MONITORING REPORT
Version 1.1
2.06.2011

WOOD WASTE TO ENERGY IN SEVEROONEZHSK, THE ARKHANGELSK REGION, THE RUSSIAN FEDERATION

Monitoring period: 1.01.2010 – 31.12.2010 (first and last days included)

CONTENTS

SECTION A. General description of the project activity

A.1. Title of the project activity and sectoral scope

Title: Wood waste to energy in Severoonezhsk, the Arkhangelsk Region, the Russian Federation

Sectoral scopes[1]: 1. Energy industries (renewable/non-renewable sources) (1)
2. Waste handling and disposal (13)

A.2. Monitoring period

Monitoring period: 1.01.2010 – 31.12.2010 (first and last days included)

A.3. Brief description of the project activity

The project is aimed at wood waste utilization for heat supply of Severoonezhsk settlement, the Plesetsk District, the Arkhangelsk Region.

The project is structured around construction of a biofuel boiler house with the installed capacity of 20 Gcal/h (23.26 MW).

Project activity starting data – December 2006.

Start of GHG emission reductions generation – August 2008.

The GHG emission reductions during the monitoring period (1 January 2010 – 31 December 2010) amount to **27 260** t CO_2e.

A.4. Location of the project activity

The project activity is implemented in the settlement of Severoonezhsk, the Plesetsk District, the Arkhangelsk Region (See Fig. A.4.1). The settlement lies on the left bank of the Onega River 30 km from the settlement of Plesetsk (See Fig. A.4.2). There is Iksa railway station in Severoonezhsk, the main railway station of Zaonezhskaya Railway. The population of the settlement is around 5 300.

Geographical latitude: 62°35'22"N. Geographical longitude: 39°49'55"E. Time zone: GMT +3:00.

The Arkhangelsk Region is located in the north of the European part of Russia and is a constituent of the North-Western Federal District of the Russian Federation. The administrative center of the region is the city of Arkhangelsk.

[1] In accordance with the list of sectors approved by the Joint Implementation Supervisory Committee http://ji.unfccc.int/Ref/Documents/List_Sectoral_Scopes.pdf.

Fig. A.4.1. Location of Severoonezhsk in the territory of the Russian Federation

Fig. A.4.2. Google Earth map pinpointing the location of the project activity

A.5. Technical description of the project

The boiler house has four hot water boilers of Global/G/M-500 model manufactured by an Italian company "Uniconfort" with the thermal capacity of 5 Gcal/h (5.8 MW) each. The boiler house also has spare area for installation of an additional boiler with the same capacity.

Global/G/M-500 boilers are fitted with a furnace with a reciprocating grate for wood waste firing. The outlet temperature of hot water is 115°C and the pressure is 0.78 MPa.

The main fuel of the boiler house is wood waste with moisture content between 30% and 50%, consisting of chips – 2.7%, bark – 5.5%, sawdust – 52% and long sawmill residues – 39.8%. Biofuel is delivered to the boiler house from the local sawmills by the fuel supplier’s motor transport. Long sawmill residues are chipped in situ before being fed for combustion. The standby fuel of the boiler house is diesel oil.

The heat supply system is open. The heat carrier is hot water. The heat from the boiler house collectors is supplied to end-users via the existing district heating network of the settlement that is connected to the boiler house by a new heat pipeline section, around 513 m long. The supply pipeline of the new heat network section is measuring 512 m, and the return pipe is measuring 514 m, the outside diameter of the heat network is 426 mm. The long section of the heat pipeline (6 650 m long) with an outside diameter of 630 mm running from the old residual fuel oil boiler house to the point where the new pipeline from the new boiler house connects with the existing district heating system is decommissioned.

The general design of the boiler house was carried out by Scientific Production Firm “ROSS MTK” Ltd.

Producer of boiler equipment - "Uniconfort" (Italy).

The supplier of boiler equipment - “TechStroiLider” Ltd.

Assembling of bearing and filler structures of the building of the boiler house and primary landing – “Green helmet” Ltd.

Assembling of boiler and auxiliary equipment, commissioning – “Eton Energetik” Ltd.

Assembling and commissioning of calculation point– OJSC “Engineering Center Skada”.

A.6. Methodology applied to the project activity

A.6.1. Baseline methodology

The developer proposes his own approach [R1] to the baseline setting and GHG emission reductions calculation and does not agree it with any methodologies for the clean development mechanism (CDM), but he certainly makes his approach consistent with the requirements of *Decision 9/CMP.1*, *Appendix B* [R2].

A.6.2. Monitoring methodology

The monitoring plan was developed following our own approach [R1] in accordance with the project specifics and requirements of *Decision 9/CMP.1*, *Appendix B* [R2] without using any approved CDM methodologies.

A.7. Person(s) responsible for the preparation of the monitoring report

CCGS LLC:
- Vladimir Dyachkov, Director of Project Implementation Department
  e-mail: v.dyachkov@ccgs.ru
- Evgeniy Zhuravskiy, Specialist of Project Implementation Department
  e-mail: e.zhuravskiy@ccgs.ru

SECTION B. Implementation of the project activity

B.1. Implementation status of the project activity

B.1.1. Key starting dates of the project activity

Activity	Dates
Construction and installation works starting date (start of the project activity)	December, 2006
Putting into operation for carrying out of starting-up and adjustment works	July, 2008

B.1.2. The information regarding the actual operation of the project activity during the monitoring period

Project activity is implemented in full compliance with the project design document.

B.2. Deviations to the registered monitoring plan

There are no deviations to the registered monitoring plan.

SECTION C. Description of the monitoring system

C.1. Organizational scheme of monitoring

Original request for primary GHG emission reductions monitoring data is made by the Director of the Project Implementation Department of CCGS LLC to the office of OJSC «Mezhregionenergogaz» in Archangelsk to the Director of "Severo-Zapadnoe" Local Division, who in his turn gives instructions to the enterprise to collect the requested data. The responsibility of persons who responsible for collection, control and transfer of monitoring data is set forth in Order No.36-09-C of 21.08.2009.

The information collected at the enterprise is transferred to the Director of "Severo-Zapadnoe" Local Division, who in his turn transfers it to the Director of the Project Implementation Department of CCGS LLC (See Fig. C.1.1.). All information is transferred by e-mail.

On the basis of the received data the Department of Project Implementation of CCGS LLC prepares a GHG emission reduction monitoring report and submits it for additional cross-check to the Project Development Department of CCGS LLC. As soon as all comments made by the Project Development Department are incorporated or resolved the monitoring report is submitted for verification to the enterprise where the project is implemented.

At CCGS LLC the procedure for verification of the monitoring reports are laid down in "Regulations on quality check and control of GHG emission reduction project design documents (PDD) and monitoring reports at CCGS LLC" (See Annex 2).

After the report is verified and amended as necessary, the Director of the Project Implementation Department of CCGS LLC informs the Director of "Severo-Zapadnoe" Local Division in Archangelsk about preliminary monitoring results and, if there are no comments on his part, the General Director of CCGS LLC takes the final decision to submit the monitoring report for verification to an independent expert organization.

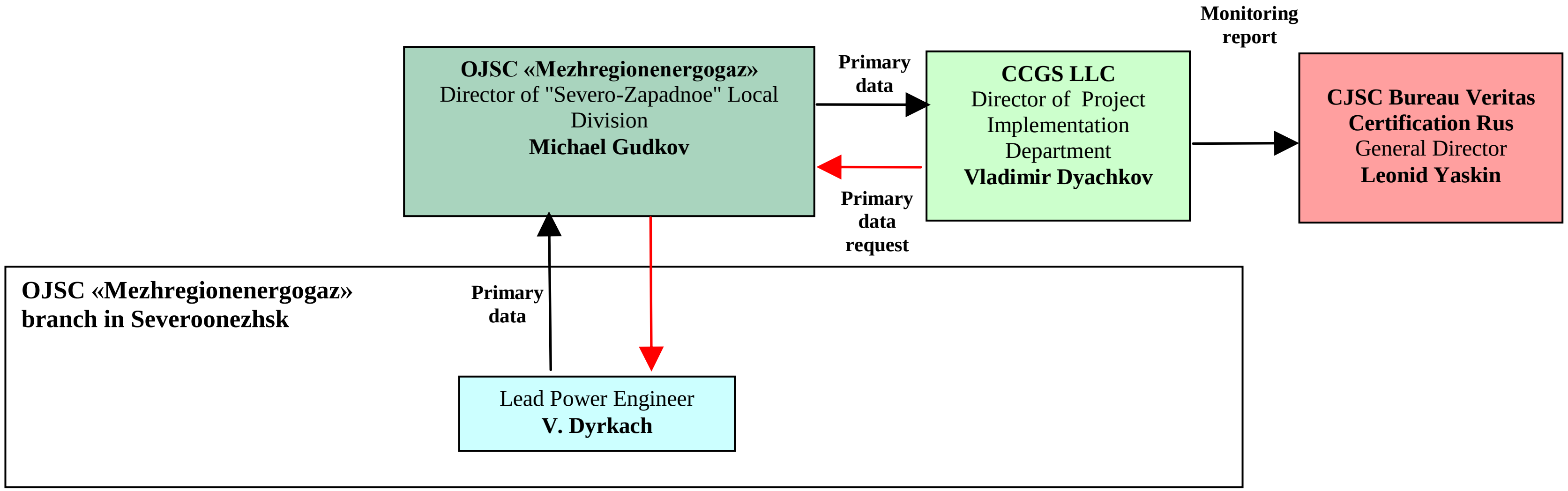


Fig. C.1.1. Data transfer scheme (from primary data to monitoring report)

C.2. Roles and responsibility

The management of CCGS LLC is responsible for:

- drawing up of the monitoring report (Director of Project Implementation Department);
- interaction with the independent expert organization concerning verification of GHG emissions reductions (Director of Project Implementation Department);
- arranging and holding training sessions for the Mill’s personnel regarding collection of data required for the GHG emissions monitoring under the project (Director of Project Implementation Department).

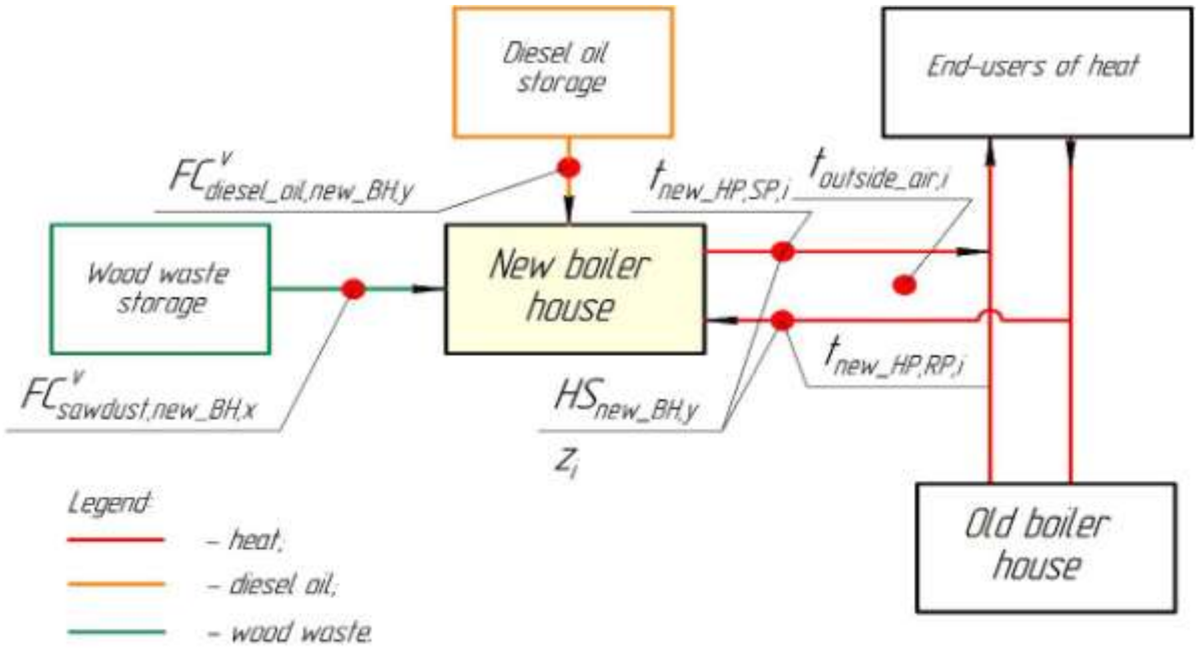
The management of OJSC “Mezhregionenergogaz” is responsible for:

- normal operation of the equipment;
- timely calibration and proper maintenance of instrumentation (Director of "Severo-Zapadnoe" Local Division);
- collection, verification, storage and transfer of primary data (Director of "Severo-Zapadnoe" Local Division, Lead Power Engineer);
- check-out of the monitoring report (Chief Engineer);
- arranging and holding training sessions for personnel regarding collection of data required for the GHG emissions monitoring under the project (Director of "Severo-Zapadnoe" Local Division).

The responsibility of these persons is specified in Orders No.36-09-C of 21.08.2009 and No.01/05 of 05.04.2010. Actions of the members of this working group are described in detail in the Monitoring Guidelines.

C.3. Location of the monitoring points

HS	Heat supply
FC	Fuel consumption
t	Temperature
Z	Length of operation of the heat network



C.4. Data on metering devices

The measuring devices are provided in accordance with the official rules “Electricity Metering Rules”, “Heat Metering Rules” etc. The devices have to undergo regular inspection and supervision under the Federal Law No.102-FZ "On assurance of measurement uniformity" of 26.06.2008.

The measuring instruments have been calibrated during scheduled shutdowns of the equipment. If necessary, the removed measuring instrument is replaced with a gaged back-up instrument. Operation of the equipment without measuring instruments is not allowed.

Table C.4.1. shows metrological performance of the measuring devices used for monitoring.

Table C.4.1. Data on metering devices for GHG emission reduction monitoring

Metered parameter	Mark and type of meter		Serial number	Measurement range	Unit	Error, accuracy class	Calibration interval (month)	Last calibration data	Organisation which performs calibration
Heat supply from the collectors of the new boiler house	Flowmeter (Supply pipeline)	CEPS-PB	300173	1600	m^3/h	1.0	48	06.08.09	FGU «Ulyanovskiy CSM»
	Flowmeter (Return pipeline)	CEPS-PB	300182	1600	m^3/h	1.0	48	06.08.09	FGU «Ulyanovskiy CSM»
	Flowmeter (Makeup pipeline)	Vzlet-ER	616764	764	m^3/h	2.0	48	20.07.07	CJSC «Vzlet»
	Pressure meter (Supply pipeline)	KRT9	842894	1.6	MPa	0.5	24	08.04.09	FGU «Ulyanovskiy CSM»
	Pressure meter (Return pipeline)	KRT9	843227	1.6	MPa	0.5	24	08.04.09	FGU «Ulyanovskiy CSM»
	Pressure meter (Makeup pipeline)	Kommunalets*	29536	1.6	MPa	0.5	48	28.12.09	FGU «Ulyanovskiy CSM»
	Temperature meter (Supply pipeline)	KTPTR-05	5780A	200	°C	1.0	48	15.10.08	FGU «Mendeleevskiy CSM»
	Temperature meter (Return pipeline)	KTPTR-05	5780	200	°C	1.0	48	15.10.08	FGU «Mendeleevskiy CSM»
	Temperature meter (Makeup pipeline)	TPT-1	1541	300	°C	A	48	15.06.09	FGU «Mendeleevskiy CSM»
Average temperature of the outside air	Temperature meter	TPT-1	1343	300	°C	A	48	01.06.09	FGU «Mendeleevskiy CSM»
Length of operation of the heat network	Heat meter	SPT961.2	16737	9999999999	hours	0.01	48	10.07.09	FGU «Ulyanovskiy CSM»

* It is replacement of the original pressure meter KRT9 (serial No.811381) for the period of its calibration.

C.5. The procedures for collection of primary data

The data (to be registered in any case) required for estimation of GHG emission reduction are collected in compliance with the highest sectoral standards and best practice of fuel and energy monitoring and environmental impact assessment.

Collection and record of data required for calculation of GHG emission reductions have been carried out in accordance with the metering points scheme shown in Section C.3.

1. Volumetric diesel oil consumption in the new boiler house during the year *y* has been determined on the basis of the level gauges in the diesel oil tanks.
2. Heat supply from the collectors of the new boiler house during the year *y* has been determined based on the readings of heat meters. Data on heat supply has been regularly transferred to the Lead Power Engineer’s computer and archived.
3. Temperatures in the supply and return pipelines running from the new boiler house to the point of connection with the existing district heating network have been determined based on the heat meter readings. Temperature data has been regularly transferred to the Lead Power Engineer’s computer and archived. Average temperatures in the supply and return pipelines running from the new boiler house to the point of connection with the existing district heating network over the month *i* have been determined as average values at the end of the month *i*.
4. Outside air temperature has been determined based on the reading of the temperature gauge mounted on the outer wall of the boiler house. Average temperature of the outside air over the month *i* has been determined as average value at the end of the month *i*.
5. Length of operation of the heat network during the month *i* has been determined based on the heat meter readings. Data on the length of operation of the heat network has been regularly transferred to the Lead Power Engineer’s computer and archived.
6. The quantity of sawdust combusted in the new boiler house has been determined by the number of loader scoops of sawdust fed for combustion. Volumetric sawdust consumption in the new boiler house during the year *x* has been determined as a cumulative volume of sawdust fed for combustion during the year *x*.

C.6. Data archiving

Electronic databases and calculation spreadsheets are kept in the computer of Lead Power Engineer of the boiler house. To provide the protection of this data it is copied to a hard disk each week and besides it is sent by e-mail to the office of OJSC “Mezhregionenergogas” in Arkhangelsk and CCGS LLC in Arkhangelsk each month where this data is also kept in computer database.

All data will be stored in the enterprise’s archive in electronic and paper form for at least 2 years after the end of the crediting period or the last issue of ERUs.

C.7. Involvement of third parties

FGU «Ulyanovskiy CSM», FGU «Mendeleevskiy CSM».

C.8. Quality control (QC) and monitoring quality assurance (QA)

C.8.1. Quality control (QC) and quality assurance (QA) of measurement of the primary data

Data	Uncertainty level of data (high/medium/low)	QA/QC procedures planned for these data
Volumetric diesel oil consumption in the new boiler house	low	Consumption of diesel oil in the new boiler house is measured by level gauges in the diesel oil tanks.
Heat supply from the collectors of the new boiler house	low	Flow meters, temperature and pressure meters are regularly calibrated. Measurement accuracy of flow meters: 1.0. Measurement accuracy of pressure meters: 0.5. Measurement accuracy of temperature meters: 1.0. Calibration frequency of flow meters: 48 months. Calibration frequency of pressure meters: 24 months. Calibration frequency of temperature meters: 48 months.
Temperature of the outside air Temperature in the supply pipeline Temperature in the return pipeline	low	Temperature gauge is regularly calibrated. Measurement accuracy: 1.0. Calibration frequency 48 months.
Length of operation of the heat network	low	Device is regularly calibrated. Measurement accuracy: 0.01. Calibration frequency 48 months.
Volumetric sawdust consumption in the new boiler house	low	Sawdust consumption in the new boiler house is measured by the number of scoops of the wood waste loader and is cross-checked with the data of the facility for wood waste delivery from the outside.

C.8.2. Internal check-out

Internal verification of the primary data was performed by Lead Power Engineer.

Internal verification of Monitoring report was performed by Chief Engineer of Local Division “North-Western” of OJSC “Mezhregionenergogas” A. Shurygin. Act of internal audit was made on results of check-out of the monitoring report (Act of 30.03.2011).

At least once every year the company carries out an internal check of observance of monitoring procedures. In 2010 such internal check was carried out on August. Act of internal audit was made on the check results (Act of 10.08.2010).

C.8.3. Cross-check

Primary data are verified by cross checking different sources where these data are recorded.

The project monitoring reports are verified by specialists of both “North West” Separate Division of OJSC “Mezhregionenergogas” and CCGS LLC.

Within CCGS LLC the monitoring report is verified by the Director of the Project Implementation Department of CCGS LLC or, on his instructions, by other specialist of the said Department who is not directly related to preparation of this report. The additional cross-check is made by the Director of the Project Preparation Department of CCGS LLC or, on his instructions, by other specialist of this Department. The quality control procedures are laid out in detail in the “Regulations on quality control of project design documents (PDD) and monitoring reports for GHG emission reduction projects within CCGS LLC”.

C.8.4. Trainings

The personnel of the boiler house underwent necessary training in certified educational institutions. All maintenance personnel have the required qualification and valid permits to operate the main equipment of the boiler house. New employees and personnel who need to confirm their admission group are required to undergo respective training, pass a test and obtain a permission certificate in accordance with the Federal law “On industrial safety of hazardous facilities”. The person responsible for the personnel training is the Director of the boiler house. His responsibilities are include:

a) Collection of training applications.

b) Drawing up training schedules.

c) Concluding contracts for training and submission to the accounting department for payment.

d) Control over training documents.

At least once per year CCGS LLC together with the management of OJSC “Mezhregionenergogas” arrange and hold training sessions for the boiler house personnel regarding collection of data required for the GHG emissions monitoring under the project.

In 2010 training on collection, check-out and transfer of primary data was carried out on October, 12-25 (Act of 27.10.2010).

The Monitoring Guidelines which describe in detail actions of each member of the working group have been approved and are in effect within the company.

C.9. Emergency monitoring procedures

In case of any emergency situations at the company which affect the project monitoring system (breakdown of equipment, failure of measuring devices) specialists of OJSC “Mezhregionenergogas” and CCGS LLC shall analyze the situation and elaborate alternative monitoring and measurement schemes for the duration of such circumstances as well as corrective actions covering the monitoring equipment and/or plan.

Shall any instrument fail, the respective parameters are to be monitored with a help of a duplicate instrument or, if such is not available, the failed instrument is to be replaced with a gaged back-up instrument. If the failed instrument cannot be replaced while the equipment is running, then the parameters are monitored for not more than 15 days in one year based on calculation of an average value of this instrument’s readings taken over the three days prior to the failure. This monitoring procedure was developed based on paragraph 9.8 of "The Rules for Heat and Heat Carrier Metering" [R5].

If the equipment is operated without instrument-based monitoring of any parameter for more than 15 days, then the calculations are made using the most conservative (in terms of GHG emission reductions) value for the monitoring period.

All incidents that take place at the enterprise are recorded by the Lead Power Engineer in the prescribed order. Information on major incidents is recorded in the monitoring report.

In case of breakdown of any of the boilers, heat generation will go down, and heat supply to end-users shall reduce. In case of any delays and problems with wood waste supplies the boilers shall run on the standby diesel oil. Any variation of fuel consumption or reduction of heat supply as a result of emergency situations will be automatically reordered by the meters.

C.10. The environmental service

The information on the environmental impact of the project are collected and archived in compliance with the Russian regulations.

SECTION D. Influence estimation on environment

Table D.1 shows calculation data on the variation of pollutant emissions as a result of the project implementation. The calculations were made in accordance with RD 34.02.305-98 “The Methodology for Calculation of Gross Pollutant Emissions from TPP Boilers” [R3], issued by VTI.

As a result of the project the residual fuel oil consumption at old boiler house in year 2010 reduces by an average of 7 989 tons. The emissions of sulfur dioxide reduce by 207.5 t, carbon oxide – by 102.1 t, nitrogen oxides (calculated as nitrogen dioxide) – by 8.1 t, and emissions of oil ash in vanadium equivalent – by 0.7 t. The overall reduction of gross pollutant emissions to the atmosphere amounts to 318.4 t.

Table D.1. Decrease of pollutant emissions in 2010, t

Pollutant emissions	Value
Emissions of oil ash in vanadium equivalent, t	0.7
Sulfur dioxide (SO_2)	207.5
Nitrogen oxides calculated as nitrogen dioxide (NO_2)	8.1
Carbon oxide (CO)	102.1
Total emissions	**318.4**

SECTION E. Data and parameters

E.1. Data to be collected in order to monitor emissions from the baseline

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e)	Recording frequency	Proportion of data to be monitored	Way of storage (electronic/ paper)	Numerical value
1. $HS_{new\_BH,y}$	Heat supply from the collectors of the new boiler house during the year *y*	The Department of Lead Power Engineer	GJ	m, c	Continuously	100 %	Electronic and paper	**201 928**
2. $t_{new\_HP,SP,i}$	Average temperature in the supply pipeline running from the new boiler house to the point of connection with the existing district heating network over the month *i*	The Department of Lead Power Engineer	°C	m	Continuously	100 %	Electronic and paper	**See Annex 3**
3. $t_{outside\_air,i}$	Average temperature of the outside air over the month *i*	The Department of Lead Power Engineer	°C	m	Four times per day	100 %	Electronic and paper	**See Annex 3**
4. z_i	Length of operation of the heat network during the month *i*	The Department of Lead Power Engineer	h	m	Continuously	100 %	Electronic and paper	**7 978**
5. $t_{new\_HP,RP,i}$	Average temperature in the return pipeline running from the new boiler house to the point of connection with the existing district heating network over the month *i*	The Department of Lead Power Engineer	°C	m	Continuously	100 %	Electronic and paper	**See Annex 3**
6. $FC^{v}_{sawdust,new\_BH,x}$	Volumetric sawdust consumption in the new boiler house during the year *y*	The Department of Lead Power Engineer , Economics Department	bulk m^3	m	Continuously	100 %	Electronic and paper	**102 530**

E.2. Data to be collected in order to monitor emissions from the project

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e)	Recording frequency	Proportion of data to be monitored	Way of storage (electronic/ paper)	Numerical value
7. $FC^{v}_{diesel\_oil,new\_BH,y}$	Volumetric diesel oil consumption in the new boiler house during the year *y*	The Department of Lead Power Engineer	l	m	Periodically	100 %	Electronic and paper	**135**

E.3. Data to be collected in order to monitor leakages

Leakages are absent.

SECTION F. Emission reductions calculation

F.1. Calculation of the baseline GHG emission

The total baseline emissions of GHG during the year y, t CO_2e:

$$BE_y = BE_{RFO,y} + BE_{WW,dump,y},$$

where $BE_{RFO,y}$ is the baseline emissions of CO_2 from combustion of residual fuel oil in the old boiler house for generation of heat supplied to end-users of the settlement during the year *y*, t CO_2e;

$$BE_{RFO,y} = FC^{settlement}_{RFO,old\_BH,BL,y} \times EF_{CO2,RFO},$$

where $FC^{settlement}_{RFO,old\_BH,BL,y}$ is the quantity of residual fuel oil fired in the old boiler house for generation of heat supplied to end-users of the settlement under the baseline scenario during the year *y*, GJ;

$$FC^{settlement}_{RFO,old\_BH,BL,y} = \frac{HS^{settlement}_{old\_BH,BL,y}}{\eta_{HWB,old\_BH} \times \left(1 - q_{old\_BH}\right)},$$

where $HS^{settlement}_{old\_BH,BL,y}$ is the heat supply from the collectors of the old boiler house to meet the heat demand of the settlement under the baseline scenario during the year *y*, GJ;

q_{old_BH} is the proportion of heat used for auxiliary needs of the old boiler house, it was assumed q_{old_BH} =0.0351 [R10, table.3];

η_{HWB,old_BH} is the efficiency factor of the hot water boilers of the old boiler house, it was assumed η_{HWB,old_BH} =0.87 [R9, page 267];

$$HS^{settlement}_{old\_BH,BL,y} = HS_{BL,y} + HL_{old\_HP,BL,y},$$

where $HS_{BL,y}$ is the heat supplied to end-users of the settlement under the baseline scenario during the year *y*, GJ;

$$HS_{BL,y} = HS_{PJ,y},$$

where $HS_{PJ,y}$ is the heat supply to end-users of the settlement under the project during the year *y*, GJ;

$$HS_{PJ,y} = HS_{new\_BH,y} - HL_{new\_HP,y},$$

where $HS_{new\_BH,y}$ is the heat supply from the collectors of the new boiler house during the year *y*, GJ;

$HL_{new\_HP,y}$ is the heat losses in the heat pipeline section running from the new boiler house to the point of connection with the existing district heating network during the year *y*, GJ;

$$HL_{new\_HP,y} = HL^{standard}_{new\_HP,SP,y} + HL^{standard}_{new\_HP,RP,y},$$

where $HL^{standard}_{new\_HP,SP,y}$ is the standard heat losses in the supply pipeline running from the new boiler house to the point of connection with the existing district heating network during the year *y*, GJ;

$$HL^{standard}_{new\_HP,SP,y} = \beta_{new\_HP} \times L_{new\_HP,SP} \times \frac{q^{standard}_{new\_HP,SP}}{10^6} \times \sum_i \left(\frac{\left(t_{new\_HP,SP,i} - t_{outside\_air,i}\right)}{t_{new\_HP,SP} - 5} \times z_i \right),$$

where β_{new_HP} is the factor of local heat losses for the new heat pipeline, it was assumed β_{new_HP}=1.15 [R8, section 11.3.3];

$L_{new\_HP,SP}$ is the length of the supply pipeline section running from the new boiler house to the point of connection with the existing district heating network, m it was assumed $L_{new\_HP,SP}$=512m (the length of the heat network was determined on the basis of the design documents);

$q^{standard}_{new\_HP,SP}$ is the standard specific heat losses in the supply pipeline running from the new boiler house to the point of connection with the existing district heating network, kJ/(m*h), it was assumed $q^{standard}_{new\_HP,SP}$=194.6 kJ/(m*h) [R8, annex 4, table 4.1];

$t_{new\_HP,SP,i}$ is the average temperature in the supply pipeline running from the new boiler house to the point of connection with the existing district heating network over the month *i*, °C;

$t_{outside\_air,i}$ is the average temperature of the outside air over the month *i*, °C;

$t_{new\_HP,SP}$ is the average temperature in the supply pipeline running from the new boiler house to the point of connection with the existing district heating network over the year, °C, it was assumed $t_{new\_HP,SP,i}$ =54.8°C (see Annex 4);

5 is the average annual rated temperature of the outside air, °C;

z_i is the length of operation of the heat network during the month i, h.

$HL^{standard}_{new\_HP,RP,y}$ is the standard heat losses in the return pipeline running from the new boiler house to the point of connection with the existing district heating network during the year *y*, GJ;

$$HL^{standard}_{new\_HP,RP,y} = \beta_{new\_HP} \times L_{new\_HP,RP} \times \frac{q^{standard}_{new\_HP,RP}}{10^6} \times \sum_i \left(\frac{\left(t_{new\_HP,RP,i} - t_{outside\_air,i}\right)}{t_{new\_HP,RP} - 5} \times z_i \right),$$

where $L_{new\_HP,RP}$ is the length of the return pipeline section running from the new boiler house to the point of connection with the existing district heating network, m, it was assumed $L_{new\_HP,RP}$ =514m (the length of the heat network was determined on the basis of the design documents);

$q^{standard}_{new\_HP,RP}$ is the standard specific heat losses in the return pipeline running from the new boiler house to the point of connection with the existing district heating network, kJ/(m*h), it was assumed $q^{standard}_{new\_HP,RP}$ =169.5 kJ/(m*h) [R8, annex 4, table 4.1];

$t_{new\_HP,RP,i}$ is the average temperature in the return pipeline running from the new boiler house to the point of connection with the existing district heating network over the month *i*, °C;

$t_{new\_HP,RP}$ is the average temperature in the return pipeline running from the new boiler house to the point of connection with the existing district heating network over the year, °C, it was assumed $t_{new\_HP,RP}$ =44.9°C (see Annex 4).

$HL_{old\_HP,BL,y}$ is the heat losses in the heat pipeline section running from the old boiler house to the point where the heat pipeline from the new boiler house connects with the existing district heating network under the baseline scenario during the year *y*, GJ;

$$HL_{old\_HP,BL,y} = HL^{standard}_{old\_HP,SP,BL,y} + HL^{standard}_{old\_HP,RP,BL,y},$$

where $HL^{standard}_{old\_HP,SP,BL,y}$ is the standard heat losses in the supply pipeline running from the old boiler house to the point where the heat pipeline from the new boiler house connects with the existing district heating network under the baseline scenario during the year *y*, GJ;

$$HL^{standard}_{old\_HP,SP,BL,y} = \beta_{old\_HP} \times L_{old\_HP} \times \frac{q^{standard}_{old\_HP,SP}}{10^6} \times \sum_i \left(\frac{\left(t_{old\_HP,SP,i} - t_{outside\_air,i}\right)}{t_{old\_HP,SP} - 5} \times z_i \right),$$

where β_{old_HP} is the factor of local heat losses for the old heat pipeline, it was assumed β_{old_HP} =1,15 [R8, section 11.3.3];

L_{old_HP} is the length of the heat pipeline section running from the old boiler house to the point where the heat pipeline from the new boiler house connects with the existing district heating network, m, it was assumed L_{old_HP} =6 650m (the length of the heat pipeline was determined based on the scheme of the district heating network of the settlement);

$q^{standard}_{old\_HP,SP}$ is the standard specific heat losses in the supply pipeline running from the old boiler house to the point where the heat pipeline from the new boiler house connects with the existing district heating network, kJ/(m*h), it was assumed $q^{standard}_{old\_HP,SP}$ =477.9 kJ/(m*h) [R8, annex 1, table 1.2];

$t_{old\_HP,SP,i}$ is the average temperature in the supply pipeline running from the old boiler house to the point where the heat pipeline from the new boiler house connects with the existing district heating network over the month *i*, °C;

$$t_{old\_HP,SP,i} = t_{new\_HP,SP,i}.$$

$t_{old\_HP,SP}$ is the average temperature in the supply pipeline running from the old boiler house to the point where the heat pipeline from the new boiler house connects with the existing district heating network over the year, °C, it was assumed $t_{old\_HP,SP}$ =54.8°C (see Annex 4).

$HL^{standard}_{old\_HP,RP,BL,y}$ is the standard heat losses in the return pipeline running from the old boiler house to the point where the heat pipeline from the new boiler house connects with the existing district heating network under the baseline scenario during the year *y*, GJ;

$$HL^{standard}_{old\_HP,RP,BL,y} = \beta_{old\_HP} \times L_{old\_HP} \times \frac{q^{standard}_{old\_HP,RP}}{10^6} \times \sum_i \left(\frac{\left(t_{old\_HP,RP,i} - t_{outside\_air,i}\right)}{t_{old\_HP,RP} - 5} \times z_i \right),$$

where $q^{standard}_{old\_HP,RP}$ is the standard specific heat losses in the return pipeline running from the old boiler house to the point where the heat pipeline from the new boiler house connects with the existing district heating network, kJ/(m*h), it was assumed $q^{standard}_{old\_HP,RP}$ =430.7 kJ/(m*h) [R8, annex 1, table 1.2];

$t_{old\_HP,RP,i}$ is the average temperature in the return pipeline running from the old boiler house to the point where the heat pipeline from the new boiler house connects with the existing district heating network over the month *i*, °C;

$$t_{old\_HP,RP,i} = t_{new\_HP,RP,i} .$$

$t_{old\_HP,RP}$ is the average temperature in the return pipeline running from the old boiler house to the point where the heat pipeline from the new boiler house connects with the existing district heating network over the year, °C, it was assumed $t_{old\_HP,RP}$ =44.9°C (see Annex 4).

η_{HWB,old_BH} is the efficiency factor of the hot water boilers of the old boiler house, it was assumed η_{HWB,old_BH} =0.87 [R9, page 267];

q_{old_BH} is the proportion of heat used for auxiliary needs of the old boiler house, it was assumed q_{old_BH} =0.0351 [R10,table 3].

$EF_{CO2,RFO}$ is the CO_2 emission factor for residual fuel oil combustion, t CO_2e/GJ. According to «2006 IPCC Guidelines for National

Greenhouse Gas Inventories» [R6] it was assumed: $EF_{CO2,RFO}$ = 0.0774 t CO_2e/GJ.

$BE_{WW,dump,y}$ is the baseline emissions of CH_4 from decomposition of wood waste at the dumps during the year *y*, t CO_2e;

The numerical value of $BE_{WW,dump,y}$ is determined using the model *"Calculation of CO_2-equivalent emission reductions from biomass prevented from stockpiling or taken from stockpiles"* developed by *"BTG biomass technology group B.V."* based on [R4] (See Annex 1).

$$BE_{WW,dump,y} = \left(1 - w_{lignin,WW}\right) \times k_{WW} \times \frac{C_{WW}^{db}}{100} \times a \times \zeta \times \left(1 - \frac{\varphi}{100}\right) \times \left(1 - \zeta_{OX}\right) \times \frac{V_m}{100} \times \rho_{CH4} \times GWP_{CH4} \times \sum_{x=2008}^{x=y} \left(WW_{dump,BL,x}^{dry} \times e^{-k_{WW}(y-x)}\right),$$

where $WW_{dump,BL,x}^{dry}$ is the wood waste disposal to the dumps under the baseline scenario during the year *x*, t d.m.;

$$WW_{dump,BL,x}^{dry} = FC_{sawdust,new\_BH,x}^{v} \times k_{sawdust},$$

where $FC_{sawdust,new\_BH,x}^{v}$ is the volumetric sawdust consumption in the new boiler house during the year *x*, bulk m^3;

$k_{sawdust}$ is the factor for conversion of bulk cubic meters of sawdust to tonnes of dry matter, t d.m./ bulk m^3, it was assumed $k_{sawdust}$=0.0879 [R1, Section B1];

$w_{lignin,WW}$ is the lignin fraction of C for the wood waste, it was assumed $w_{lignin,WW}$=0.25 [R4, page43];

k_{WW} is the decomposition rate constant for the wood waste, $year^{-1}$, it was assumed k_{WW} = ln(1/2)/15 = 0.046 $year^{-1}$ [R4, page 42];

C_{WW}^{db} is the organic carbon content in the wood waste on dry basis, %, it was assumed C_{WW}^{db} =50% [R4, page 45];

a is the conversion factor from kg carbon to landfill gas quantity, m^3/kg carbon, it was assumed a =1.87 m^3/kg carbon [R4, page 24];

ζ is the generation factor, it was assumed ζ =0.77 [R4, page 41];

φ is the percentage of the stockpile under aerobic conditions, %, it was assumed φ =10% [R4, page 80];

ζ_{OX} is the methane oxidation factor, it was assumed ζ_{OX} =0.10 [R4, page 43];

V_m is the methane concentration biogas, %, it was assumed V_m =60% [R4, page 41];

ρ_{CH4} is the density of methane, kg/m^3, it was assumed ρ_{CH4} =0.714 kg/m^3 [R1, Section E4];

GWP_{CH4} is the global warming potential of methane, t CO_2e/t CH_4, it was assumed

GWP_{CH4}=21 t CO_2e/t CH_4 [R4, page 12];

y is the year for which to calculate the CO_2-equivalent reduction, year;

x is the year in which fresh biomass is utilized instead of stockpiled, year.

The calculation of methane emissions for each year *y* uses data on sawdust disposal to the dumps starting from 2008.

F.2. Calculation of the project GHG emission

The total project emissions of GHG during the year y, t CO_2e:

$$PE_y = PE_{diesel\_oil,y},$$

where $PE_{diesel\_oil,y}$ is the project emissions of CO_2 from combustion of diesel oil in the new boiler house during the year *y*, t CO_2e;

$$PE_{diesel\_oil,y} = FC^{v}_{diesel\_oil,new\_BH,y} \times NCV_{diesel\_oil} \times EF_{CO2,diesel\_oil},$$

where $FC^{v}_{diesel\_oil,new\_BH,y}$ is the volumetric diesel oil consumption in the new boiler house during the year *y*, l;

NCV_{diesel_oil} is the net calorific value of diesel oil, GJ/l, it was assumed NCV_{diesel_oil}=0.0371 GJ/l [R7, page 8, table 3];

$EF_{CO2,diesel\_oil}$ is the CO_2 emission factor for diesel oil combustion, t CO_2e/GJ. According to «2006 IPCC Guidelines for National Greenhouse Gas Inventories» [R6] it was assumed: $EF_{CO2,diesel\_oil}$ = 0.0741 t CO_2e/GJ.

F.3. Emission reductions calculation

The GHG emission reductions during the year y, t CO_2e:

$$ER_y = BE_y - PE_y.$$

The calculation method of GHG emission reductions was implemented in the computational model in the form of excel-files (See Annex 5). This model is integral part of the monitoring report. Main results of calculations are summarized in Table F.3.1.

Table F.3.1. Summary table of GHG emission reductions in 2010

Parameter	Symbol	Unit	Value
Baseline emissions of GHG	$BE_{NG,y}$	t CO_2e	27 260.38
Project emissions of GHG	$PE_{NG,y}$	t CO_2e	0.37
GHG emission reductions	ER_y	t CO_2e	27 260.01

F.4. Comparison of actual emission reductions with estimates in the registered PDD

According to the project design document, GHG emission reductions in 2010 were estimated at **29 765** tCO_2e. GHG emission reductions according to the monitoring amounted to **27 260** tCO_2e, which is 2 505 tCO_2e or 8.4% less than the projected level.

The reasons why the monitored amount of ERUs is lower than the PDD estimation are as follows:

1. Actual supply of heat from the new boiler house turned out to the lower than the projected supply by 11 058 GJ or by 5.2% (See Table F.4.1). After adjustment to heating medium temperature and ambient temperature, this factor reduced the amount of ERUs by 821 tCO_2e or by 2.8 % (See Table F.4.2).
2. Actual quantity of bark and wood wastes (BWW) prevented from dumping turned out to be smaller that the projected amount by 1 483 t or by 14.1%. This factor reduced the ERU amount by 270 tCO_2e or by 0.9 %.

   Reduction in the quantity of BWW prevented from dumping was also recorded in 2009 and 2008, which reduced the amount of ERUs in 2010 by 3.9% and 0.9%, respectively (See Table. F.4.2).

Table F.4.1. Reasons of reduction in the monitored amount of GHG emission reductions against the amount projected in the PDD

Reason	Unit	PDD	Monitoring report
Heat supply from the new boiler house	GJ	212 986	201 928
Quantity of BWW prevented from dumping in 2010	t d.m.	10 496	9 012
Quantity of BWW prevented from dumping in 2009	t d.m.	10 496	3 886
Quantity of BWW prevented from dumping in 2008	t d.m.	2 703	1 096
Combustion of diesel fuel in the new boiler house	l	0	135

Table F.4.2. Impact of various factors on reduction in the amount of ERUs

Factor	Reduction in ERUs against project values	
	tCO_2e	%
Reduction in heat supply from the new boiler house	821	2.76
Reduction in BWW quantity prevented from dumping in 2010	270	0.91
Reduction in BWW quantity prevented from dumping in 2009	1147	3.86
Reduction in BWW quantity prevented from dumping in 2008	266	0.90
Combustion of diesel fuel in the new boiler house	0.37	0.001
Total	**2 505**	**8.42**

CCGS LLC
2.06.2011

Vladimir Dyachkov - Director of Project Implementation Department

Evgeniy Zhuravskiy, Specialist of Project Implementation Department

REFERENCES

[R1] Project Design Document **"** Wood waste to energy in Severoonezhsk, the Arkhangelsk Region, the Russian Federation **".** Version 1.0/ 28.08.2009.

[R2] Decision 9/CMP.1. Guidelines for the implementation of Article 6 of the Kyoto Protocol. FCCC/KP/CMP/2005/8/Add.2. March 30, 2006.

[R3] RD 34.02.305-98 "The Methodology for Calculation of Gross Pollutant Emissions from TPP Boilers.". VTI. 1998.

[R4] Methane and Nitrogen Oxide Emissions from Biomass Waste Stockpiles, PCFplus Research, World Bank, August 2002.

[R5] The Rules for Heat and Heat Carrier Metering. Central administrative board of the state power supervision. Moscow. 1995.

[R6] 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2, Energy.

[R7] The World Resources Institute (WRI) and World Business Council for Sustainable Development. 2001. Calculating CO_2 emissions from mobile sources - Guide to calculation worksheets. Washington, DC: World Resources Institute.

[R8] Guidelines for calculation and justification of standards of process losses for heat delivery in the Russian Ministry of Energy. Approved by the order of the Ministry of Energy of the Russia Federation dated December 30, 2008 No.325. (http://www.spbustavsud.ru/printdoc?tid=&nd=902148459&nh=0&ssect=0).

[R9] Reference Book on Small Boiler Units/Edited by K.F.Roddatis. M.: Energoatomizdat, 1989.

[R10] Methodology for determination of fuel, electricity and water demand for production and delivery of heat and heat carriers in the public heating systems. MDK 4-05.2004. Moscow, 2004.

[R11] S.I.Golovkov. Wood Waste-To-Energy. – M.: Forest Industry, 1987.

[R12] Annex to Contract No.15/2008 dated 07.07.2008 for heat supply.

Annex 1

Calculation of methane emissions from anaerobic decomposition of BWW at the dump

Calculation of CO_2-equivalent emission reduction from BWW prevented from stockpiling or taken from stockpiles

BWW - bark wood waste

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,714	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	15	year
Decomposition constant (k)	0,046	$year^{-1}$
Generation factor (zeta)	0,77	
Methane oxidation factor	0,10	
Percentage of the stockpile under aerobic conditions	10%	

LEGEND

db = dry basis
wb = wet basis
yellow cells = unprotected cells
red marks = comment field included

Biomass specific input data	Biomass from stockpile	Fresh	
Organic carbon content (db)		50,0%	db
Moisture content		0%	wb
Organic carbon content (wb)	0,0%	50,0%	wb
Lignin fraction of C		0,25	

Year	Fresh biomass prevented from stockpiling or taken from stockpile: Biomass from stockpile (ton$_w$)	Age of biomass (years)	Fresh (ton$_w$)	Year / ton CO2-eq: 2008	2009	2010
2008			1 096	199	190	182
2009			3 886		707	675
2010			9 012			1 639
2011						
2012						
2013						
2014						
2015						
2016						
2017						
2018						
2019						
2020						
2021						
2022						
2023						
Total	0		13 995			
Total emission prevention				199	897	2 495
Cumulative total emission prevention				199	1 096	3 591

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This spreadsheet model is based on the report: "Methane and Nitrous Oxide Emissions from Biomass Waste Stockpiles", Worldbank PCF*plus* research, August 2002

Annex 2

The provisions for quality control procedure in relation to preparation of project design documents and monitoring reports for greenhouse gas emission reduction projects at CCGS LLC

CCGS

Approved by
Director General
M.Yulkin
December 8, 2009

REGULATIONS

on quality check and control of GHG emission reduction project design documents (PDD) and monitoring reports at CCGS LLC

1. GENERAL PROVISIONS

1.1. These regulations specify the quality control procedure for development of project design documents (PDDs) and monitoring reports for the projects aimed at GHG emission reduction from sources and/or increase of removal by sinks (hereinafter the “Projects”).

1.2. The quality control of PDDs and monitoring reports is carried out in conjunction with the structural subdivisions (departments) of CCGS LLC (hereinafter the “Company”) and the Project Owners (hereinafter the “Client”).

1.3. The quality control of PDDs and monitoring reports precedes their submission to an independent auditor for review.

2. QUALITY CONTROL OF PROJECT DESIGN DOCUMENTS

2.1. The PDD developed by a specialist of the Project Development Department shall undergo the following quality control procedure:

2.1.1. The PDD shall be checked up by the Director of the Project Development Department or, on his instructions, by other specialist of the Project Development Department who was not directly involved in development of this PDD;

2.1.2. Corrective actions shall be taken by the PDD developer and all corrections and amendments shall be agreed with the Director of the Project Development Department;

2.1.3. The PDD shall be checked up by the Director of the Project Implementation Department or, on his instructions, by other specialist of the Project Implementation Department;

2.1.4. Corrective actions shall be taken by the PDD developer and all corrections and amendments shall be agreed with the Director of the Project Implementation Department;

2.1.5. Final check-up and correction of the PDD shall be made by the Director of the Project Development Department;

2.1.6. The PDD shall be submitted to the Client for review;

2.1.7. Corrective actions shall be taken by the PDD developer and all corrections and amendments shall be agreed with the Client and the Director of the Project Development Department and if necessary with the Director of the Project Implementation Department;

2.1.8. The PDD shall be furnished to the Director General and the Client.

2.2. Upon completion of the above-described procedure and if there are no comments from the Director General and/or from the Client the PDD shall be deemed ready for determination by an independent auditor. Otherwise the procedure shall be repeated.

2.3. The Director of the Project Development Department shall check all sections of the PDD.

2.4. The Director of the Project Implementation Department shall check those sections of the PDD which describe the project monitoring plan and procedure. Other sections shall be checked by the Director of the Project Implementation Department if necessary or at his discretion.

2.5. The Director General shall take the final decision regarding submission of the PDD for determination to an independent auditor.

3. QUALITY CONTROL OF PROJECT MONITORING REPORTS

3.1. The project monitoring report prepared by a specialist of the Project Implementation Department shall undergo the following quality control procedure:

3.1.1. The project monitoring report shall be checked up by the Director of the Project Implementation Department or, on his instructions, by other specialist of the Project Implementation Department who was not directly involved in preparation of this project monitoring report;

3.1.2. Corrective actions shall be taken by the monitoring report developer and all corrections and amendments shall be agreed with the Director of the Project Implementation Department;

3.1.3. The project monitoring report shall be checked up by the Director of the Project Development Department or, on his instructions, by other specialist of the Project Development Department;

3.1.4. Corrective actions shall be taken by the monitoring report developer and all corrections and amendments shall be agreed with the Director of the Project Development Department;

3.1.5. Final check-up and correction of the monitoring report shall be made by the Director of the Project Implementation Department;

3.1.6. The monitoring report shall be submitted to the Client for review;

3.1.7. Corrective actions shall be taken by the monitoring report developer and all corrections and amendments shall be agreed with the Client and the Director of the Project Implementation Department and, if necessary, with the Director of the Project Development Department;

3.1.8. The monitoring report shall be submitted to the Director General and the Client.

3.2. Upon completion of the above-described procedure and if there are no comments from the Director General and/or from the Client the monitoring report shall be deemed ready for verification by an independent auditor. Otherwise the procedure shall be repeated.

3.3. The Director of the Project Implementation Department shall check all sections of the monitoring report.

3.4. The Director of the Project Development Department shall check those sections of the monitoring report which contain results of calculations of GHG emission reductions from sources and/or increase of GHG removals by sinks. Other sections shall be checked up by the Director of the Project Development Department if necessary or at his discretion.

3.5. The Director General shall take the final decision regarding submission of the monitoring report for verification to an independent auditor.

Annex 3

Primary data for monitoring of greenhouse gas emission reductions in 2010 for the project "Wood Waste to Energy in Severoonezhsk, the Arkhangelsk Region, the Russian Federation"

No.	Parameter	Unit	January	February	March	April	May	June	July	August	September	October	November	December	2010
1	Heat supply from of the header of the new boiler house	Gcal	6 104	6 848	6 184	4 137	2 315	1 714	-	1 207	2 637	4 274	5 244	7 563	48 227
2	Average temperature in the supply pipeline in the section running from the new boiler house to the connection point with the existing district heating network	^{0}C	72.9	67.8	62.4	52.8	56.0	59.9	-	59.03	58.99	56.73	63.24	72.6	62.04
3	Average temperature in the return pipeline in the section running from the new boiler house to the connection point with the existing district heating network	^{0}C	-16.3	-12.1	-6.1	4.7	13.9	14.5	-	15.72	9.70	3.03	-5.40	-15.6	0.55
4	Average outside air temperature	^{0}C	744	672	744	720	744	720	-	706	720	744	720	744	7 978
5	Running hours of the heat pipeline	h	55.4	52.3	49.2	42.9	48.1	53.4	-	54.52	48.28	43.72	49.39	56.2	50.31
6	Volumetric consumption of diesel fuel in the new boiler house	l	0	0	0	0	0	0	-	40	25	0	50	20	135
7	Volumetric consumption of sawdust in the new boiler house	bulk m^3	13 134	12 621	13 056	9 394	5 221	3 635	-	3 048	6 224	9 044	11 539	15 614	102 530

Annex 4

Heat losses through insulated surface of supply and return pipelines from the point where the measuring device of the heat metering unit is installed to the border line of ownership and operational responsibility (Annex to Contract No.15/2008 dated 07.07.2008 for heat supply)

50^0C	100^0C
44.600	75.120

No.	Operation periods	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1	Number of hours in the period, hours,T	744	678	744	720	744	720	744	744	720	744	720	744	8 766
2	Average monthly and annual temperatures of outside air t_{oa}	-14.1	-12.8	-7.3	-0.1	6.6	13.4	16.1	13.9	8.0	1.2	-4.5	-10.2	0.9
3	Temperatures in the supply pipeline according to the heating chart t_s	68	67	57.6	50	50	50	50	50	50	50	53	62	54.8
4	Temperatures in the return pipeline according to the heating chart t_r	53	52	46.3	42	42	42	42	42	42	42	44.5	49	44.9
5	Deviations of temperature in the supply pipeline from the table data Δt_s	18.0	17.0	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	12.0	4.8
6	Deviations of temperature in the return pipeline from the table data Δt_r	3	2	-3.7	-8	-8	-8	-8	-8	-8	-8	-5.5	-1	-5.1
7	Specific losses in the supply pipeline per 1 running m normalized to the chart temperature. (kcal/(m*h) $q_{in.s}$	55.587	54.977	49.239	44.600	44.600	44.600	44.600	44.600	44.600	44.600	46.431	51.925	47.501
8	Specific losses in the return pipeline per 1 running m normalized to the chart temperature, (kcal/(m*h) $q_{in.r}$	46.431	45.821	42.342	39.717	39.717	39.717	39.717	39.717	39.717	39.717	41.243	43.990	41.470
9	Total losses in the supply pipeline for the period normalized to the temperature chart, (Gcal) $Q_{in.s}$	24.351	21.947	21.570	18.908	19.538	18.908	19.538	19.538	18.908	19.538	19.684	22.747	245.172
10	Total losses in the return pipeline for the period normalized to the temperature chart, (Gcal) $Q_{in.r}$	20.419	18.363	18.621	16.903	17.467	16.903	17.467	17.467	16.903	17.467	17.553	19.346	214.878
11	Sum of losses in both pipelines (Gcal) $\sum Q$	44.770	40.310	40.191	35.811	37.004	35.811	37.004	37.004	35.811	37.004	37.236	42.092	460.050