration in the outlet wastewater prior to Dewatering unit (DW)

Measurement of biogas production
For the purpose of monitoring the emission reductions the following parameters are to be measured:

- Measuring of the biogas quantity generated by the digesters
- Measuring of the CH4 concentration in the biogas generated by the digesters

The biogas flow-rate and methane concentration has been measured by automatic gas-analyzer-flow-meter process analysis system AWITE. The system was integrated in a modern automatic controlling on-line, including high accuracy measuring instruments and sensors as well as control and stop valves activated by remote drives. All data collected has been screened at the operator’s desk in the control room. Afterwards the work parameters have been channeled to the central dispatching office for further review and archiving.
The system monitors the followings parameters for the calculation of emission reductions:
- Biogas flow-rate;
- Methane concentration;

Measurement of electric and thermal energy displaced
After commissioning of the CHP the electricity that has been imported from the grid is replaced by electricity generated by the co-generation units. The excess energy is exported to the grid. In case of emergency or insufficient generation by the CHP electricity will be imported from the national grid. According to Bulgarian law the commercial electric meter mounted at the point of connection to the grid are two-directional and measure the difference between the exported and imported electricity, i.e. the net electricity exported to the grid.
The thermal energy generated by the CHP will, if needed be supplemented by heating in the boilers using biogas as fuel or diesel fuel in emergency cases. The boilers are outside the project boundary and no emission reductions generated by them are envisaged. In case of need the excess biogas will be flared.
The following parameters are monitored:
- Biogas flow-rate to the CHP
- Biogas flow-rate to the boilers and flares
- Electricity generated by the CHP
- Electricity exported to the grid (net)

Following is a table with monitoring equipment:

Measuring equipment	**Measured parameter, variable**	**Equipment producer and type**	**Serial number**	**Installation date**	**Date of latest calibration**	**Periodicity of calibration**	**Measurement error data**	**Comments**
Flow-meter – primary settling tank No1 at plant inlet	Domestic waste-water flow	ABB-Germany, MAG-XM; DN=1400 mm; with magnetic flow-meter and converter	DM41F/000250	2004	20 October 2011	2 years	+/- 0.4% on flow-rate	The magnetic flow-meter is essentially maintenance free.
Flow-meter – primary settling tank No2 at plant inlet	Domestic waste-water flow	ABB-Germany, MAG-XM; DN=1400 mm; with magnetic flow-meter and converter	DM41F/00251	2004	20 October 2011	2 years	+/- 0.4% on flow-rate	The magnetic flow-meter is essentially maintenance free.
Flow-meter – primary settling tank No3 at plant inlet	Domestic waste-water flow	ABB-Germany, MAG-XM; DN=1400 mm; with magnetic flow meter and converter	DM41F/000248	2004	20 October 2011	2 years	+/- 0.4% on flow-rate	The magnetic flow-meter is essentially maintenance free.
Flow-meter – primary settling tank No4 at plant inlet	Domestic waste-water flow	ABB-Germany, MAG-XM; DN=1400 mm; with magnetic flow-meter and converter	DM41F/000249	2004	20 October 2011	2 years	+/- 0.4% on flow-rate	The magnetic flow-meter is essentially maintenance free.
Laboratory equipment	BOD concentration	WTW, table oxymeter , Oxi	08310958	08.06.2008	08.03.2012	Once at two years.	+/- 1%	The calibrating is

		730						according internal laboratory methodology based on EN ISO 25814 and ISO 5813. Before purchasing of the oxymeter the BOD concentration has been measured manually in the laboratory by titring
Automatic gas analyzer, flow-meter system	Methane concentration in the biogas Methane – 0-100 Vol% Oxygen – 0-25 Vol% Carbon dioxide – 0-100 Vol% H2S – 0-500 ppm Absolute pressure 0-1600 mbar	Draeger, Awite AwiFlex	564_09	01 July 2009	08 July 2012	Six months	+/-1 % for Methane and Carbon Dioxide +/- 0.015 % for temperature	
Automatic gas analyzer, flow-meter system	Biogas flow 24 V DC ; max. 3 W; IP 65 by EN 60529 -20 oC to +60 oC	Binder , Combimass eco basic switch bio EEx de Messsystems	IBExU05 ATEX10 68	01 July 2009	08 July 2012	Six months	+/-1%	The flow-meter is integral part of the AWITE automatic gas analyzer, flow-meter system.
Digital electric meter	Electricity generated by the CHP	Combined device	Ser. No 21-	July 2009	July 2009 – factory	4 years	+/- 0.5%	

		"Integra 1630"; current transformer 200/5	091420; annunciator module LSB6RGB		calibrated			
Digital electric meter	Electricity exported to the grid	ABB, AINRTAL-X; Current transformer HMO 110 110/V3//01/V3 //0.1 kV; Voltage transformer TMO 126 4x200/5/5/5A	Ser. No 02364831	October 2009	29.12.2008 calibrated by NEC	4 years according to the regulation	+/- 0.5%	The commercial electric meter is property of the electric distribution company (NEC)
Digital electric meter	Electricity exported to the grid	ABB, AINRTAL-X; Current transformer HMO 110 110/V3//01/V3 //0.1 kV; Voltage transformer TMO 126 4x200/5/5/5A	Ser. No 02364856	October 2009	06.02.2009, calibrated by NEC	4 years according to the regulation	+/- 0.5%	The commercial electric meter is property of the electric distribution company (NEC)

Table 1: List of metering equipment.

Calibration procedures:

For Electricity meters:

QA/QC procedures	Body responsible for calibration and certification
Calibration interval of such meters is 4 years. Calibration procedures for meters are implemented in compliance with calibration methodology developed for National Electric Company.	Bulgarian Centre for Standardization and Metrology

For Flow-meters

QA/QC procedures	Body responsible for calibration and certification
Calibration interval of such meters is 2 years. Calibration procedures for meters are implemented in compliance with calibration methodology and Bulgarian/EC standards.	Directorate for Measures and Metering Devices/Region Sofia

For Gas analyzers/flow-meters, chemichal analyzers

QA/QC procedures	Body responsible for calibration and certification
Calibration interval of such meters is 6 months. Calibration procedures for meters are implemented in compliance with calibration methodology developed for Draeger Safety. Manufacturer's warranty-24 months The calibration interval of the laboratory oxymeter used for measuring of BOD is 2 years. The calibration is made following the internal laboratory procedures of Sofiyska voda. The laboratory has valid accreditation until 28.02.2014	Draeger Safety Bulgaria Sofiyska voda company laboratory

Data processing and archiving (incl. Software used):

All data from the laboratory and different sections of the installation will be transferred in paper and electronic form to Process management dept (PM). and will be summarized in Excel sheets by the personnel in charge there. Primary data in electronic (Excel) and paper form as well as final Excel sheets will be archived at PM.
Through SCADA control and monitoring system all data from different meters and control rooms are transmitted directly on screen at PM chief's office and is treated by the staff of the department.

Special event log:

- Any special events which occurred should be listed here with date and details.

There were no special events.

Quality assurance and quality control measures

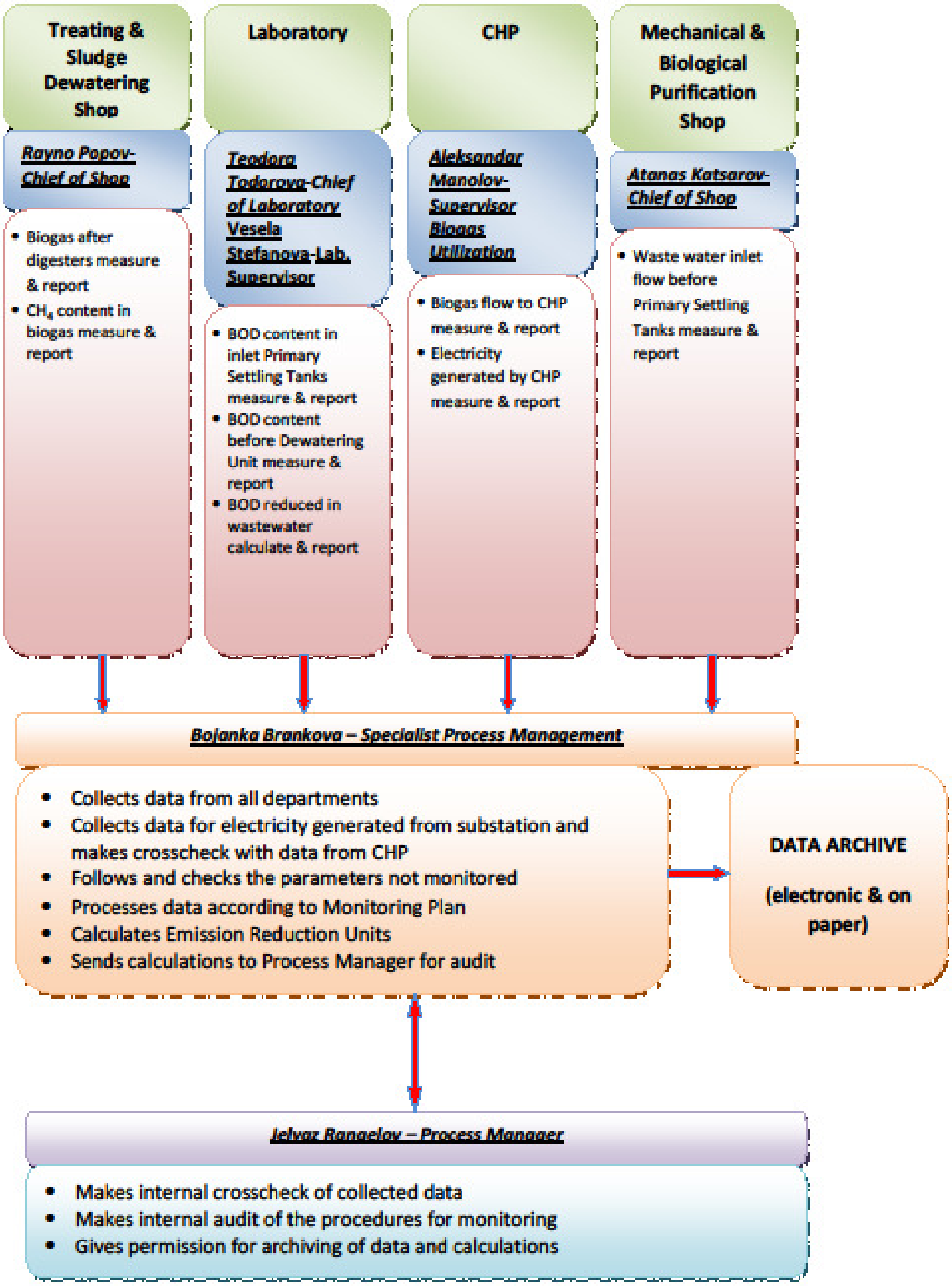
Documented procedures and management plan:

The Kubratovo WwTP is certified under ISO 14001:2004 by Tuev Nord and has certificate No 44 104 087290, valid until 12 Sept. 2014. The WwTP is also certified under ISO 18001:2007 with certificate No 44 116087290, valid until 15.01.2015.
The scope of services is:
“Management and maintenance of water supply and sewerage systems on the territory of Sofia Municipality. Water supply, sewerage and treatment of waste waters services on the territory of Sofia Municipality.”

Roles and responsibilities:

The general project management will be implemented by Mr. Jelyaz Rangelov – Manager of Kubratovo WwTP through supervising and coordinating activities of his subordinates, such as head of laboratory, head of Process Management dept., head of accounting department, head of planning unit. During the daytime a group of mechanics who will be responsible for maintenance of all technological and measuring equipment as well as automation tools will be present on-site.
On-line information will be transmitted to the Process Management chief Mr. Boris Preslavski. His department will calculate finally emission reductions based on this data and will archive all data.
The personnel of Treating and Dewatering of the sludge shop, listing 26 people and headed by the Chief of shop Mr. Rayno Popov are authorized to take all measurements related to the generation of biogas.
The plant laboratory in the face of Mrs. Vesela Stefanova and Mrs. Damyana Dimova measure the BOD content in the wastewater at inlet of Primary settling tanks and before the Dewatering units and calculate the quantity of BOD reduced. The data is transferred to the Process Management dept. for further processing.
The roles and responsibilities of the people involved in the monitoring process are indicated in the following chart:

Flow chart with procedures for monitoring reporting and data flow



Trainings:

Trainings for different types of major equipment have been carried out by the suppliers and as part of the EPC contract which contains obligations in that respect that can be at the auditors team disposal at any time.
All executive and management personnel involved in operation and maintenance has been trained initially by the supplier of the basic equipment like:

- Digesters and auxiliary equipment – process management training
- CHP – operation and maintenance of the engines and electric generators & auxiliaries
- Biogas flares

In addition to the specific operational training and courses the members of all operating teams have passed training in more specific matters like working with inflammable and explosive gases, vessels under pressure and lifting equipment. The training and courses are conducted periodically on a regular base by authorised bodies.
Copies of all protocols for trainings and courses are kept in the office of the Process Manager Mr. Boris Preslavski.

Involvement of Third Parties:

- Calibration of some metering equipment is done by Bulgarian National Calibration Laboratory
- Directorate for Measures and Metering Devices/Region Sofia
- Draeger Safety Bulgaria.

Internal audits and control measures:

All metering equipment is controlled by the Instrument department. It makes periodical checking and calibration of metering equipment as per approved schedule.
The plant laboratory has its own certification and follows all calibration and measuring procedures according to EN ISO 25814 and ISO 5813
The procedure for periodic internal verification of data and GHG reductions calculation is the following:

The internal audit is performed on a monthly basis by the Process Manager. After the specialist in Process Management dept. Mrs. Bojanka Brankova collects the data from the different department she makes the necessary calculations and aggregates the data where necessary according to the Monitoring plan. The data about CHP electricity production registered on the dedicated electric meter in the plant sub-station is cross-checked with the data from the electric meters mounted at the CHP generators. Any discrepancy in the records is analyzed and dealt with. In case of abnormal differences between the readings the Chief of Instrument dept. have to be informed to check and if necessary replace the gauge.
Then all data is sent to the Process Manager who compares it with the data in his process computer run by a program that monitors all processes in the plant and the process computers running other processes not incorporated into the SCADA system that runs the plant.
The Process Manager cross-checks the calculations of the GHG reductions and in case everything is correct gives permission to the Process Management dept. specialist to save and archive all data and calculations.
At the end of the relevant monitoring period the data is aggregated and emission reductions are calculated after the same internal auditing procedure as in the monthly procedure.

Troubleshooting procedures:

The troubleshooting is made by maintenance mechanics or on-duty electrician/operator. The internal system requires that the broken meter has to be replaced in few hours by the Instrument department.
The Chief of Instrument dpt., M-r Lyuben Sotirov is in charge with the above activities.

The troubleshooting procedures concerning the commercial electric meters which are property of the electricity distributing company are according to the national standards for that kind of equipment, i.e. in max. 5 days the distributing company has to replace the meter. During that period

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SECTION D. Data and parameters
D.1. Data and parameters fixed ex ante or at renewal of crediting period

ID number	Fixed data	Source of data	Data unit	Value
18	EFel,y ; Carbon emission factor of Bulgarian grid for the year y	See Annex 2 of PDD (See Table 8 of this MR)	tCO2/MWh	Varries for each year in the crediting period. The most recent EF, if published by NEC will be used. See table bellow.
19	EFlosses , Losses in the grid	See PDD, section D. The data for losses in generation and distribution of electric energy for 2008, published by Bulgarian National Statistics Institute show common losses of the grid of 12.85% (http://www.nsi.bg/otrasal.php?otr=30&a1=175&a2=216#cont). So accepting 10% for the grid losses is a conservative approach.	%	10
20	EFplant , Carbon emission factor of plant electricity consumption	Calculated on the base of grid emission factor EFel,y (See Item 20 & Table 8 of this MR)	tCO2/MWh	Varries for each year in the crediting period. The most recent EF, if published by NEC will be used
21	Bo ; Maximum methane producing potential of the sludge	Rrevised IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 5:Waste,p.5.17; See PDD, D.1.1.2.Description of formulae used to estimate project emissions (for each gas, source etc.; emissions in units of CO2 equivalent):	tCH4/tBOD	0.60
22	MCFDB ; Methane conversion factor of the	IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Chapter 6:Waste,	n.a.	0.7

	baseline	p.6.21; See PDD, D.1.1.2.Description of formulae used to estimate project emissions (for each gas, source etc.; emissions in units of CO2 equivalent):		
23	MCFLf ; Methane conversion factor of the landfill	IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Chapter 6:Waste, p.6.21; See PDD, D.1.1.2.Description of formulae used to estimate project emissions (for each gas, source etc.; emissions in units of CO2 equivalent):	n.a.	0.90
24	HSRDB ; Ratio of organic waste that degrades in drying beds in the absence of the project	See PDD, D.1.1.2.Description of formulae used to estimate project emissions (for each gas, source etc.; emissions in units of CO2 equivalent):	n.a.	1.0
25	HSRLF ; Ratio of organic waste that degrades in the landfill	See PDD, D.1.1.2.Description of formulae used to estimate project emissions (for each gas, source etc.; emissions in units of CO2 equivalent):	n.a.	0.01
26	EFdiesel ; Emission factor of the diesel fuel	2006 IPCC Guidelines for National GHG Inventories, V2: Energy, Table 1.2	kgCO2 / GJ	74.10
27	LHVdiesel; Low Heating Value of the diesel fuel	2006 IPCC Guidelines for National GHG Inventories, V2: Energy, Table 1.2	MJ/kg	43.00
28	LHVCH4; Low Heating Value of the methane	2006 IPCC Guidelines for National GHG Inventories, V2: Energy, Table 1.2 – biogas	MJ/kg	50.40
29	ηth,CHP , thermal coefficient of efficiency of the CHP	GE Jenbacher: Manufacturer’s documentation		0.47
30	LESys; Physical leakage emissions from the digesters system	See PDD, D.1.1.2.Description of formulae used to estimate project emissions (for each gas, source etc.; emissions in units of CO2 equivalent)	%	5.0
31	GWPCH4	*“*IPCC Second Assessment: Climate Change 1995. A Report of the Intergovernmental Panel on Climate Change*”*.Bolin, B. *Et al. (1995). IPCC website*. http://www.ipcc.ch/pdf/climate-changes-1995/ipcc-2nd-assessment/2nd-assessment-en.pdf.	n.a.	21

32	PCH4 , specific weight of methane (density)	http://en.wikipedia.org/wiki/Methane	kg/m3	0.717

Table 2: List of fixed data.

The following table presents the currently valid emission factors: (http://www3.moew.government.bg/files/file/Climate/Climate_Change_Policy_Directorate/IETM/Joint_Implementation/JI_documents/Baseline_CEF_Summary.pdf) of the Bulgarian National grid (http://www3.moew.government.bg/files/file/Climate/Climate_Change_Policy_Directorate/IETM/Joint_Implementation/JI_documents/Baseline_CEF_Report.pdf):

Description	Unit	2008	2009	2010	2011	2012
Official up-dated Carbon Emission Factor of Bulgarian National electric grid, EFgrid,y	tCO2/MWh	1.059	0.947	0.908	0.884	0.833
Emission factor for plant internal consumption Of electricity generated by CHP (grid losses 10%), EFplant,y	tCO2/MWh	1.165	1.042	0.999	0.972	0.916

Table 3: Carbon emission factors of the Bulgarian National grid.

D.2. Data and parameters monitored

List of variables:

Qin,PST,y , Flowrate of domestic waste-water into the WwTP prior Primary Settling Tanks (PST) in the year y	m3
BODin,PST, Biochemical oxygen demand concentration in waste-water prior to PST	mgO2/l
BODin,DW, Biochemical oxygen demand concentration in sludge prior to Dewatering unit	mgO2/l
BODin,Dig,y ; Reduced biochemical oxygen demand (Total Organic Substance) at digesters inlet in the year y	t
EGCHP,y , Electricity generation by the CHP in the year y	MWh
EGgrid,y , Electricity exported to the grid in the year y	MWh
FRCHP,y , Biogas flow-rate to the CHP in the year y	m3
FRFlare,y , Biogas flow-rate to the flare in the year y	m3
FRDig,y , Biogas flow-rate at digesters outlet in the year y	m3
PCH4,Dig , Methane concentration in biogas after digesters	%
QCH4,dig,y , Methane production by the digesters in the year y	t

Table 4: List of variables.

Table 5: Baseline emissions parameters									
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.	Primary Settling tanks	Qin,PST,y ; Flow-rate of domestic wastewater into the WwTP prior Primary Settling Tanks(PST) in the year y.	m3	M	Continuously	100%	On paper and electronic	Two years after last Carbon Credit delivery (April 2013)	Data will be aggregated monthly and yearly by summarizing the readings of the four flow-meters mounted at the inlet of each

									Primary settling tank
2.	Drying beds	BODin,PST, Biochemical oxygen demand concentration prior to Primary Settling Tanks (PST)	mgO2/l	M/C	Weekly	100 %	On paper and electronic	Two years after last Carbon Credit delivery (April 2013)	Data will be aggregated monthly and yearly
3.	Drying beds	BODin,DW ; Biochemical oxygen demand concentration prior Dewatering Unit	mgO2/l	M/C	Weekly	100 %	On paper and electronic	Two years after last Carbon Credit delivery (April 2013)	Data will be aggregated monthly and yearly
4.	Drying beds	BODin,Dig,y ; Reduced biochemical oxygen demand (Total organic substance) at digesters inlet in the year y.	t	C	Yearly	100%	On paper and electronic	Two years after last Carbon Credit delivery (April 2013)	Data will be monitored weekly but will be aggregated monthly and yearly
5.	Drying beds	SMDB,y ; Methane emissions from drying beds in the year y	t	C	Yarly	100%	On paper and electronic	Two years after last Carbon Credit delivery (April 2013)	Data will be monitored weekly but will be aggregated monthly and yearly
6.	Electricity generation	EGCHP,y, ; Electricity generation by the CHP in the year y.	MWh	M	Continuous	100 %	Electronic	Two years after last Carbon Credit delivery (April 2013)	Data will be aggregated monthly and yearly.
7.	Electricity generation	EGgrid,y ; Electricity exported to the grid in the year y.	MWh	M	Continuous	100 %	Electronic	Two years after last Carbon Credit delivery (April 2013)	Data will be aggregated monthly and yearly.
8.	Heat generation	FRCHP,y ; Biogas flow-rate to the CHP in the year y.	m3	M/C	Continuous	100 %	Electronic	Two years after last Carbon Credit delivery (April	Data will be aggregated monthly and yearly.

								2013)	
9	Flare	FRFlare,y ; Biogas flow-rate to the flare in the year y.	m3	C	Continuous	100 %	Electronic	Two years after last Carbon Credit delivery (April 2013)	Data will be aggregated monthly and yearly.

Table 6: Project emissions parameters									
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**
10	Digesters	BODin,DW ; Biochemical oxygen demand concentration after plant prior to Dewatering unit	mgO2/l	M/C	Weekly	100 %	On paper and electronic	Two years after last Carbon Credit delivery (April 2013)	Data will be aggregated monthly and yearly
11	Digesters	BODin,Dig,y ; Reduced biochemical oxygen demand at digesters inlet (Total organic substance) at digesters inlet in the year y.	t	C	Yearly	100%	On paper and electronic	Two years after last Carbon Credit delivery (April 2013)	Data will be monitored weekly but will be aggregated monthly and yearly
12	Digesters	FRDig,y ; Biogas flow-rate at digesters outlet in the year y.	m3	M	Continuous	100%	On paper and electronic	Two years after last Carbon Credit delivery (April 2013)	Data will be aggregated monthly and yearly by summarizing the readings of the four flow-meters installed at each digester outlet. After installation of the new AWITE automatic gas analyzer and flow-meter system the data will be taken and recorded automatically.
13	Digesters	PCH4,Dig ; Methane concentration in	%	M	Weekly	100 %	On paper and electronic	Two years after last Carbon Credit	Data will be aggregated monthly

		biogas after digesters						delivery (April 2013)	and yearly. The data will be collected by portable gas analyzer MULTIWARN_II. After installation of the new AWITE automatic gas analyzer and flow-meter system the data will be taken and recorded automatically.
14	Digesters	QCH4,y ; Methane production by the digesters in the year y	t	C	Continuous	100 %	On paper and electronic	Two years after last Carbon Credit delivery (April 2013)	Data will be aggregated monthly and yearly
15	Flare	Tflare,y ; Ignition in flare in the year y - duration	h	M	Continuous	100%	On paper and electronic	Two years after last Carbon Credit delivery (April 2013)	Data will be aggregated monthly and yearly.

D.3. Implementation of sampling plan
N/A

SECTION E. Calculation of emission reductions
E.1. Calculation of baseline emissions

Data concerning GHG emissions by sources of the baseline :

Month/Year	Qin,PST	BODin,PST	BODout,DW	BODin,Dig , reduced
	[m3]	[mgO2/l]	[mgO2/l]	[t]
01.2012	13,462,524	140.84	14.55	1,700.14
02.2012	13,225,072	141.31	25.12	1,536.66
03.2012	15,005,453	142.14	15.51	1,900.08
04.2012	13,527,937	147.22	12.13	1,827.44
05.2012	15,704,139	140.84	14.24	1,988.14
06.2012	12,943,211	127.00	13.08	1,474.58
07.2012	11,789,537	135.19	14.22	1,426.19
08.2012	11,024,905	124.64	12.72	1,233.90
09.2012	10,257,559	94.73	11.90	849.67
10.2012	11,394,803	128.10	12.60	1,316.10
Total for the period	**128,335,140**			**15,252.91**

Table 7: Data concerning emissions due to sludge treatment /baseline emissions/.

Baseline emission:

Emissions from methane from drying beds:

$$SM_{DB,y} = HSR_{DB} \times TOS_y \times MCF_{DB} \times Bo \times GWP_{CH4} \quad [tCO_{2,e}] \qquad (6)$$

and

$$SM_{CH4,DB,y} = HSR_{DB} \times TOS_y \times MCF_{DB} \times Bo \quad [tCH_4] \qquad (6A)$$

where:

$SM_{DB,y}$ = total emissions due to methane generation from sludge in the drying beds in the year y, tCO2,e;
HSR_{DB} = **1.0** = default ratio of organic waste that would degrade in the baseline drying beds accepted in the PDD;
TOS_y = **$BOD_{in,Dig,y}$** = total organic waste in tDC in the year y. For domestic streams, the DC (Degradable Organic Component) is the **BOD**, t
MCF_{DB} = **0.7** = default methane conversion factor accepted in the PDD.
Bo = **0.6** = default maximum methane producing potential of the sludge accepted in the PDD, tCH4/tDC (tCH4/tBOD)
$SM_{CH4,DB,y}$ = methane emissions from sludge in the drying bed in the year y, tCH4

$$\mathbf{BOD_{in.Dig} = Q_{in,PST} \times (BOD_{in,PST} - BOD_{in,DW}) \times 10^{-6} \quad [t] \qquad (7)}$$

Where:

$\mathbf{Q_{in,PST,y}}$ = inlet waste-water flow prior Primary Settling Tanks (PST) in the year y, t
$\mathbf{BOD_{in,PST}}$ = biochemical oxygen demand prior PST, mgO2/l
$\mathbf{BOD_{in,DW}}$ = biochemical oxygen demand prior Dewatering unit (DW), mgO2/l

<u>Emissions from displaced electricity:</u>

$$\mathbf{EE_{dis,y} = EG_{grid,y} \times EF_{grid,y} + (EG_{CHP,y} - EG_{grid,y}) \times EF_{grid,y} \times (1 + EF_{losses} / 100) \quad [tCO_{2,e}] \qquad (8)}$$

Where:

$\mathbf{EE_{dis,y}}$ = emissions from displaced electricity in the year y, tCO2,e
$\mathbf{EG_{grid,y}}$ = electricity exported to the grid in the year y, MWh
$\mathbf{EF_{grid,y}}$ = emission factor of the national grid in the year y, tCO2,e / MWh
$\mathbf{EG_{CHP,y}}$= electricity production of the CHP in the year y, MWh
$\mathbf{EF_{losses}}$ = losses in the national grid, %

Emissions from fuel switch and displaced thermal energy by the CHP:

$$\mathbf{EH_{av,y} = EH_{CHP,y} \quad [tCO_{2,e}] \qquad (9)}$$

Where:

$\mathbf{EH_{av,y}}$ = emissions due to avoided combustion of fossil fuel in the year y, tCO2,e
$\mathbf{EH_{CHP,y}}$ = emission due to avoided combustion of fossil fuel in the CHP in the year y, tCO2,e

$$\mathbf{EH_{CHP,y} = Q_{CH4,CHP,y} \times \eta_{th,CHP} \times LHV_{CH4} \times EF_{diesel} / 1000 \quad [tCO_{2,e}] \qquad (10)}$$

Where:

$\mathbf{Q_{CH4,CHP,y}}$ = quantity of methane combusted in the CHP in the year y, t
$\mathbf{\eta_{th,CHP}}$ = thermal coefficient of efficiency of the CHP
$\mathbf{LHV_{CH4}}$ = low heating value of the methane, MJ/kg
$\mathbf{EF_{diesel}}$ = emission factor of the diesel fuel, kgCO2,e/GJ

For conservativeness only the net quantity of displaced thermal energy is used to calculate the emissions from displaced fossil fuel.

Also for conservativeness and because the CHP has not been working during the whole monitored period, and though biogas has been combusted in the boilers for heat production, emission reductions for displacement of fossil fuel in the boilers are not claimed.

<u>Total baseline emissions:</u>

$$\mathbf{BE_y = SM_{DB,y} + EE_{dis,y} + EH_{dis,y}} \qquad [\mathbf{tCO_{2,e}}] \qquad \mathbf{(11)}$$

Where:

$\mathbf{BE_y}$ = baseline emissions in the year y,tCO2,e

E.2. Calculation of project emissions

Data concerning GHG emissions by sources of the project activity :

Month/ Year	Qin,PST	BODin,PST	BODout,DW	BODin,Dig , reduced	Biogas flow-rate outlet digesters, FRDig,	CH4 concentration in biogas, PCH4	Biogas flow-rate to CHP, FRCHP	Biogas flow-rate to flares, FRboiler	Quantity of CH4 at outlet digesters, QCH4,dig	Quantity of CH4 to the CHP (with 5% sys.leakage), QCH4,CHP	Quantity of CH4 to the flares (with 5% sys.leakage), QCH4,boiler	Electric energy, generated by the CHP (net), EGCHP	Electric energy, exported to the grid (net), EGGrid
	[m3]	[mgO2/l]	[mgO2/l]	[t]	[m3]	[%]	[m3]	[m3]	[t]	[t]	[t]	[MWh]	[MWh]
01.2012	13,462,524	140.84	14.55	1,700.14	892,260	65.00	752,172	140,088	415.84	350.55	65.29	1,306.60	4.99
02.2012	13,225,072	141.31	25.12	1,536.66	815,280	63.93	603,762	211,518	373.69	276.74	96.95	918.40	0.35
03.2012	15,005,453	142.14	15.51	1,900.08	717,790	65.00	569,833	147,957	334.53	265.57	68.96	1,067.20	0.03
04.2012	13,527,937	147.22	12.13	1,827.44	862,550	65.00	754,135	108,415	401.99	351.46	50.53	1,393.60	2.24
05.2012	15,704,139	140.84	14.24	1,988.14	931,030	65.00	770,365	160,665	433.91	359.03	74.88	1,378.30	6.46
06.2012	12,943,211	127.00	13.08	1,474.58	870,730	64.00	860,066	10,664	399.56	394.67	4.89	1,664.60	52.82
07.2012	11,789,537	135.19	14.22	1,426.19	1,000,920	64.00	932,884	68,036	459.30	428.08	31.22	1,720.90	161.01
08.2012	11,024,905	124.64	12.72	1,233.90	902,850	64.00	892,233	10,617	414.30	409.43	4.87	1,705.10	68.16
09.2012	10,257,559	94.73	11.90	849.67	755,042	64.00	728,750	26,292	346.47	334.41	12.06	1,426.20	74.78
10.2012	11,394,803	128.10	12.60	1,316.10	1,060,533	62.00	992,279	68,254	471.45	441.11	30.34	1,727.60	103.56
Total for the period	**128,335,140**			**15,252.91**	**8,808,985**		**7,856,479**	**952,506**	**4,051.04**	**3,611.05**	**439.99**	**14,308.50**	**474.39**

Table 8: Data concerning emissions due to biogas production and utilisation /project emissions/.

Project emissions:

Physical leakage from the biogas system:

$$LE_{Sys,y} = 0.05 \times Q_{CH4,dig,y} \times GWP_{CH4} \quad [tCO_{2,e}] \quad (1)$$

Where:

0.05 = the default value of the percentage of the physical leakages from the system accepted in the PDD
$LE_{Sys,y}$ = physical leakage from the sludge treatment and biogas system in the year y, tCO2,e
$Q_{CH4,dig,y}$ = quantity of methane produced in the digesters in the year y, t
GWP_{CH4} = **21** = Global Warming Potential of Methane

$$Q_{CH4,dig} = FR_{dig} \times P_{CH4} \times \rho_{CH4} / 1000 \quad [t] \quad (2)$$

Where:

$Q_{CH4,dig}$ = quantity of methane at digesters outlet. T
FR_{dig} = flow-rate of the biogas at digesters outlet, m3
P_{CH4} = concentration of methane in the biogas at digesters outlet, %
ρ_{CH4} = specific weight of methane, ISO conditions, kg/m3

Emissions from the landfill:

$$SM_{Lf,y} = HSR_{Lf} \times TOS_y \times MCF_{Lf} \times Bo \times GWP_{CH4} \quad [tCO_{2,e}] \quad (3)$$

Where:

$SM_{Lf,y}$ = project emissions from landfill application of the effluent sludge in the year y, tCO2
HSR_{Lf} = **0.1** = default Ratio of organic waste that degrades in the landfill
TOS_y = $BOD_{in,Dig.y}$ = Reduced Biochemical Oxygen Demand of the waste-water at digesters inlet in the year y, t
MCF_{Lf} = **0.9** = default Methane conversion factor of the landfill
Bo = **0.6** = maximum methane producing potential of the sludge, tCH4/tBOD

$$BOD_{in.Dig} = Q_{in,PST} \times (BOD_{in,PST} - BOD_{in,DW}) \times 10^{-6} \quad [t] \quad (4)$$

Where:

$Q_{in,PST,y}$ = inlet waste-water flow prior Primary Settling Tanks (PST) in the year y, t
$BOD_{in,PST}$ = biochemical oxygen demand prior PST, mgO2/l
$BOD_{in,DW}$ = biochemical oxygen demand prior Dewatering unit (DW), mgO2/l

Total Project emissions:

$$PE_y = SM_{Lf,y} + LE_{Sys,y} \qquad [tCO_{2,e}] \qquad (5)$$

Where:

PE_y = project emissions for the year y, tCO2,e

<u>Additional information on formulas used in Table 8</u>:

The data in Column 10 of Table 8 (respectively Column K in Excel file: “20121110_Kubratovo Data_flows_MR2012”) are calculated as per Formula (2) in Chapter 3.1….. Project emissions of the present Monitoring Report and presents the quantity of methane content in the biogas $Q_{CH4,dig}$. :

$$Q_{CH4,dig} = FR_{dig} \times P_{CH4} \times \rho_{CH4} / 1000 \qquad [t] \qquad (2)$$

Where:

$Q_{CH4,dig}$ = quantity of methane at digesters outlet. T
FR_{dig} = flow-rate of the biogas at digesters outlet, m3
P_{CH4} = concentration of methane in the biogas at digesters outlet, %
ρ_{CH4} = specific weight of methane, ISO conditions, kg/m3

The data Column 12 of Table 8 (respectively Column M in Excel file: “20121110_Kubratovo Data_flows_MR2012”) are calculated as per formula analogical to Formula (2) in Chapter 3.1:

$$Q_{CH4,boiler,flare} = FR_{boile,flarer} \times P_{CH4} \times \rho_{CH4} / 1000 \qquad [t] \qquad (2A)$$

Where:

$Q_{CH4,boiler,flare}$ = quantity of methane at boilers inlet, t
$FR_{boiler,flare}$ = flow-rate of the biogas at boiler inlet, m3
P_{CH4} = concentration of methane in the biogas at digesters outlet, %
ρ_{CH4} = specific weight of methane, ISO conditions, kg/m3

E.3. Calculation of leakage

N/A

E.4. Summary of calculation of emission reductions

Emission reductions:

$$ER_y = BE_y - PE_y \qquad [tCO_{2,e}] \qquad (12)$$

Where:

ER_y = emission reductions in the year y, tCO2,e

Time Period	Baseline emissions or baseline net GHG removals by sinks (tCO_2e)	Project emissions or actual net GHG removals by sinks (tCO_{2e})	Leakage (tCO_2e)	Emission reductions or net anthropogenic GHG removals by sinks (tCO_2e)
Total	**153,940**	**21,550**	**0**	**132,390**

E.5. Comparison of actual emission reductions estimates in registered PDD

Item	Values estimated in ex-ante calculation of registered PDD	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks (tCO_2e)	**187,475**	**132,390**

E.6. Remarks on difference from estimated value in registered PDD

The ERUs generated by the project during the monitored period (01.01.2012 – 31.10.2012) is lower than the estimated amount for the same period in the registered PDD due to less quantity of BOD reduced treated by the digesters compared to the estimated in the PDD from one hand, and the lower electric energy generated by the CHP as a result of that. However the difference is ~29% down which is a good result having in mind that the PDD was registered in 2005.

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Annex 1

Definitions and acronyms

Acronyms and Abbreviations

ERU	EMISSION REDUCTION UNITS
CH_4	methane
CHP	combinED heat and power
CO_2	Carbon Dioxide
BOD	Biochemical Oxygen Demand
TOS	Total Organic Substance
GHG	Greenhouse gases
GJ	gigajoulE
GWP	GLOBAL WARMING POTENTIAL
IPCC	intergovermental panel on climate change
MWh	megawat hour
PDD	project design document

Definitions

Baseline	The scenario that reasonably represents what would have happened to greenhouse gases in the absence of the proposed project, and covers emissions from all gases, sectors and source categories listed in Annex A of the Protocol and anthropogenic Removals by sinks, within the project boundary.
Emissions reductions	Emissions reductions generated by a JI project that have not undergone a verification or determination process as specified under the JI guidelines, but are contracted for purchase.
Global Warming Potential (GWP)	An index that compares the ability of greenhouse gases to absorb heat in the atmosphere in comparison to carbon dioxide. The index was established by the Intergovernmental Panel of Climate Change.
Greenhouse gas (GHG)	A gas that contributes to climate change. The greenhouse gases included in the Kyoto Protocol are: carbon dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O), Hydrofluorcarbons (HFCs), Perfluorcarbons (PFCs) and Sulphurhexafluoride (SF6).

Joint Implementation (JI)	Mechanism established under Article 6 of the Kyoto Protocol. JI provides Annex I countries or their companies the ability to jointly implement greenhouse gas emissions reduction or sequestration projects that generate Emissions Reduction Units.
Monitoring plan	Plan describing how monitoring of emission reductions will be undertaken. The monitoring plan forms a part of the Project Design Document (PDD).

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Annex 2

Technical drawings

Annex 3

Energy and material flowchart including metering positions

Annex 4

Excel tables for calculation of ERU