Sawdust 2000 - Project Implementation

Baseline Study

Version 3 – 2005 01 05

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Abbreviation

Annex B countries	Emssion capped industrialised countries and economies in transition listed in Annex B - Kyoto Protocol.
Annex I countries	Industrialised countries and economies in transition listed in Annex I of the UNFCC.
AIJ	Activities Implemented Jointly. In the first UNFCC Conference of Parties (COP 1) in Berlin 1995 a pilot phase for bilateral GHG mitigation projects was created with the name Activities Implemented Jointly. During the AIJ phase experience shall be established, but without allowing carbon credit transfer between countries.
AAU	Assigned Amount Unit is tradable units of the Assigned Amount of an Annex B country as issued pursuant to the rules of article 17 of the Kyoto Protocol, expressed as one metric ton of CO2.
ARCE	Romanian Agency for Energy Conservation
Baseline	A description of the most likely future development in the considered GHG emission or sequestrating system without the JI or CDM project.
BAU	Buisness As Usual. The BAU scenario describes the future development of the existing fossil fuel based district heating sytem if it was continued to be in operation.
Btu (btu)	British Thermal Unit (1 Btu = 1055 Joules)
CDE	Carbon Dioxide Equivalent
CDM	Clean Development Mechanism
CEECs	Central and East European Countries
CER	Certified Emission Reduction
CH_4	Methane
CO_2	Carbon Dioxide
DEPA	Danish Evironmental Protection Agency
DERSA	Danish Emission Reduction System Administration
DH	District Heating
EPI	Enviromental Protection Inspectorate (Romanian facility with 48 county offices)
ERU	Emission Reduction Unit describes the technical term for GHG emission reduction output of JI - Project according to the Kyoto Protocol.
EU-NARD	National Agency for Regional Development - European Union
EUR	Euro (currency European Union)
Gcal	Giga-calorie (1.0 Gcal = 4.187 GJ)
GES	Gross Energy Supply (total energy demand of DH system including losses boiler system, distribution pipe network, under buildings and in buildings).
GHG	Greenhouse Gasses
GWP	Global Warming Potential
Host Contry	Country in which the JI or CDM project is implemented
IPCC	Intergovernmetal Panel on Climate Change
JI	Joint implementation Porject according to Article 6 - Kyoto Protocol.
kWh	Kilowatt hour (1.0 KWh = 3,600,000 Joule)
Leakage	The net change of anthropogeni GHG emission which occur outside the project boundary.
MDP	Romanian Ministry of Development and Prognosis
MOU	Memorandum of Understanding between countries
MP	Monitoring Plan
MWh	Megawatt hour (1.0 MWh = 3,600,000,000 Joule)
N_2O	Nitrous Oxide
NED	Net Energy Demand (energy demand in buildings, excluding losses in basements).
PCF	Prototype Carbon Fund of the World Bank
PDD	Project Design Document
ROL	Romanian Lei (currency)
RSFESD	Romanian Special Fund for Energy System Development
SINK	A procees, activity or mechanism, which removes anthropogenic GHG from the atmosphere.
STEP	Swiss Thermal Energy Project in Bauzau and Pascani (Romania)
UNFCC	United Nations Framework Convention on Climate Change

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1. Introduction

This baseline study has been elaborated after the guidelines in the "Manual for project developers - Joint Implementation and Clean Development Mechanism Projects – version 1 May 2002" publicised by the Danish Energy Authority.

When elaborating this baseline study for the project focus has also been addressed towards similar projects and studies like the PCF Plus Research financed project named "Methane and Nitrous Oxide emission from wood waste stockpiles", the Swiss STEP project implemented in Buzau and Pascani Romania (Final Report and Validation Report year 2002) and to the Dutch project "Biomass energy portfolio in the Czech Republic (Validation Report year 2001 – see paragraph 4.4).

The methodology used for establishing and assessing the emission baselines in this Baseline Study is based on conclusions from similar district heating projects and CH_4 emission projects like the Swiss STEP project implemented in the Romanian towns Buzau and Pascani.

This Baseline Study presents several baseline proposals describing possible future development scenarios for the district heating systems and the GES in the five towns Vlahita, Gheorgheni, Huedin, Vatra Dornei and Intorsura Buzaului. The emission baselines have been developed in order to identify the most likely emission baseline for the project.

In February 2003 the Romanian Government (Ministry of Waters and Environmental Protection) and the Danish Ministry of Environment signed a Memorandum of Understanding based on Project Design Document version 3 – 2004 09 29 and Baseline Study version 2 – 2002 09 16. The MoU was the first step in establishing the formal and legal basis for GHG trading between the two countries according to the Kyoto Protocol.

This Baseline Study version 3 – 2005 01 05 shall serve as the second step in the process realising GHG trading agreement between Romania and Denmark in compliance with requirements for JI - projects (Article 6 of the Kyoto Protocol) and GHG trading between countries (Article 17 Kyoto Protocol).

It should be emphasised that implementation of the project is expected to increase the GES in all the five towns even though the new district heating systems are operating with a higher efficiency when wood residues will be available almost for free. According to experience from other projects utilisation of biomass fuels in Romania will secure stable and sufficient heat supply to heat consumers during the whole year, when the heat production costs will be payable by public funds or by the heat consumers. According to experience gained from a similar biomass DH project in Tasca - Neamt County the GES will increase to a level where the indoor temperature as minimum is 20 °C.

The reader of this baseline study is advised to follow the guidelines presented below and read the PDD. Steps described below are referring to the contents of this baseline study.

Project category : Describes the project category as a Methane Emission Reduction Project, and the GHG emission reduction caused by the project within the two areas:

1) CO_2 emission reduction from substituting fossil fuels (oil and natural gas) with wood residues.
2) CH_4 emission reduction (anaerobic digestion of wood residues) from reducing the quantity of wood residues dumped in stockpiles in the nature.

Step 1 Project Characteristics	**:**	Describes the fuel consumption of existing DH systems, the efficiency of the DH systems, which will be used developing the different emission baselines. Step 1 also describes the project category, project capacity, project output, project time schedule and time period for the emission baselines.
Step 2 Project Boundaries	**:**	Describes the boundaries for the project within which the project's impact will be assessed in terms of GHG emission reduction. Boundaries described in Step 2 are used when estimating the CO_2 emission and CH_4 emission in the different emission baselines. The boundaries related to leakages are described in the paragraph 2.3.
Step 3 Selection of the most appropriate baseline methodology	**:**	Describes the methodology and principles used to develop the four emission baselines in this baseline study. Reference projects are reviewed to investigate the outcome and experience from similar projects. Different emission baseline and their assumptions are presented and the selection of the most likely emission baseline is identified (baseline IV).
Step 4 Baseline Conditions	**:**	Describe barriers (fuel prices, heat price, capital costs, consumer satisfaction etc.) that might affect the emission baselines developed in this baseline study.
Step 5 Calculation of baseline emission	**:**	Describes the methodology and theoretical assumptions used for estimating emission factors concerning CH_4 emission from anaerobic digestion of wood stockpiles. Several methods from similar projects for estimation of CH_4 emission from anaerobic digestion of wood stockpiles are reviewed and a conservative emission factor for the project is selected. Emission factors for substituting fossil fuels (liquid oil and natural gas) with biomass fuels are also presented.
Step 6 Project Scenario	**:**	Describes the calculation principles used in developing the different emission baselines. All data used in calculations are presented in paragraph 4 (Annexes). **Calculation methods reviewed in Step 6:** Calculations of heat demand used as basic for developing emission baselines. Calculations of the quantity of wood residues substituting fossil fuels. Calculations of the quantity of wood residues removed from the nature. CO_2 emission reduction from substituting fossil fuels with wood residues. CH_4 emission reduction from removing wood residues from the nature. Step 6 also includes the paragraphs Leakages, Net Emission Reductions and Conclusion.

2. Emission Baseline

2.1 Project Categories for baseline development

The project is a fuel switch project addressing the Romanian district heating sector aiming to substitute fossil fuels like oil and natural gas with local wood residues like sawdust, wood chips and bark originating from wood processing industry (like sawmills etc.) and forestry. The biomass fuel to be used by all the new biomass boiler systems will be sawdust, which is the background for the name of the project.

An important aspect of forest carbon management in Romania and other countries in the region is the way wood residues are used or disposed by wood processing companies. In particular large stockpiles of wood residues from all kind of wood species have been accumulated in forest areas around Romania.

Fig: 1: Sawdust stockpile in Vatra Dornei (dated 4 May 2004l)

Fig: 2: Sawdust used for road construction

The high number of wood stockpiles is causing local nuisances (such as the spreading of sawdust by the wind), but they also generate emission of CH_4 and N_2O in large quantities from the stockpiles. In the most likely baseline the project will mitigate dumping and stockpiling of wood residues making it possible to obtain significant GHG emission reductions.

Therefore it is foreseen in the project that the GHG emission reduction will be based upon the following elements.

1. Reduction of CH_4 emission from anaerobic digestion of wood residues which today is dumped in the nature.

2. Substituting fossil fuels with a locally produced CO_2 neutral biomass fuels.

CH_4 emission from anaerobic digestion of wood residues is having a global warming potential 21 times greater than CO_2, meaning that the greatest part of the GHG reduction generated by implementation of this project will originate from reduction of the quantities of wood residues dumped in nature and the corresponding reduction in CH_4 emission. The calculations made in this Baseline Study is showing that up to 78 % of the total GHG emission reduction from the project is caused by the reduction in wood residues dumped in the nature.

Therefore the project can be categorised as a **Methane Emission Reduction Project** including also CO2 - emission reduction caused by substituting fossil fuels with biomass.

Possible N_2O emission reduction has not been taken into account when estimating the total GHG emission reduction generated by the different emission baselines.

2.2 Steps in emission Baseline Development

2.2.1 Step 1 - Project Characteristics

As mentioned earlier the project is addressing fuel switch from natural gas and oil to biomasses.

The biomass resources will be existing wood residues supplied from the forest- and sawmill industry (mostly sawdust). Residues, which today are illegally, dumped in the nature causing a considerable environmental impact. Until now the fuel used in the DH plants selected has been oil and natural gas.

When examining the existing fuel consumption presented in paragraph 2.2.1.1 it seems quite surprising that the fuel consumption is mainly declining and a relevant question in why?

1) Is the decline in fuel consumption the result of successful demand side management?

2) Is the decline in fuel consumption the result of improved boiler efficiency?

3) Is the decline in fuel consumption the result of improved network efficiency?

Unfortunately the answer to all three questions is **no**.

All the three factors mentioned are in fact moving in the opposite direction and therefore it seems pretty strange that the fuel consumption is declining at a time where the DH systems are moving towards the edge at there lifetime.

Asking the questions mentioned before to the utilities involved the following answer was obtained.

The fuel consumption is directly connected to the financial recourses available in the towns and these are very limited. I.e. the revenues from selling heat are insufficient for purchasing the necessary quantities of fuel. Therefore heat supply is terminated when no more money for purchasing of fuel is available.

This is of course a very effective way to save energy and money. However, insufficient heat supply is constantly undermining the confidence in the heat supply provided by the public utilities, and the willingness to pay for insufficient services is at a low level. I.e. a vicious circle is created in which financial shortage constantly is being a more and more serious problem and the service provided is constantly reduced which is accelerating the financial shortage because of the missing payment of heat.

Also the high level of unemployment is a key factor when speaking about missing payment.

2.2.1.1 Fuel consumption existing DH systems

The fuel consumption for the last five years in the five towns is based upon the actual quantities of fuel purchased from year 1997 to year 2001 as illustrated in the table below.

Town	Fuel	Unit	Fuel Consumption - Existing DH systems					
			A	B	C	D	E	F = (A+B+C+D+E) / 5
			1997	1998	1999	2000	2001	Average
Vlahita	Natural Gas	Nm3	953.835,00	975.582,00	1.003.420,00	892.830,00	599.210,00	884.975,40
Gheorgheni	Gas oil	ton/year	1.180,50	1.297,60	857,70	600,90	854,90	958,32
Huedin	Gas oil	ton/year	315,00	450,00	320,00	300,00	300,00	337,00
Intorsura Buzaului	Gas oil	ton/year	965,00	940,00	772,00	611,00	489,00	755,40
Vatra Dornei	Gas oil	ton/year	1.589,20	1.665,70	1.112,00	913,60	-	1.056,10
Total (oil)			4.049,70	4.353,30	3.061,70	2.425,50	1.643,90	

Table 1: Annual Fuel Consumption

The annual fuel consumption of the five towns has been converted into energy (MWh) using the heat values of natural gas and liquid oil and is presented in the table below.

Town	Fuel	Heat value	Energy Value of Fuel Consumed - Existing DH Systems					
			1997	1998	1999	2000	2001	Average Fuel consumption (1997-2001)
			A	B	C	D	E	F = (A+B+C+D+E) / 5
			MWh/Year	MWh/Year	MWh/Year	MWh/Year	MWh/Year	MWh/year
Vlahita	Natural Gas	9.167 Mwh/1000 Nm3	8.743,49	8.942,84	9.198,02	8.184,28	5.492,76	8.112,27
Gheorgheni	Gas oil	11.11 MWh/ton	13.116,67	14.417,78	9.530,00	6.676,67	9.498,89	10.648,00
Huedin	Gas oil	11.11 MWh/ton	3.500,00	5.000,00	3.555,56	3.333,33	3.333,33	3.744,44
Intorsura Buzaului	Gas oil	11.11 MWh/ton	10.722,22	10.444,44	8.577,78	6.788,89	5.433,33	8.393,33
Vatra Dornei	Gas oil	11.11 MWh/ton	17.657,78	18.507,78	12.355,56	10.151,11	-	11.734,44
Total (oil)		MWh/year	53.740,15	57.312,84	43.216,91	35.134,28	23.758,31	42.632,50

Table 2 Heat value of fuel consumption

To estimate the quantity of energy supplied to buildings the overall effectiveness of the existing boiler systems and distribution systems need to be estimated. Today valid measurements of the actual heat losses from the Romanian DH systems are not available. In this respect estimation of heat losses from DH systems is the only possibility. Based on several years of experience from DH projects in Eastern Europe including Romania combined with estimation of heat losses in projects like the Swiss STEP project the heat losses from existing DH system has been estimated and assessed. The result is presented in the below table together with an estimate of the efficiency for a new or a totally rehabilitated system.

Losses in Existing and New District Heating Systems	Oil		Natural Gas		New biomass DH system	
	%	Net energy available after looses in the previous systems	%	Net energy available after looses in the previous systems	%	Net energy available after looses in the previous systems
Boiler Plant	20	0,80	15	0,85	15	0,85
Network	30	0,56	30	0,60	10	0,77
Piping in buildings	7	0,52	7	0,55	5	0,73
Total losses	48		45		27	
Net Energy supplied	52		55		73	

Table 3: Heat losses existing fossil based DH systems and new biomass based DH systems.

To evaluate the actual service level provided by the limited GES the fuel consumption in the five towns as presented in Table 4 has been converted into key figures like net heat energy (MWh/m^2) supplied to buildings connected.

The Tasca DH system can provide the most reliable information about heat consumption of a DH system supplied with heat from a biomass based DH system with high efficiency. In Tasca energy meters are mounted at the building level and from here the specific NED supplied to the end users has been measured for two heat seasons. The measured data from Tasca has been used for calculating key the key figures included in together with key figures calculated for the five towns under the project.

Subject	Unit	Existing District Heating System					Tasca Biomass Project (measured)	Denmark (block of flat connect to DH system)	Switzer-land
		Vlahita	Gheorgheni	Huedin	Intorsura Buzaului	Vatra Dornei			
A	B	C	D	E	F	G	H	I	J
Gross energy supply	MWh/year	8.112	10.648	3.744	8.393	13.588			
Total building stock to be heated	m2	60.741	52.860	26.557	56.355	67.299			
Fuel used today		Natural Gas	Gas oil	Gas oil	Gas oil	Gas oil			
Total losses	%	45	48	48	48	48			
Net energy demand	%	55	52	52	52	52			
Net energy demand (existing)	MWh/year	4.462	5.537	1.947	4.365	7.066			
Net energy demand	MWh/m2/year	0,07	0,10	0,07	0,08	0,10	0,221	0,117	0,201
Net energy demand (Tasca level - column H)	MWh/year	13.424	11.682	5.869	12.454	14.873			
Difference between Tasca level and net energy demand	MWh/year	8.962	6.145	3.922	8.090	7.807			

Table 4: Net heat supply to end users, which has been used to develop the different emission baselines

The metered heat consumption data from Tasca are considered to be very reliable and according to reports the room temperature in buildings connected to the new Tasca DH system is never below 20 ºC and domestic hot water is continuously supplied, which is a big contrast to the situation in the five towns under the project. I.e. the average heat supply to the end users in the five towns under the project is approx. 38 % of what is actually supplied in

Tasca and the consequence is of course that the consumers in the five towns are suffering from insufficient heat supply and very low indoor temperature.

2.2.1.2 Characteristics of the existing DH systems

Component	Unit	Vlahita	Gheorgheni	Huedin	Vatra Dornei		Intorsura Buzaului
Existing thermal sources		CTI and substion	CTII	CTII	CTI	CTII	CT
Total heat output capacity of existing boiler system	MW	6,00	6,80	4,65	6,98	6,98	9,86
Existing heat output capacity, specified	W/m^2	83,25	85,11	154,21	248,18	178,18	174,96
Supply of hot water for space heating	Yes/No	Yes	Yes	Yes	Yes	Yes	Yes
Supply of hot water for production of hot potable water	Yes/No	Yes	Yes	Yes	Yes	Yes	Yes
Number of heated apartments	No. flats	716	410	270	310	531	701
Number of block of flats connected to network	No	44	17	24	27	34	40
Number of individual buildings (dwellings) connected to network	No		16				
Number of individual buildings connected to network	No	19	17				11
Total heated floor surface apartments	m^2	60.741	52.860	26.557	28.125	39.174	56.355
Total heated surface individual buildings (dwellings)	m^2		3.060				
Total heated floor surface individual buildings	m^2	11.333	23.977	3.596			
Total length of existing distribution pipe network	km	2,0	2,5	1,2	0,9	1,2	1,5

Table 5: Characteristics of the existing fossil based DH systems in the five towns.

2.2.1.3 Rehabilitation of existing system

As described above and in the PDD the key elements in the project is substitution of fossil fuels with wood residues and to introduce a complete rehabilitation of the exiting DH systems in general.

The objectives are:

1) To utilise a renewable domestic produced and environmental friendly energy resource.

2) To increase service level provided to the consumers connected to district heating systems in the five towns.

3) To increase the overall effectiveness of the heat production and heat distribution.

In paragraph 2.2.1.1 (Table 3) the effectiveness of the existing and proposed new DH system has been estimated and described. The effectiveness stated for the new equipment will be normal market standard, which will be included in the technical specifications in the tender dossiers.

2.2.1.4 Sawdust piles and CH_4 emission

As previously indicated and depicted, the current Romania solution for disposing of wood waste from sawmills is to dump the waste in nature. This wood waste, which is mostly sawdust, has accumulated over the past years into extremely large stockpiles or into many medium sized stockpiles. Once dumped into the stockpiles the wood waste never removed and eventually decomposes under anaerobic degradation. This anaerobic degradation causes the release of CH_4 from the stockpiles that will continue for many years after the last bit of waste is placed on the stockpile.

The release of CH_4 from waste wood stockpiles has not been investigated to a large extent, however the release of CH_4 from waste wood stockpiles is expected to have similar characterises as CH_4 emissions from landfills. In this context the Dutch consultant company Biomass Technology Group "BTG" has developed two Joint Implementation projects which claim CH_4 emission reductions through the utilization of wood waste. These JI projects are currently in operation and are located in the Czech Republic and Bulgaria.

The project in the Czech Republic is entitled "Biomass Energy Portfolio for Czech Republic" and was developed under the Dutch ERUPT program in 2001. The Baseline study from this project references a method which is used to estimate CH_4 emissions. These methods are presented in paragraph 2.2.6.2.

The project in Bulgaria is entitled "Svilosa Biomass Project" and was developed under the PCF program in 2002. The Baseline study from this project references a model that was developed in connection with the JI project as part of the PCF-plus program. The model estimates emission using first-order multiphase degradation, and is based on anaerobic decomposition in landfills. The model is compared to actual measured CH_4 emissions from waste wood stockpiles in the report entitled "Methane and Nitrous Oxide Emissions from Biomass Waste Stockpiles." The results of this project are presented in paragraph 2.2.6.2.

2.2.1.5 Project capacity

1) Reduce CO_2 and CH_4 emission,
2) Reduce uncontrolled and illegal dumping of sawdust in the nature,
3) Introduce a complete rehabilitation of the district heating systems in the five towns involved.
4) Improving the comfort level in buildings (stable heat supply and sufficient room temperature).

Establishing new biomass based district heating systems in the five towns under the project will secure stable heat supply to heat consumers during the whole year. The new biomass based district heating systems will comprise boiler systems for production of hot water for space heating and for production of hot potable water in the following Romanian towns

1) Vatra Dornei - Suceava County
2) Vlahita - Harghita County
3) Gheorgheni - Harghita County
4) Huedin - Cluj County
5) Intorsura Buzaului - Covasna County

Implementation of the project will substitute the existing gas and oil based boiler plants, and the distribution network to cover the heat demand of the buildings connected. The main characteristics of the existing district heating systems are presented in Table 6.

2.2.1.6 Project Output

The project output will include upgrading the district heating systems in five towns comprising introduction of new technology like modern biomass boiler technology, pre-insulated distribution pipe network systems, consumer connection units for decentralised production of domestic hot water and replacement of existing leaking heating pipes under buildings with new pre-insulated piping components.

The headlines of the modification and extension of the DH systems in the five towns under the project are presented in the following table

Town	Activity
Huedin	Complete rehabilitation of entire DH systems
Vlahita	Complete rehabilitation of existing DH systems
Intorsura Buzaului	Complete rehabilitation of existing DH systems
Gheorgheni	Complete rehabilitation of the existing DH system connected to and supplied from the existing boiler plant CT2, which is one of five existing boiler plants. The number of heat consumers supplied with heat from DH system after rehabilitation will be extended with a high school and a hospital.
Vatra Dornei	Complete rehabilitation of the existing DH systems, which today is connected to and supplied from the boiler plants CTI and CTII. The number of heat consumers supplied with heat from the DH systems after rehabilitation will be extended with two hotels. The new main supply pipe network is designed for supplying heat to the consumers today supplied from and connected to the boiler plants CTIII, CTIV (not in operation), CTV and CTVI. The new boiler house layout is designed for easy extension when more consumers will be connected later

Table 6: Key elements of the rehabilitation activities

All emission baselines developed in this Baseline Study are based on conservative assumptions when speaking about estimating the CH_4 emission reduction due to uncertainty and limited knowledge about CH_4 emission from wood stockpiles.

2.2.1.7 Technology to be implemented

The technology generally utilised in the project is based upon standardised West European District Heating technology with key components like:

1) Automatically controlled biomass boiler systems with high efficiency and most modern flue gas cleaning facilities complying with West Europeans standards.

2) Pre-insulated district heating piping components

3) Consumer connection units with plate heat exchangers for decentralised production of domestic hot water and automatic controlled mixing loops for space heating supply.

4) Pre-insulated heating piping components in basements under buildings.

The expected lifetime for the equipment implemented under the project will be minimum fifteen years for biomass boiler systems if insufficient maintenance conducted. For new modern pre-insulated piping components the lifetime is estimated to approximately from thirty to forty years.

2.2.1.8 Project implementation plan

The original project implementation plan has been changed several times due to discussions about financial issues like implementation of the project as a JI – Project. The draft time schedule below illustrates the intentions and key activities to be conducted before the beginning of the heating season year 2003 to 2004.

Activitity	2001	2002	2003	2004
Erection sawdust buffer storage				
Purchasing of tractor, wagons and front end loader				
Baseline Study - first evaluation				
Baseline Study - final evaluation				
Publication of tender dossiers				
Evaluation of tenders				
Signing of contracts				
Delivery of biomass boiler systems				
Delivery of pre-insulated piping components				
Delivery of heat consumer connection units				
Testing of new district heating systems				
Commissioning of new district heating systems				

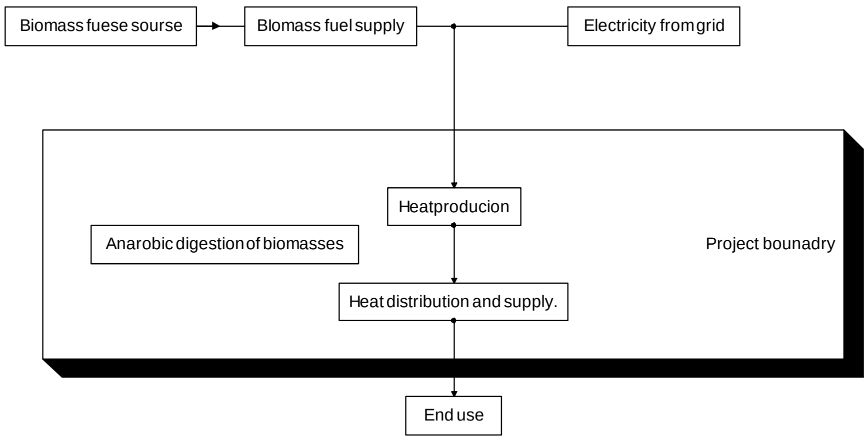
Table 7: Draft time schedule

2.2.1.9 Time period for accreditation of ERUs

The time period for generation and transfer of ERUs has been set to fourteen (14) years.

2.2.2 Step 2 - Project Boundaries

The proposed boundaries of the project are illustrated below.



The proposed project boundaries are valid for the lifetime of the GHG crediting period of the project.

The activities included for development of emission baselines comprise fuels consumption in the five towns. Transportation of natural gas and oil to the five towns is not included in the development of the emission baseline scenarios. Likewise GHG emission from production and transportation of wood residues is not included in the development of the baselines.

The Baseline Study does not include estimation of N_2O emission reduction from wood stockpiles, which undoubtedly will occur when wood stockpiles in the future will be burned in the new biomass boiler systems. During elaboration of the Baseline Study it has not been possible to identify a reliable emission factors when speaking about N_2O emission, this assumption serves to make the Baseline Study more conservative.

The CH_4 emission from anaerobic digestion of wood residues is described in details in paragraph 2.2.6.2.

2.2.3 Selection of the most appropriate baseline methodology

The starting point for emission baselines is based on the average fuel consumption of the five towns as mentioned in paragraph 2.2.1.1.

The key question is to predict the most likely scenario when considering the actual technical standard and the fact that financial shortage is interrupting the heat supply in the five towns. During the wintertime this may lead to a total collapse of the DH infrastructure. This will result in optimal energy savings together with similar CO_2 emission reductions if no fuel were used.

However, total collapse of DH systems in the five Romanian towns is not considered to be a realistic scenario for a county located in the centre of Europe and having signed a Pre-Accession Agreement with the European Union according to the European Union's Enlargement Program. The last information about the development in the Romanian GDP is also for the first time since the revolution pointing in the right direction with positive figures. Finally if a total breakdown was considered as the most likely scenario a huge number of towns in Romania will be in a similar situation as the technical standard mapped for the towns involved is very common for such systems all over Romanian Therefore our basic conclusion is that the DH infrastructure will remain operational in the fourteen years planning period actual for this project.

The preliminary conclusion is therefore that the baseline will begin in January 2004 and the future developments from here are what will be focussed on in the following paragraphs.

2.2.3.1 Reference projects

Before the description of the different baselines for the project is presented some elements from the Swiss STEP project will be discussed.

Emission Baseline predictions in the SWISS STEP Project

In the STEP project the technical basis of the DH systems are identical with the findings made in the Sawdust 2000. The STEP project team has identified exactly the same problems in the two towns Bauzau and Pascani, which was identified by Grue & Hornstrup in the Tasca project dated 1998 and again the findings from the Tasca project are similar to what was mapped in the Sawdust 2000. The solutions recommended by the STEP team and Danish team are almost identical including installation of a new boiler systems, new two-track distribution network pipe systems, rehabilitation of leaking pipe installations under buildings and installation of new heat consumer connection units in each building.

In the STEP project the time period for the baseline is considered to be fifteen years, while the time period for the baseline development used in the Sawdust 2000 is fourteen years according to recently adopted CDM guidelines and the project purchasing agreement. JI – projects are here expected to follow the same guidelines later.

In the STEP baseline the following assumptions are made: To secure the operation of the DH systems and to avoid a total collapse the STEP project foresees rehabilitation of the existing boiler system in year eight. Further more the indoor temperature is assumed to increase from 17 ^{o}C to 20 ^{o}C in year five.

In the STEP Project the following assumptions are made for the most likely scenario.

Assumptions in the STEP Project	Baseline Development
Time period for baseline development	Fifteen years
Further deterioration of existing boiler systems and distribution pipe network	CO_2 emission will increase with 2.0 % annually
Provisional rehabilitation of the distribution system in year five (5) which will make it possible to increase the room temperature from 17 °C to 20 °C.	CO_2 emission will increase with nine 9.0 % in year five
Provisional rehabilitation of existing boiler system in year eight (8)	CO_2 emission will decrease with eight 8 % in year eight

Table 8 Emission baseline STEP - Project

The above information shall be considered as a reference from a project which is implemented and validated.

2.2.4 Potential Emission Baselines for Sawdust 2000 – Project.

To identify the most likely emission baseline for the Sawdust 2000 project it is relevant to summarise the actual status for the heat supply in the five towns under the project.

1) The emission baselines are based on the fuel consumed by the existing boiler systems and based on the emission factors presented in paragraph 2.2.6.2 and the heat losses presented in paragraph 2.2.1.1.

2) The actual GES is insufficient and the heat supply is interrupted during the heating season with the consequence that the indoor temperature is far below what can be considered as a decent service level. Several visits to the five towns involved have been performed during wintertime and outdoor temperatures below minus (-) 20 °C are not unusual and the need for popper space heating is indeed obvious.

3) The actual technical conditions of the district heating system and the technical installations in all block of flats are very poor.

4) In all emission baselines it is taken into consideration that depositing of wood residues in stockpiles in the nature will lead to emission of CH_4 (equivalent CO_2) from an anaerobic digestion processes.

5) The sawdust combusted in the new biomass boiler systems will not be illegally dumped in nature, which means that every ton of sawdust combusted will decrease the CH_4 emission. The principles for calculating the CH_4 emission is illustrated in paragraph Step 5 – Calculation of baseline emission.

Four (4) possible emission baselines are considered and described in details in the coming chapters

Emission Curves for emission baseline I, II, III and IV are presented in Annex I.

Detailed data behind emission baseline I, II, III and IV are presented in Annex II.

2.2.4.1 Emission Baseline I - Sawdust 2000

The proposed development of emission baseline I is inspired by the methodology used in the STEP Project modified according to the actual planning period and as described below.

Item	Sawdust 2000	Emission Baseline I Development
B.I.A	Time period for emission baseline I	14 years
B.I.B	Year 2004 starting point emission baseline I.	The GES is equal to the average GES of the five towns for the time period of year 1997 - 2000. CO_2 emission and CH_4 emission reductions are calculated according to development in the GES.
B.I.C	Year 2004 – 2008 emission baseline I.	The GES will develop from a demand equal to an average GES of the five towns in year 2004 (item B.I.B) to a GES in year 2008 equal to a level as measured in Tasca in year 1999 to 2000. I.e. proper indoor comfort is obtained in year 2004. CO_2 emission and CH_4 emission reductions are calculated according to development in the GES.
B.I.D	Year 2009 – 2017 emission baseline I.	GES, CO_2 emission and CH_4 emission reductions will increase with two percentages per year taking new consumers and the development in the technical standard into consideration.

Table 9: key data for the emission baseline I

Comments to item *B.I.C. (year 2004 – 2008):*

Assumption I The Average GES for the existing DH systems in the five towns in year 2004 is equal to 42,632.50 MWh/year (based on the figures in (paragraph 2.2.1.1).

Assumption II The specific net heat energy demand in Tasca is 0.19 Gcal/m^2/year or 0.221 MWh/m^2/year.

Assumption III: Total area heated in the five towns is approx. 263,812 m^2 with a heat loss factor of 45 % (natural gas) and 48 % (oil). Please see Table 3).

Assumption IV The development in GES from year 2004 up to the Tasca level in year 2008 will be equally divided over five years (heat seasons).

Calculation:

Annual increase in heat demand

$$= \frac{(110{,}696.9 - 42{,}632.50)\ \text{MWh/year}}{5}$$

$$= 13{,}612.90\ \text{MWh/year}$$

2.2.4.2 Emission Baseline II - Sawdust 2000

The proposed development of emission baseline II is like emission baseline I inspired by the methodology used in the STEP Project modified according to the actual planning period and as described below.

Item	Sawdust 2000	Emission Baseline II Development
B.II.A	Time period for emission baseline II	14 years
B.II.B	Year 2004 starting point emission baseline II.	The GES is equal to the average GES of the five towns for the time period of year 1997 - 2000. CO_2 emission and CH_4 emission reductions are calculated according to development in the GES.
B.II.C	Year 2004 – 2008 emission baseline II.	The GES will increase with two percentages per year due to deterioration of existing boiler systems and distribution systems.
B.II.D	Year 2008 emission baseline II	Part of the distribution pipe network will be rehabilitated and the room temperature level will increase from 17 °C to 20 °C, which will increase the CO_2 emission and CH_4 emission reductions with 9.0 % in year four (4).
B.II.E	Year 2008 – 2012 emission baseline II	Further deterioration of the existing boiler plant, which will increase the GES and the CO_2 emission and CH_4 emission reductions will increase with 2.0 % annually.
B.II.F	Year 2010 emission baseline II	Provisional rehabilitation of the existing boiler systems will decrease the CO_2 emission and CH_4 emission reduction with nine 9.0 %.
B.II.G	Year 2010 – 2017 emission baseline II	CO_2 emission and CH_4 emission reduction will increase with 2.0 % annually.

Table 10: Key data for emission baseline II.

The development of emission baseline II can be questioned from an economical point of view as financing of improvements is difficult to identify today. However, from the point of view that Romania hopefully will develop according to intentions of for instance the EU, and it may foreseen that also the Romanian DH sector will be at least provisional rehabilitated, making emission baseline II realistic.

2.2.4.3 Emission Baseline III - Sawdust 2000

The proposed development of emission baseline III is like emission baseline I and baseline II inspired by the methodology used in the STEP Project modified according to the actual planning period and as described below.

Item	Sawdust 2000	Emission Baseline III Development
B.III.A	Time period for emission baseline III	14 years
B.III.B	Year 2004 starting point emission baseline III	The GES is equal to the average GES in the five towns under the sawdust project in the time period from year 1997 to 2000. CO_2 and CH_4 emission reductions calculated according to development in the GES.
B.III.C	Year 2004 – 2013 emission baseline III	The GES will develop from the starting level mentioned above (item B.III.B) to a GES in year 2013 equal to a level as measured in Tasca in year 1999 to 2000. I.e. in year 2013 the population will achieve the same service level as in Tasca in 1999. CO_2 emission and CH_4 emission reductions are calculated according to development in the GES.
B.III.C	Year 2013 - 2017 emission baseline III	The GES will be equal to the level in 2013

Table 11: Emission baseline III – Sawdust 2000.

Item B.III.C. (2004 – 2013):

Assumption I Average GES of the existing DH systems in the five towns year 2004 is equal to 42,632.50 MWh/year (based on the data from the period from 1997 to 2001).

Assumption II NED measurements in Tasca are equal to 0.19 Gcal/m^2/year or 0.221MWh/m^2/year.

Assumption III Total area heated in the five towns is approx. 263,812 m^2 with a heat loss factor of 45% (natural gas) and 48% (oil).

Assumption IV The development in GES will from year 2004 increase to Tasca level in year 2013.

Calculation:

Annual increase in heat demand $= \frac{(110{,}696.9 - 42{,}632.50)\ \text{MWh/year}}{9}$

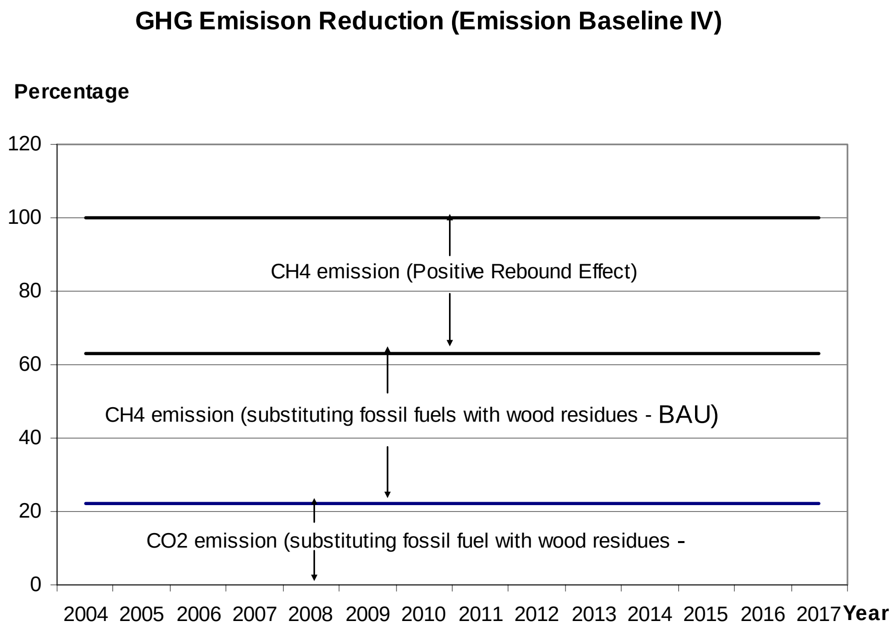
$= 7{,}562.7\ \text{MWh/year}$

2.2.4.4 Emission Baseline IV - Sawdust 2000

The development of emission baseline IV is based on the assumption that the annual GES for the crediting time period year 2004 – 2017 will be equal to the average annual GES measured in the five towns from year 1997 to year 2001 (see Table 1 and Table 2). Further to this it is foreseen that the GES supplied after implementation of the project will be similar to the service level provided in Tasca, and that this service level will be provided from the first day after commissioning. I.e. the biomass consumption will be considerable higher than what was necessary only to substitute the oil and gas as foreseen to be consumed in the BAU scenario.

The emission baselines developed for baseline IV consist of 1) CO_2 emission from substituting fossil fuels with biomass fuels and 2) equivalent CO_2 emission from anaerobic decomposition of wood stockpiles, which are based on the following main assumptions:

- CO_2 emission substituting fossil fuels with biomass fuels is estimated using the fuel consumption from the BAU. The annual fuel consumption in the BAU scenario is equal to the average fuel consumption in the five towns, which has been measured from year 1997 to year 2001.
- CH_4 emission estimated using the fuel consumption from the BAU scenario.
- CH_4 emission estimated using the fuel consumption necessary to obtain the comfort level in buildings as measured in Tasca after a new biomass based DH system was commissioned in year 1999.



The above diagram illustrates the basis principles used to develop the emission baseline IV.

Item	Sawdust 2000	Emission Baseline IV Development
B.IV.A	Time period for emission baseline IV	14 years
B.IV.B	Year 2004 – 2017 emission baseline IV	The GES is the same every year during the time period. CO_2 emission and CH_4 emission reductions from substitution of fossil fuel will be constant. CH_4 emission reductions from higher GES caused by increasing the comfort level in buildings to comfort level measured in Tasca.

Table 12: Emission baseline IV – Sawdust 2000

2.2.4.5 Selection of the method (emission baseline)

The net emission reduction achieved through the four emission baselines described in former paragraphs above can be found in paragraph 2.4.

From our point of view there is no doubt when pointing out the most likely emission baseline, which is emission baseline IV. Emission baseline IV is conservative when speaking about the emission reduction generated by substituting oil and natural gas with wood residues. On the other hand we know exactly from Tasca that when fuel (wood residues) will be available for free or nearly for free nobody will keep the tradition with interrupted heat supply. The heat will be affordable and heat consumers will definitely not accept that utilities introduce artificial shortages when the wood stockpiles are visible in the landscape. Therefore the CH_4 contribution to the GHG emission reduction are assumed to be significantly higher than estimated in emission baseline I, II, III and IV.

2.2.5 Step 4 – Barriers and Uncertainties

During elaboration of this Baseline Study potential barriers and uncertainties, which could influence the development of the different emission baselines has been considered.

Barrier	Description of barrier
Fuel price	The price of fossil fuels could probably increase in the future decreasing the quantity of fuel purchased by the district heating systems in the five towns even more.
Heat price	For some years the heat price level has been so high than heat consumers have not had the ability to pay, and only state subsidises or financial support from county budgets has secured heat supply a few hours every day during the heating season. The heat price is set by the office of competition in Bucharest (ministerial office), stipulating a maximum heat consumer price to be obeyed by heat utility companies.
Fuel quantity	In the time period 1997 – 2001 fuel consumption in the five towns has decreased due to high prices of fossil fuels. The current level of fuel quantity is foreseen to be a minimum consumption but there is a risk for a future decrease in the fuel consumption.
Consumer satisfaction	It is doubtful if heat consumers will continue to accept the actual low comfort level where heat supply to heat consumers during the winter season is only performed a few hours per day.
Technical Performance	The technical performance of the existing district heating systems is poor with low efficiency of the DH systems.
Know-how related	Introduction of new fuel type and biomass boiler technology increase the know-how related risk. The Romanian staff members who shall operate the new biomass boiler technology and handling the wood residues will receive instructions. Experience from the Tasca project is that the local staff members have been fast to adopt the new technology introduced and to perform maintenance of new equipment at a high professional level.
CH_4 emission	The CH_4 emission from anaerobic digestion of wood residues will continue and increase in the future if the project is not implemented as forestry and the wood processing industry will continue to dump wood residues in the nature.
CO_2 emission	On one side the actual low quantity of heat supplied, which is based on combustion of fossil fuels cannot continue. The quantity of fossil fuels combusted must increase in order to raise the comfort level, which will increase the CO_2 emission to. Further deterioration of the Romanian economy will occur and heat supply in the five towns will stop. In this respect the CO_2 emission will decrease or be zero.

Table 13: Barriers.

Some of the barriers mentioned before may under certain circumstances be able to affect the different baselines elaborated in this baseline study and may even undermine the foundation of which some of the baselines depend on.

Affect of Barriers:

1 Higher fossil fuel prices will properly decrease the heat production in all the five towns or even terminate the heat production, which will affect all baselines in this Baseline Study. In other words high fuel prices may eliminate all baselines.

2 Technical performance of all existing DH system in the five towns is continuously deteriorated. Without rehabilitation of existing technical installations and introduction of proper maintenance of the existing equipment the DH systems will properly not operate after another fourteen years.

3 Risk related to CH_4 emission from anaerobic digestion of wood stockpiles is linked to the limited knowledge of the CH_4 emission process in wood stockpiles. Most of the reduction of GHG emission in all emission baselines is linked to CH_4 emission (up to 78 % of reduction in GHG). As mentioned earlier the GHG emission related to CH_4 emission has been calculated very conservative and field measurements indicate a higher quantity of CH_4 emission (1.15 tonnes CH_4 is emitted per ton wet wood stockpile – water content 50 %) from wood stockpiles than estimated in this Baseline Study. However, if lower emission values are measured in the future this will affect the emission baselines calculated in this Baseline Study. However, it is important to remember that much higher GHG emission reduction will occur if the field measurements from the Bulgarian study will prevail.

4 Risk related to CO_2 emission is limited when CO_2 emission from substituting fossil fuels with wood residues correspond to approx. 15 % of the total reduction of GHG emissions generated by the different emission baselines. The affect of CO_2 emission from substituting fossil fuels with wood residues can decrease the reduction of GHG emission but not significantly.

However, the barriers affecting the baselines will properly not develop similarly in all five towns at the same time meaning that higher fossil fuel prices may close down the operation of DH systems in three towns and maybe not in two towns. The same pattern will appear when speaking about deterioration of the technical performance of the existing DH systems in all the five towns.

Assessing the different barriers and how they might affect the emission baselines during a time period of ten years, it is assumed that the consumption of fossil fuels may decrease but elimination of all emission baselines in all five towns at the same time is unlikely.

2.2.6 Step 5 – Calculation of baseline emission

2.2.6.1 Emission factors substituting fossil fuels with biomass fuels

Typical emission factors used when estimating the $CO_{2\text{-eq}}$ emission from substituting fossil fuels with biomass fuel is presented in the following table.

Fuel type	kg CO_2 / GJ fuel used (based on lower heating values)	kg CO_2 / million btu fuel used (based on lower heating values)	kg CO_2 / MWh fuel used (based on lower heating values)
Liquid fossil			
Gasoline / petrol	69,25	73,06	249,28
Kerosene	71,45	75,38	257,20
Jet Fuel	70.72 (EIA)	74.61 (EIA)	254.64 (EIA)
Aviation gasoline	69.11 (EIA)	72.92 (EIA)	248.86 (EIA)
Distillate fuel (No.1, No.2, No.4 fuel oil and diesel)	74,01	78,08	266,41
Residual fuel oil (No.5, No.6 fuel oil)	77,30	81,55	278,26
LPG	63,20	66,68	227,50
Propane	62.99 (EIA)	66.45 (EIA)	226.8 (EIA)
Gaseous fossil			
Natural gas (dry)	56,06	59,14	201,80
Solid fossil			
Anthracite	98,30	103,70	353,85
Bituminous coal	94,53	99,73	340,28
Sub-bituminous coal	96,00	101,28	345,57
Lignite	101,12	106,68	364,00
Peat	105,89	111,71	381,26
Other fossil fuels			
Petroleum coke	100,76	106,30	362,71
Coke oven / gas coke	108,09	114,03	389,18

Table 14: Typical emission factors (default values).

2.2.6.2 CH_4 emission from anaerobic digestion of wood stockpiles

In estimating the quantity of CH_4 emitted from anaerobic digestion of wood stockpiles there are foreseen several factors which influence the anaerobic digestion process. Before elaborating this Baseline Study relevant literature was surveyed and relevant baseline studies have been subject to investigation. It should be mentioned that currently methodologies for the assessment of factors affecting methane emission from wood residue stockpiles are not fully developed for the scale of this project, or at least not recognised by our team. Therefore the four estimation methods detailed in this chapter and the factors presented below have carefully been investigated.

Methane emission from landfills is described in a lot of literature where the theory has been proven by many surveys. Only a few articles about methane emission from anaerobic digestion of wood residue stockpiles can be found. It is expected that the mechanisms and variations known from methane emission from landfills (household waste) would also take place in wood residue stockpiles.

To establish exact knowledge concerning methane emission from sawdust stock piles measurement of methane emission from the specific pile or piles will be needed. In regards to the performance of methane emission from sawdust stock piles the following parameters will among other things affect the emission of methane.

- Quantity of available carbon in the wood stockpile.
- Temperature in the wood stockpiles
- Water content in the wood stockpile.
- Size of wood stockpile and surface area of wood stockpile.
- Type of wood (spruce, beech, pine, oak, hornbeam etc.) used for production of sawdust.
- Size of sawdust particles.
- Time period of CH_4 emission from anaerobic digestion of wood stockpiles.

Other factors affecting the methane emission from sawdust stockpiles include are presented below.

Half-life value for decomposition of wood in landfills
The half-life value is a default value from decomposition of wood in landfills equal to a half-life time of years. The half-life value predicting the CH_4 emission and decomposition of woodchips indicates that sawdust stockpiles will decompose faster than households waste.

Percentage of wood stockpile under anaerobic composition
The percentage of wood stockpile under anaerobic composition is often estimated to approx. 90% when the default value for the part of the stockpile in which no anaerobic digestion is selected to 10%.

Organic carbon
The quantity of organic carbon selected for wet biomass could be 53.6 % (biomass from existing stockpile) and 26.8 % (fresh biomass).

Lignin
The content of lignin in spruce is approx. 28.6 %, pine approx. 27.8 % and beech approx. 12.7 %. The sawmills under the Sawdust 2000 process mostly wood species like spruce and pine while beech only represent a small part (1 – 15%) of the wood processed. In this respect a default value equal to approx. 27.8 % should be selected when predicting the CH_4 emission.

Type of wood residues
The water content of the wood residue has been selected to 50 % while the average water content of the wood residues is expected to be from 40 – 50 %. The water content will affect the prediction of CH_4 emission from wood stockpiles when lower water content will decrease the emission of methane tons.

Net calorific value of existing fuel used
The CH_4 emission (kg CH_4/ton wet wood stockpile) is based on the average fuel consumption of the five towns under the project measured from year 1997 to year 2001. Converting the fuel consumption of the five towns into heat energy the following net calorific values for natural gas and light liquid oil (CLU – Romanian characteristic) have been used.

Natural gas	:	33.0 GJ/1000 Nm^3
Gas oil (2 % sulphur)	:	40.0 GJ/ton

2.2.6.2.1 Limitations

The main source of error for the detailed methods lies in the carbon content of the wood stockpiled. Because of the large variety in wood types, each assessment will need to be conducted separately taking into account the type of timber that is being stored.

The forming factor comprises a considerable uncertainty, which is used to assess the proportion of available carbon, which is actually converted to CH_4. The forming factor is a measure for the environmental conditions (water content, temperature in stock pile, mix of wood species, time period of digestion etc.), which would reduce the effectiveness of decomposition.

2.2.6.2.2 Biomass fuel to be used in new DH Systems

The new biomass DH systems are assumed to combust sawdust from sawmills located in or nearby the towns involved, but the new biomass boiler systems are all designed for combustion of other biomass fractions like e.g. wet woodchips and woodchips mixed with bark. The biomass fuel has an average water content up to 50 %.

Location of sawmills and estimation of the quantity of sawdust produced by each sawmill has been performed in co-operation with the respective EPA agencies in each four counties.

The sawdust supplied to the new biomass boiler systems in the five towns comprise wood residues from a large number of sawmills, processing different wood species in different quantities. The quantities and species of wood processed in sawmills depend of several factors like tree growing in the area, market demand, fuel price level etc, which means that the type of wood processed will vary through the accrediting period used in the baseline study.

However, the type of wood processed today by sawmills expected to supply sawdust to the new biomass boiler systems in the five towns has been surveyed by the local EPAs with the following result:

Town	Unit	Wood used for sawdust production			
		coniferous tree	deciduous tree	Other Residues	Comments
Vlahita	%	99,0	1,0	0,0	
Gheorgheni	%	98,0	2,0	0,0	
Huedin	%	95,0	5,0	0,0	
Intorsura Buzaului	%	85,0	15,0	0,0	
Vatra Dornei	%	100,0	0,0	0,0	

Table 15: Composition of wood residues

However, calculating CH_4 emission from anaerobic digestion of wood stockpiles the quantity of available carbon in wood residues from coniferous tree and deciduous tree is presumed to be identical.

The three main components in wood are the polymers cellulose, hemi-cellulose and lignin, which together correspond to approximately 96 % of the wood material. The elementary composition of the wood is as stated below.

50 %	C (carbon)
6 %	H (hydrogen)
43 %	O (oxygen)
0.2 %	N (nitrogen)
0.8 %	Other materials

The composition of wood material varies from the individual type of cell, wood species, from pith to bark, wood material and heartwood. For instance the content of hemi-cellulose in coniferous tree (spruce 26%) is higher than in hardwood (beech 21%) and coniferous tree has a higher content of lignin (spruce approx. 28 – 29%) compared to hardwood (beech approx. 12-13%).

2.2.6.2.3 Reference Studies (CH_4 emission)

The assumption of the process calculating CH_4 emission is inspired by a project idea developed by the UK consultant Energy sustainable Development LtD ESD with further reference to the Dutch consultant company “Biomass Technology Group” BTG. As mentioned BTG developed a baseline study for the project named “Biomass Energy Portfolio for Czech Republic”, where CH_4 emissions are based on a zero-order model for anaerobic degradation.

BTG has since developed another model (after the first submission of this baseline study) that was developed in connection with a PCF JI project in Bulgaria. That model was developed under the PCFplus programme and is described later in this document.

The Clean Development Mechanism has issued a baseline method for the avoidance CH_4 emission from biomass or other organic matter for small scale projects which also has been reviewed before selecting the model for estimating CH_4 emission from baselines included in this document.

CH_4 emission from anaerobic digestion of wood stockpiles has become relevant due to reduction of GHG emission to the atmosphere. In this Baseline Study calculation of CH_4 emission is based on experience generated by similar projects, and through comparison of theoretical models published by different institutions or organisations (literature surveying). Generally speaking the knowledge of CH_4 emission from wood stockpiles is unfortunately limited when speaking about theoretically models.

For estimating CH_4 emission from the different baselines included in this baseline study the CH_4 emission model (see Annex II Data Emission Baseline I, II, III and IV) developed under the PCFplus project in Bulgaria has been selected.

Before selecting the PCFplus model, three methods outside of the PCFplus survey have been developed for estimating the CH_4 emission from anaerobic digestion of wood stockpiles. These methods are based on estimating the quantity of digestible carbon available for the decomposition process. The estimation of the methane emission from anaerobic digestion of wood stockpiles is affected by several factors like the part of wood stockpile under decomposition, half-life of biomass resource, content of organic carbon, surface of wood stockpile, water content, generation factor, lignin fraction, temperature etc.

In elaborating this Baseline Study conservative assumptions have been chosen to avoid a to optimistic prediction of GHG emission reduction, which means that CH_4 emission from wood stockpiles is less than that of the CH_4 emission used in similar projects or models. However, the following sections comprise methods for calculation of CH_4 emission and the quantity of CH_4 emitted to the atmosphere.

At the time of developing baseline study version 1 and version 2 the best available information (named method One and method Two) was used for estimating the CH_4 emission. Method One and method Two are not included in this document.

2.2.6.2.4 PCFplus Research Study

The PCF has financed the case study "Methane and Nitrous Oxide Emissions from Biomass Waste Stockpiles" in an aim to establish an accurate and easy accessible model for calculating methane emission from anaerobic digestion of wood stockpiles. The model developed within the study includes three key aspects when estimating methane emission from anaerobic digestion of wood stockpiles, and is thus a first-order multiphase model:

1. The model should be able to predict methane emissions as a function of time for wood stockpiles;
2. The model should only require easily obtainable input parameters;
3. The model should be applicable for a variety of locations, and be able to incorporate wood waste of various ages and types

The developed model was calibrated using flux data gathered from measuring the CH_4 flux from two very large wood waste stockpiles in Bulgaria (Razlog and Svishtov). A large number of samples from the two stock piles were taken over a two week period, which allowed for the determination of a 90% confidence interval. The 90% confidence interval for the data indicates a flux at Razlog and Svishtov of 2.0-9.5 $l/m^2/hr$ and 3.1-9.5 $l/m^2/hr$ respectively. With an average flux at the sites of 5.7 $l/m^2/hr$ at Razlog and 6.4 $l/m^2/hr$ at Svishtov.

The model was calibrated using the half-life as a variable with a default value of 15 years which is taken from CH_4 emissions from landfills. The default value gave a modelled flux of 1.9 $l/m^2/hr$ at Razlog and 2.8 $l/m^2/hr$ at Svishtov, which is outside of the 90% confidence interval on the low end. When calibrating the model for the average measured flux vales the half-life at Razlog was 0.9 years and Svishtov 3.8 years. The explanation of why the calibration presents such a difference in half-life is likely due to the more favourable conditions for anaerobic digestion in waste wood stockpiles as opposed to landfills.

The model as presented (default) is considered to be very conservative for two reasons.

1. The model estimates the emission of CH_4 during a given time period. The intent of developing the model was to account for the emission of CH_4 during a crediting period (e.g. 2008-2012). This approach does not reflect the real emission reduction achieved by using wood waste in boilers. When wood waste is burned it is assumed that all of the degradable organic carbon is converted to CO_2, therefore all of the CH_4 potential release is eliminated. The model can not account for this by choosing an emissions period that is less than that of the approximate life of the degradable organic carbon. Even from a conservative point of view the emissions period should not be less than the half-life.

2. A half-life that accurately reflects the CH_4 emissions from a wood waste stockpiles has not been established by the study. The study recommends the default value established from landfill studies of 15 years, despite the fact that the default value leads to flux that is outside of the 90% confidence interval. By definition any flux within the 90% confidence interval could reflect the actual flux from the investigated wood waste stockpiles. Thus the actual half-life could give a result that is anywhere within the 90% confidence interval. In using the default half-life the model does not account for 90% of the probable flux from the investigated stockpiles and thus the half-life is likely to be much lower than 15 years.

The default half-life value in the PCFplus model for CH_4 emission is considered to be too conservative, due to the fact that the model would then predict only the lowest 10% of CH_4 flux as compared to field measurements. In this case the accumulative CH_4 emission from the expected amount of utilized sawdust in the project from 2004-2017 is estimated for four cases using the PCFplus model. This means that the annual volume of sawdust utilized is set at 34,761 tons from 2004-2017 and the lignin fraction of carbon is 28.6%. The table presents emissions using the model default half-life (15 yrs) at 256,950 tonnes CO_2e, the calibrated half-lives for the average measured flux at Ravlog (0.9 yrs) at 1,204,460 tonnes CO_2e and Svishtov (3.8 yrs) at 656,810 tonnes CO_2e, and a half-life (5.1 yrs) which is fitted to the expected baseline emissions at 557.609 tonnes CO_2e. It must be noted that all wood waste stockpiles are different and the investigated piles in Ravlog and Svishtov may note reflect those which would exist in the absence of this project activity.

2.2.6.2.5 CDM method for methane avoidance

The Clean Development Mechanism has issued a baseline method for the avoidance CH_4 emission from biomass or other organic matter. This method is published in the Appendix B of the simplified modalities and procedures for small-scale CDM project activities entitled "Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories," (Version 3 - 30 June 2004). This method takes into account the elimination of the total anthropogenic emission of CH_4 from biomass based on the estimated amount available organic carbon. The methodology is to be used for projects which emit less than 15,000 CO2e/yr. The baseline calculations uses default IPCCC values and are composed of the following equations.

$CH_4\_IPCCdecay = (MCF * DOC * DOC_F * F * 16/12)$

where,

$CH_4\_IPCC_{decay}$ = IPCC CH_4 emission factor for decaying biomass in the region of the project activity (tonnes of CH_4/tonne of biomass or organic waste)

MCF = methane correction factor (fraction) (default is 0.4)

DOC = degradable organic carbon (fraction, see equation below or default is 0.3)

DOC_F = fraction DOC dissimilated to landfill gas (default is 0.77)

F = fraction of CH_4 in landfill gas (default is 0.5)

For DOC, the following equation may be used instead of the default:

DOC = 0.4 (A) + 0.17 (B) + 0.15 (C) + 0.30 (D)

where,

A = per cent waste that is paper and textiles

B = per cent waste that is garden waste, park waste or other non-food organic putrescibles

C = per cent waste that is food waste

D = per cent waste that is wood or straw

$BE_y = Q_{biomass} * CH_4\_IPCC_{decay} * GWP\_CH_4$

where,

BE_y = Baseline methane emissions from biomass decay (tonnes of CO_2 equivalent)

$Q_{biomass}$ = Quantity of biomass treated under the project activity (tonnes)

CH_4_GWP = GWP for CH_4 (tonnes of CO_2 equivalent/tonne of CH_4)

The project emissions are then estimated through the following equation:

$PE_y = Q_{biomass} * E_{biomass} (CH_4bio\_comb * CH_4\_GWP + N_2Obio\_comb * N_2O\ \_GWP)/10\text{^}6$

where,

PE_y = Project activity emissions (kilotonnes of CO_2 equivalent)

$Q_{biomass}$ = Quantity of biomass treated under the project activity (tonnes)

$E_{biomass}$ = Energy content of biomass (TJ/tonne)

CH_4bio_comb = CH_4 emission factor for biomass and waste (which includes dung and agricultural, municipal and industrial wastes) combustion (kg of CH_4/TJ, default value is 300)

CH_4_GWP = GWP for CH_4 (tonnes of CO_2 equivalent/tonne of CH_4)

N_2Obio_comb = N_2O emission factor for biomass and waste (which includes dung and agricultural, municipal and industrial wastes) combustion (kg/TJ, default value is 4)

N_2O_GWP = GWP for N_2O (tonnes of CO_2 equivalent/tonne of N_2O)

In the case of this basline study a modification is made since the amount of DOC degradable organic carbon is described and used in other estimations of this baseline study. The derived DOC from this knowledge is based on the Lignin carbon fraction (28.6%), the dry organic carbon fraction (53.6%) and the water content (50%):

$$DOC = (1 - 0.286) * 0.536 * 0.50 = 0.191$$

⇓

Therefore, the emission factor can be derived, though the fraction of CH_4 is changed to 0.60 based on the gathered information for the PCFplus study:

$$CH_4\_IPCCdecay = (0.4 * 0.193 * 0.77 * 0.60 * 16/12) = 0.0471$$

⇓

The baseline emissions for each ton of wet wood waste are then derived

BE_y = 1000 kg * 0.0471 * 21 = 989 kg CO2e/ton wet wood waste

⇓

Following this the project emissions are dirived for ach ton of wet wood waste using an energy content of 0.00827 TJ/ton of wet wood waste.

PE_y = 1 ton * 0.00827 TJ/ton (300 kg of CH_4/TJ * 21 + 4 kg of N2O/TJ * 320)

= 63 kg CO2e/ton wet wood waste

⇓

This gives a net emission reduction of:

989 kg – 63 kg CO2e = 926 kg CO2e/ton wet wood waste

⇓

Utilizing 34,761 tons annually from 2004-2017 this gives

34,761 tons/yr * 14 yrs * 0.926 tons CO2e/ton wet wood waste = 450,640 tons CO2e

2.2.6.2.6 Model for estimation CH_4 Emission

As discussed in earlier parts of the baseline study CH_4 emission from anaerobic digestion of wood stockpiles is affected by several factors, where measured emissions can be seen from the PCFplus funded study.

Methods used in different studies do not describe all factors which are assumed to influence the CH_4 emission from anaerobic digestion of wood residues. The PCFplus study confirms that CH_4 emission from anaerobic digestion of wood residues does occur, but the extent of CH_4 emission varies widely and precise parameters (such as half-life) for a CH_4 emission model are not clearly defined by the study. In addition to this the CDM method is considered to be limited to emissions at a small scale (< 15,000 tons CO2e/yr) and is considered to be not applicable for the scale of this project.

Since a precise tool for estimating the CH_4 emission from anaerobic digestion of wood stockpiles is not available, estimation in this project has been calculated in a conservative manner as not to overestimate probable CH_4 emissions.

The PCF model also predicts higher emissions when using the calibrated (half-lives) models from measured data at Svishtov and Razlog in Bulgaria. When the total baseline emissions are fitted to the PCF model the resulting half-life is higher than that of the calibrated Svishtov and Razlog models. The CDM model does predict lower emissions than the baseline but is considered not to be applicable since it is only approved for small-scale CDM projects and may not reflect the scale of this project.

The PCFplus model is considered to be the best available knowledge in January 2005 and therefore to be used in the final version of the baseline study. It should be mentioned that when the first version of the baseline study was submitted for validation in September 2002 where models estimating CH_4 emission to occur over a time period of two years which does not reflect the reality. To perform the most accurate estimation of CH_4 emission submission of the final baseline study has been postponed for comparing different CH_4 emission models (PCF and CDM).

When estimating the CH_4 emission using the PCF model the below assumptions and models in Annex II have been used.

Assumptions used in PCF model

1. The half life time factor for biomass is chosen to 5.1 years. As mentioned earlier the PCF model was calibrated using the half-life as a variable with a default value of 15 years which is taken from CH_4 emissions from landfills. The default value gave a modelled flux of 1.9 $l/m^2/hr$ at Razlog and 2.8 $l/m^2/hr$ at Svishtov, which is outside of the 90% confidence interval on the low end. When calibrating the model for the average measured flux vales the half-life at Razlog was 0.9 years and Svishtov 3.8 years. The explanation of why the calibration presents such a difference in half-life is likely due to the more favourable conditions for anaerobic digestion in waste wood stockpiles as opposed to landfills.

2. Developing the Sawdust 2000 project no field measurements of methane emitted from anaerobic digestion of sawdust wood stockpiles was conducted and calculation is based on the best available knowledge (theoretical and project outcomes).

3. Therefore it should be emphasised that the empirical values measured and used in the PCF model reflects the actually emission from two specific wood stock piles in Bulgaria. In the Sawdust 2000 project sawdust stockpiles of various sizes will be

used and no measurements of methane emission from existing sawdust stockpiles have been performed.

4. Lignin fraction of carbon is 28.6 %, organic carbon content (wet) 26.8 % and other factors are described in Annex II.

2.2.7 Step 6 - Project Scenario

This paragraph will review the calculation methodologies used estimating the CO_2 - and equivalent CO_2 emission reduction from the four emission baselines (I, II, III and IV). The emission baseline IV has been selected to be the most likely emission baseline and presentation of calculation methodologies will be based on figures and assumptions used developing baseline IV.

Assumptions and basic data for each baseline is presented in

Paragraph 2.2.1.1- Fuel consumption existing DH systems,

Paragraph 2.2.3 - Selection of the most appropriate baseline methodology

Paragraph 2.2.6 - Step 5 – Calculation of baseline emission

Paragraph 2.2.6.2.6 - Model for estimation CH_4 Emission

Paragraph 4 (Annexes)

Calculations are calculated in MS Excel, which means rounding of figures in tables (text baseline study) can cause small differences using rounding of figures to calculate final results.

2.2.7.1 Calculation of CO_2 emission reduction substituting fossil fuels with biomass fuels

The average fuel consumption used in this calculation is equal to the BAU scenario see paragraph 2.2.4.4. The calculation conducted in this paragraph comprises only year 2004 using the average fuel consumption for each town presented in paragraph 2.2.1.1 (Table 2 Heat value of fuel consumption).

The average fuel consumption (MWh/year) for each town has been converted into GJ per year (multiplying MWh/year with a factor 3.6).

Step 1 – Converting avearage fuel consumption MWh/Year into GJ/year–baseline IV

For each of the five towns the conversion of MWh/year into GJ/year is conducted in the following way.

Vlahita year 2004 = Average fuel consumption = 8,112.27 MWh/year

Vlahita year 2004 = 8,112.27 x 3.6 = 29,204.19 GJ/year

Step 2 – CO_2 emission from substitution of fossil fuels with wood residues – baseline IV

The CO_2 emission factor for liquid oil and natural gas is presented in Table 14: Typical emission factors (default values).

Oil	:	77.30 kg CO_2/GJ fuel used
Natural gas	:	56.06 kg CO_2/GJ fuel used

Step 3 – Calculation CO2 emission from existing DH systems – Baseline IV

Town	Year	Fuel type	Calculation - Step 3				
			A	B	C	D	E
			Quantity of fuel burned	Unit used to measure quantitiy of fuel used	CO_2 emission factor	CO_2 emissions in kg	CO_2 emissions in metric tons
						D = A * C	E = D / 1000
			GJ	GJ/ton or GJ/1000 Nm3	kg CO2 / GJ fuel used		
Vlahita	2008	Natural Gas	29.204,19	33,00	56,06	1.637.187	1.637,19
Gheorgheni	2008	Oil	38.332,80	40,00	77,30	2.963.125	2.963,13
Huedin	2008	Oil	13.480,00	40,00	77,30	1.042.004	1.042,00
Intorsura Buzaului	2008	Oil	30.216,00	40,00	77,30	2.335.697	2.335,70
Vatra Dornei	2008	Oil	48.917,60	40,00	77,30	3.781.330	3.781,33
							11.759,34

Table 16: CO_2 emission from existing boiler system – Baseline IV

The equivalent CO_2 emission from anaerobic digestion of wood stockpiles can be see in paragraph 4.2 (Annex II Data Emission Baseline I, II, III and IV).

Step 4 – Calculation of the quantity of wood residues needed to substitute fossil fuels

The wood residue will be sawdust with a water content of 50 % and with a net calorific value of 8.27 GJ/ton.

Town	Energy value of average fuel consumption 1997 - 2001	Calorific value - Sawdust (50 % water content)	2004 Sawdust consumption	Total 2004 - 2017
	GJ/year	GJ/ton sawdust	Tons sawdust/year	Tons sawdust
A	B	C	D = B / C	E = D x 14
Vlahita	29.204,19	8,27	3.531,34	49.438,77
Gheorgheni	38.332,80	8,27	4.635,16	64.892,29
Huedin	13.480,00	8,27	1.629,99	22.819,83
Intorsura Buzaului	30.216,00	8,27	3.653,69	51.151,63
Vatra Dornei	42.244,00	8,27	5.108,10	71.513,42
Total	153.476,99	8,27	18.558,28	259.815,94

Table 17: Quantity of sawdust based on BAU

2.2.7.2 Calculation of project emissions from anaerobic digestion of wood stockpiles

As explained in paragraph 2.2.4.4 CH_4 emission reduction (equivalent CO_2) related to emission baseline IV is based on the fuel consumption in the BAU scenario and the fuel consumption used to reach the comfort level in buildings in Tasca.

However, the quantity of sawdust needed in the BAU was identified in the earlier paragraph (2.2.7.1), which will be taken into account when calculating the equivalent CO_2 emission.

Step 1 – Converting fuel consumption from MWh/Year to GJ/year–baseline IV

The fuel consumption needed to increase the comfort level in buildings to a comfort level as measured in Tasca. In paragraph 4 (Annex III) the heat demands for emission baselines IV are presented.

A	B	C
Town	Energy value of annual fuel consumption needed to reach a comfort level as in Tasca MWh/year	Energy value of annual fuel consumption needed to reach a comfort level as in Tasca GJ/year
		C = B x 3.6
Vlahita	10.273,92	36.986,13
Gheorgheni	5.352,63	19.269,47
Huedin	4.294,24	15.459,26
Intorsura Buzaului	8.665,31	31.195,11
Vatra Dornei	8.636,87	31.092,73
Total	37.222,97	134.002,71

Table 18: Energy value of annual fuel consumption to reach Tasca comfort level

Step 2 – Calculation, quantity of wood residues needed to reach Tasca level–baseline IV

The wood residue will be sawdust with a water content of 50 % and net calorific value of 8.27 GJ/ton.

Town	Energy value of average fuel consumption 1997 - 2001	Calorific value - Sawdust (50 % water content)	2004 Sawdust consumption	Total 2004 - 2017
	GJ/year	GJ/ton sawdust	Tons sawdust/year	Tons sawdust
A	B	C	D = B / C	E = D x 14
Vlahita	36.986,13	8,27	4.472,33	62.612,55
Gheorgheni	19.269,47	8,27	2.330,05	32.620,63
Huedin	15.459,26	8,27	1.869,32	26.170,45
Intorsura Buzaului	31.195,11	8,27	3.772,08	52.809,14
Vatra Dornei	31.092,73	8,27	3.759,70	52.635,83
Total	134.002,71	8,27	16.203,47	226.848,59

Table 19: Quantity of wood residues needed

The quantity of sawdust needed in the BAU scenario (paragraph 2.2.7.1 – step 4) and for reaching the comfort level in Tasca (this step 2) is now known and the CH_4 emission reduction for baseline IV can now be calculated according to the equation described in Step III.

Step 3 – Total emission of CH_4 (Step I and Step II)

Total emission of CH_4 = (Step I + Step II) x CH_4 emission factor

= ((Tons of sawdust Step I) x (Tons of sawdust Step II)) x 600 kg CH_4/year

The total CH_4 emission reduction for each baseline is presented in paragraph 2.4) based on the data presented in Annex II.

2.3 Leakage

Refers to the assumptions mentioned in chapter 2.2.2

The new biomass boiler systems to be implemented in the five towns will consist of biomass boiler systems. The new biomass boiler systems will be the only boiler systems operating in all load conditions, which means no fossil fired boiler systems will be used under normal operation conditions. This means no gas fired boilers will be used when starting up the biomass boiler systems.

In Vatra Dornei, Vlahita and Intorsura Buzaului fossil fired boiler systems will be installed or connected to the new DH-systems to be used as standby boiler. The standby boilers will only be put into operation if the new biomass boiler system will breakdown.

If standby boilers are put into operation the fuel consumption, calorific value of fuels, emission factors etc. will be recorded in the MP for calculation of GHG emission.

2.4 Net Emission Reductions

The net CO_2 emission reductions of emission baseline I, II, III and IV are calculated according to the principles illustrated in earlier chapters. CH_4 emission from anaerobic digestion of wood stockpiles has been calculated into a quantity of equivalent CO_2 emission. Curves for emission baseline I, II, III and IV are presented in Annex I. The table below shows the emission reduction from 2004-2017.

EMISSION SOURCE	EQUIVALENT CO2 EMISSION AND CO2 EMISSION - BASELINE I, II, III and IV (Tons/Year)														
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	TOTAL
Baseline I															
Anaerobic Digestion	4.639	10.169	16.478	23.466	31.047	39.146	46.457	53.084	59.120	64.644	69.727	74.430	78.807	82.904	654.117
Existing DH system	11.243	14.783	18.322	21.861	25.400	28.939	29.518	30.108	30.710	31.324	31.951	32.590	33.242	33.906	373.895
Total	**15.882**	**24.952**	**34.799**	**45.326**	**56.447**	**68.085**	**75.974**	**83.192**	**89.830**	**95.968**	**101.678**	**107.020**	**112.048**	**116.810**	**1.028.012**
Baseline II															
Anaerobic Digestion	4.639	8.781	12.491	15.826	19.279	22.402	24.739	26.882	28.858	30.691	32.402	34.007	35.522	36.962	333.480
Existing DH system	11.243	11.468	11.698	11.932	13.244	13.509	12.563	12.815	13.071	13.332	13.599	13.871	14.148	14.431	180.926
Total	**15.882**	**20.249**	**24.189**	**27.758**	**32.523**	**35.911**	**37.302**	**39.696**	**41.929**	**44.024**	**46.001**	**47.878**	**49.671**	**51.393**	**514.405**
Baseline III															
Anaerobic Digestion	4.639	9.511	14.586	19.840	25.249	30.793	36.456	42.222	48.078	54.013	59.193	63.715	67.663	71.109	547.066
Existing DH system	11.243	13.210	15.176	17.142	19.108	21.074	23.040	25.006	26.973	28.939	28.939	28.939	28.939	28.939	316.666
Total	**15.882**	**22.720**	**29.762**	**36.982**	**44.357**	**51.867**	**59.496**	**67.228**	**75.050**	**82.951**	**88.132**	**92.654**	**96.601**	**100.047**	**863.732**
Baseline IV															
Anaerobic Digestion (average heat demand of the five towns year 1997 - 2001)	4.639	8.688	12.222	15.308	18.001	20.352	22.405	24.196	25.760	27.125	28.317	29.357	30.265	31.057	297.691
Anaerobic Digestion (heat demand measured in Tasca)	4.050	7.585	10.672	13.365	15.717	17.770	19.562	21.126	22.491	23.683	24.724	25.632	26.425	27.117	259.918
Existing DH system	11.243	11.243	11.243	11.243	11.243	11.243	11.243	11.243	11.243	11.243	11.243	11.243	11.243	11.243	157.409
Total	**19.932**	**27.517**	**34.137**	**39.917**	**44.962**	**49.366**	**53.210**	**56.565**	**59.495**	**62.052**	**64.284**	**66.232**	**67.933**	**69.417**	**715.017**

Table 20: Net Emission Reductions.

2.5 Conclusion

Based on development of four different emission baselines and assessments **Baseline IV** has been identified as the must likely baseline, which fulfils all necessary criteria for a JI-Project to be validated by an independent entity.

The GHG emission reduction from implementing the project is generated by equivalent CO_2 emission from CH_4 emission from anaerobic digestion of wood stockpiles and CO_2 emission from substituting fossil fuels with biomasses. The equivalent CO_2 emission reduction is originating from reduced CH_4 emission from anaerobic digestion of wood stockpiles calculated into equivalent $CO_{2\text{-eq}}$.

When speaking about a Joint Implementation Project (Kyoto Protocol) based on baseline IV the project shall be characterised as a **Methane Emission Reduction Project**.

Emission baseline IV

Emission baseline IV is based on the preconditions that the consumption of fossil fuels in the five towns will be equal to the average fuel consumption of the last five years from 1997 to 2000. Substituting the fossil fuels consumed in emission baseline IV with wood residues generates a reduction of GHG emission corresponding to approx. 22 % (157,409 tonnes/14 years) of the total GHG emission generated by emission baseline IV. Variation in the quantity of fossil fuel substituted with biomass fuel will only affect the bottom line of the emission baseline IV very little.

CH4 emission form anaerobic digestion of wood stockpiles in Baseline IV is representing approx. 78 % (557,609 tonnes/14 years) of the total GHG emission generated by emission baseline IV, which means the biggest reduction of GHG emission is generated by CH4 emission.

I.e. that the total number of ERU gained by implementation of emission baseline IV is calculated to be approximately 715,017 tonnes if summarised over a fourteen year period.

Risks

The GHG emission reduction generated by emission baseline IV is strongly connected to CH_4 emission from anaerobic digestion of wood stockpiles actually will occur in the areas surrounding the five towns.

Environmental Benefits

Implementation of the project will generate a number of environmental benefits like reducing the risk of polluting ground water and decreasing diseases in forest areas by removing wood residues.

3. Monitoring Plan

It will not be possible to monitor the quantities of biomasses consumed on a daily basis but directly weighbridges are located near all the new biomass boiler plants and measurement of the quantities of sawdust used will be performed on weekly basis.

Therefore the only way the fuel consumption and heat supply can be monitored is to note down the quantities of heat delivered from the five boiler plants and consumed in the connected buildings. Modern electronic heat meters are included both at boiler plant level as well as on block level.

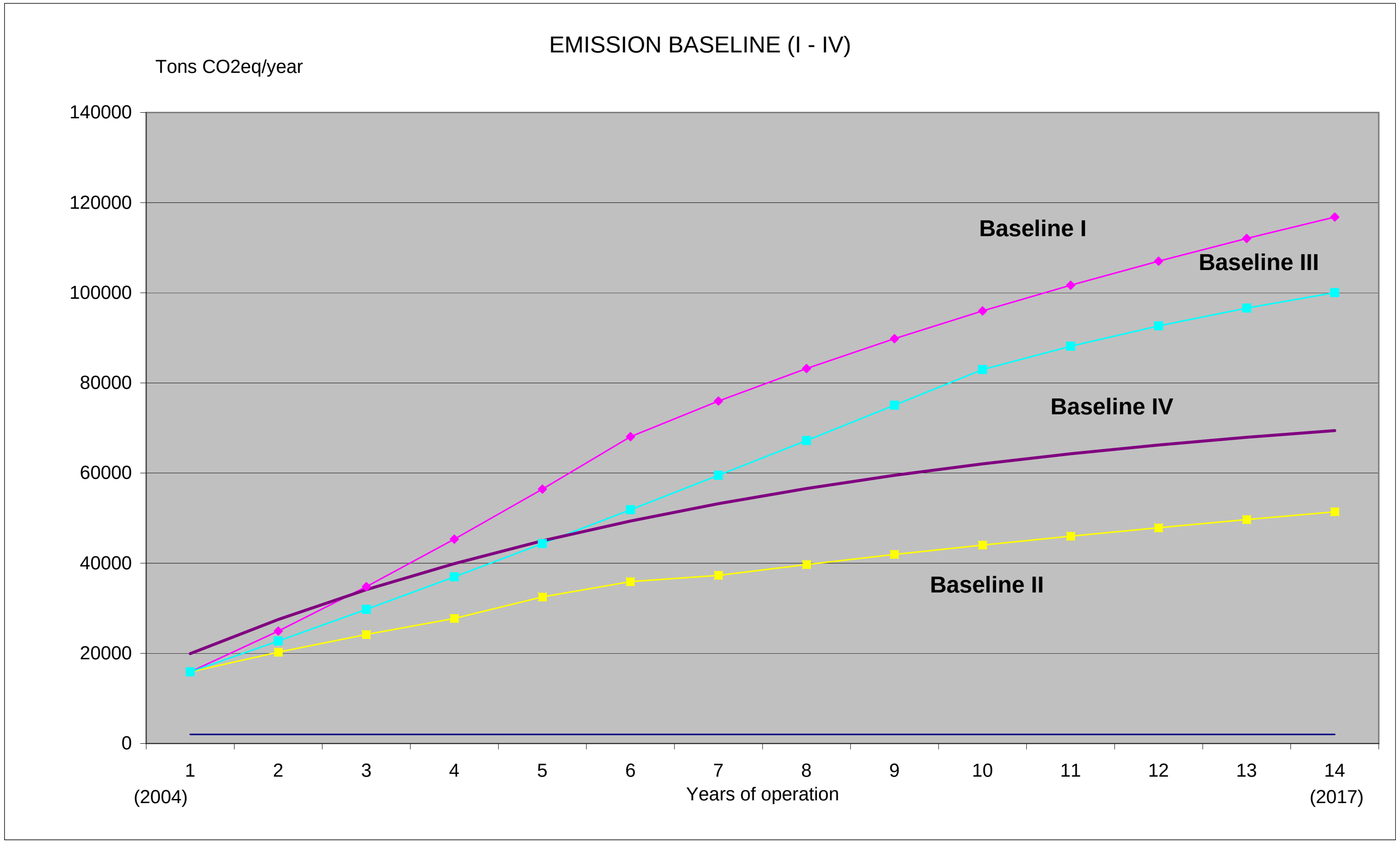
Therefore it is very simple e.g. on monthly basis to note down meter readings and from here all relevant data can be calculated. Only the biomass consumption needed to rely on heat values and boiler efficiency calculation.

To increase the accuracy of measuring the water content of the sawdust combusted in the five towns new small kilns have been purchased. The new small kilns are with forced ventilation and will be delivered in November 2004.

Monitoring Plan has been elaborated as a separate document (Named: Monitoring Plan – Version 3 - 2003 03 12).

4. Annexes

4.1 Annex I Curves Illustrating Emission Baselines I, II, III and IV


EMISSION BASELINE (I - IV)
Tons CO2eq/year
140000
120000
100000
80000
60000
40000
20000
0
Baseline I
Baseline III
Baseline IV
Baseline II
1
2
3
4
5
6
7
8
9
10
11
12
13
14
(2004)
Years of operation
(2017)

4.2 Annex II Data Emission Baseline I, II, III and IV

EMISSION BASELINE I - EQUIVALENT C02 EMISSION (ANAEROBE DIGESTION OF WOOD RESIDUES)

	2.004,00	2.005,00	2.006,00	2.007,00	2.008,00	2.009,00	2.010,00	2.011,00	2.012,00	2.013,00	2.014,00	2.015,00	2.016,00	2.017,00	Total
	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year
Vlahita	882,66	2.007,67	3.344,22	4.865,45	6.547,87	8.371,00	10.015,55	11.505,29	12.860,95	14.100,70	15.240,38	16.293,86	17.273,27	18.189,22	141.498,07
Gheorgheni	1.158,56	2.426,99	3.791,32	5.239,36	6.760,49	8.345,40	9.777,78	11.078,00	12.263,84	13.350,86	14.352,64	15.281,09	16.146,60	16.958,27	136.931,21
Huedin	407,42	927,15	1.544,93	2.248,29	3.026,37	3.869,65	4.630,34	5.319,40	5.946,44	6.519,87	7.047,00	7.534,26	7.987,25	8.410,89	65.419,25
Intorsura Buzaului	913,24	2.048,91	3.378,73	4.878,05	6.525,31	8.301,72	9.904,49	11.356,74	12.678,66	13.887,89	14.999,86	16.028,05	16.984,27	17.878,84	139.764,75
Vatra Dornei	1.276,77	2.758,27	4.418,47	6.234,66	8.187,03	10.258,26	12.128,52	13.824,58	15.369,85	16.784,79	18.087,29	19.292,97	20.415,52	21.466,90	170.503,89
Total	4.638,65	10.168,98	16.477,67	23.465,81	31.047,06	39.146,03	46.456,68	53.084,00	59.119,75	64.644,10	69.727,16	74.430,23	78.806,92	82.904,12	654.117,17

EMISSION BASELINE I - C02 EMISSION (EXISTING BOILER SYSTEMS)

	2.004,00	2.005,00	2.006,00	2.007,00	2.008,00	2.009,00	2.010,00	2.011,00	2.012,00	2.013,00	2.014,00	2.015,00	2.016,00	2.017,00	Total
	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year
Vlahita	1.637,19	2.294,75	2.952,32	3.609,88	4.267,45	4.925,02	5.023,52	5.123,99	5.226,47	5.331,00	5.437,62	5.546,37	5.657,30	5.770,44	62.803,30
Gheorgheni	2.963,13	3.620,67	4.278,21	4.935,76	5.593,30	6.250,84	6.375,86	6.503,38	6.633,45	6.766,11	6.901,44	7.039,47	7.180,25	7.323,86	82.365,72
Huedin	1.042,00	1.461,69	1.881,37	2.301,05	2.720,73	3.140,41	3.203,22	3.267,28	3.332,63	3.399,28	3.467,27	3.536,61	3.607,34	3.679,49	40.040,37
Intorsura Buzaului	2.335,70	3.201,39	4.067,09	4.932,78	5.798,47	6.664,17	6.797,45	6.933,40	7.072,07	7.213,51	7.357,78	7.504,94	7.655,03	7.808,14	85.341,91
Vatra Dornei	3.265,46	4.204,03	5.142,60	6.081,17	7.019,74	7.958,30	8.117,47	8.279,82	8.445,42	8.614,33	8.786,61	8.962,34	9.141,59	9.324,42	103.343,30
Total	11.243,47	14.782,53	18.321,58	21.860,64	25.399,69	28.938,74	29.517,52	30.107,87	30.710,03	31.324,23	31.950,71	32.589,73	33.241,52	33.906,35	373.894,61

EMISSION BASELINE I - TOTAL C02 EMISSION (ANAEROBE DIGESTION OF WOOD RESIDUES + EXISTING BOILER SYSTEM)

	2.004,00	2.005,00	2.006,00	2.007,00	2.008,00	2.009,00	2.010,00	2.011,00	2.012,00	2.013,00	2.014,00	2.015,00	2.016,00	2.017,00	Total
	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year
Vlahita	2.519,85	4.302,42	6.296,54	8.475,33	10.815,32	13.296,02	15.039,07	16.629,27	18.087,42	19.431,69	20.677,99	21.840,23	22.930,56	23.959,66	204.301,38
Gheorgheni	4.121,69	6.047,66	8.069,53	10.175,12	12.353,79	14.596,24	16.153,65	17.581,38	18.897,28	20.116,97	21.254,08	22.320,56	23.326,86	24.282,13	219.296,93
Huedin	1.449,42	2.388,84	3.426,30	4.549,34	5.747,10	7.010,06	7.833,55	8.586,68	9.279,07	9.919,15	10.514,27	11.070,87	11.594,60	12.090,38	105.459,62
Intorsura Buzaului	3.248,94	5.250,30	7.445,82	9.810,83	12.323,78	14.965,88	16.701,94	18.290,14	19.750,73	21.101,40	22.357,64	23.532,99	24.639,31	25.686,98	225.106,67
Vatra Dornei	4.542,23	6.962,30	9.561,06	12.315,83	15.206,77	18.216,57	20.245,99	22.104,40	23.815,27	25.399,12	26.873,90	28.255,32	29.557,11	30.791,33	273.847,19
Total	15.882,13	24.951,51	34.799,25	45.326,45	56.446,75	68.084,78	75.974,20	83.191,87	89.829,77	95.968,33	101.677,88	107.019,96	112.048,44	116.810,47	1.028.011,78

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,6%	53,6%	db
Moisture content	0%	50%	wb
Organic carbon content (wb)	53,6%	26,8%	wb
Lignin fraction of C	0,25	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	3.531,34	882,66	770,49	672,58	587,11	512,50	447,37	390,52	340,89	297,57	259,76	226,75	197,93	172,78	150,82	5.910
2005	0	0	4.949,68		1.237,18	1.079,96	942,71	822,91	718,34	627,05	547,37	477,81	417,09	364,08	317,82	277,43	242,17	8.072
2006	0	0	6.368,02			1.591,69	1.389,42	1.212,85	1.058,72	924,18	806,74	704,22	614,72	536,60	468,41	408,89	356,93	10.073
2007	0	0	7.786,36				1.946,21	1.698,88	1.482,99	1.294,53	1.130,02	986,42	861,06	751,64	656,12	572,74	499,96	11.881
2008	0	0	9.204,71					2.300,72	2.008,35	1.753,13	1.530,34	1.335,86	1.166,10	1.017,91	888,56	775,64	677,07	13.454
2009	0	0	10.623,05						2.655,24	2.317,81	2.023,26	1.766,15	1.541,70	1.345,78	1.174,76	1.025,47	895,16	14.745
2010	0	0	10.835,51							2.708,34	2.364,16	2.063,73	1.801,47	1.572,54	1.372,70	1.198,26	1.045,98	14.127
2011	0	0	11.052,22								2.762,51	2.411,45	2.105,00	1.837,50	1.603,99	1.400,15	1.222,22	13.343
2012	0	0	11.273,26									2.817,76	2.459,68	2.147,10	1.874,25	1.636,07	1.428,16	12.363
2013	0	0	11.498,73										2.874,11	2.508,87	2.190,04	1.911,73	1.668,79	11.154
2014	0	0	11.728,70											2.931,59	2.559,05	2.233,84	1.949,97	9.674
2015	0	0	11.963,28												2.990,23	2.610,23	2.278,52	7.879
2016	0	0	12.202,54													3.050,03	2.662,43	5.712
2017	0	0	12.446,59														3.111,03	3.111
Total	**0**		**135.464,00**															
	Total emission prevention			**882,66**	**2.007,67**	**3.344,22**	**4.865,45**	**6.547,87**	**8.371,00**	**10.015,55**	**11.505,29**	**12.860,95**	**14.100,70**	**15.240,38**	**16.293,86**	**17.273,27**	**18.189,22**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**882,66**	**2.890,33**	**6.234,55**	**11.100,00**	**17.647,86**	**26.018,86**	**36.034,42**	**47.539,70**	**60.400,66**	**74.501,35**	**89.741,73**	**106.035,59**	**123.308,86**	**141.498,07**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,6%	53,6%	db
Moisture content	0%	50%	wb
Organic carbon content (wb)	53,6%	26,8%	wb
Lignin fraction of C	0,25	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year															
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total	
2004	0	0	4.635,16	1.158,56	1.011,33	882,81	770,62	672,69	587,21	512,59	447,45	390,58	340,95	297,62	259,80	226,78	197,96	7.757	
2005	0	0	5.663,75		1.415,66	1.235,75	1.078,72	941,63	821,97	717,51	626,33	546,74	477,26	416,61	363,67	317,45	277,11	9.236	
2006	0	0	6.692,33			1.672,75	1.460,18	1.274,62	1.112,64	971,25	847,82	740,08	646,03	563,93	492,27	429,71	375,10	10.586	
2007	0	0	7.720,91				1.929,85	1.684,60	1.470,52	1.283,65	1.120,52	978,13	853,83	745,32	650,61	567,93	495,76	11.781	
2008	0	0	8.749,50					2.186,94	1.909,02	1.666,43	1.454,66	1.269,80	1.108,43	967,57	844,61	737,28	643,59	12.788	
2009	0	0	9.778,08						2.444,04	2.133,45	1.862,33	1.625,67	1.419,08	1.238,74	1.081,32	943,91	823,96	13.572	
2010	0	0	9.973,64							2.492,92	2.176,12	1.899,58	1.658,18	1.447,46	1.263,51	1.102,95	962,78	13.003	
2011	0	0	10.173,12								2.542,77	2.219,64	1.937,57	1.691,34	1.476,41	1.288,78	1.125,01	12.282	
2012	0	0	10.376,58									2.593,63	2.264,03	1.976,32	1.725,17	1.505,93	1.314,56	11.380	
2013	0	0	10.584,11										2.645,50	2.309,31	2.015,85	1.759,67	1.536,05	10.266	
2014	0	0	10.795,79											2.698,41	2.355,50	2.056,16	1.794,87	8.905	
2015	0	0	11.011,71												2.752,38	2.402,61	2.097,29	7.252	
2016	0	0	11.231,94													2.807,43	2.450,66	5.258	
2017	0	0	11.456,58														2.863,58	2.864	
Total	**0**		**128.843,20**																
	Total emission prevention			**1.158,56**	**2.426,99**	**3.791,32**	**5.239,36**	**6.760,49**	**8.345,40**	**9.777,78**	**11.078,00**	**12.263,84**	**13.350,86**	**14.352,64**	**15.281,09**	**16.146,60**	**16.958,27**	**tonne CO_2-eq/yr**	
	Cumulative total emission prevention			**1.158,56**	**3.585,55**	**7.376,87**	**12.616,23**	**19.376,72**	**27.722,12**	**37.499,90**	**48.577,90**	**60.841,74**	**74.192,60**	**88.545,24**	**103.826,33**	**119.972,93**	**136.931,21**	**tonne CO_2-eq/project**	

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,6%	53,6%	db
Moisture content	0%	50%	wb
Organic carbon content (wb)	53,6%	26,8%	wb
Lignin fraction of C	0,25	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	1.629,99	407,42	355,64	310,45	271,00	236,56	206,50	180,25	157,35	137,35	119,90	104,66	91,36	79,75	69,62	2.728
2005	0	0	2.286,49		571,51	498,88	435,48	380,14	331,83	289,66	252,85	220,72	192,67	168,19	146,81	128,16	111,87	3.729
2006	0	0	2.942,99			735,60	642,12	560,52	489,29	427,11	372,83	325,45	284,10	247,99	216,48	188,97	164,95	4.655
2007	0	0	3.599,49				899,69	785,36	685,56	598,44	522,39	456,00	398,05	347,47	303,31	264,77	231,12	5.492
2008	0	0	4.255,99					1.063,79	928,60	810,59	707,58	617,66	539,17	470,65	410,84	358,63	313,06	6.221
2009	0	0	4.912,49						1.227,88	1.071,84	935,63	816,73	712,94	622,34	543,25	474,22	413,95	6.819
2010	0	0	5.010,74							1.252,44	1.093,28	954,34	833,07	727,20	634,79	554,12	483,70	6.533
2011	0	0	5.110,95								1.277,48	1.115,14	973,43	849,73	741,74	647,48	565,20	6.170
2012	0	0	5.213,17									1.303,03	1.137,44	992,90	866,72	756,58	660,43	5.717
2013	0	0	5.317,43										1.329,09	1.160,19	1.012,76	884,06	771,71	5.158
2014	0	0	5.423,78											1.355,68	1.183,40	1.033,01	901,74	4.474
2015	0	0	5.532,26												1.382,79	1.207,07	1.053,67	3.644
2016	0	0	5.642,90													1.410,45	1.231,21	2.642
2017	0	0	5.755,76														1.438,66	1.439
Total	**0**		**62.634,42**															
	Total emission prevention			**407,42**	**927,15**	**1.544,93**	**2.248,29**	**3.026,37**	**3.869,65**	**4.630,34**	**5.319,40**	**5.946,44**	**6.519,87**	**7.047,00**	**7.534,26**	**7.987,25**	**8.410,89**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**407,42**	**1.334,57**	**2.879,50**	**5.127,79**	**8.154,16**	**12.023,81**	**16.654,15**	**21.973,54**	**27.919,99**	**34.439,85**	**41.486,85**	**49.021,11**	**57.008,36**	**65.419,25**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,6%	53,6%	db
Moisture content	0%	50%	wb
Organic carbon content (wb)	53,6%	26,8%	wb
Lignin fraction of C	0,25	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	3.653,69	913,24	797,19	695,88	607,45	530,25	462,87	404,05	352,70	307,88	268,75	234,60	204,79	178,76	156,05	6.114
2005	0	0	5.007,88		1.251,72	1.092,65	953,80	832,59	726,78	634,42	553,80	483,43	421,99	368,36	321,55	280,69	245,02	8.167
2006	0	0	6.362,07			1.590,20	1.388,12	1.211,72	1.057,73	923,32	805,98	703,56	614,15	536,10	467,98	408,50	356,59	10.064
2007	0	0	7.716,26				1.928,68	1.683,59	1.469,64	1.282,87	1.119,85	977,54	853,31	744,87	650,21	567,59	495,46	11.774
2008	0	0	9.070,45					2.267,16	1.979,05	1.727,55	1.508,02	1.316,38	1.149,09	1.003,07	875,60	764,33	667,20	13.257
2009	0	0	10.424,64						2.605,64	2.274,52	1.985,47	1.733,16	1.512,91	1.320,65	1.152,82	1.006,32	878,44	14.470
2010	0	0	10.633,13							2.657,76	2.320,01	2.025,18	1.767,82	1.543,17	1.347,06	1.175,88	1.026,45	13.863
2011	0	0	10.845,79								2.710,91	2.366,41	2.065,69	1.803,18	1.574,03	1.374,00	1.199,40	13.094
2012	0	0	11.062,71									2.765,13	2.413,74	2.107,00	1.839,24	1.605,51	1.401,48	12.132
2013	0	0	11.283,96										2.820,43	2.462,01	2.149,14	1.876,03	1.637,62	10.945
2014	0	0	11.509,64											2.876,84	2.511,25	2.192,12	1.913,55	9.494
2015	0	0	11.739,83												2.934,38	2.561,48	2.235,96	7.732
2016	0	0	11.974,63													2.993,06	2.612,71	5.606
2017	0	0	12.214,12														3.052,93	3.053
Total	**0**		**133.498,80**															
	Total emission prevention			**913,24**	**2.048,91**	**3.378,73**	**4.878,05**	**6.525,31**	**8.301,72**	**9.904,49**	**11.356,74**	**12.678,66**	**13.887,89**	**14.999,86**	**16.028,05**	**16.984,27**	**17.878,84**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**913,24**	**2.962,15**	**6.340,88**	**11.218,93**	**17.744,24**	**26.045,96**	**35.950,45**	**47.307,19**	**59.985,84**	**73.873,73**	**88.873,58**	**104.901,64**	**121.885,91**	**139.764,75**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
Generation factor (zeta)	0,77	
Methane oxidation factor	0,10	
Percentage of the stockpile under aerobic conditions	10%	

LEGEND

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

Biomass specific input data	Biomass from stockpile	Fresh	
Organic carbon content (db)	53,6%	53,6%	db
Moisture content	0%	50%	wb
Organic carbon content (wb)	53,6%	26,8%	wb
Lignin fraction of C	0,25	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile	Age of biomass	Fresh	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
	(ton_w)	(years)	(ton_w)	ton CO2-eq														
2004	0	0	5.108,10	1.276,77	1.114,52	972,89	849,25	741,33	647,12	564,89	493,10	430,44	375,74	327,99	286,31	249,92	218,16	8.548
2005	0	0	6.576,29		1.643,75	1.434,86	1.252,52	1.093,35	954,41	833,12	727,25	634,83	554,15	483,73	422,26	368,60	321,76	10.725
2006	0	0	8.044,47			2.010,72	1.755,20	1.532,15	1.337,44	1.167,48	1.019,12	889,61	776,56	677,87	591,73	516,53	450,89	12.725
2007	0	0	9.512,66				2.377,69	2.075,54	1.811,78	1.581,54	1.380,56	1.205,11	1.051,97	918,28	801,59	699,72	610,80	14.515
2008	0	0	10.980,85					2.744,67	2.395,88	2.091,41	1.825,63	1.593,63	1.391,11	1.214,33	1.060,01	925,31	807,72	16.050
2009	0	0	12.449,03						3.111,64	2.716,21	2.371,04	2.069,73	1.806,71	1.577,11	1.376,69	1.201,74	1.049,02	17.280
2010	0	0	12.698,01							3.173,87	2.770,54	2.418,46	2.111,12	1.842,84	1.608,65	1.404,23	1.225,78	16.555
2011	0	0	12.951,97								3.237,35	2.825,95	2.466,83	2.153,34	1.879,70	1.640,83	1.432,31	15.636
2012	0	0	13.211,01									3.302,10	2.882,47	2.516,16	2.196,41	1.917,29	1.673,64	14.488
2013	0	0	13.475,23										3.368,14	2.940,12	2.566,49	2.240,34	1.955,64	13.071
2014	0	0	13.744,74											3.435,50	2.998,92	2.617,82	2.285,15	11.337
2015	0	0	14.019,63												3.504,21	3.058,90	2.670,17	9.233
2016	0	0	14.300,02													3.574,30	3.120,08	6.694
2017	0	0	14.586,02														3.645,78	3.646
Total	**0**		**161.658,05**															
	Total emission prevention			**1.276,77**	**2.758,27**	**4.418,47**	**6.234,66**	**8.187,03**	**10.258,26**	**12.128,52**	**13.824,58**	**15.369,85**	**16.784,79**	**18.087,29**	**19.292,97**	**20.415,52**	**21.466,90**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**1.276,77**	**4.035,04**	**8.453,50**	**14.688,17**	**22.875,20**	**33.133,46**	**45.261,98**	**59.086,56**	**74.456,41**	**91.241,20**	**109.328,49**	**128.621,46**	**149.036,98**	**170.503,89**	**tonne CO_2-eq/project**

EMISSION BASELINE II - EQUIVALENT C02 EMISSION (ANAEROBE DIGESTION OF WOOD RESIDUES)

	2.004,00 Tons/year	2.005,00 Tons/year	2.006,00 Tons/year	2.007,00 Tons/year	2.008,00 Tons/year	2.009,00 Tons/year	2.010,00 Tons/year	2.011,00 Tons/year	2.012,00 Tons/year	2.013,00 Tons/year	2.014,00 Tons/year	2.015,00 Tons/year	2.016,00 Tons/year	2.017,00 Tons/year	Total Tons/year
Vlahita	882,66	1.670,81	2.376,80	3.011,44	3.668,47	4.262,80	4.707,36	5.115,16	5.491,25	5.840,07	6.165,50	6.470,92	6.759,31	7.033,26	63.455,79
Gheorgheni	1.158,56	2.193,06	3.119,74	3.952,76	4.815,16	5.595,26	6.178,78	6.714,05	7.207,70	7.665,55	8.092,70	8.493,59	8.872,12	9.231,71	83.290,73
Huedin	407,42	771,21	1.097,08	1.390,01	1.693,28	1.967,61	2.172,81	2.361,04	2.534,64	2.695,65	2.845,85	2.986,83	3.119,94	3.246,40	29.289,77
Intorsura Buzaului	913,24	1.728,69	2.459,15	3.115,78	3.795,57	4.410,49	4.870,45	5.292,38	5.681,50	6.042,41	6.379,11	6.695,11	6.993,49	7.276,93	65.654,28
Vatra Dornei	1.276,77	2.416,83	3.438,05	4.356,07	5.306,46	6.166,16	6.809,22	7.399,10	7.943,12	8.447,69	8.918,42	9.360,21	9.777,37	10.173,64	91.789,11
Total	4.638,65	8.780,60	12.490,81	15.826,05	19.278,94	22.402,31	24.738,63	26.881,72	28.858,20	30.691,36	32.401,57	34.006,66	35.522,23	36.961,94	333.479,68

EMISSION BASELINE II - C02 EMISSION (EXISTING BOILER SYSTEMS)

	2.004,00 Tons/year	2.005,00 Tons/year	2.006,00 Tons/year	2.007,00 Tons/year	2.008,00 Tons/year	2.009,00 Tons/year	2.010,00 Tons/year	2.011,00 Tons/year	2.012,00 Tons/year	2.013,00 Tons/year	2.014,00 Tons/year	2.015,00 Tons/year	2.016,00 Tons/year	2.017,00 Tons/year	Total Tons/year
Vlahita	1.637,19	1.669,93	1.703,33	1.737,40	1.928,51	1.967,08	1.829,38	1.865,97	1.903,29	1.941,36	1.980,18	2.019,79	2.060,18	2.101,39	26.344,98
Gheorgheni	2.963,13	3.022,39	3.082,84	3.144,49	3.490,39	3.560,19	3.310,98	3.377,20	3.444,74	3.513,64	3.583,91	3.655,59	3.728,70	3.803,28	47.681,47
Huedin	1.042,00	1.062,84	1.084,10	1.105,78	1.227,42	1.251,97	1.164,33	1.187,62	1.211,37	1.235,60	1.260,31	1.285,51	1.311,22	1.337,45	16.767,52
Intorsura Buzaului	2.335,70	2.382,41	2.430,06	2.478,66	2.751,31	2.806,34	2.609,90	2.662,09	2.715,34	2.769,64	2.825,03	2.881,54	2.939,17	2.997,95	37.585,13
Vatra Dornei	3.265,46	3.330,77	3.397,39	3.465,33	3.846,52	3.923,45	3.648,81	3.721,79	3.796,22	3.872,15	3.949,59	4.028,58	4.109,15	4.191,33	52.546,54
Total	11.243,47	11.468,34	11.697,71	11.931,66	13.244,15	13.509,03	12.563,40	12.814,67	13.070,96	13.332,38	13.599,03	13.871,01	14.148,43	14.431,40	180.925,63

EMISSION BASELINE II - TOTAL C02 EMISSION (ANAEROBE DIGESTION OF WOOD RESIDUES + EXISTING BOILER SYSTEM)

	2.004,00 Tons/year	2.005,00 Tons/year	2.006,00 Tons/year	2.007,00 Tons/year	2.008,00 Tons/year	2.009,00 Tons/year	2.010,00 Tons/year	2.011,00 Tons/year	2.012,00 Tons/year	2.013,00 Tons/year	2.014,00 Tons/year	2.015,00 Tons/year	2.016,00 Tons/year	2.017,00 Tons/year	Total Tons/year
Vlahita	2.519,85	3.340,74	4.080,13	4.748,84	5.596,98	6.229,88	6.536,75	6.981,13	7.394,54	7.781,43	8.145,68	8.490,71	8.819,49	9.134,65	89.800,76
Gheorgheni	4.121,69	5.215,45	6.202,57	7.097,25	8.305,54	9.155,45	9.489,76	10.091,25	10.652,44	11.179,19	11.676,61	12.149,18	12.600,82	13.034,98	130.972,19
Huedin	1.449,42	1.834,05	2.181,18	2.495,80	2.920,70	3.219,58	3.337,14	3.548,66	3.746,01	3.931,24	4.106,16	4.272,34	4.431,17	4.583,84	46.057,30
Intorsura Buzaului	3.248,94	4.111,10	4.889,21	5.594,44	6.546,88	7.216,83	7.480,35	7.954,47	8.396,83	8.812,05	9.204,14	9.576,65	9.932,66	10.274,88	103.239,41
Vatra Dornei	4.542,23	5.747,60	6.835,44	7.821,40	9.152,98	10.089,61	10.458,03	11.120,88	11.739,34	12.319,83	12.868,01	13.388,79	13.886,52	14.364,98	144.335,64
Total	15.882,13	20.248,94	24.188,52	27.757,72	32.523,09	35.911,34	37.302,03	39.696,38	41.929,16	44.023,74	46.000,60	47.877,67	49.670,66	51.393,34	514.405,31

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,6%	53,6%	db
Moisture content	0%	50%	wb
Organic carbon content (wb)	53,6%	26,8%	wb
Lignin fraction of C	0,25	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	3.531,34	882,66	770,49	672,58	587,11	512,50	447,37	390,52	340,89	297,57	259,76	226,75	197,93	172,78	150,82	5.910
2005	0	0	3.601,97		900,31	785,90	686,03	598,85	522,75	456,32	398,33	347,71	303,52	264,95	231,28	201,89	176,23	5.874
2006	0	0	3.674,01			918,32	801,62	699,75	610,83	533,20	465,44	406,29	354,66	309,59	270,25	235,91	205,93	5.812
2007	0	0	3.747,49				936,69	817,65	713,75	623,04	543,87	474,75	414,42	361,76	315,78	275,65	240,62	5.718
2008	0	0	4.159,71					1.039,72	907,59	792,26	691,58	603,69	526,97	460,01	401,55	350,52	305,98	6.080
2009	0	0	4.242,90						1.060,52	925,75	808,10	705,41	615,77	537,51	469,21	409,58	357,53	5.889
2010	0	0	3.945,90							986,28	860,94	751,53	656,03	572,66	499,89	436,36	380,91	5.145
2011	0	0	4.024,82								1.006,01	878,16	766,57	669,15	584,12	509,89	445,09	4.859
2012	0	0	4.105,32									1.026,13	895,73	781,90	682,53	595,80	520,08	4.502
2013	0	0	4.187,42										1.046,65	913,64	797,53	696,18	607,71	4.062
2014	0	0	4.271,17											1.067,58	931,91	813,49	710,11	3.523
2015	0	0	4.356,59												1.088,93	950,55	829,76	2.869
2016	0	0	4.443,73													1.110,71	969,56	2.080
2017	0	0	4.532,60														1.132,93	1.133
Total	0		56.824,97															
	Total emission prevention			**882,66**	**1.670,81**	**2.376,80**	**3.011,44**	**3.668,47**	**4.262,80**	**4.707,36**	**5.115,16**	**5.491,25**	**5.840,07**	**6.165,50**	**6.470,92**	**6.759,31**	**7.033,26**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**882,66**	**2.553,47**	**4.930,26**	**7.941,71**	**11.610,18**	**15.872,97**	**20.580,34**	**25.695,49**	**31.186,74**	**37.026,81**	**43.192,31**	**49.663,22**	**56.422,53**	**63.455,79**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,6%	53,6%	db
Moisture content	0%	50%	wb
Organic carbon content (wb)	53,6%	26,8%	wb
Lignin fraction of C	0,25	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	4.635,16	1.158,56	1.011,33	882,81	770,62	672,69	587,21	512,59	447,45	390,58	340,95	297,62	259,80	226,78	197,96	7.757
2005	0	0	4.727,87		1.181,73	1.031,56	900,47	786,04	686,15	598,95	522,84	456,39	398,40	347,77	303,57	265,00	231,32	7.710
2006	0	0	4.822,42			1.205,37	1.052,19	918,48	801,76	699,87	610,93	533,29	465,52	406,36	354,72	309,65	270,30	7.628
2007	0	0	4.918,87				1.229,47	1.073,23	936,85	817,79	713,87	623,15	543,96	474,83	414,49	361,82	315,84	7.505
2008	0	0	5.459,95					1.364,72	1.191,29	1.039,90	907,75	792,39	691,70	603,80	527,06	460,09	401,62	7.980
2009	0	0	5.569,15						1.392,01	1.215,11	1.060,70	925,90	808,24	705,53	615,87	537,61	469,29	7.730
2010	0	0	5.179,31							1.294,57	1.130,06	986,45	861,09	751,66	656,14	572,76	499,97	6.753
2011	0	0	5.282,89								1.320,46	1.152,66	1.006,18	878,31	766,70	669,27	584,22	6.378
2012	0	0	5.388,55									1.346,87	1.175,71	1.026,30	895,88	782,03	682,65	5.909
2013	0	0	5.496,32										1.373,81	1.199,22	1.046,83	913,80	797,67	5.331
2014	0	0	5.606,25											1.401,28	1.223,21	1.067,76	932,07	4.624
2015	0	0	5.718,37												1.429,31	1.247,67	1.089,12	3.766
2016	0	0	5.832,74													1.457,90	1.272,63	2.731
2017	0	0	5.949,40														1.487,05	1.487
Total	**0**		**74.587,25**															
	Total emission prevention			**1.158,56**	**2.193,06**	**3.119,74**	**3.952,76**	**4.815,16**	**5.595,26**	**6.178,78**	**6.714,05**	**7.207,70**	**7.665,55**	**8.092,70**	**8.493,59**	**8.872,12**	**9.231,71**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**1.158,56**	**3.351,62**	**6.471,36**	**10.424,12**	**15.239,27**	**20.834,53**	**27.013,31**	**33.727,36**	**40.935,06**	**48.600,61**	**56.693,31**	**65.186,90**	**74.059,02**	**83.290,73**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,6%	53,6%	db
Moisture content	0%	50%	wb
Organic carbon content (wb)	53,6%	26,8%	wb
Lignin fraction of C	0,25	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile		
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)
2004	0	0	1.629,99
2005	0	0	1.662,59
2006	0	0	1.695,84
2007	0	0	1.729,76
2008	0	0	1.920,03
2009	0	0	1.958,43
2010	0	0	1.821,34
2011	0	0	1.857,77
2012	0	0	1.894,92
2013	0	0	1.932,82
2014	0	0	1.971,48
2015	0	0	2.010,91
2016	0	0	2.051,12
2017	0	0	2.092,15
Total	0		26.229,13

Year	Year: 2004 (ton CO2-eq)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	407,42	355,64	310,45	271,00	236,56	206,50	180,25	157,35	137,35	119,90	104,66	91,36	79,75	69,62	2.728
2005		415,56	362,75	316,66	276,42	241,29	210,63	183,86	160,49	140,10	122,30	106,75	93,19	81,35	2.711
2006			423,88	370,01	322,99	281,94	246,11	214,84	187,54	163,70	142,90	124,74	108,89	95,05	2.683
2007				432,35	377,41	329,45	287,58	251,04	219,13	191,29	166,98	145,76	127,24	111,07	2.639
2008					479,91	418,93	365,69	319,22	278,65	243,24	212,33	185,35	161,79	141,23	2.806
2009						489,51	427,30	373,00	325,60	284,22	248,10	216,58	189,05	165,03	2.718
2010							455,24	397,39	346,89	302,81	264,33	230,74	201,42	175,82	2.375
2011								464,35	405,34	353,83	308,86	269,61	235,35	205,44	2.243
2012									473,64	413,45	360,91	315,04	275,01	240,06	2.078
2013										483,11	421,72	368,12	321,34	280,51	1.875
2014											492,77	430,15	375,49	327,77	1.626
2015												502,63	438,75	383,00	1.324
2016													512,68	447,53	960
2017														522,93	523
Total emission prevention	**407,42**	**771,21**	**1.097,08**	**1.390,01**	**1.693,28**	**1.967,61**	**2.172,81**	**2.361,04**	**2.534,64**	**2.695,65**	**2.845,85**	**2.986,83**	**3.119,94**	**3.246,40**	**tonne CO_2-eq/yr**
Cumulative total emission prevention	**407,42**	**1.178,62**	**2.275,70**	**3.665,71**	**5.359,00**	**7.326,61**	**9.499,42**	**11.860,46**	**14.395,10**	**17.090,75**	**19.936,60**	**22.923,43**	**26.043,38**	**29.289,77**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,6%	53,6%	db
Moisture content	0%	50%	wb
Organic carbon content (wb)	53,6%	26,8%	wb
Lignin fraction of C	0,25	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile: Biomass from stockpile (ton$_w$)	Age of biomass (years)	Fresh (ton$_w$)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010
2004	0	0	3.653,69	913,24	797,19	695,88	607,45	530,25	462,87	404,05
2005	0	0	3.726,76		931,51	813,13	709,80	619,60	540,86	472,13
2006	0	0	3.801,30			950,14	829,39	723,99	631,99	551,68
2007	0	0	3.877,32				969,14	845,98	738,47	644,63
2008	0	0	4.303,83					1.075,74	939,04	819,71
2009	0	0	4.389,91						1.097,26	957,82
2010	0	0	4.082,61							1.020,45
2011	0	0	4.164,26							
2012	0	0	4.247,55							
2013	0	0	4.332,50							
2014	0	0	4.419,15							
2015	0	0	4.507,53							
2016	0	0	4.597,68							
2017	0	0	4.689,64							
Total	**0**		**58.793,73**							
	Total emission prevention			**913,24**	**1.728,69**	**2.459,15**	**3.115,78**	**3.795,57**	**4.410,49**	**4.870,45**
	Cumulative total emission prevention			**913,24**	**2.641,93**	**5.101,08**	**8.216,86**	**12.012,42**	**16.422,91**	**21.293,36**

Year	2011	2012	2013	2014	2015	2016	2017	Total
2004	352,70	307,88	268,75	234,60	204,79	178,76	156,05	6.114
2005	412,13	359,76	314,04	274,13	239,29	208,88	182,34	6.078
2006	481,57	420,37	366,95	320,32	279,61	244,08	213,06	6.013
2007	562,71	491,20	428,78	374,29	326,72	285,20	248,96	5.916
2008	715,54	624,61	545,23	475,94	415,46	362,66	316,58	6.291
2009	836,10	729,85	637,10	556,14	485,46	423,77	369,92	6.093
2010	890,77	777,57	678,76	592,50	517,21	451,48	394,11	5.323
2011	1.040,86	908,59	793,12	692,33	604,35	527,55	460,51	5.027
2012		1.061,68	926,76	808,99	706,18	616,44	538,10	4.658
2013			1.082,91	945,29	825,17	720,30	628,77	4.202
2014				1.104,57	964,20	841,67	734,71	3.645
2015					1.126,66	983,48	858,50	2.969
2016						1.149,19	1.003,15	2.152
2017							1.172,18	1.172
Total emission prevention	**5.292,38**	**5.681,50**	**6.042,41**	**6.379,11**	**6.695,11**	**6.993,49**	**7.276,93**	**tonne CO_2-eq/yr**
Cumulative total emission prevention	**26.585,74**	**32.267,24**	**38.309,65**	**44.688,75**	**51.383,86**	**58.377,35**	**65.654,28**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,6%	53,6%	db
Moisture content	0%	50%	wb
Organic carbon content (wb)	53,6%	26,8%	wb
Lignin fraction of C	0,25	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	5.108,10	1.276,77	1.114,52	972,89	849,25	741,33	647,12	564,89	493,10	430,44	375,74	327,99	286,31	249,92	218,16	8.548
2005	0	0	5.210,26		1.302,31	1.136,81	992,34	866,24	756,16	660,06	576,18	502,96	439,05	383,25	334,55	292,03	254,92	8.497
2006	0	0	5.314,47			1.328,35	1.159,55	1.012,19	883,56	771,28	673,27	587,71	513,02	447,83	390,92	341,24	297,87	8.407
2007	0	0	5.420,76				1.354,92	1.182,74	1.032,44	901,23	786,71	686,73	599,46	523,28	456,78	398,74	348,06	8.271
2008	0	0	6.017,04					1.503,96	1.312,84	1.146,00	1.000,37	873,24	762,27	665,40	580,84	507,03	442,60	8.795
2009	0	0	6.137,38						1.534,04	1.339,10	1.168,92	1.020,38	890,71	777,52	678,71	592,46	517,17	8.519
2010	0	0	5.707,77							1.426,66	1.245,36	1.087,10	948,95	828,36	723,09	631,20	550,99	7.442
2011	0	0	5.821,92								1.455,19	1.270,27	1.108,84	967,93	844,93	737,55	643,82	7.029
2012	0	0	5.938,36									1.484,30	1.295,67	1.131,02	987,29	861,82	752,30	6.512
2013	0	0	6.057,13										1.513,98	1.321,58	1.153,64	1.007,03	879,06	5.875
2014	0	0	6.178,27											1.544,26	1.348,02	1.176,71	1.027,17	5.096
2015	0	0	6.301,83												1.575,15	1.374,98	1.200,25	4.150
2016	0	0	6.427,87													1.606,65	1.402,48	3.009
2017	0	0	6.556,43														1.638,78	1.639
Total	**0**		**82.197,59**															
	Total emission prevention			**1.276,77**	**2.416,83**	**3.438,05**	**4.356,07**	**5.306,46**	**6.166,16**	**6.809,22**	**7.399,10**	**7.943,12**	**8.447,69**	**8.918,42**	**9.360,21**	**9.777,37**	**10.173,64**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**1.276,77**	**3.693,60**	**7.131,65**	**11.487,72**	**16.794,18**	**22.960,33**	**29.769,56**	**37.168,65**	**45.111,77**	**53.559,46**	**62.477,88**	**71.838,09**	**81.615,46**	**91.789,11**	**tonne CO_2-eq/project**

EMISSION BASELINE III - EQUIVALENT C02 EMISSION (ANAEROBE DIGESTION OF WOOD RESIDUES)

	2.004,00	2.005,00	2.006,00	2.007,00	2.008,00	2.009,00	2.010,00	2.011,00	2.012,00	2.013,00	2.014,00	2.015,00	2.016,00	2.017,00	Total
	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year
Vlahita	882,66	1.850,10	2.891,56	3.997,62	5.160,07	6.371,76	7.626,41	8.918,58	10.243,49	11.596,98	12.778,48	13.809,82	14.710,11	15.495,99	116.333,64
Gheorgheni	1.158,56	2.312,72	3.463,04	4.610,01	5.754,06	6.895,55	8.034,81	9.172,12	10.307,73	11.441,86	12.431,87	13.296,06	14.050,44	14.708,95	117.637,78
Huedin	407,42	854,22	1.335,41	1.846,61	2.384,01	2.944,28	3.524,51	4.122,17	4.735,04	5.361,19	5.907,77	6.384,89	6.801,38	7.164,94	53.773,81
Intorsura Buzaului	913,24	1.898,47	2.946,54	4.049,47	5.200,29	6.392,90	7.622,00	8.882,95	10.171,70	11.484,73	12.630,89	13.631,40	14.504,77	15.267,15	115.596,51
Vatra Dornei	1.276,77	2.595,17	3.949,89	5.336,34	6.750,47	8.188,76	9.648,15	11.125,96	12.619,84	14.127,75	15.444,04	16.593,06	17.596,05	18.471,59	143.723,85
Total	4.638,65	9.510,69	14.586,45	19.840,05	25.248,89	30.793,24	36.455,88	42.221,77	48.077,81	54.012,52	59.193,05	63.715,24	67.662,75	71.108,61	547.065,59

EMISSION BASELINE III - C02 EMISSION (EXISTING BOILER SYSTEMS)

	2.004,00	2.005,00	2.006,00	2.007,00	2.008,00	2.009,00	2.010,00	2.011,00	2.012,00	2.013,00	2.014,00	2.015,00	2.016,00	2.017,00	Total
	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year
Vlahita	1.637,19	2.002,50	2.367,82	2.733,13	3.098,44	3.463,76	3.829,07	4.194,39	4.559,70	4.925,02	4.925,02	4.925,02	4.925,02	4.925,02	52.511,09
Gheorgheni	2.963,13	3.328,43	3.693,73	4.059,03	4.424,33	4.789,64	5.154,94	5.520,24	5.885,54	6.250,84	6.250,84	6.250,84	6.250,84	6.250,84	71.073,22
Huedin	1.042,00	1.275,16	1.508,32	1.741,47	1.974,63	2.207,79	2.440,94	2.674,10	2.907,25	3.140,41	3.140,41	3.140,41	3.140,41	3.140,41	33.473,71
Intorsura Buzaului	2.335,70	2.816,64	3.297,58	3.778,52	4.259,46	4.740,40	5.221,34	5.702,29	6.183,23	6.664,17	6.664,17	6.664,17	6.664,17	6.664,17	71.656,00
Vatra Dornei	3.265,46	3.786,89	4.308,32	4.829,74	5.351,17	5.872,60	6.394,02	6.915,45	7.436,88	7.958,30	7.958,30	7.958,30	7.958,30	7.958,30	87.952,05
Total	11.243,47	13.209,62	15.175,76	17.141,90	19.108,04	21.076,00	23.040,32	25.006,46	26.972,60	28.938,74	28.938,74	28.938,74	28.938,74	28.938,74	316.666,07

EMISSION BASELINE III - TOTAL C02 EMISSION (ANAEROBE DIGESTION OF WOOD RESIDUES + EXISTING BOILER SYSTEM)

	2.004,00	2.005,00	2.006,00	2.007,00	2.008,00	2.009,00	2.010,00	2.011,00	2.012,00	2.013,00	2.014,00	2.015,00	2.016,00	2.017,00	Total
	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year
Vlahita	2.519,85	3.852,61	5.259,38	6.730,75	8.258,52	9.835,52	11.455,49	13.112,97	14.803,19	16.522,00	17.703,49	18.734,84	19.635,13	20.421,00	168.844,72
Gheorgheni	4.121,69	5.641,15	7.156,77	8.669,05	10.178,39	11.685,18	13.189,74	14.692,36	16.193,27	17.692,71	18.682,71	19.546,91	20.301,28	20.959,79	188.711,00
Huedin	1.449,42	2.129,38	2.843,72	3.588,08	4.358,64	5.152,06	5.965,45	6.796,27	7.642,29	8.501,60	9.048,18	9.525,30	9.941,79	10.305,35	87.247,52
Intorsura Buzaului	3.248,94	4.715,11	6.244,12	7.827,99	9.459,75	11.133,30	12.843,34	14.585,24	16.354,93	18.148,90	19.295,06	20.295,57	21.168,94	21.931,32	187.252,51
Vatra Dornei	4.542,23	6.382,06	8.258,21	10.166,08	12.101,64	14.061,36	16.042,18	18.041,41	20.056,72	22.086,06	23.402,35	24.551,36	25.554,36	26.429,90	231.675,90
Total	15.882,13	22.720,30	29.762,21	36.981,95	44.356,93	51.867,42	59.496,20	67.228,24	75.050,41	82.951,26	88.131,79	92.653,98	96.601,49	100.047,35	863.731,66

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,6%	53,6%	db
Moisture content	0%	50%	wb
Organic carbon content (wb)	53,6%	26,8%	wb
Lignin fraction of C	0,25	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	3.531,34	882,66	770,49	672,58	587,11	512,50	447,37	390,52	340,89	297,57	259,76	226,75	197,93	172,78	150,82	5.910
2005	0	0	4.319,31		1.079,61	942,42	822,65	718,11	626,85	547,19	477,66	416,96	363,97	317,72	277,34	242,10	211,33	7.044
2006	0	0	5.107,28			1.276,57	1.114,34	972,73	849,12	741,21	647,02	564,79	493,02	430,37	375,68	327,94	286,26	8.079
2007	0	0	5.895,24				1.473,52	1.286,26	1.122,81	980,12	855,57	746,84	651,93	569,09	496,77	433,64	378,53	8.995
2008	0	0	6.683,21					1.670,47	1.458,19	1.272,88	1.111,12	969,92	846,67	739,07	645,15	563,16	491,60	9.768
2009	0	0	7.471,18						1.867,42	1.630,11	1.422,96	1.242,13	1.084,28	946,49	826,21	721,21	629,56	10.370
2010	0	0	8.259,15							2.064,38	1.802,04	1.573,03	1.373,13	1.198,64	1.046,31	913,35	797,28	10.768
2011	0	0	9.047,11								2.261,33	1.973,96	1.723,11	1.504,14	1.312,99	1.146,14	1.000,49	10.922
2012	0	0	9.835,08									2.458,28	2.145,88	1.873,19	1.635,14	1.427,35	1.245,96	10.786
2013	0	0	10.623,05										2.655,24	2.317,81	2.023,26	1.766,15	1.541,70	10.304
2014	0	0	10.623,05											2.655,24	2.317,81	2.023,26	1.766,15	8.762
2015	0	0	10.623,05												2.655,24	2.317,81	2.023,26	6.996
2016	0	0	10.623,05													2.655,24	2.317,81	4.973
2017	0	0	10.623,05														2.655,24	2.655
Total	**0**		**113.264,13**															
	Total emission prevention			**882,66**	**1.850,10**	**2.891,56**	**3.997,62**	**5.160,07**	**6.371,76**	**7.626,41**	**8.918,58**	**10.243,49**	**11.596,98**	**12.778,48**	**13.809,82**	**14.710,11**	**15.495,99**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**882,66**	**2.732,77**	**5.624,32**	**9.621,94**	**14.782,02**	**21.153,78**	**28.780,19**	**37.698,77**	**47.942,25**	**59.539,24**	**72.317,72**	**86.127,54**	**100.837,65**	**116.333,64**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,6%	53,6%	db
Moisture content	0%	50%	wb
Organic carbon content (wb)	53,6%	26,8%	wb
Lignin fraction of C	0,25	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	4.635,16	1.158,56	1.011,33	882,81	770,62	672,69	587,21	512,59	447,45	390,58	340,95	297,62	259,80	226,78	197,96	7.757
2005	0	0	5.206,60		1.301,39	1.136,01	991,65	865,63	755,62	659,60	575,78	502,61	438,74	382,98	334,31	291,83	254,74	8.491
2006	0	0	5.778,03			1.444,22	1.260,69	1.100,48	960,63	838,56	731,99	638,97	557,77	486,89	425,02	371,00	323,86	9.140
2007	0	0	6.349,47				1.587,05	1.385,37	1.209,32	1.055,64	921,49	804,38	702,16	612,93	535,04	467,05	407,70	9.688
2008	0	0	6.920,90					1.729,88	1.510,05	1.318,15	1.150,64	1.004,42	876,78	765,36	668,10	583,19	509,08	10.116
2009	0	0	7.492,34						1.872,71	1.634,73	1.426,99	1.245,65	1.087,35	949,17	828,55	723,26	631,35	10.400
2010	0	0	8.063,78							2.015,54	1.759,41	1.535,82	1.340,65	1.170,28	1.021,56	891,74	778,42	10.513
2011	0	0	8.635,21								2.158,37	1.884,09	1.644,66	1.435,66	1.253,21	1.093,95	954,94	10.425
2012	0	0	9.206,65									2.301,21	2.008,77	1.753,49	1.530,66	1.336,14	1.166,35	10.097
2013	0	0	9.778,08										2.444,04	2.133,45	1.862,33	1.625,67	1.419,08	9.485
2014	0	0	9.778,08											2.444,04	2.133,45	1.862,33	1.625,67	8.065
2015	0	0	9.778,08												2.444,04	2.133,45	1.862,33	6.440
2016	0	0	9.778,08													2.444,04	2.133,45	4.577
2017	0	0	9.778,08														2.444,04	2.444
Total	0		111.178,54															
	Total emission prevention			1.158,56	2.312,72	3.463,04	4.610,01	5.754,06	6.895,55	8.034,81	9.172,12	10.307,73	11.441,86	12.431,87	13.296,06	14.050,44	14.708,95	tonne CO_2-eq/yr
	Cumulative total emission prevention			1.158,56	3.471,28	6.934,33	11.544,34	17.298,40	24.193,95	32.228,75	41.400,87	51.708,60	63.150,47	75.582,33	88.878,40	102.928,83	117.637,78	tonne CO_2-eq/project

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,6%	53,6%	db
Moisture content	0%	50%	wb
Organic carbon content (wb)	53,6%	26,8%	wb
Lignin fraction of C	0,25	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile: Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	Year: 2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	1.629,99	407,42	355,64	310,45	271,00	236,56	206,50	180,25	157,35	137,35	119,90	104,66	91,36	79,75	69,62	2.728
2005	0	0	1.994,71		498,58	435,22	379,91	331,63	289,49	252,70	220,59	192,56	168,09	146,73	128,08	111,80	97,60	3.253
2006	0	0	2.359,43			589,74	514,80	449,38	392,27	342,42	298,91	260,92	227,76	198,82	173,55	151,50	132,25	3.732
2007	0	0	2.724,15				680,90	594,37	518,84	452,91	395,35	345,11	301,25	262,97	229,55	200,38	174,92	4.157
2008	0	0	3.088,88					772,07	673,95	588,31	513,54	448,28	391,32	341,59	298,18	260,29	227,21	4.515
2009	0	0	3.453,60						863,23	753,53	657,77	574,18	501,21	437,52	381,92	333,39	291,02	4.794
2010	0	0	3.818,32							954,39	833,11	727,24	634,82	554,15	483,73	422,25	368,59	4.978
2011	0	0	4.183,04								1.045,55	912,68	796,70	695,46	607,08	529,93	462,59	5.050
2012	0	0	4.547,76									1.136,72	992,26	866,17	756,09	660,01	576,14	4.987
2013	0	0	4.912,49										1.227,88	1.071,84	935,63	816,73	712,94	4.765
2014	0	0	4.912,49											1.227,88	1.071,84	935,63	816,73	4.052
2015	0	0	4.912,49												1.227,88	1.071,84	935,63	3.235
2016	0	0	4.912,49													1.227,88	1.071,84	2.300
2017	0	0	4.912,49														1.227,88	1.228
Total	**0**		**52.362,32**															
	Total emission prevention			**407,42**	**854,22**	**1.335,41**	**1.846,61**	**2.384,01**	**2.944,28**	**3.524,51**	**4.122,17**	**4.735,04**	**5.361,19**	**5.907,77**	**6.384,89**	**6.801,38**	**7.164,94**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**407,42**	**1.261,64**	**2.597,04**	**4.443,65**	**6.827,66**	**9.771,93**	**13.296,44**	**17.418,61**	**22.153,65**	**27.514,84**	**33.422,61**	**39.807,50**	**46.608,87**	**53.773,81**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,6%	53,6%	db
Moisture content	0%	50%	wb
Organic carbon content (wb)	53,6%	26,8%	wb
Lignin fraction of C	0,25	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	3.653,69	913,24	797,19	695,88	607,45	530,25	462,87	404,05	352,70	307,88	268,75	234,60	204,79	178,76	156,05	6.114
2005	0	0	4.406,02		1.101,29	961,33	839,17	732,53	639,44	558,18	487,24	425,33	371,28	324,09	282,91	246,96	215,57	7.185
2006	0	0	5.158,34			1.289,33	1.125,48	982,46	857,61	748,62	653,49	570,44	497,95	434,67	379,43	331,21	289,12	8.160
2007	0	0	5.910,67				1.477,37	1.289,63	1.125,74	982,68	857,81	748,80	653,64	570,57	498,07	434,77	379,52	9.019
2008	0	0	6.663,00					1.665,42	1.453,78	1.269,03	1.107,76	966,99	844,10	736,84	643,20	561,46	490,11	9.739
2009	0	0	7.415,33						1.853,46	1.617,93	1.412,32	1.232,84	1.076,17	939,41	820,03	715,82	624,86	10.293
2010	0	0	8.167,65							2.041,51	1.782,07	1.555,61	1.357,92	1.185,36	1.034,72	903,23	788,45	10.649
2011	0	0	8.919,98								2.229,55	1.946,22	1.698,90	1.483,00	1.294,54	1.130,03	986,43	10.769
2012	0	0	9.672,31									2.417,60	2.110,37	1.842,18	1.608,08	1.403,73	1.225,34	10.607
2013	0	0	10.424,64										2.605,64	2.274,52	1.985,47	1.733,16	1.512,91	10.112
2014	0	0	10.424,64											2.605,64	2.274,52	1.985,47	1.733,16	8.599
2015	0	0	10.424,64												2.605,64	2.274,52	1.985,47	6.866
2016	0	0	10.424,64													2.605,64	2.274,52	4.880
2017	0	0	10.424,64														2.605,64	2.606
Total	**0**		**112.090,18**															
	Total emission prevention			**913,24**	**1.898,47**	**2.946,54**	**4.049,47**	**5.200,29**	**6.392,90**	**7.622,00**	**8.882,95**	**10.171,70**	**11.484,73**	**12.630,89**	**13.631,40**	**14.504,77**	**15.267,15**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**913,24**	**2.811,71**	**5.758,26**	**9.807,73**	**15.008,02**	**21.400,92**	**29.022,92**	**37.905,87**	**48.077,57**	**59.562,30**	**72.193,19**	**85.824,60**	**100.329,37**	**115.596,51**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,6%	53,6%	db
Moisture content	0%	50%	wb
Organic carbon content (wb)	53,6%	26,8%	wb
Lignin fraction of C	0,25	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	5.108,10	1.276,77	1.114,52	972,89	849,25	741,33	647,12	564,89	493,10	430,44	375,74	327,99	286,31	249,92	218,16	8.548
2005	0	0	5.923,76		1.480,65	1.292,49	1.128,24	984,86	859,71	750,45	655,09	571,84	499,17	435,73	380,36	332,03	289,83	9.660
2006	0	0	6.739,42			1.684,52	1.470,45	1.283,59	1.120,47	978,08	853,79	745,29	650,58	567,90	495,73	432,73	377,74	10.661
2007	0	0	7.555,08				1.888,40	1.648,42	1.438,94	1.256,08	1.096,46	957,12	835,49	729,31	636,63	555,73	485,11	11.528
2008	0	0	8.370,74					2.092,27	1.826,38	1.594,29	1.391,69	1.214,83	1.060,45	925,69	808,05	705,36	615,73	12.235
2009	0	0	9.186,40						2.296,14	2.004,35	1.749,64	1.527,29	1.333,21	1.163,78	1.015,89	886,79	774,10	12.751
2010	0	0	10.002,06							2.500,02	2.182,32	1.904,99	1.662,90	1.451,58	1.267,11	1.106,09	965,53	13.041
2011	0	0	10.817,71								2.703,89	2.360,28	2.060,34	1.798,51	1.569,96	1.370,45	1.196,29	13.060
2012	0	0	11.633,37									2.907,77	2.538,25	2.215,69	1.934,12	1.688,33	1.473,78	12.758
2013	0	0	12.449,03										3.111,64	2.716,21	2.371,04	2.069,73	1.806,71	12.075
2014	0	0	12.449,03											3.111,64	2.716,21	2.371,04	2.069,73	10.269
2015	0	0	12.449,03												3.111,64	2.716,21	2.371,04	8.199
2016	0	0	12.449,03													3.111,64	2.716,21	5.828
2017	0	0	12.449,03														3.111,64	3.112
Total	**0**		**137.581,79**															
	Total emission prevention			**1.276,77**	**2.595,17**	**3.949,89**	**5.336,34**	**6.750,47**	**8.188,76**	**9.648,15**	**11.125,96**	**12.619,84**	**14.127,75**	**15.444,04**	**16.593,06**	**17.596,05**	**18.471,59**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**1.276,77**	**3.871,94**	**7.821,83**	**13.158,17**	**19.908,64**	**28.097,40**	**37.745,55**	**48.871,51**	**61.491,35**	**75.619,11**	**91.063,15**	**107.656,21**	**125.252,26**	**143.723,85**	**tonne CO_2-eq/project**

EMISSION BASELINE IV - EQUIVALENT C02 EMISSION (based on average heat demand of the five towns year 1997 - 2001)

	2.004,00	2.005,00	2.006,00	2.007,00	2.008,00	2.009,00	2.010,00	2.011,00	2.012,00	2.013,00	2.014,00	2.015,00	2.016,00	2.017,00	Total
	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year
Vlahita	882,66	1.653,15	2.325,73	2.912,84	3.425,33	3.872,70	4.263,22	4.604,11	4.901,68	5.161,44	5.388,18	5.586,11	5.758,89	5.909,71	56.645,77
Gheorgheni	1.158,56	2.169,89	3.052,70	3.823,33	4.496,02	5.083,23	5.595,81	6.043,26	6.433,84	6.774,79	7.072,41	7.332,21	7.559,00	7.756,96	74.352,04
Huedin	407,42	763,06	1.073,50	1.344,50	1.581,06	1.787,55	1.967,81	2.125,15	2.262,51	2.382,40	2.487,06	2.578,42	2.658,18	2.727,79	26.146,42
Intorsura Buzaului	913,24	1.710,43	2.406,31	3.013,76	3.544,01	4.006,88	4.410,93	4.763,63	5.071,51	5.340,26	5.574,86	5.779,65	5.958,41	6.114,46	58.608,32
Vatra Dornei	1.276,77	2.391,29	3.364,18	4.213,43	4.954,76	5.601,88	6.166,77	6.659,87	7.090,31	7.466,04	7.794,03	8.080,34	8.330,26	8.548,43	81.938,38
Total	4.638,65	8.687,82	12.222,43	15.307,85	18.001,18	20.352,25	22.404,54	24.196,02	25.759,85	27.124,94	28.316,56	29.356,74	30.264,74	31.057,35	297.690,93

EMISSION BASELINE IV - EQUIVALENT C02 EMISSION (based on the heat demand measured in Tasca)

	2.004,00	2.005,00	2.006,00	2.007,00	2.008,00	2.009,00	2.010,00	2.011,00	2.012,00	2.013,00	2.014,00	2.015,00	2.016,00	2.017,00	Total
	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year
Vlahita	1.117,86	2.093,66	2.945,46	3.689,01	4.338,07	4.904,65	5.399,23	5.830,95	6.207,82	6.536,79	6.823,95	7.074,63	7.293,44	7.484,45	71.739,97
Gheorgheni	582,40	1.090,78	1.534,56	1.921,94	2.260,10	2.555,28	2.812,95	3.037,88	3.234,22	3.405,61	3.555,22	3.685,82	3.799,82	3.899,34	37.375,94
Huedin	467,24	875,10	1.231,13	1.541,91	1.813,20	2.050,02	2.256,74	2.437,19	2.594,71	2.732,21	2.852,24	2.957,01	3.048,47	3.128,31	29.985,48
Intorsura Buzaului	942,83	1.765,85	2.484,28	3.111,41	3.658,85	4.136,72	4.553,86	4.917,99	5.235,84	5.513,31	5.755,51	5.966,93	6.151,49	6.312,59	60.507,45
Vatra Dornei	939,74	1.760,06	2.476,13	3.101,20	3.646,84	4.123,14	4.538,91	4.901,85	5.218,66	5.495,21	5.736,62	5.947,35	6.131,30	6.291,88	60.308,88
Total	4.050,06	7.585,45	10.671,56	13.365,48	15.717,06	17.769,80	19.561,69	21.125,85	22.491,25	23.683,13	24.723,54	25.631,74	26.424,53	27.116,57	259.917,72

EMISSION BASELINE IV - C02 EMISSION (EXISTING BOILER SYSTEMS)

	2.004,00	2.005,00	2.006,00	2.007,00	2.008,00	2.009,00	2.010,00	2.011,00	2.012,00	2.013,00	2.014,00	2.015,00	2.016,00	2.017,00	Total
	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year
Vlahita	1.637,19	1.637,19	1.637,19	1.637,19	1.637,19	1.637,19	1.637,19	1.637,19	1.637,19	1.637,19	1.637,19	1.637,19	1.637,19	1.637,19	22.920,62
Gheorgheni	2.963,13	2.963,13	2.963,13	2.963,13	2.963,13	2.963,13	2.963,13	2.963,13	2.963,13	2.963,13	2.963,13	2.963,13	2.963,13	2.963,13	41.483,76
Huedin	1.042,00	1.042,00	1.042,00	1.042,00	1.042,00	1.042,00	1.042,00	1.042,00	1.042,00	1.042,00	1.042,00	1.042,00	1.042,00	1.042,00	14.588,06
Intorsura Buzaului	2.335,70	2.335,70	2.335,70	2.335,70	2.335,70	2.335,70	2.335,70	2.335,70	2.335,70	2.335,70	2.335,70	2.335,70	2.335,70	2.335,70	32.699,76
Vatra Dornei	3.265,46	3.265,46	3.265,46	3.265,46	3.265,46	3.265,46	3.265,46	3.265,46	3.265,46	3.265,46	3.265,46	3.265,46	3.265,46	3.265,46	45.716,46
Total	11.243,47	11.243,47	11.243,47	11.243,47	11.243,47	11.243,47	11.243,47	11.243,47	11.243,47	11.243,47	11.243,47	11.243,47	11.243,47	11.243,47	157.408,64

EMISSION BASELINE IV - TOTAL C02 EMISSION (ANAEROBE DIGESTION OF WOOD RESIDUES + EXISTING BOILER SYSTEM)

	2.004,00	2.005,00	2.006,00	2.007,00	2.008,00	2.009,00	2.010,00	2.011,00	2.012,00	2.013,00	2.014,00	2.015,00	2.016,00	2.017,00	Total
	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year	Tons/year
Vlahita	3.637,71	5.384,00	6.908,38	8.239,03	9.400,59	10.414,54	11.299,63	12.072,25	12.746,69	13.335,41	13.849,32	14.297,93	14.689,52	15.031,35	151.306,36
Gheorgheni	4.704,08	6.223,80	7.550,39	8.708,40	9.719,25	10.601,64	11.371,89	12.044,26	12.631,19	13.143,53	13.590,76	13.981,16	14.321,95	14.619,43	153.211,74
Huedin	1.916,66	2.680,16	3.346,64	3.928,42	4.436,26	4.879,58	5.266,55	5.604,35	5.899,22	6.156,62	6.381,31	6.577,44	6.748,65	6.898,11	70.719,95
Intorsura Buzaului	4.191,77	5.811,98	7.226,29	8.460,86	9.538,55	10.479,29	11.300,48	12.017,31	12.643,04	13.189,26	13.666,07	14.082,28	14.445,60	14.762,75	151.815,53
Vatra Dornei	5.481,97	7.416,81	9.105,77	10.580,09	11.867,06	12.990,48	13.971,14	14.827,18	15.574,43	16.226,72	16.796,11	17.293,15	17.727,03	18.105,76	187.963,71
Total	19.932,19	27.516,75	34.137,46	39.916,81	44.961,72	49.365,53	53.209,70	56.565,35	59.494,57	62.051,54	64.283,58	66.231,96	67.932,75	69.417,40	715.017,29

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,60%	53,60%	db
Moisture content	0,00%	50,00%	wb
Organic carbon content (wb)	53,60%	26,80%	wb
Lignin fraction of C	0,250	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	3.531,34	882,66	770,49	672,58	587,11	512,50	447,37	390,52	340,89	297,57	259,76	226,75	197,93	172,78	150,82	5.910
2005	0	0	3.531,34		882,66	770,49	672,58	587,11	512,50	447,37	390,52	340,89	297,57	259,76	226,75	197,93	172,78	5.759
2006	0	0	3.531,34			882,66	770,49	672,58	587,11	512,50	447,37	390,52	340,89	297,57	259,76	226,75	197,93	5.586
2007	0	0	3.531,34				882,66	770,49	672,58	587,11	512,50	447,37	390,52	340,89	297,57	259,76	226,75	5.388
2008	0	0	3.531,34					882,66	770,49	672,58	587,11	512,50	447,37	390,52	340,89	297,57	259,76	5.161
2009	0	0	3.531,34						882,66	770,49	672,58	587,11	512,50	447,37	390,52	340,89	297,57	4.902
2010	0	0	3.531,34							882,66	770,49	672,58	587,11	512,50	447,37	390,52	340,89	4.604
2011	0	0	3.531,34								882,66	770,49	672,58	587,11	512,50	447,37	390,52	4.263
2012	0	0	3.531,34									882,66	770,49	672,58	587,11	512,50	447,37	3.873
2013	0	0	3.531,34										882,66	770,49	672,58	587,11	512,50	3.425
2014	0	0	3.531,34											882,66	770,49	672,58	587,11	2.913
2015	0	0	3.531,34												882,66	770,49	672,58	2.326
2016	0	0	3.531,34													882,66	770,49	1.653
2017	0	0	3.531,34														882,66	883
Total	**0**		**49.438,77**															
	Total emission prevention			**882,66**	**1.653,15**	**2.325,73**	**2.912,84**	**3.425,33**	**3.872,70**	**4.263,22**	**4.604,11**	**4.901,68**	**5.161,44**	**5.388,18**	**5.586,11**	**5.758,89**	**5.909,71**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**882,66**	**2.535,81**	**4.861,54**	**7.774,38**	**11.199,71**	**15.072,42**	**19.335,64**	**23.939,75**	**28.841,43**	**34.002,87**	**39.391,05**	**44.977,16**	**50.736,06**	**56.645,77**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,60%	53,60%	db
Moisture content	0,00%	50,00%	wb
Organic carbon content (wb)	53,60%	26,80%	wb
Lignin fraction of C	0,250	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	4.635,16	1.158,56	1.011,33	882,81	770,62	672,69	587,21	512,59	447,45	390,58	340,95	297,62	259,80	226,78	197,96	7.757
2005	0	0	4.635,16		1.158,56	1.011,33	882,81	770,62	672,69	587,21	512,59	447,45	390,58	340,95	297,62	259,80	226,78	7.559
2006	0	0	4.635,16			1.158,56	1.011,33	882,81	770,62	672,69	587,21	512,59	447,45	390,58	340,95	297,62	259,80	7.332
2007	0	0	4.635,16				1.158,56	1.011,33	882,81	770,62	672,69	587,21	512,59	447,45	390,58	340,95	297,62	7.072
2008	0	0	4.635,16					1.158,56	1.011,33	882,81	770,62	672,69	587,21	512,59	447,45	390,58	340,95	6.775
2009	0	0	4.635,16						1.158,56	1.011,33	882,81	770,62	672,69	587,21	512,59	447,45	390,58	6.434
2010	0	0	4.635,16							1.158,56	1.011,33	882,81	770,62	672,69	587,21	512,59	447,45	6.043
2011	0	0	4.635,16								1.158,56	1.011,33	882,81	770,62	672,69	587,21	512,59	5.596
2012	0	0	4.635,16									1.158,56	1.011,33	882,81	770,62	672,69	587,21	5.083
2013	0	0	4.635,16										1.158,56	1.011,33	882,81	770,62	672,69	4.496
2014	0	0	4.635,16											1.158,56	1.011,33	882,81	770,62	3.823
2015	0	0	4.635,16												1.158,56	1.011,33	882,81	3.053
2016	0	0	4.635,16													1.158,56	1.011,33	2.170
2017	0	0	4.635,16														1.158,56	1.159
Total	**0**		**64.892,29**															
	Total emission prevention			**1.158,56**	**2.169,89**	**3.052,70**	**3.823,33**	**4.496,02**	**5.083,23**	**5.595,81**	**6.043,26**	**6.433,84**	**6.774,79**	**7.072,41**	**7.332,21**	**7.559,00**	**7.756,96**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**1.158,56**	**3.328,45**	**6.381,16**	**10.204,49**	**14.700,51**	**19.783,74**	**25.379,55**	**31.422,81**	**37.856,65**	**44.631,45**	**51.703,86**	**59.036,08**	**66.595,07**	**74.352,04**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,60%	53,60%	db
Moisture content	0,00%	50,00%	wb
Organic carbon content (wb)	53,60%	26,80%	wb
Lignin fraction of C	0,250	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	1.629,99	407,42	355,64	310,45	271,00	236,56	206,50	180,25	157,35	137,35	119,90	104,66	91,36	79,75	69,62	2.728
2005	0	0	1.629,99		407,42	355,64	310,45	271,00	236,56	206,50	180,25	157,35	137,35	119,90	104,66	91,36	79,75	2.658
2006	0	0	1.629,99			407,42	355,64	310,45	271,00	236,56	206,50	180,25	157,35	137,35	119,90	104,66	91,36	2.578
2007	0	0	1.629,99				407,42	355,64	310,45	271,00	236,56	206,50	180,25	157,35	137,35	119,90	104,66	2.487
2008	0	0	1.629,99					407,42	355,64	310,45	271,00	236,56	206,50	180,25	157,35	137,35	119,90	2.382
2009	0	0	1.629,99						407,42	355,64	310,45	271,00	236,56	206,50	180,25	157,35	137,35	2.263
2010	0	0	1.629,99							407,42	355,64	310,45	271,00	236,56	206,50	180,25	157,35	2.125
2011	0	0	1.629,99								407,42	355,64	310,45	271,00	236,56	206,50	180,25	1.968
2012	0	0	1.629,99									407,42	355,64	310,45	271,00	236,56	206,50	1.788
2013	0	0	1.629,99										407,42	355,64	310,45	271,00	236,56	1.581
2014	0	0	1.629,99											407,42	355,64	310,45	271,00	1.345
2015	0	0	1.629,99												407,42	355,64	310,45	1.074
2016	0	0	1.629,99													407,42	355,64	763
2017	0	0	1.629,99														407,42	407
Total	**0**		**22.819,83**															
	Total emission prevention			**407,42**	**763,06**	**1.073,50**	**1.344,50**	**1.581,06**	**1.787,55**	**1.967,81**	**2.125,15**	**2.262,51**	**2.382,40**	**2.487,06**	**2.578,42**	**2.658,18**	**2.727,79**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**407,42**	**1.170,47**	**2.243,98**	**3.588,48**	**5.169,54**	**6.957,09**	**8.924,90**	**11.050,05**	**13.312,56**	**15.694,96**	**18.182,03**	**20.760,45**	**23.418,63**	**26.146,42**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,60%	53,60%	db
Moisture content	0,00%	50,00%	wb
Organic carbon content (wb)	53,60%	26,80%	wb
Lignin fraction of C	0,250	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	3.653,69	913,24	797,19	695,88	607,45	530,25	462,87	404,05	352,70	307,88	268,75	234,60	204,79	178,76	156,05	6.114
2005	0	0	3.653,69		913,24	797,19	695,88	607,45	530,25	462,87	404,05	352,70	307,88	268,75	234,60	204,79	178,76	5.958
2006	0	0	3.653,69			913,24	797,19	695,88	607,45	530,25	462,87	404,05	352,70	307,88	268,75	234,60	204,79	5.780
2007	0	0	3.653,69				913,24	797,19	695,88	607,45	530,25	462,87	404,05	352,70	307,88	268,75	234,60	5.575
2008	0	0	3.653,69					913,24	797,19	695,88	607,45	530,25	462,87	404,05	352,70	307,88	268,75	5.340
2009	0	0	3.653,69						913,24	797,19	695,88	607,45	530,25	462,87	404,05	352,70	307,88	5.072
2010	0	0	3.653,69							913,24	797,19	695,88	607,45	530,25	462,87	404,05	352,70	4.764
2011	0	0	3.653,69								913,24	797,19	695,88	607,45	530,25	462,87	404,05	4.411
2012	0	0	3.653,69									913,24	797,19	695,88	607,45	530,25	462,87	4.007
2013	0	0	3.653,69										913,24	797,19	695,88	607,45	530,25	3.544
2014	0	0	3.653,69											913,24	797,19	695,88	607,45	3.014
2015	0	0	3.653,69												913,24	797,19	695,88	2.406
2016	0	0	3.653,69													913,24	797,19	1.710
2017	0	0	3.653,69														913,24	913
Total	**0**		**51.151,63**															
	Total emission prevention			**913,24**	**1.710,43**	**2.406,31**	**3.013,76**	**3.544,01**	**4.006,88**	**4.410,93**	**4.763,63**	**5.071,51**	**5.340,26**	**5.574,86**	**5.779,65**	**5.958,41**	**6.114,46**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**913,24**	**2.623,67**	**5.029,98**	**8.043,73**	**11.587,74**	**15.594,62**	**20.005,54**	**24.769,17**	**29.840,68**	**35.180,94**	**40.755,80**	**46.535,45**	**52.493,86**	**58.608,32**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,60%	53,60%	db
Moisture content	0,00%	50,00%	wb
Organic carbon content (wb)	53,60%	26,80%	wb
Lignin fraction of C	0,250	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	5.108,10	1.276,77	1.114,52	972,89	849,25	741,33	647,12	564,89	493,10	430,44	375,74	327,99	286,31	249,92	218,16	8.548
2005	0	0	5.108,10		1.276,77	1.114,52	972,89	849,25	741,33	647,12	564,89	493,10	430,44	375,74	327,99	286,31	249,92	8.330
2006	0	0	5.108,10			1.276,77	1.114,52	972,89	849,25	741,33	647,12	564,89	493,10	430,44	375,74	327,99	286,31	8.080
2007	0	0	5.108,10				1.276,77	1.114,52	972,89	849,25	741,33	647,12	564,89	493,10	430,44	375,74	327,99	7.794
2008	0	0	5.108,10					1.276,77	1.114,52	972,89	849,25	741,33	647,12	564,89	493,10	430,44	375,74	7.466
2009	0	0	5.108,10						1.276,77	1.114,52	972,89	849,25	741,33	647,12	564,89	493,10	430,44	7.090
2010	0	0	5.108,10							1.276,77	1.114,52	972,89	849,25	741,33	647,12	564,89	493,10	6.660
2011	0	0	5.108,10								1.276,77	1.114,52	972,89	849,25	741,33	647,12	564,89	6.167
2012	0	0	5.108,10									1.276,77	1.114,52	972,89	849,25	741,33	647,12	5.602
2013	0	0	5.108,10										1.276,77	1.114,52	972,89	849,25	741,33	4.955
2014	0	0	5.108,10											1.276,77	1.114,52	972,89	849,25	4.213
2015	0	0	5.108,10												1.276,77	1.114,52	972,89	3.364
2016	0	0	5.108,10													1.276,77	1.114,52	2.391
2017	0	0	5.108,10														1.276,77	1.277
Total	**0**		**71.513,42**															
	Total emission prevention			**1.276,77**	**2.391,29**	**3.364,18**	**4.213,43**	**4.954,76**	**5.601,88**	**6.166,77**	**6.659,87**	**7.090,31**	**7.466,04**	**7.794,03**	**8.080,34**	**8.330,26**	**8.548,43**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**1.276,77**	**3.668,06**	**7.032,24**	**11.245,68**	**16.200,44**	**21.802,32**	**27.969,09**	**34.628,96**	**41.719,27**	**49.185,31**	**56.979,35**	**65.059,69**	**73.389,95**	**81.938,38**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,60%	53,60%	db
Moisture content	0,00%	50,00%	wb
Organic carbon content (wb)	53,60%	26,80%	wb
Lignin fraction of C	0,250	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	4.472,33	1.117,86	975,80	851,80	743,55	649,06	566,58	494,58	431,73	376,86	328,97	287,17	250,67	218,82	191,01	7.484
2005	0	0	4.472,33		1.117,86	975,80	851,80	743,55	649,06	566,58	494,58	431,73	376,86	328,97	287,17	250,67	218,82	7.293
2006	0	0	4.472,33			1.117,86	975,80	851,80	743,55	649,06	566,58	494,58	431,73	376,86	328,97	287,17	250,67	7.075
2007	0	0	4.472,33				1.117,86	975,80	851,80	743,55	649,06	566,58	494,58	431,73	376,86	328,97	287,17	6.824
2008	0	0	4.472,33					1.117,86	975,80	851,80	743,55	649,06	566,58	494,58	431,73	376,86	328,97	6.537
2009	0	0	4.472,33						1.117,86	975,80	851,80	743,55	649,06	566,58	494,58	431,73	376,86	6.208
2010	0	0	4.472,33							1.117,86	975,80	851,80	743,55	649,06	566,58	494,58	431,73	5.831
2011	0	0	4.472,33								1.117,86	975,80	851,80	743,55	649,06	566,58	494,58	5.399
2012	0	0	4.472,33									1.117,86	975,80	851,80	743,55	649,06	566,58	4.905
2013	0	0	4.472,33										1.117,86	975,80	851,80	743,55	649,06	4.338
2014	0	0	4.472,33											1.117,86	975,80	851,80	743,55	3.689
2015	0	0	4.472,33												1.117,86	975,80	851,80	2.945
2016	0	0	4.472,33													1.117,86	975,80	2.094
2017	0	0	4.472,33														1.117,86	1.118
Total	**0**		**62.612,55**															
	Total emission prevention			**1.117,86**	**2.093,66**	**2.945,46**	**3.689,01**	**4.338,07**	**4.904,65**	**5.399,23**	**5.830,95**	**6.207,82**	**6.536,79**	**6.823,95**	**7.074,63**	**7.293,44**	**7.484,45**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**1.117,86**	**3.211,52**	**6.156,98**	**9.845,99**	**14.184,06**	**19.088,71**	**24.487,94**	**30.318,89**	**36.526,71**	**43.063,50**	**49.887,45**	**56.962,08**	**64.255,52**	**71.739,97**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,60%	53,60%	db
Moisture content	0,00%	50,00%	wb
Organic carbon content (wb)	53,60%	26,80%	wb
Lignin fraction of C	0,250	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	2.330,05	582,40	508,39	443,78	387,38	338,16	295,18	257,67	224,93	196,34	171,39	149,61	130,60	114,00	99,51	3.899
2005	0	0	2.330,05		582,40	508,39	443,78	387,38	338,16	295,18	257,67	224,93	196,34	171,39	149,61	130,60	114,00	3.800
2006	0	0	2.330,05			582,40	508,39	443,78	387,38	338,16	295,18	257,67	224,93	196,34	171,39	149,61	130,60	3.686
2007	0	0	2.330,05				582,40	508,39	443,78	387,38	338,16	295,18	257,67	224,93	196,34	171,39	149,61	3.555
2008	0	0	2.330,05					582,40	508,39	443,78	387,38	338,16	295,18	257,67	224,93	196,34	171,39	3.406
2009	0	0	2.330,05						582,40	508,39	443,78	387,38	338,16	295,18	257,67	224,93	196,34	3.234
2010	0	0	2.330,05							582,40	508,39	443,78	387,38	338,16	295,18	257,67	224,93	3.038
2011	0	0	2.330,05								582,40	508,39	443,78	387,38	338,16	295,18	257,67	2.813
2012	0	0	2.330,05									582,40	508,39	443,78	387,38	338,16	295,18	2.555
2013	0	0	2.330,05										582,40	508,39	443,78	387,38	338,16	2.260
2014	0	0	2.330,05											582,40	508,39	443,78	387,38	1.922
2015	0	0	2.330,05												582,40	508,39	443,78	1.535
2016	0	0	2.330,05													582,40	508,39	1.091
2017	0	0	2.330,05														582,40	582
Total	**0**		**32.620,63**															
	Total emission prevention			**582,40**	**1.090,78**	**1.534,56**	**1.921,94**	**2.260,10**	**2.555,28**	**2.812,95**	**3.037,88**	**3.234,22**	**3.405,61**	**3.555,22**	**3.685,82**	**3.799,82**	**3.899,34**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**582,40**	**1.673,18**	**3.207,74**	**5.129,68**	**7.389,78**	**9.945,06**	**12.758,02**	**15.795,90**	**19.030,12**	**22.435,73**	**25.990,96**	**29.676,78**	**33.476,60**	**37.375,94**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,60%	53,60%	db
Moisture content	0,00%	50,00%	wb
Organic carbon content (wb)	53,60%	26,80%	wb
Lignin fraction of C	0,250	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														Total
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	
2004	0	0	1.869,32	467,24	407,86	356,03	310,79	271,29	236,82	206,72	180,45	157,52	137,50	120,03	104,77	91,46	79,84	3.128
2005	0	0	1.869,32		467,24	407,86	356,03	310,79	271,29	236,82	206,72	180,45	157,52	137,50	120,03	104,77	91,46	3.048
2006	0	0	1.869,32			467,24	407,86	356,03	310,79	271,29	236,82	206,72	180,45	157,52	137,50	120,03	104,77	2.957
2007	0	0	1.869,32				467,24	407,86	356,03	310,79	271,29	236,82	206,72	180,45	157,52	137,50	120,03	2.852
2008	0	0	1.869,32					467,24	407,86	356,03	310,79	271,29	236,82	206,72	180,45	157,52	137,50	2.732
2009	0	0	1.869,32						467,24	407,86	356,03	310,79	271,29	236,82	206,72	180,45	157,52	2.595
2010	0	0	1.869,32							467,24	407,86	356,03	310,79	271,29	236,82	206,72	180,45	2.437
2011	0	0	1.869,32								467,24	407,86	356,03	310,79	271,29	236,82	206,72	2.257
2012	0	0	1.869,32									467,24	407,86	356,03	310,79	271,29	236,82	2.050
2013	0	0	1.869,32										467,24	407,86	356,03	310,79	271,29	1.813
2014	0	0	1.869,32											467,24	407,86	356,03	310,79	1.542
2015	0	0	1.869,32												467,24	407,86	356,03	1.231
2016	0	0	1.869,32													467,24	407,86	875
2017	0	0	1.869,32														467,24	467
Total	0		26.170,45															
	Total emission prevention			467,24	875,10	1.231,13	1.541,91	1.813,20	2.050,02	2.256,74	2.437,19	2.594,71	2.732,21	2.852,24	2.957,01	3.048,47	3.128,31	tonne CO_2-eq/yr
	Cumulative total emission prevention			467,24	1.342,33	2.573,46	4.115,37	5.928,58	7.978,59	10.235,33	12.672,52	15.267,23	17.999,44	20.851,68	23.808,69	26.857,17	29.985,48	tonne CO_2-eq/project

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21	
Density methane	0,7	kg/m^3
Methane concentration biogas	60%	
Half-life biomass (tau)	5,1	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,60%	53,60%	db
Moisture content	0,00%	50,00%	wb
Organic carbon content (wb)	53,60%	26,80%	wb
Lignin fraction of C	0,250	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	3.772,08	942,83	823,02	718,43	627,13	547,44	477,87	417,14	364,13	317,86	277,46	242,20	211,42	184,56	161,10	6.313
2005	0	0	3.772,08		942,83	823,02	718,43	627,13	547,44	477,87	417,14	364,13	317,86	277,46	242,20	211,42	184,56	6.151
2006	0	0	3.772,08			942,83	823,02	718,43	627,13	547,44	477,87	417,14	364,13	317,86	277,46	242,20	211,42	5.967
2007	0	0	3.772,08				942,83	823,02	718,43	627,13	547,44	477,87	417,14	364,13	317,86	277,46	242,20	5.756
2008	0	0	3.772,08					942,83	823,02	718,43	627,13	547,44	477,87	417,14	364,13	317,86	277,46	5.513
2009	0	0	3.772,08						942,83	823,02	718,43	627,13	547,44	477,87	417,14	364,13	317,86	5.236
2010	0	0	3.772,08							942,83	823,02	718,43	627,13	547,44	477,87	417,14	364,13	4.918
2011	0	0	3.772,08								942,83	823,02	718,43	627,13	547,44	477,87	417,14	4.554
2012	0	0	3.772,08									942,83	823,02	718,43	627,13	547,44	477,87	4.137
2013	0	0	3.772,08										942,83	823,02	718,43	627,13	547,44	3.659
2014	0	0	3.772,08											942,83	823,02	718,43	627,13	3.111
2015	0	0	3.772,08												942,83	823,02	718,43	2.484
2016	0	0	3.772,08													942,83	823,02	1.766
2017	0	0	3.772,08														942,83	943
Total	0		52.809,14															
	Total emission prevention			**942,83**	**1.765,85**	**2.484,28**	**3.111,41**	**3.658,85**	**4.136,72**	**4.553,86**	**4.917,99**	**5.235,84**	**5.513,31**	**5.755,51**	**5.966,93**	**6.151,49**	**6.312,59**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**942,83**	**2.708,69**	**5.192,97**	**8.304,38**	**11.963,23**	**16.099,94**	**20.653,80**	**25.571,78**	**30.807,62**	**36.320,93**	**42.076,44**	**48.043,37**	**54.194,86**	**60.507,45**	**tonne CO_2-eq/project**

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

General input data		
Conversion factor organic carbon to biogas (a)	1,87	m^3 biogas/kg carbon
GWP CH_4	21,0	
Density methane	0,654	kg/m^3
Methane concentration biogas	0,60	
Half-life biomass (tau)	5,10	year
Decomposition constant (k)	0,136	$year^{-1}$
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)	53,60%	53,60%	db
Moisture content	0,00%	50,00%	wb
Organic carbon content (wb)	53,60%	26,80%	wb
Lignin fraction of C	0,250	0,286	

Year	Fresh biomass prevented from stockpiling or taken from stockpile			Year														
	Biomass from stockpile (ton_w)	Age of biomass (years)	Fresh (ton_w)	2004 ton CO2-eq	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
2004	0	0	3.759,70	939,74	820,32	716,07	625,07	545,64	476,30	415,77	362,94	316,81	276,55	241,41	210,73	183,95	160,57	6.292
2005	0	0	3.759,70		939,74	820,32	716,07	625,07	545,64	476,30	415,77	362,94	316,81	276,55	241,41	210,73	183,95	6.131
2006	0	0	3.759,70			939,74	820,32	716,07	625,07	545,64	476,30	415,77	362,94	316,81	276,55	241,41	210,73	5.947
2007	0	0	3.759,70				939,74	820,32	716,07	625,07	545,64	476,30	415,77	362,94	316,81	276,55	241,41	5.737
2008	0	0	3.759,70					939,74	820,32	716,07	625,07	545,64	476,30	415,77	362,94	316,81	276,55	5.495
2009	0	0	3.759,70						939,74	820,32	716,07	625,07	545,64	476,30	415,77	362,94	316,81	5.219
2010	0	0	3.759,70							939,74	820,32	716,07	625,07	545,64	476,30	415,77	362,94	4.902
2011	0	0	3.759,70								939,74	820,32	716,07	625,07	545,64	476,30	415,77	4.539
2012	0	0	3.759,70									939,74	820,32	716,07	625,07	545,64	476,30	4.123
2013	0	0	3.759,70										939,74	820,32	716,07	625,07	545,64	3.647
2014	0	0	3.759,70											939,74	820,32	716,07	625,07	3.101
2015	0	0	3.759,70												939,74	820,32	716,07	2.476
2016	0	0	3.759,70													939,74	820,32	1.760
2017	0	0	3.759,70														939,74	940
Total	0		52.635,83															
	Total emission prevention			**939,74**	**1.760,06**	**2.476,13**	**3.101,20**	**3.646,84**	**4.123,14**	**4.538,91**	**4.901,85**	**5.218,66**	**5.495,21**	**5.736,62**	**5.947,35**	**6.131,30**	**6.291,88**	**tonne CO_2-eq/yr**
	Cumulative total emission prevention			**939,74**	**2.699,80**	**5.175,92**	**8.277,12**	**11.923,96**	**16.047,10**	**20.586,01**	**25.487,86**	**30.706,52**	**36.201,73**	**41.938,35**	**47.885,70**	**54.017,00**	**60.308,88**	**tonne CO_2-eq/project**

4.3 Annex III Heat Demand and Sawdust Consumption Baseline I, II, III and IV

4.4 Annex IV References

- The World Bank – PCFplus Research Project no. 1050, Project title: Methane and Nitrous Oxide Emissions from Biomass Waste Stockpiles – Final Report – August 2002.

  Especially the methane emission model and related spreadsheet model.

- The BGT project in the Czech Republic was validated by the consultant company SGS Société Générale de Surveillance S.A. and the project was accepted by the Dutch government in the first ERUPT.

- The Prototype Carbon Fund (PCFplus Research) study: CH_4 emissions from biomass stockpiles – Final report for the Silvosa pile, performed by BTG biomass technology group BV Consulting Company.

- The Prototype Carbon Fund – Baseline Study: Bulgaria – Wood Industries, Silvosa Biomass Boiler Project, performed by BTG biomass technology group BV Consulting Company.

- Federal Office for Foreign Economic Affairs – Financial Assistance to Central and Eastern Europe: Swiss Thermal Energy Project in Buzau and Pascani, Romania, performed by Ernst Basler + Partner AG.

- The Australian Greenhouse Office: Waste Management Workbook – Methane Capture and Use.

- Danish Energy Authority – Manual for Project Developers – version 1 – May 2002: Joint Implementation and Clean Development Mechanism projects.