CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 03 - in effect as of: 28 July 2006

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

- Title of the project activity: Mondi Richards Bay Biomass Project
- Version number of the document: Version N^{o} 04
- Date of the document: 18 October 2006

A.2. Description of the project activity:

The project activity includes the collection of biomass residues from plantations and nearby chipping facilities, transported to Mondi Business Paper Richards Bay (hereafter referred to as Mondi), cleaned (for example removal of metal objects and sand), shredded and fired as fuel in a co-fired boiler, replacing coal. The proposed project activity is designed to increase the use of self generated bark and enable the introduction of third party generated biomass residues as feed into a co-fired boiler for the generation of steam. The proposed project consists of the following components:

- **Collection** of (1)biomass residues that consist of fines, contaminated wood chips, off-cuts etc. presently landfilled at a municipal landfill site and (2)plantation residues currently left in the plantations to decay and (3)additional biomass waste from the debarking process in the wood yard, previously not fired due to handling and capacity restrictions.
- **Transport** of the collected biomass from nearby chipping facilities and plantations to the Mondi operation.
- The use of biomass residues in the co-fired boiler involves a significant additional capital investment in a new dedicated biomass supply chain established for the purpose of the project (i.e. collection and cleaning new sources of biomass residues that will otherwise not be used for energy purposes).
- The replacement of coal (fossil fuel) by biomass residues in an existing co-fired boiler that produces steam at the Mondi operation.

Mondi SilvaCel and other wood chipping operations in the area of Richards Bay transport and landfill biomass waste at a local municipal landfill site. With the implementation of the project activity, these operations will no longer transport the biomass residues for landfill. The biomass residues are collected at the chipping operations, transported to the Mondi operation where it is processed through a cleaning and hogging routine before it is fired in a co-fired boiler. Other potential sources of biomass from surrounding plantations (stumps, off-cuts and branches) typically left in the plantations to decay will be collected, transported to the Mondi operation, cleaned to ensure compliance to the necessary quality requirements before being fired in the co-fired boiler.

A co-fired boiler is presently used at Mondi to generate heat for plant use in the production of pulp and linerboard. Biomass residues from chipping facilities that are landfilled and other potential biomass waste from plantations will be used as a renewable energy resource in a co-fired boiler, thereby replacing coal in the co-fired boiler during normal operating conditions. The co-fired boiler is utilised below capacity for biomass, mainly because of the quality requirements that biomass residues have to comply to for it to be fired in the co-fired boiler. Implementation of biomass cleaning and shredding equipment in the wood handling area of the operation will ensure that biomass residues comply to the necessary quality requirements and therefore introduce the potential to increase biomass residue firing in the co-fired boiler by approximately 290 tonnes per day (refer to Table 26: Historical biomass and coal consumption). By introducing additional biomass residue, the total quantity of fossil fuel (coal) currently utilised to produce heat to the operation will reduce. Methane emissions from landfilling biomass waste and methane emissions generated by decaying plantation waste in the baseline scenario will be avoided by implementation of the project activity. The total amount of emission reductions delivered as a result of the project activity, is approximately 4.7 million tonnes CO_{2e} over a 10 year period.

The project activity is presented by Mondi Business Paper, an international pulp and paper manufacturing company.

The purpose of the project activity is to (1)maximise the amount of biomass residues fired in the co-fired boiler, (2)to prevent biomass residues from nearby facilities going to landfill and (3)to prevent biomass residue in plantations from decay. Mondi believes that heat generation from biomass residue constitutes a sustainable source of energy generation that brings obvious advantages to mitigate global warming. Using the available natural resources in a rational way, the Mondi project activity helps to promote the development of renewable energy sources in South Africa, in particular the use of biomass generated as a by-product of the forestry industry, which has a significant potential in the country.

An incentive to Mondi Business Paper, the investor, to pursue the sourcing of biomass residues as energy source for the Richards Bay operation is the prospect to develop CDM opportunities. The proposed project activity will publicly confirm its participant's commitment to environmental improvement. When registered with the CDM Executive Board, the Biomass project will be one of the first industrial related CDM projects in the pulp and paper industry in South Africa. Project participants, particularly Mondi, will also benefit from pioneering the learning experience for the CDM process, opening a new and attractive option for future project developments, in Mondi and South Africa.

The project contributes to sustainable development in South Africa (the host country) in a number of ways:

1. The use of renewable energy is in line with the targets set by the national government (Department of Minerals and Energy) to increase the use of biomass as energy source in South Africa[1]. The use of gas to generate electricity introduces a step towards the diversification of supply options in the South African electricity and energy supply mix, reducing the heavy reliance (>70%) on coal for energy services.
2. The project activity complies with relevant legislation (mainly air quality)[2].
3. Through implementation of new hogging equipment, the country is gaining access to a technology that has not been used in the region on this scale before.
4. Energy efficiency improvement and the use of renewable energy reduce the use of fossil based resources, contributing to the sustainable use of natural resources.
5. The use of biomass residue rather than coal as a fuel has local environmental benefits in that there is a reduction in the emissions of SO_2 and NOx, thereby improving the local air quality in Richards Bay.
6. Furthermore, the project activity accomplishes an additional greenhouse (GHG) reduction benefit derived from a reduced disposal of biomass residue to landfill, that results in less methane emissions from landfill in the Richards Bay area.
7. The project activity reduces methane emissions that are formed in plantations as a result of natural decay of plantation residues.

There will be a small increase in employment due to construction and commissioning of the equipment, and in the supply of the additional transport needs. This will occur specifically in the small to medium sized enterprises (SMME).

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[1] White Paper on Renewable Energy (2003): http://www.dme.gov.za/energy/renewable.stm, October 2006

[2] The boiler emissions comply to existing air quality permit requirements. Permit: Registration in terms of the Atmospheric Pollution Prevention Act, Act 45 of 1965, 1382/4. 16 February 2004

A.3. Project participants:

Name of the Party involved	Private or public entity (ies) project participants (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant
Republic of South Africa Government (Host)	Mondi Business Paper South Africa Richards Bay Mill	No

A.4. Technical description of the project activity:

The co-fired biomass boiler at the Richards Bay Mill is currently operated below its designed capacity in terms of biomass utilisation. The co- fired boiler has the capacity to fire more than 175 000 t/yr of wet biomass (bark and wood waste) but, due to flow limitations on the biomass feed to this boiler, the actual quantity fired is less than half this amount. Hence coal substitution has to take place for the required steam outputs from the boiler. By modifying the biomass feed system to improve the flow rates of biomass into the boiler, it is possible to fire more than 500 tonnes of wet biomass residues per day. Coal consumption in the boiler can therefore be reduced. Additional or imported biomass from outside the mill will need to be brought on site to meet this target.

This project involves two modifications to the biomass feed system and one to the fly ash handling system on the boiler. Modifications to the existing co-fired boiler will be made (if necessary) to accommodate a higher ratio of biomass to coal in the feed. These modifications will not increase the total heat capacity delivered by the co-fired boiler, i.e. the total capacity of the co-fired boiler will remain unchanged. It is only the fuel mix in the co-fired boiler that will change as a result of the project activity. The total steam delivery capacity of the boiler will not change. New technology will be introduced in the wood yard to clean the biomass residues received from chipping facilities and to ensure that the biomass residues comply with the necessary quality requirements for boiler firing. The biomass residue feed to the boiler must be free of any metal and sand. In addition, the feed must be as homogenous as possible to enable problem free operation of the co-fired boiler. The various sources of biomass will provide a variety of forms of biomass residues. To ensure a fairly homogenous feed into the co-fired boiler, the biomass residue will pass through a cleaner and shredder system.

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

The host country is South Africa

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

The Province is Kwa-Zulu Natal

A.4.1.3. City/Town/Community etc:

The town is Richards Bay in the City of uMhlathuze

A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity (maximum one page):

The project activity will be located at the Mondi operation. This operation is located in Richards Bay, a harbour and industrial town that has developed since the early 1980's and is situated approximately 180 km north of Durban on the East Coast of South Africa. The Mill site has a spacious layout with ample space for large-scale expansions. It has good road and rail connections, and is located only a few kilometres from the Richards Bay harbour. The Richards Bay mill is an integrated pulp and paper process producing bleached eucalyptus pulp and white top linerboard. The mill was commissioned during October 1984.

Richards Bay is surrounded by plantation forests that supply wood to a variety of wood related industries.

Figure 1: Location of South Africa and Richards Bay

Figure 1: Location of South Africa and Richards Bay

Figure 2: Mondi Business Paper Richards Bay operation

A.4.2. Category(ies) of project activity:

The Mondi Biomass project is categorized into sectoral scopes 1 (Energy industries (renewable - / non-renewable sources) and 4 (Manufacturing industry).

A.4.3. Technology to be employed by the project activity:

The project activity includes the investment in technology that will allow the replacement of all or part of the fossil fuels by biomass residues in the existing energy generation plant. The project proposes the installation of cleaning and hogging equipment in the wood yard of the Mondi plant.

Currently, the operation continually utilises a co-fired boiler that produces heat for process use. The type of biomass waste that is fired in the boiler has to adhere to certain quality requirements and therefore, the biomass currently fired in the boiler consists of mainly bark generated by the process and some fines. No biomass waste from potential external sources can be utilised because of the poor quality associated with it and the amount of biomass waste used from the existing debarking operation on-site is limited due to poor quality. To utilise biomass waste from external sources and optimise the co-fired boiler for biomass waste, biomass residues cleaning equipment has to be implemented in the wood handling area of the mill.

The proposed technology includes equipment to separate, shred, clean and convey the processed biomass residues to the boiler.

This project involves modifications to the biomass feed system and to the fly ash handling system on the boiler:

4.1 Installation of a new Saalastic Crush Size 1212 Bark Shredder in the Wood yard to effectively shred all the hardwood slivers, logs and planks that currently clog up and damage the primary biomass feed system.

4.2 Installation of a secondary biomass feed system to tie into the primary feed system and a smaller Saalasti Crush Size 0609 Bark Shredder to handle the imported biomass.

4.3 Upgrade of the fly ash conveyors on the power boiler to handle the ash that will be generated.

By installing a Saalastic Crush Size 1212 Shredder designed to process hardwood slivers, logs and planks, the texture of the biomass will be a lot finer and fibres a lot shorter. This will improve the operation of the feed screws substantially and the feed rate will be steadier.

The new equipment does not introduce complex operational control methodologies compared to the rest of the operation and therefore, minimum additional training is required. Training of operators will be conducted prior to commissioning of the equipment. The control system for the new equipment will be integrated with the existing DCS (Digital Control System) and training will be conducted prior and during commissioning of the equipment. Maintenance of the equipment will be done by Mondi and will be integrated with the continuous maintenance programme of the mill[3].

The replacement of coal with biomass residues in the co-fired boiler will reduce GHG emissions. It is conceived that implementation of this technology will encourage replication in other pulp and paper mills and other industry sectors within South Africa and the region.

Table 1:Description of equipment implemented

Description of equipment	Tag number	Motor kW	Motor F.L.C.	Motor running current	Motor volts
Saalasti Crusher motor	321-370	500 kW	110 amp	84 amps	3300 vlt
Feed Conveyor	321-531	7.5 kW	12 amp	6 amps	525 vlt
Inclined Conveyor	321-374	5.5 kW	8.7 amp	5.0 amps	525 vlt
Hydraulic Pack	321-375	3.0 kW	4.4 amp	4.0 amps	525 vlt
Kone Shredder motor	321-336	200 kW	271 amp	amps	525 vlt

<u>Note on safety</u>:

Adequate fire fighting prevention equipment is installed in the wood yard and on the boiler feed system. The Richards Bay Mill and City of uMhlathuze (local authority) fire fighting personnel undergo regular fire fighting and prevention training. The biomass residue reticulation system is designed such that biomass residues are not left in storage for long periods in order to minimise the risk of spontaneous combustion.

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[3] ISO document

A.4.4 Estimated amount of emission reductions over the chosen crediting period:

Crediting period: 10 years from October 2005 onwards

Table 2: Estimated emissions reductions over the crediting period

Years	**Annual estimation of emissions reductions in tonnes of $CO_{2\,e}$**
2005-2006	109587
2006-2007	195786
2007-2008	275948
2008-2009	356506
2009-2010	442921
2010-2011	528439
2011-2012	599190
2012-2013	668332
2013-2014	735903
2014-2015	801937
Total estimated reductions (tonnes of CO_2e)	**4,714,548**
Total number of crediting years	**10**
Annual average over the crediting period (tonnes of CO_2e)	**471,455**

A.4.5. Public funding of the project activity:

No public funding is involved in the proposed project. Mondi Business Paper funded the investment with own resources.

SECTION B. Application of a baseline and monitoring methodology

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

The name of the baseline methodology applied to the project activity is:
"Baseline Methodology for heat generation from biomass residues"., and is referenced as AM0036/Version 01, 29 September 2006.

The methodology draws on 1) *Tool to determine methane emissions avoided from dumping waste at the solid waste disposal site*[4] and 2) *Tool for the demonstration and assessment of additionality (version 02)*[5]

B.2 Justification of the choice of the methodology and why it is applicable to the project activity:

Methodology AM0036 is applied in this particular project. The methodology is applicable to project activities that switch from use of fossil fuels to biomass residues in and existing co-fire boiler.
The project activity is the retrofit of an existing co-fired boiler to enable an increase in the amount of biomass use beyond historical levels. Without the project activity an increase in biomass residue use would not be possible. Capital investment is required to establish a dedicated biomass residue supply chain from new sources of biomass residues and feeding system (including cleaning equipment) into the boiler. Therefore, the proposed project activity is eligible for use of this methodology under scenario 4(b)[6]. The project activity is based on the operation of a heat generation boiler in an industrial plant where biomass residues are generated, supplemented with biomass residues procured from nearby chipping facilities and plantations.

Nine required conditions for which AM0036 is applicable[7]:

1. The heat generated in the boiler is:

- **Not used for power generation; or**
- **If power is generated with heat from the boiler, it is not increased as a result of the project activity, i.e.,**
  a) site, the power generation capacity installed remains unchanged due to the implementation of the project activity and this power generation capacity is maintained at the pre-project level throughout the crediting period; and
  b) the annual power generation during the crediting period is not more than 10% larger than the highest annual power generation in the most recent three years prior to the implementation of the project activity.

The co-fired boiler contributes to less than 5% of the electricity generated on site and is therefore not significant. For the purpose of this project activity, the co-fired boiler is used for the generation of heat only. No additional investment to increase the heat generation capacity is made to the co-fired boiler as a result of the project activity. The total output capacity of the co-fired boiler will not change

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[4] http://cdm.unfccc.int/EB/026/eb26_repan14.pdf; EB 26 Meeting report Annex 14

[5] http://cdm.unfccc.int/methodologies/PAmethodologies/AdditionalityTools/Additionality_tool.pdf

[6] Table 1, AM0036 / Version 1

[7] Page 3 and 4 of AM0036

as a result of the project activity throughout the crediting period. The methodology is eligible and can be treated as heat only[8].

2. The use of biomass residues or increasing the use of biomass residues beyond historical levels is technically not possible at the project site without a significant capital investment in

- **Either the retrofit or replacements of existing boilers or the installation of new boilers;**
- **Or in a new dedicated biomass supply chain established for the purpose of the project (e.g. collecting and cleaning contaminated new sources of biomass residues that could otherwise not be used for energy purposes).**

This project activity involves minor retrofitting to an existing boiler (modifications necessary on the ash system and air distribution system). The project activity also requires larger capital investment to implement a dedicated biomass residue handling and supply system (refer to technical description of the project activity). The project activity uses biomass residues above historical levels because new sources of biomass residues have been made available through capital investment in the biomass supply chain (wood yard facility including the biomass residue handling system).

3. Existing boilers at the project site have used no biomass or have used only biomass residues (but no other type of biomass) for heat generation during the most recent three years[9] prior to the implementation of the project activity.

The boiler at Mondi has used only biomass residue as co-firing material since 1986.

4. No biomass types other than *biomass residues*, as defined above, are used in the boiler(s) during the crediting period (some fossil fuels may be co-fired);

The project is designed to utilise only the following types of biomass residues: bark, off-cuts, chipping plant waste, fines and plantation residue (stumps, coppice). To ensure stable operating conditions of the boiler, coal might be fired on occasion to stabilize the air distribution and combustion in the boiler.

5. For projects that use biomass residues from a production process (e.g. production of sugar or wood panel boards), the implementation of the project shall not result in an increase of the processing capacity of raw input (e.g. sugar, rice, logs, etc.) or in other substantial changes (e.g. product change) in this process;

The implementation of the project will not result in an increase of the processing capacity of raw input (wood logs) or the production capacity of the final product. The sources of energy are not directly linked to either the raw material input (wood) or the final product (pulp and linerboard) and therefore, the project activity does not impact on the production capacity of the mill. The biomass residues sourced from chipping plants are classified as a waste stream at the chipping facility and supplying it to Mondi does not impact on the raw material input or processing capacity thereof. Removing biomass residue from the existing plantations does not cause any substantial change in the plantation cycles or the amount of logs harvested per hectare.

6. The biomass residues used at the project site, site where the project activity is implemented, should not be stored for more than one year;

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[8] The conservative approach is followed in that emission reductions associated with the replaced grid electricity are not accounted for in the project activity. The efficiency and performance of the co-fired boiler is better that the overall efficiencies reached at the electricity supplier and the amount of transfer and distribution losses are insignificant due to the short distances over which electricity is transported compared to imported electricity from the grid. It is therefore a conservative approach to not take into account the potential emission reductions generated from replaced electricity.

[9] The three most recent historical years prior to the implementation of the project activity are representative of the situation at the project site.

The wood yard operates the biomass residue collection and reticulation system in such way that ensures that no biomass residues are stored for more than one year.

7. No significant energy quantities, except from transportation or mechanical treatment of the biomass residues, are required to prepare the biomass residues for fuel combustion, i.e. projects that process the biomass residues prior to combustion (e.g. esterification of waste oils) are not eligible under this methodology.

Mechanical processing to clean and shred biomass use minimum amount of electricity. Refer to Table 1:Description of equipment implemented and Table 19: Indirect emissions from imported electricity.

8. The biomass residues are directly generated at the project site or transported to the project site by trucks.

Bark is generated at Mondi; chipping residues and plantation residues are transported to the project site by trucks.

9. In case of project activities that involve the replacement or retrofit of existing boiler(s), all boiler(s) existing at the project site prior to the implementation of the project activity should be able to operate until the end of the crediting period without any retrofitting or replacement, i.e. the remaining technical lifetime of each existing boiler should at the start of the crediting period be larger than the duration of the crediting period (7 or 10 years as applicable). For the purpose of demonstrating this applicability condition, project participants should determine and document the typical average technical lifetime of boilers in the country and sector in a conservative manner, taking into account common practices in the sector and country. This may be done based on industry surveys, statistics, technical literature, historical replacement records of boilers in the company, etc. The age of the existing boiler(s) and the average technical lifetime of boilers in the country and sector should be documented in the CDM-PDD.

It is common practice to refurbish and maintain industrial coal fired boilers in South Africa that ultimately results in extended technical lifetimes of the boilers. Boiler efficiency depends largely on operational procedures.[10]This practice is extended to the pulp and paper industry in South Africa and has been applied by Mondi since 1984. If common practice is maintained, the expected lifetime of the co-fired boiler at Mondi exceeds 10 years.

Required plausible baseline scenarios for which AM0036 is applicable[11]:

The most plausible baseline scenario[12] is reflected by option H2, i.e. the continued operation of the existing co-fired boiler using the same fuel mix as in the past. In forests surrounding the Richards Bay area, plantation biomass residues are left to decay under mainly aerobic conditions on fields (B1) or in

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[10] Efficiency of industrial coal fired boilers in South Africa, CSIR study conducted for the Department of Minerals and Energy, 1999.

[11] Page 3 and 4 of AM0036.

[12] From AM0036 page 4: Furthermore, this methodology is only applicable if the most plausible baseline scenario(s):

- For heat generation is either case H2 (Continued operation of the existing boiler(s) using the same fuel mix or less biomass residues as in the past) or case H5 (Continued operation of the existing boiler(s) using the same fuel mix or less biomass residues as in the past AND installation of (a) new boiler(s) that is/are fired with the same fuel type(s) and the same fuel mix (or a lower share of biomass) as the existing boiler(s)); and
- For the use of biomass residues is case B1, B2, B3, B4 and/or B5. If case B5 is the most plausible scenario, the methodology is only applicable if:

a) The plant where the biomass residues would be used as feedstock in the absence of the project activity can be clearly identified throughout the crediting periods; and
b) The fuels used as substitutes for the biomass residues at that plant can be monitored by project participants.

some cases (minor) biomass residues are burnt in an uncontrolled manner without utilizing them for energy purposes (B3). The biomass residues from chipping facilities are landfilled in landfills. Therefore, AM0036 is applicable.

Applicability conditions from "*Tool to determine methane emissions avoided from dumping waste at the solid waste disposal site*"[13]:

This tool calculates baseline emissions of methane from waste that would in the absence of the project activity be disposed at solid waste disposal sites (SWDS). Emission reductions are calculated with a first order decay model. The tool is applicable in cases where the solid waste disposal site where biomass waste will be landfilled, can be identified. This is the case for this particular project as a municipal landfill site exists where the waste is landfilled. The tool is not applicable to hazardous wastes. No hazardous waste is generated in the project activity.

B.3. Description of the sources and gases included in the project boundary

The project activity will reduce anthropogenic GHG emissions by replacing fossil fuel-based heat with heat generated from renewable biomass residue. The project will assist South Africa with greenhouse gas (GHG) reduction by curbing methane emissions formed during biomass residue (derived from wood chipping operations and forest plantations) decay.

Sources of greenhouse gas emissions included in the project boundary

1. Avoidance of methane emissions formation associated with landfill of biomass residue and decay in plantations
    - Methane formation from landfilled biomass and decaying plantation waste will be prevented, as the biomass residues will not be landfilled in future.
2. Reduction in CO_2 and CH_4 emissions from coal burnt in the co-fired boiler on site
    - The replacement of coal by biomass residues in the co-fired boiler at the operation will result in a reduction of GHG emissions at the operation associated with the combustion of coal.
3. Reduction in emissions associated with the rail transport of coal to the operational site
    - Coal is transported by rail to the operational site. Coal will be reduced when the project is implemented, thereby reducing coal transport to the operation. The reduction of GHG emissions from transport will be in proportion to the reduction in coal use and its replacement by biomass. The conservative approach is taken in that emission reductions from reduced rail transport are not accounted. In addition, biomass residues from chipping facilities are transported over shorter distances (the landfill is further away from chipping facilities that Mondi). Once again, to maintain a conservative approach, the emission reductions from reduced transport are not accounted for.

The project differs from the general practice hitherto seen in South Africa for the handling of biomass residue and utilization. It is not common practice to generate energy from biomass residue. Whilst other projects rely on one large source of fuel for the supply of all or nearly all of the biomass used at their power plants, this project sources a part of its consumption requirements from a number of small suppliers (mostly local chipping facilities and nearby plantations), for whom efficient energy generation from biomass is not feasible[14]. In the absence of the project activity, the biomass residues at the chipping facilities will be landfilled or left to decay in the forest operations.

To handle additional incoming biomass residues with variations in quality, equipment will be installed in the wood yard to shred and clean biomass residues received from nearby chipping facilities and plantations. The equipment will require an amount of electricity import from the grid, which will result in a small increase (in comparison to the decrease in coal use) in GHG emissions.

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[13] Page 4 of AM0036.

[14] Requires large capital expenditure to achieve high efficiencies and logistics are problematic.

Table 3: Emissions sources included in or excluded from the project boundary shows the emissions included and excluded.

Table 3[15]: Emissions sources included in or excluded from the project boundary

	Source	**Gas**	**Included as per methodology**	**Included in this project**	**Justification / Explanation**
Baseline	Heat generation	CO_2	Included	√	Main emission source
		CH_4	Excluded	√	Excluded for simplification. This is conservative.
		N_2O	Excluded	√	Excluded for simplification. This is conservative.
	Uncontrolled burning or decay of surplus biomass	CO_2	Excluded	√	It is assumed that CO_2 emissions from surplus biomass residues do not lead to changes of carbon pools in the LULUCF sector.
		CH_4	To be decided by project participants	**Included**	Project participants may decide to include this emission source. [a]
		N_2O	Excluded	√	Excluded for simplification. This is conservative. Note also that emissions from natural decay of biomass are not included in GHG inventories as anthropogenic sources. [a]
Project Activity	On-site fossil fuel or electricity consumption for hoppers and	CO_2	Included	√	May be an important emission source
		CH_4	Excluded	√	Excluded for simplification. This emission source is assumed to be very small. [c]

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[15] Table 2 in AM0036.

	Source	Gas	Included as per methodology	Included in this project	Justification / Explanation
		N_2O	Excluded	√	Excluded for simplification. This emission source is assumed to be very small. [c]
	Off-site transportation of biomass	CO_2	Included	√	May be an important emission source
		CH_4	Excluded	√	Excluded for simplification. This emission source is assumed to be very small. [c]
		N_2O	Excluded	√	Excluded for simplification. This emission source is assumed to be very small. [c]
	Combustion of biomass for heat generation	CO_2	Excluded	√	It is assumed that CO_2 emissions from surplus biomass do not lead to changes of carbon pools in the LULUCF sector.
		CH_4	Included or excluded	**Included**	This emission source must be included if CH_4 emissions from uncontrolled burning or decay of biomass in the baseline scenario are included. [b]
		N_2O	Excluded	√	Excluded for simplification. This emission source is assumed to be small.
	Biomass storage	CO_2	Excluded	√	It is assumed that CO_2 emissions from surplus biomass residues do not lead to changes of carbon pools in the LULUCF sector.
		CH_4	Excluded	√	Excluded for simplification. Since biomass is stored for not longer than one year, this emission source is assumed to be small.
		N_2O	Excluded	√	Excluded for simplification. This emissions source is assumed to be very small.

The project boundary includes all activities that are under the control of the project activity. The boundary includes:

- the co-fired biomass boiler at Mondi and all new or retrofitted equipment in the wood yard implemented to handle the additional biomass fuel;
- vehicle transport of the biomass from wood chipping facilities and plantations to the Richards Bay operation;
- methane generation from landfill of biomass residues and plantation residues left for decay in the absence of the project activity.

Direct on-site emissions for the project activity and baseline are:

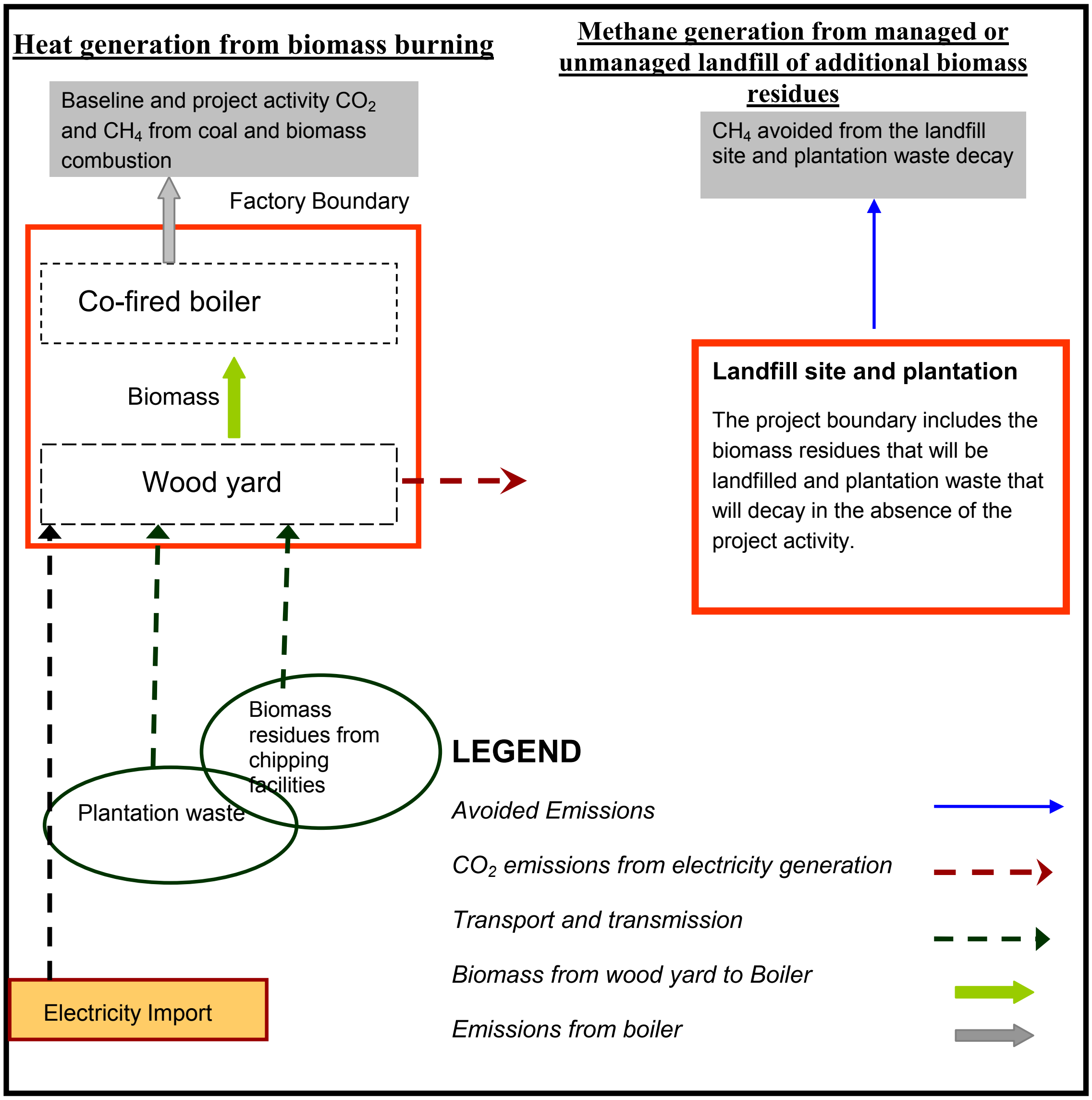
- CH_4 emissions from controlled combustion of additional biomass in the co-fired boiler.
- CO_2 emissions from the combustion of additional supplementary fossil fuel in the co-fired boiler.

Direct off-site emissions for the project activity are:

- CO_2 emissions from additional fossil fuel consumption from on-site biomass transportation to the operation.

CO_2 emissions from on-site electricity consumption that is attributable to the new equipment implemented in the wood yard.

Figure 3: Project activity boundary



B.4. Description of how the baseline scenario is identified and description of the identified baseline scenario:

The following steps 1 to 9 are applied to establish the project baseline scenario and emissions. The key information and the data sources that were used in the determination of the baseline, are included in Annex 3.

STEP 1. Identification of alternative scenarios to the proposed CDM project activity that are consistent with current laws and regulations

Realistic and credible alternatives were separately determined regarding:

- What happens to the biomass residues in the absence of the project activity i.e. the methane generation from managed or unmanaged landfill/plantations
- Heat generation in the absence of the project activity.

There are/were no regulations and programs, either on national, regional or local that constrain the facility from using coal, nor policies that enforce replacement of coal with biomass residues. All the realistic alternatives identified in step 1, summarized in *Table 4: Alternative baseline options and barrier analysis*, comply with the relevant existing laws and regulation in the host country, South Africa.

STEP 2: Barrier analysis to eliminate alternatives to the project activity that face prohibitive barriers

Plausible alternatives to the project activities are listed and briefly described in table 3. The aspects that are considered in identifying possible baseline scenarios are:

- Legal constraints.
- Strategic considerations within the company, pre – existing practices or common practice.
- Availability of technology and applicability of technology to the project activity.
- Consideration of technology developments within the national scenario
- Economics: in the case of an alternative being clearly uneconomical
- Technological barriers

The identified barriers are only sufficient grounds for demonstration of additionality if they would prevent Mondi from carrying out the proposed project activity.

Comment: Step 2 in Table 4 reflects the content required in *Sub-step 3a of* "*Tool for the demonstration and assessment of additionality*". The likely baseline scenarios column in Table 4 reflects the content required in *Sub-step 3b.*

Table 4: Alternative baseline options and barrier analysis

	Step 1 **Alternative baseline options**	**Step 2** **Barriers**	**Likely baseline scenarios**
Heat generation from biomass residues			
H1	The proposed project activity not undertaken as a CDM project activity (heat generation with biomass residues). Generation of	The amount of risk relating to inconsistent supply and the quality of biomass residues introduced to Mondi by implementing the project activity is significant. The capital expenditure that must be	No

	Step 1 Alternative baseline options	Step 2 Barriers	Likely baseline scenarios
	steam in co-fired boiler using biomass residue from chipping facilities, plantation waste and bark thereby replacing most of the coal based fuel (proposed project activity);	incurred to enable an increase of biomass residues to the boiler is large. Uncertainty regarding cost of fuel for transport and competitive cost of coal provides little incentive to Mondi to undertake the project, considering the amount of risk the project will introduce.	
H2	Continued operation of the existing boiler using the same fuel mix or less biomass residues as in the past. Continue utilising coal as the main fuel in the existing co-fired boiler. This is the status quo.	The most likely future scenario for the Richards Bay mill is to continue firing the co-fired boiler with coal and only a limited amount of biomass waste. Coal makes up the backbone of South Africa's energy supply, accounting for about 76% of primary energy consumption. [16] Currently, coal supply is reliable with little logistical risk associated with it. It is therefore still the preferred operational option.	Yes
H3	Continued operation of the existing boiler(s) using a different fuel (mix). Generate steam from fuels other than coal, bark and biomass residues	Fuels other than coal and biomass residues include renewable energy sources such as wind and solar. Wind and solar energy are known to be expensive although maturing rapidly. For the purpose of industrial heat generation, these sources are not practical alternatives because of the amount of heat required and the important requirement that the heat is required on a continuous basis. Other options include the use of piped gas. A new turbine facility will be required if gas is to be utilised and it has been shown to be additional when comparing the project to self-generation of heat (using coal) and imported electricity, despite decreasing quality of electricity supply.	No
H4	Improvement of the performance of the existing boiler	The improvement of the boiler performance will not increase the quantity of biomass residues utilized in the boiler. The boiler performance is not the determining factor in how much biomass residue is burnt. In addition, the boiler performance is close to the design performance.	No
H6	Replacement of the existing boiler with new a boiler(s).	The capital expenditure associated with replacing the existing boiler with a new boiler is excessive. In addition, the existing boiler has an expected lifetime of more than 10 years if the current maintenance practices are maintained by the mill and therefore, it would not be a sensible option to replace the boiler with a new one.	No

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[16] Sources: BP Statistical Review of World Energy 2005, International Energy Agency

	Step 1 **Alternative baseline options**	**Step 2** **Barriers**	**Likely baseline scenarios**
H7	Import steam from external utilities	It is the aim of the Mondi operation to become energy self sufficient as far as possible to hedge against energy price and imported energy quality shocks. There are no current facilities in close proximity providing steam and the establishment of such a facility is not envisaged over the medium to long term. This option does not support the current and future strategy of Mondi Business Paper, Richards Bay to become energy self-sufficient.	No
Methane generation from managed or unmanaged landfill of additional biomass residues in the absence of the project activity			
B1	Plantation managers continue to leave biomass residues in the plantation to decay under aerobic conditions. This situation presents the status quo.	The logistics involved in separation, collection and transportation of plantation waste is complicated and requires significant effort, co-ordination and costs and introduces unnecessary risk to the operation. Therefore, the most likely future scenario for plantation residues is to be left in the forest where decay will occur.	Yes
B2	Chipping facilities continue to landfill biomass residues in the regional landfill site where anaerobic decay occurs. This situation presents the status quo.	Biomass residues from nearby chipping facilities are landfilled, mainly because the quality of the biomass is of such a nature that it has no other use.	Yes
B3	The biomass residues in plantations are burnt in an uncontrolled manner without utilizing them for energy purposes.	This situation may occur from time to time although it is not the policy of most plantation owners. Plantation residues will be collected from various plantations, not necessarily only from Mondi plantations. These plantations owners might burn residues from time to time.	Yes
B4	B4: The biomass residues are sold to other consumers in the market and the predominant use of the biomass residues in the region/country is for energy purposes.	Although markets for biomass residues exist (for example Europe[17]), the quality requirements of the biomass products are such that only good quality biomass residues can be processed into an export product for energy purposes.	No
B5	B5: The biomass residues are used as feedstock in a process (e.g. in the pulp and paper industry)	The quality requirements[18] associated with the feedstock for the pulping process exclude biomass residues from being used as a raw material input.	No
B6	B6: The biomass residues are used as fertilizer	Production, logistics and freight costs associated with the collection and distribution of biomass	No

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[17] Mondi internal study was conducted: "Assessment of European Pellet market", January 2006.

[18] Chip density, chip size etc.

	Step 1 Alternative baseline options	Step 2 Barriers	Likely baseline scenarios
		residues for fertilizer purposes, will make such enterprises uneconomical in South Africa.	
B7	B7: The proposed project activity not undertaken as a CDM project activity (use of the biomass residues for heat generation). Collection of chipping and plantation residues, transport to Mondi, combined with bark and combusted in a co-fired boiler. This represents the proposed project activity.	The strength of this project activity lies in the large amount of biomass residues that can be collected at several point sources and utilised at one facility as energy source. Without CDM, there exists no incentive to producers of relatively small quantities of biomass residues (chipping facilities for example) to collect and utilise it as energy source. Without developing and enforcing new legislation around landfill and plantation residue, changes to current practice are unlikely. The project activity is the first of its kind in that heterogenic biomass residue from various relatively small sources are combined on site. No project activity of this type is currently operational in the host country or region. The capital expenditure associated with the project activity including the costs associated with establishing the supply chain in the plantations is excessive and the project will not be financially feasible unless there is a income from emission reductions. The project activity is not adopted due to the following barriers: a) Investment Barriers • Technology (equipment) is expensive as it is mostly imported • Transport of biomass residues is expensive due to the bulky nature of the material b) Technology Barriers c) Risk Barriers The complexity of the collection and transport activities add risk to the process facility.	No
B8	Any other use of the biomass residues, for example the production of charcoal.	The scale on which charcoal is manufactured is small and does not fall within the core or peripheral business of Mondi. Safety, health and logistical barriers for large scale charcoal production are significant.	No

In summary, the evaluation in table 3 leaves H2, B1, 2 and 3 as the most plausible baseline scenarios.

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (assessment and demonstration of additionality): >>

Additionality

The additionality of this project is assessed and demonstrated by the following steps:
(If all 3 steps are satisfied, then the project is considered additional)

For the appraisal of additionality, H2 (heat baseline) is compared against the proposed project activity, in conjunction with B1, B2 and B3 (together representing the biomass residue baseline) that are compared to the project activity.

Step 0 – Preliminary screening based on the starting date of the project activity

The Mondi Biomass project was implemented in the third quarter of 2005. Given that the project proponent of the Mondi Biomass Project wishes to have the crediting period starting prior to the registration of the project activity, the following evidence must be provided:

(a) Evidence that the starting date of the CDM project activity falls between 1 January 2000 and the date of the registration of a first CDM project activity:

- The evidence that the starting date of the project activity complies with the above requirements is the date in which the construction of the project actually began – 3rd quarter of 2005. The project was designed in 2003 initially as a small-scale project activity. After the small-scale methodology amendments were approved, the decision was taken to submit the project as a regular scale project activity. Documentation and correspondence can verify this statement.

(b) Evidence that incentive from the CDM was seriously considered in the decision to proceed with the project activity. This evidence shall be based on (preferably official, legal and /or other corporate) documentation that was available to third parties at, or prior to, the start of the project activity:

- During 2003, and considering the very few (if any) approved methodologies for biomass heat generation projects suitable for Mondi heat project types, Mondi embarked on the development of a new baseline methodology for the proposed biomass project. The first methodology drafts and calculations are dated June / July 2003. The baseline methodology for biomass projects got the approval of the methodology by the Executive Board during 2005. The effort and resources that Mondi committed to successfully develop the methodology demonstrates Mondi's commitment to CDM and applying CDM in development of the Biomass Project.
- In the capital expenditure application documentation submitted as motivation to the Mondi board, the CDM incentives were specifically referred to (2005).

Step 2: Investment analysis

Mondi Business Paper South Africa has specific requirements in terms of return on investment of a proposed project in order to approve the project. Any small scale to medium scale project has to meet a minimum of between 17-20% IRR for approval, if the project is a stand-alone one (Mondi Executive Board guidelines). IRR is used for the investment analysis.

The project activity does not meet this IRR requirement without income from the CDM component. Based on financial calculations the annual cash flow without income from the sale of credits, produces a pre-tax internal rate of return of below 10% per annum (after-tax this is negative) well below the Mondi requirement for the project to go ahead. In the calculations, an inflation rate of 5.5% was used.

Step 3: Barrier analysis

Alternatives will comply with all South African regulations, but are not mandatory requirements. The proposed project activity is not the only alternative amongst the ones considered by Mondi that comply with all regulations. The logistics involved in collection, separation and transport of biomass residues from nearby facilities and plantations are complex and require major effort. The increased amount of vehicles that enter the operational site requires additional security resources and adds to the complexity of the vehicle access control system of the operation. The additional amount of vehicles on the road adds to road congestion and increases the risk of accidents in the proximity of the operation. Therefore, the increase in road transport to and from the fill is a potential risk factor as it can impact negatively on the public image and adds to Mondi's liability. Therefore, additional effort must be made by Mondi to ensure that trucks and contractors comply with standards. Additional liaison efforts with local stakeholders regarding transport issues will be initiated. This is compared to the transport of coal by rail into the operational site, a simple risk free activity. The project faces mainly investment barriers and a risk-based barrier due to the increased complexity added to the process.

Step 4: Common practice analysis

The analysis focuses on industry situated in South Africa. Firing biomass as an energy source in the pulp and paper industry is common practice. It is not common practise in South Africa to collect biomass residues from plantations in the form of off-cuts and stumps and transport these to the operational site for utilisation as energy source. The proposed project, is the first of its kind in South Africa, and provides an opportunity for knowledge and experience transfer to other areas in South Africa. The project activity increases the utilisation of biomass residues beyond that which is common practise in South African paper mills.

It is almost certain that implementation of this technology will encourage replication in other pulp and paper mills and within other industry sectors in South Africa and the region. Among the main factors that drive the decision for using coal instead of biomass residue is the price of coal compared to the price of collecting, transporting, cleaning and processing of biomass.

Step 5: Impact of CDM registration

The project has been under development since 2002 and had reached the stage of conditional validation as a small-scale project prior submission as a regular size project. The growing confidence in the appraisal of the project resulted in a decision to proceed with investment in the project. Registration therefore will not affect the project's implementation or financing.

CDM registration would conservatively allow for credits to accrue until 2012 (and beyond subject to a second commitment period being negotiated). The increased rate of return resulting from the income of CER's would contribute to the project's feasibility, though still marginal with respect to Mondi's expected rate of return threshold.

The registration of the proposed project activity will have a positive impact in paving the way for similar projects to be implemented in South Africa, which may bring about among other things development in gas turbine with heat recovery technologies.

Methane generation from managed or unmanaged landfill of additional biomass residues baseline

The biomass residues from nearby chipping facilities consisting of fines, off-cuts and woodchips contaminated with sand and metal are being landfilled in a municipal landfill site where it ferments over time, emitting methane. The general practise with waste from plantations is to leave the biomass in the plantation where it would decay. There is practically no use for biomass generated from forestry operations (thinning, pruning and harvesting operations), which is mostly left on the ground for natural decay and / or sometimes burned in the open air to avoid the risk of fires in new forest plantations.

As there are no circumstances to suggest that the current biomass residues in the forests will decrease in the foreseeable future, the methodology deems the baseline to be emissions from uncontrolled open-air burning of the equivalent amount of biomass residues originating from plantations that the project will consume. It must be noted that this is a highly conservative assumption, since when biomass is left to decay, it releases more of the carbon it contains as methane than when it is burned in the open air. This results in a significantly greater baseline emission given the GWP of methane as GHG. By assuming open-air burning of all currently unused biomass and excluding from the baseline methane emission from decaying biomass, the project's PDD understates the amount of carbon reductions.

An investment analysis on the methane avoidance part of the project alone revealed that there is not a sufficient economic incentive for Mondi to undertake the activity. Such a project would only encounter costs with neither savings nor income being made in the project activity base case.

Summary of the outcome of the application of the methodology

From the application of the baseline methodology, the status quo of using coal for steam generation is shown to be the baseline. The status quo is the least-cost and most economically attractive course of action. The project activity is the firing of biomass residues from plantations and nearby chipping facilities in a co-fired boiler for heat generation. The biomass will be collected and transported from nearby facilities and plantations, thereby avoiding the biomass residues from nearby facilities being landfilled and biomass residues decay in plantations. The project activity is shown to be additional mainly based on the investment analysis.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

The methodological choices are described at the hand of the formulae prescribed in the methodology.

B6.1.1 Baseline emissions

Baseline emissions include CO_2 emissions from fossil fuel combustion in the boilers in the absence of the project activity and, included in the project boundary, CH_4 emissions from the treatment of biomass residues in the absence of the project activity.

$$BE_y = BE_{HG,y} + BE_{BF,y}$$

Equation 1

Where:

BE_y = Baseline emissions during the year *y* (tCO_2e/yr)

$BE_{HG,y}$ = Baseline emissions from fossil fuel combustion for heat generation in the boiler(s) (tCO_2 /yr)

$BE_{BF,y}$ = Baseline emissions due to uncontrolled burning or decay of the biomass residues (tCO_2e/yr)

a) Baseline emissions from fossil fuel combustion in boiler(s) for heat generation ($BE_{HG,y}$)

Baseline emissions from fossil fuel combustion in the boiler are determined by multiplying the heat generated with fossil fuels that are displaced by biomass residues with the CO_2 emission factor of the least carbon-intensive fossil fuels that would be used in the absence of the project activity (coal) and by dividing by the average net efficiency of heat generation in the boiler, as follows:

$$BE_{HG,y} = \frac{HG_{PJ,biomass,y} \times EF_{FF,CO2,i}}{\eta_{boiler,FF}}$$

Equation 2

Where:

$BE_{HG,y}$ = Baseline emissions from fossil fuel combustion for heat generation in the boiler (tCO_{2e} /yr)

$HG_{PJ,biomass,y}$ = Heat generated with incremental biomass residues used as a result of the project activity during the year *y* (GJ/yr)[19]

$EF_{FF,CO2,y}$ = CO_2 emission factor of the fossil fuel type displaced by biomass residues (tCO_{2e} /GJ)

$\eta_{boiler,FF}$ = Average net efficiency of heat generation in the boiler(s) when fired with fossil fuels

For the purpose of determining $EF_{FF,CO2,y}$, as a conservative approach, the least carbon intensive fuel type (i.e. the fuel type with the lowest CO_2 emission factor per GJ) will be used among the fossil types used in boiler at the project site during the most recent three years prior to the implementation of the project activity and the fossil fuel types used in boilers at the project site during the year y[20]. The only fossil fuel utilized in the boiler since 1984 is bituminous coal and the CO_2 emission factor for bituminous coal will be used.

In the absence of the project activity, a small amount of biomass residue will be used for heat generation in the boiler and the most plausible baseline scenario is that heat would continue to be generated partly

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[19] This generated heat displaces the heat generated by fossil fuel in the boiler in the absence of the project activity.

[20] As per methodology AM0036 page 9

with coal and partly with biomass residue (mainly bark). Therefore, case B as described in AM0036 page 12 is applicable to calculate $HG_{PJ,biomass,y}$.

For case B, only the use of biomass residues beyond historical levels must be attributed to the CDM project activity. Hence, $HG_{PJ,biomass,y}$ refers to the additional (i.e. additional to the baseline scenario) quantity of heat generated from the combustion of biomass residues, as a result of the CDM project activity.

As the level of biomass residue use in the absence of the project activity is associated with significant uncertainty, the conservative approach will be followed in determining $HG_{PJ,biomass,y}$. As a conservative approach, the minimum value for $HG_{PJ,biomass,y}$ among the following two options will be used:

Option 1

The difference between the total quantity of heat generated from biomass residues in all boilers at the project site in the year *y* ($HG_{PJ,biomass,total,y}$) and the highest annual historical heat generation with biomass residues among the most recent three years prior to the implementation of the project activity:

$$HG_{PJ,biomass,y} = HG_{PJ,biomass,total,y} - MAX\left\{HG_{biomass,historic,n}; HG_{biomass,historic,n-1}; HG_{biomass,historic,n-2}\right\}$$

Equation 3

Where:

$HG_{PJ,biomass,y}$ = Heat generated with incremental biomass residues used in the project activity during the year *y* (GJ/yr)

$HG_{PJ,biomass,total,y}$ = Total heat generated from firing biomass residues in all boilers at the project site during the year *y* (GJ/yr)

$HG_{biomass,historic,n}$ = Historical annual heat generation from firing biomass residues in boilers at the project site during the year *n* (GJ/yr)

n = Year prior to the implementation of the project activity

Option 2

The difference between the total quantity of heat generated from biomass residues in all boilers in the year *y* ($HG_{PJ,biomass,total,y}$) and the total heat generation during the year *y* ($HG_{PJ,total,y}$) multiplied with the highest historical fraction of heat generation with biomass residues from the most recent three years, as follows:

$$HG_{PJ,biomass,y} = HG_{PJ,biomass,total,y} - HG_{PJ,total,y} \cdot MAX\left\{\frac{HG_{biomass,historic,n}}{HG_{total,historic,n}}; \frac{HG_{biomass,historic,n-1}}{HG_{total,historic,n-1}}; \frac{HG_{biomass,historic,n-2}}{HG_{total,historic,n-2}}\right\}$$

Equation 4

Where:

$HG_{PJ,biomass,y}$ = Heat generated with incremental biomass residues used as a result of the project activity during the year *y* (GJ/yr)

$HG_{PJ,biomass,total,y}$ = Total heat generated from firing biomass residues in all boilers at the project site during the year *y* (GJ/yr)

$HG_{PJ,total,y}$ = Total heat generated in boilers at the project site, using both biomass residues and fossil fuels, during the year *y* (GJ/yr)

$HG_{biomass,historic,n}$ = Historical annual heat generation from using biomass residues in boilers at the project site during the year *n* (GJ/yr)

$HG_{total,historic,n}$ = Historical annual total heat generation, from using biomass residues and fossil fuels, in boilers at the project site during the year *n* (GJ/yr)

n = Year prior to the implementation of the project activity

The historical fraction of heat generation with biomass residues can be determined based on the quantities of biomass residue types *k* and fossil fuel types *i* used historically in the boiler(s) at the project site, as follows:

$$\frac{HG_{biomass,historic,n}}{HG_{total,historic,n}} = \frac{\sum_{k} BF_{k,n} \cdot NCV_k}{\sum_{k} BF_{k,n} \cdot NCV_k + \sum_{i} FC_{i,n} \cdot NCV_i}$$

Equation 5

Where:

$HG_{biomass,historic,n}$ = Historical annual heat generation from using biomass residues in boilers at the project site during the year *n* (GJ/yr)

$HG_{total,historic,n}$ = Historical annual total heat generation, from using biomass residues and fossil fuels, in boilers at the project site during the year *n* (GJ/yr)

$BF_{k,n}$ = Quantity of biomass residue type *k* used in all boiler(s) at the project site during the historical year *n* (tons of dry matter)

NCV_k = Net calorific value of the biomass residue type *k* (GJ/ton of dry matter)

$FC_{i,n}$ = Quantity of fossil fuel type *i* fired in all boiler(s) at the project site during the historical year *n* (mass unit)

NCV_i = Net calorific value of the fossil fuel type *i* (GJ / mass unit)

n = Year prior to the implementation of the project activity

To estimate the energy efficiency of the boiler in the baseline scenario, the following two options are suggested in the methodology:

Option 1

Use the highest value between the following two values as a conservative approach:

1. Measured efficiency prior to project implementation;
2. Manufacturer's information on efficiency of the existing boilers.

Option 2

Assume a boiler efficiency of 100% based on the net calorific values as a conservative approach.

The Richards Bay operation will follow the approach in **option 1**. The boiler efficiency will either be measured or the manufacturer's information will be used.

Comment: project activity emissions compared to baseline emissions from the co-fired boiler

CO_2 emissions from fossil fuels fired in the co-fired boiler occur in the baseline. The baseline scenario also includes the possible case where100% of the heat is generated from fossil fuel (coal). With investment in the project activity, the heat is produced from biomass. HG_{PJ} (additional biomass heat in GJ/yr) is determined by formula and is based on the heat produced from the biomass (in GJ/yr) compared to how much heat we produced from biomass over the most recent three years prior to implementation of the project activity. This heat quantity is then converted into a coal (fossil fuel) equivalent. Emission reductions are calculated against the baseline which is based on historical information. Should there ever be a situation where the operation fires more fossil fuel than in the baseline for some operational reasons, the formula delivers a negative HG_{PJ}, that indicates an increase and not a reduction in CO_2e emissions. This scenario will be reflected in the calculations as a net emissions increase and will be reflected as such during verification.

b) **Baseline emissions due to uncontrolled burning or decay of the biomass residues**

The types of biomass residues differ in the baseline scenario, therefore, the total biomass decay emissions in the baseline scenario consist of emissions from two methodologies: 1) *Uncontrolled burning or aerobic decay of the biomass residues* and 2) *Anaerobic decay of the biomass residues*

$$BE_{BF,y} = BE_{Biomass,burning,y} + BE_{Biomass,anaerobic,y} \quad \text{Equation 6}$$

Biomass residues have already been used for heat generation at the project site prior to the implementation of the project activity. The most plausible baseline scenario is that heat would continue to be generated partly with fossil fuels and partly with biomass residues. In line with the methodology, only the use of biomass residues over and above the historical levels will attribute to the CDM project activity and consequently be considered when determining $BE_{BF,y}$.

Mainly one type of biomass residue *(bark)* has been used for heat generation at the project site prior to the implementation of the project activity, but after implementation of the project activity, biomass residues from more than one source and type will be used. In this particular case, $BF_{PJ,k,y}$ is determined based on the specific circumstances of the project activity, thereby ensuring that the total quantity of all biomass residues types *k* used for heat generation as a result of the project activity is related to the increase in heat generation as a result of the project activity, as follows:

$$\sum_k BF_{PJ,k,y} \times NCV_k = \sum BF_{k,y} \times NCV_k \quad \times \frac{HG_{PJ,biomass,y}}{HG_{PJ,biomass,total,y}}$$

Equation 7

Where:

$BF_{PJ,k,y}$ = Quantity of biomass residue type *k* used for heat generation as a result of the project activity during the year *y* (tons of dry matter)

$BF_{k,y}$ = Quantity of biomass residue type *k* fired in all boiler(s) at the project site during the year *y* (tons of dry matter)

NCV_k = Net calorific value of the biomass residue type *k* (GJ/ton of dry matter)

$HG_{PJ,biomass,y}$ = Heat generated with incremental biomass residues used as a result of the project activity during the year *y* (GJ/yr)

$HG_{PJ,biomass,total,y}$ = Total heat generated from firing biomass residues in all boilers at the project site during the year *y* (GJ/yr)

Plantation biomass residues (uncontrolled burning)

The most likely baseline scenario for the use of the plantation biomass residues is that the biomass residues will be left to decay under mainly aerobic conditions (B1 in table 3) without utilizing it for energy purposes (B3 in table 3). Baseline emissions are calculated for natural decay, and as per the methodology, the emissions are calculated assuming that the biomass residues would be burnt in an uncontrolled manner.

Baseline emissions are calculated by multiplying the quantity of biomass residues that would be left to decay in the absence of the project activity with the net calorific value and an appropriate emission factor, as follows:

$$BE_{BF,y} = GWP_{CH4} \times \sum_{k} BF_{PJ,k,y} \times NCV_{k} \times EF_{burning,CH4,k,y}$$

Equation 8[21]

Where:

$BE_{BF,y}$ = Baseline emissions due to uncontrolled burning or decay of the biomass residues (tCO_2e/yr)

GWP_{CH4} = Global Warming Potential of methane valid for the commitment period (tCO_2e/tCH_4)

$BF_{PJ,k,y}$ = Quantity of biomass residue type *k* used for heat generation as a result of the project activity during the year *y* (tons of dry matter)

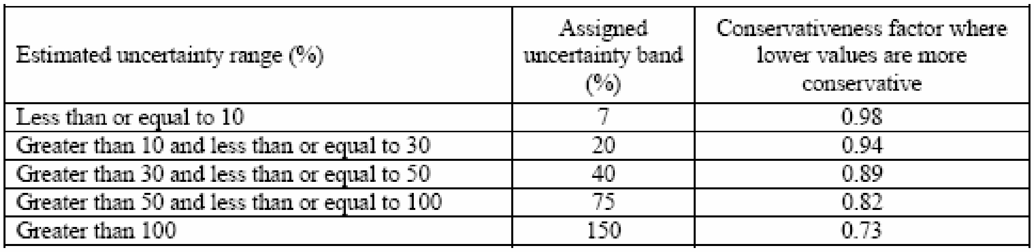
NCV_k = Net calorific value of the biomass residue type *k* (GJ/ton of dry matter)

$EF_{burning,CH4,k,y}$ = CH_4 emission factor for uncontrolled burning of the biomass residue type *k* during the year *y* (tCH_4/GJ)

Referenced default values for the CH_4 emission factor will be used. In the absence of more accurate information, it is recommended in the methodology that 0.0027 t CH_4 per ton of biomass should be used as default value for the product of NCV_k and $EF_{burning,CH4,k,y}$

The uncertainty of the CH_4 emission factor is in many cases relatively high. In order to reflect this and for the purpose of providing conservative estimates of emission reductions, a conservativeness factor will be applied to the CH_4 emission factor. The level of the conservativeness factor depends on the uncertainty range of the estimate for the CH_4 emission factor. An appropriate conservativeness factor from Table 5: Conservativeness factors for estimated uncertainty ranges below shall be chosen and multiplied with the estimate for the CH_4 emission factor. Mondi will apply the most conservative factor of 0.73.

Table 5: Conservativeness factors for estimated uncertainty ranges



Estimated uncertainty range (%)	Assigned uncertainty band (%)	Conservativeness factor where lower values are more conservative
Less than or equal to 10	7	0.98
Greater than 10 and less than or equal to 30	20	0.94
Greater than 30 and less than or equal to 50	40	0.89
Greater than 50 and less than or equal to 100	75	0.82
Greater than 100	150	0.73

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[21] Equation 5 in AM0140

Chipping biomass residues (decay of the biomass residues)
The most likely baseline scenario for the use of the chipping biomass residues is that the biomass residues would decay under anaerobic conditions (case B2[22]). (The variable $BE_{CH4,SWDS,y}$ calculated by the tool corresponds to $BE_{BF,y}$ in this methodology).

For the biomass residues that would have decayed under anaerobic conditions in a landfill, the following methodology is used to calculate methane generation from the additional biomass:

The amount of methane that would be generated each year in the baseline scenario ($BE_{BF,,y}$) is calculated for each year with a multi-phase model. The model is based on a first order decay equation. It differentiates between the different types of biomass waste *i* with respectively different decay rates k_i (fast, moderate, slow) and fraction of degradable organic carbon (DOC_i). The model calculates the methane generation based on the actual waste streams $A_{i,x}$ disposed in the most recent year (y) and all previous years since the project start (x=1 to x=y). The amount of methane produced in the year y ($BE_{BF,,y}$) is calculated as follows:

$$BE_{BF,y} = \varphi \times (1-f) \times (1-OX) \times \frac{16}{12} \times F \times DOC_f \times MCF \times \sum_{x=1}^{y} BF_x \times DOC_i \times \left(1-e^{-k_i}\right) \times e^{-k_i.(y-x)}$$

Equation 9

Where:

$BE_{BF,\,y}$	is methane produced in the landfill in the absence of the project activity in year y (tCH_4)
Φ	is model correction factor (default 0.9) to correct for the model-uncertainties
F	is fraction of methane in the landfill gas (default 0.5 will be used as access to landfill is not practical)
OX	is the oxidation factor
f	Fraction of methane captured at the SWDS and flared, combusted or used in another manner
DOC_i	is percent of degradable organic carbon (by weight) in the biomass waste type i (30 applicable to wood waste)
DOC_f	is fraction of DOC dissimilated to landfill gas (0.5 will be used as lignin-C is included in the estimated amount of degradable organic carbon)
MCF	is Methane Correction Factor (fraction)
$BF_{i,x}$	is amount of biomass waste type i prevented from disposal in the year x (tonnes/year)
K_i	is decay rate for the biomass waste type i (0.023 applicable to wood waste)
i	is biomass waste type distinguished into the waste categories (from A to D), as illustrated in Table 2 below
x	is year during the crediting period: x runs from the first year of the first crediting period (x=1) to the year for which emissions are calculated (x=y)
y	is year for which LFG emissions are calculated

Model Correction Factor (Φ)
Oonk et el. have validated several landfill gas models based on 17 realized landfill gas projects.[23] The mean relative error of multi-phase models was assessed to be 18%. Given the uncertainties associated with the model and in order to estimate emission reductions in a conservative manner, a discount of 10% should be applied to the model results.

Methane correction factor (MCF)

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[22] As per AM0036

[23] Oonk, Hans et al.: Validation of landfill gas formation models. TNO report. December 1994

The methane correction factor (MCF) accounts for the fact that unmanaged landfills produce less methane from a given amount of waste than managed landfills, because a larger fraction of waste decomposes aerobically in the top-layers of unmanaged landfills. The proposed default values for MCF are listed in the 2000 IPCC Good Practice Guidance Table 5.1.

Table 6: Solid Waste Disposal Site (SDWS) Classification and Methane Correction Factors[24]

Type of site	MCF default values
Managed site	1.0
Unmanaged site – deep (> 5 m waste)	0.8
Unmanaged site – shallow (< 5 m waste)	0.4
Note: Managed SWDS must have controlled placement of waste (i.e. waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include some of the following: cover material, mechanical compacting or leveling of waste.	

Fraction of degradable organic carbon dissimilated (DOC_f)

The decomposition of degradable organic carbon does not occur completely and some of the potentially degradable material always remains in the site even over a very long period of time. The revised IPCC Guidelines propose a default value of 0.77 for DOC_f. A lower value of 0.5 should be used if lignin-C is included in the estimated amount of degradable organic carbon.[25]

Degradable carbon content in waste (DOC_i) and decay rates (k_i)

In the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (module 6), default values for degradable organic carbon are presented, as shown in Table 3 below[26].

Table 7: Waste stream decay rates (kj) and associated IPCC default values for DOC_j

Waste stream A to E	Percent DOC_i (by weight)	Decay-rate (k_i)
A. Paper and textiles	40	0.023
B. Garden and park waste and other (non-food) putrescibles	17	0.023
C. Food waste	15	0.231
D. Wood and straw waste 1)	30	0.023
E. Inert material	0	0

1) Excluding lignin-C

Given the nature of this project, the waste under consideration will be biomass residue. Wood and straw waste (D) are considered as slow degradable waste.

Calculation of F

No access to a landfill and therefore the conservative default value of 0.5 would be applied, being the lower end of IPCC range of 0.5 – 0.6.

The project activity results in an increase in road transport from new biomass sources (chipping facilities and plantations) to the mill and a decrease for road transport of ash and rail transport of coal.

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[24] 2000 IPCC Good Practice Guidance

[25] IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories – chapter 5

[26] For the categories of waste considered as well as the values of DOC, project participants should consider any revisions to the Revised 1996 IPCC Guidelines and the 2000 IPCC Good Practice Guidance.

Table 8: Baseline information used to calculate methane emissions

Parameter	Description	
Φ	Model correction factor to correct for the model uncertainties	Default of 0.9[27] is suggested to account for model uncertainty.
F	Fraction of methane in the landfill gas	Default of 0.5 is used which is the lower end of the range suggested by IPCC guidelines.
DOC	Percent of degradable organic carbon (by weight) in the biomass waste	30 is used for wood waste. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (module 6).
DOC_f	Fraction of DOC dissimilated to landfill gas	0.5 is used as lignin-C is included in the estimated amount of degradable organic carbon[28]
MCF	Methane Correction Factor (fraction)	Default of 1[29] is used for managed landfills.
BF_x	Amount of biomass waste prevented from disposal in the year x (tonnes/year)	
k	Decay rate for the biomass waste	0.023 is used for wood waste. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (module 6).

B6.1.2 Project activity emissions

Project emissions include CO_2 emissions from on-site fossil fuel and electricity consumption that is attributable to the project activity ($PE_{CO2,FF,y}$ and $PE_{CO2,EC,y}$), CO_2 emissions from off-site transportation of biomass residues that are combusted in the boiler(s) to the project site ($PE_{CO2,TR,y}$), and, if included in the project boundary, CH_4 emissions from combustion of biomass residues for heat generation ($PE_{CH4,BF,y}$):

Project emissions are calculated by:

$$PE_y = PE_{CO2,TR,y} + PE_{CO2,EC,y} + PE_{CO2,FF,y} + GWP_{CH4} \times PE_{CH4,BF,y}$$

Equation 10[30]

Where:

PE_y = Project emissions during the year *y* (tCO_2/yr)
$PE_{CO2,FF,y}$ = CO_2 emissions from on-site fossil fuel combustion attributable to the project activity (tCO_2/yr)
$PE_{CO2,EC,y}$ = CO_2 emissions from on-site electricity consumption attributable to the project activity (tCO_2/yr)
$PE_{CO2,TR,y}$ = CO_2 emissions from off-site transportation of biomass residues to the project site (tCO_2/yr)
GWP_{CH4} = Global Warming Potential of methane valid for the commitment period (tCO_2e/tCH_4)
$PE_{CH4,BF,y}$ = CH_4 emissions from combustion of biomass residues in the boiler(s) (tCH_4/yr)

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[27] Oonk, Hans et al.: Validation of landfill gas formation models. TNO report. December 1994

[28] IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories – chapter 5

[29] See D.2.1.4.2. Table 5.1: Solid Waste Disposal Site (SDWS) Classification and Methane Correction Factors

[30] Equation 10 in AM0036

B6.1.2.1 Transport emissions of biomass residues transported to the project site

Transporting biomass from the suppliers to the Mondi operation is generally done by trucks, which result in the emissions of direct off-site GHG.

Emissions are calculated on the basis of distance traveled and the average truckload (TL) of biomass transported from nearby chipping facilities and plantations. Diesel-fuelled trucks will mostly be used for transportation.

$$PE_{CO2,TR,y} = \frac{\sum_{k} BF_{PJ,k,y}}{TL_{y}} \times AVD_{y} \times EF_{km,CO2,y}$$

Equation 11[31]

Where:

$$BF_{PJ,k,y,wet} = MC_{k} \times BF_{PJ,k,y}$$

Equation 12

Where:

$PE_{CO2,TR,y}$ = CO_2 emissions from off-site transportation of biomass residues to the project site (tCO_2/yr)
AVD_y = Average round trip distance (from and to) between the biomass fuel supply sites and the site of the project plant during the year *y* (km)
$EF_{km,CO2,y}$ =Average CO_2 emission factor for the trucks measured during the year y (tCO_2/km)
$BF_{PJ,k,y}$ = Quantity of biomass residue type *k* used for heat generation as a result of the project activity during the year *y* (tons of dry matter)
TL_y = Average truck load of the trucks used (tons)
$BF_{PJ,k,,y,wet}$ = the additional quantity of biomass type *i* used as fuel in the project plant during the year *y* in mass unit (as received over the weighbridge)
MC_i =Moisture content of biomass i (%)

Note: The average truck load (TL) differs for various types of biomass depending on the packing density of the biomass on the track.[32] The truck load for plantation biomass is different from the truck load of biomass originating from chipping facilities. To take account of this difference, $PE_{CO2,TR,y}$ consists of project emissions from transport of plantation biomass ($PE_{CO2,TR,p,y\ p,y}$) and emissions from transport of biomass from chipping facilities ($PE_{CO2,TR,c,y}$).

Therefore,

$$\sum PE_{CO2,TR,y} = \sum_{k} PE_{CO2,TR,p,y} + \sum_{k} PE_{CO2,TR,c,y}$$

Equation 13

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[31] Equation 14 in AM0036

[32] The packing density is a function of the type and form of the biomass being transported.

Where

$\sum_k PE_{CO2,TR,p,y}$ is the total project emissions due to transport of the biomass to the project plant from every plantation *k* and

$\sum_k PE_{CO2,TR,c,y}$ is the total project emissions due to transport of the biomass to the project plant from every chipping facility *k*

Equation 4 is expanded for plantation biomass and biomass from chipping facilities:

$$PE_{CO2,TR,y} = \frac{\sum_k BF_{PJ,p,y}}{TL_{p,y}} \times AVD_y \times EF_{km,CO2,y} + \frac{\sum_k BF_{PJ,c,y}}{TL_{c,y}} \times AVD_y \times EF_{km,CO2,y}$$

Equation 14

B6.1.2.2 Emissions from on-site consumption of electricity

Emissions from the use of on-site equipment, for example hoppers and shredders that consume electricity, are accounted for.

The total annual electricity consumption is less than 15 GWh for the biomass residues equipment (refer to Table 19: Indirect emissions from imported electricity). Therefore, the average grid CO_2e emission factor for the South African grid can be used in calculations.

$$PE_{CO2,EC,y} = EC_{PJ,y} \times EF_{grid,y}$$

Equation 15[33]

Where:

$PE_{CO2,EC,y}$ = CO_2 emissions from on-site electricity consumption attributable to the project activity (tCO_2/yr)

$EC_{PJ,y}$ = On-site electricity consumption attributable to the project activity during the year *y* (MWh)

$EF_{grid,y}$ = CO_2 emission factor for electricity used from the grid (tCO_2/MWh). The electricity consumption ($EC_{PJ,y}$) is less than 15GWh/yr, therefore the average grid emission factor (including all grid-connected power plants) may be used.

B6.1.2.3 CH_4 emissions from combustion of biomass residues in the boiler(s) ($PE_{CH4,BF,y}$)

Consistent with IPCC Guidelines[34], CO_2 emissions from biomass combustion at the Mondi operation are equivalent to the release of the CO_2 absorbed on a sustainable basis by the forest that is replanted every year (forest companies replant the surfaces they harvest[35]). The same argument does not apply to methane emissions from controlled burning of biomass. When biomass is combusted in a well-controlled environment, methane emissions are small in quantity but still not zero. This source has been included in the project boundary and emissions are calculated as follows:

$$PE_{CH4,BF,y} = EF_{CH4,BF} \times \sum_{k} BF_{PJ,k,y} \times NCV_k$$

Equation 16[36]

Where:

$PE_{CH4,BF,y}$ = CH_4 emissions from combustion of biomass residues in the boiler(s) (tCH_4/yr)

$EF_{CH4,BF}$ = CH_4 emission factor for the combustion of the biomass residues in the boilers (tCH_4/GJ)

$BF_{PJ,k,y}$ = Quantity of biomass residue type *k* used for heat generation as a result of the project activity during the year *y* (tons of dry matter)

NCV_k = Net calorific value of the biomass residue type *k* (GJ/ton of dry matter)

Types of biomass residues collected and utilized as a result of the project activity:

k = p biomass collected from plantations and transported to the operation

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[33] Equation 12 in AM0036

[34] Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, p.6.1 Please also see Revised 1996 IPCC Guidelines for National Greenhouse Inventories, Workbook and IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, P.5.5

[35] General practise by South African forest companies is to reforest the areas that have been harvested, unless the area is not suitable for forest activity.

[36] Equation 16 in AM0036

$k = c$ biomass collected from nearby chipping facilities and transported to the operation
$k = b$ biomass collected from mill operation

To determine the total amount of energy available from biomass residues, the following calculation is done:

$$\sum_k BF_{PJ,k,y} \times NCV_k \quad = \quad BF_{PJ,p,y} \times NCV_p \quad + BF_{PJ,c,y} \times NCV_c + BF_{PJ,b,y} \times NCV_b$$

Equation 17

Where:
$BF_{PJ,p,y}$ the additional quantity of biomass from plantations used as fuel in the project plant during year in tonnes
$BF_{PJ,c,y}$ additional quantity of biomass from nearby chipping facilities used as fuel in the project plant during year in tonnes
$BF_{PJ,b,y}$ additional quantity of biomass from mill operation used as fuel in the project plant during year y in tonnes

IPCC default values will be used to determine the CH_4 emission factor. The uncertainty of the CH_4 emission factor is in many cases relatively high. In order to reflect this and for the purpose of providing conservative estimates of emission reductions, a conservativeness factor must be applied to the CH_4 emission factor. The level of the conservativeness factor depends on the uncertainty range of the estimate for the CH_4 emission factor. The assumed uncertainty for wood waste is 300% and the associated conservativeness factor is therefore chosen as 1.37[37]. This factor is used to multiply with the estimate for the CH_4 emission factor. The CH_4 emission factor of 21.55kg/TJ is used in calculations.

The following items must be taken into consideration for the Mondi Biomass project activity

- According to the chosen baseline methodology, the project proponent will monitor the consumption and net calorific values of each type of biomass consumed in the co-fired boiler.
- As previously mentioned, only the additional quantities of biomass and fossil fuels will be considered to calculate the baseline and project emissions. The additional biomass is the biomass that is related to the implementation of the CDM project activity. The energy of the co-fired boiler is a variable that will be permanently monitored by the project proponent, the additional biomass calculation will always be based on directly monitored and reliable data

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[37] Values are based on the 2006 IPCC Guidelines, Volume 2, Chapter 2, Tables 2.2 to 2.6.

B6.1.2.4 CO_2 emissions from on-site fossil fuel combustion

CO_2 emissions from on-site fossil fuel combustion that is attributable to the project activity ($PE_{CO2,FF,y}$) are calculated by multiplying the fossil fuels consumption with appropriate net calorific values and CO_2 emission factors, as follows:

$$PE_{CO2,FF,y} = \sum_i FC_{on-site,i,y} \times NCV_i \times EF_{CO2,FF,i}$$

Equation 18

Where:

$PE_{CO2,FF,y}$ = CO_2 emissions from on-site fossil fuel combustion attributable to the project activity (tCO_2/yr)

$FC_{on-site,i,y}$ = Quantity of fossil fuel type *i* combusted at the project site for purposes other than heat generation as a result of the project activity during the year *y* (mass or volume unit)

NCV_i = Net calorific value of the fossil fuel type *i* (GJ / mass or volume unit)

$EF_{CO2,FF,i}$ = CO_2 emission factor for fossil fuel type *i* (tCO_2/GJ)

$FC_{on-site,i,y}$ does not include fossil fuels co-fired in the boiler but will include all other fossil fuel consumption at the project site that is attributable to the project activity. The only fossil fuel consumed as a result of the project activity is from on-site transportation of biomass residues. The transport on-site is insignificant compared to the transport occurring off-site (the distances of the wood yard facility is about 400m). Therefore, for this project activity $PE_{CO2,FF,y}$ will mainly be zero.

B6.1.3 Leakage

The main source of potential leakage is that the project diverts biomass from other users and thereby increases fossil fuel use in the surrounding area. Changes in carbon stocks in the LULUCF[38] sector are expected to be insignificant since this methodology is limited to biomass *residues*, as defined in the applicability conditions above.

No leakage is anticipated as a result of the project activity. The project does not quantify any leakage effect related to biomass availability, because there is enough biomass available to satisfy all the requirements of different consumers. This is principally guaranteed by the provision of Mondi's own biomass, and especially, by additional biomass sources from thinning, pruning and harvesting operations of the plantation industry.

The baseline scenario is that the biomass residues from nearby facilities are landfilled and plantation biomass is left to decay without utilizing it for energy purposes. Mondi Richards Bay shall demonstrate that the use of the biomass residues does not result in increased fossil fuel consumption elsewhere. To this effect the following will be done:

1. Demonstrate that at the plantation sites from which biomass residues are supplied, the biomass has not been collected or utilized (e.g. as energy carrier, fertilizer or feedstock), but has been left for decay prior to the implementation of the project activity. Demonstrate that this practice would continue in the absence of the CDM project activity, e.g. by showing that no market has emerged for the biomass considered or by showing that it would not be feasible to utilize the biomass residues for any purposes (e.g. due to the remote location where the biomass is generated).

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[38] Land use and land use change

2. Demonstrate that suppliers of the biomass residues in the region of the project activity are not able to sell all of their biomass. For this purpose, project participants shall demonstrate that the ultimate supplier of biomass (who supplies the project) and a representative sample of biomass suppliers in the region had a surplus of biomass (e.g. at the end of the period during which biomass is sold), which they could not sell and which is not utilized.

The geographical boundary of the region has been established as the area within a 50km radius around the Richards Bay operation.

3. If during any year one of the approaches above cannot demonstrate that the use of the biomass does not result in leakage, a leakage penalty will be applied to the quantity of biomass. The leakage penalty will adjust emission reductions for leakage effects in a conservative manner, assuming that this quantity of biomass is substituted by the most carbon intensive fuel in South Africa.

If for a certain type of biomass *i* used in the project activity, leakage effects cannot be ruled out with one of the approaches above, leakage effects for the year *y* shall be calculated as follows:

$$LE_y = EF_{CO2,LE} \times \sum_i BF_{LE,n,y} \times NCV_n$$

Equation 19[39]

Where:

LEy = Leakage emissions during the year *y* (tCO2/yr)
$EF_{CO2,LE}$ = CO2 emission factor of the most carbon intensive fuel used in the country (tCO2/GJ)
$BF_{LE,n,y}$ = Quantity of biomass residue type *n* used for heat generation as a result of the project activity during the year *y* and for which leakage can not be ruled out using one of the approaches L1, L2, L3 or L4 (tons of dry matter or liter)
NCV_n = Net calorific value of the biomass residue type *n* (GJ/ton of dry matter or GJ/liter)
n = Biomass residue type *n* for which leakage can not be ruled out using one of the approaches L1, L2, L3 or L4

The project activity mainly reduces CO_2 emissions through substitution of heat generation and/or cogeneration with fossil fuels by energy generation with biomass. The emission reduction ER_y by the project activity during a given year *y* is the difference between the emissions from the baseline and the project activity (PE_y), and emissions due to leakage (LE_y).

B6.1.4 Emissions reductions

$$ER_y = BE_y - PE_y - LE_y$$

Equation 20

Where:
ER_y = Emission reductions during the year *y* (tCO_2/yr)
BE_y = Baseline emissions during the year *y* (tCO_2/yr)
PE_y = Project emissions during the year *y* (tCO_2/yr)
LE_y = Leakage emissions during the year *y* (tCO_2/yr)

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[39] Equation 14 in AM0140

In determining emission coefficients, emission factors or calorific values in this methodology, guidance by the 2000 IPCC Good Practice Guidance should be followed where appropriate. Where such data is not available, IPCC default emission factors (country-specific, if available) will be used if they are deemed to reasonably represent local circumstances. All values will be chosen in a conservative manner.

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

Data / Parameter:	$\eta_{Boiler, FF}$
Data unit:	%
Description:	The energy efficiency of the boiler using fossil fuels to generate heat
Source of data used:	Either use the higher value among (a) the measured efficiency prior to the implementation of the project activity and (b) manufacturer's information on the efficiency.
Value applied:	77.6%
Justification of the choice of data or description of measurement methods and procedures actually applied :	The data is available to use option 1. Manufacturer's information (77.6%) is used and this efficiency will be the higher value as the boiler is 22 years old. The measured efficiency is 60%.
Any comment:	

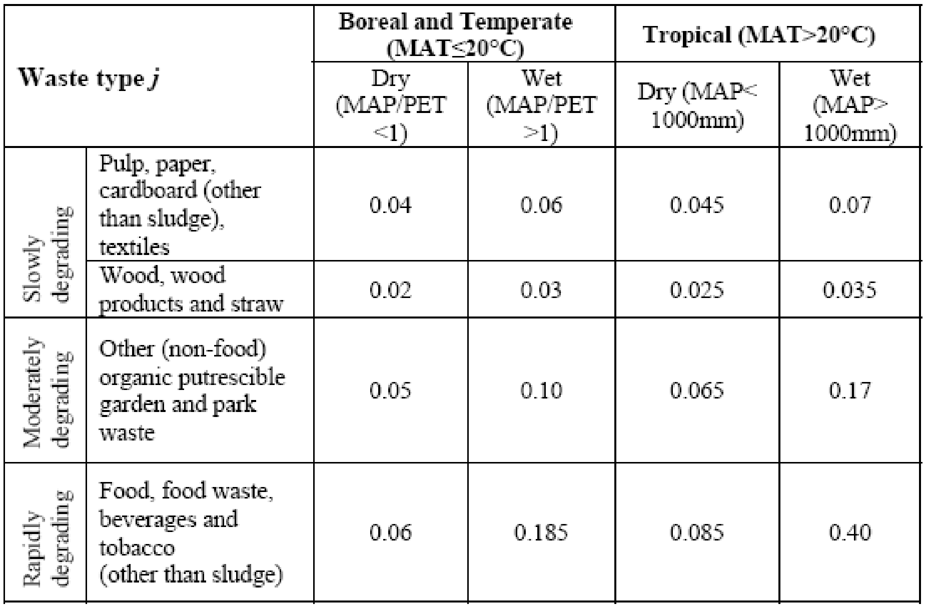
Data / Parameter:	$HG_{biomass, historic,n}$/$HG_{biomass, historic,n-1}$ / $HG_{biomass, historic,n-2}$
Data unit:	GJ
Description:	Historical annual heat generation from firing biomass residues in boilers at the project site during the year *n, n-1,n-2*, where *n* corresponds to the year prior to the implementation of the project activity
Source of data used:	Calculated from boiler efficiency and energy input (GJ) from biomass residue into the boiler which is measured on site.
Value applied:	For n-2: 578,271GJ For n-1: 689,057 GJ For n: 752,655 GJ
Justification of the choice of data or description of measurement methods and procedures actually applied :	The biomass residue feed to the boiler was measured and recorded. The efficiency of the boiler is known and the net calorific value of the biomass feed. Heat generation is determined by an energy calculation.
Any comment:	

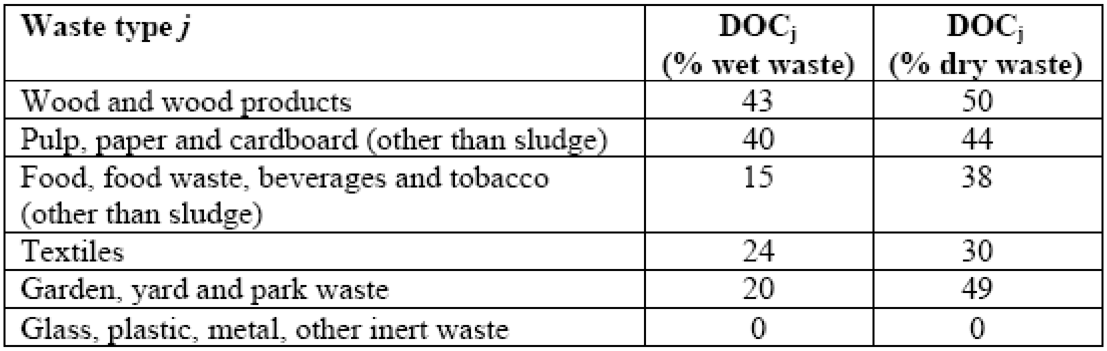
Data / Parameter:	$BF_{i, biomass, historic, 3 y}$
Data unit:	Dry tonne
Description:	The annual net quantity of biomass of type i fired in all boilers at the project site during the most recent three years using the same type of biomass i as the project plant
Source of data:	Mondi historical plant records for last 3 years prior to project implementation. Quantities were measured on site and recorded daily. Calculated once at project start for three years prior to project implementation.
Value applied:	For n-2: 43822 tonnes For n-1: 52218 tonnes For n: 57037 tonnes
Justification of the	Historically, only bark has been co-fired in the boiler.

choice of data or description of measurement methods and procedures actually applied :	
Any comment:	

Data / Parameter:	$FC_{i,n}$ / $FC_{i,n}$ / $FC_{i,n-2}$
Data unit:	Mass in tonne
Value used:	105 000 t/annum for each of the three years
Description:	Quantity of fossil fuel type *i* fired in the boiler at the project site during the historical year *n, n-1, n-2*, where *n* corresponds to the year prior to the implementation of the project activity
Source of data:	Mondi Historical plant records for last 3 years
Justification of the choice of data or description of measurement methods and procedures actually applied :	Use of weight meter readings as recorded by the Process Information (PI) system on site. This quantity is crosschecked with the quantity of steam generated, the amount of biomass fired, and coal delivered.
Any comment:	

Data / Parameter:	$EF_{CO2, FF,i}$
Data unit:	Kg CO_2/GJ
Description:	CO_2 emission factor for fossil fuel type displaced by biomass residues for the year y
Source of data used:	Appendix B as referenced in Calculation tools for greenhouse gas emissions for pulp and paper industry, 2001
Value applied:	92.7 kg CO_2/GJ fuel
Justification of the choice of data or description of measurement methods and procedures actually applied :	Value is based on lower heating value for bituminous coal and spreader stoker boilers. The value is specific to bituminous coal and is also specifically applicable to spreader stoker boilers, which is what Mondi operates.
Any comment:	

<table>
<tr><td>Data / Parameter:</td><td>k_i</td></tr>
<tr><td>Data unit:</td><td>-</td></tr>
<tr><td>Value used:</td><td>0.035</td></tr>
<tr><td>Description:</td><td>Decay rate for the waste type <i>j</i></td></tr>
<tr><td>Source of data:</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)</td></tr>
<tr><td>Justification of the choice of data or description of measurement methods and procedures actually applied :</td><td>

<table>
<tr><th colspan="2" rowspan="2">Waste type <i>j</i></th><th colspan="2">Boreal and Temperate (MAT≤20°C)</th><th colspan="2">Tropical (MAT>20°C)</th></tr>
<tr><th>Dry (MAP/PET <1)</th><th>Wet (MAP/PET >1)</th><th>Dry (MAP< 1000mm)</th><th>Wet (MAP> 1000mm)</th></tr>
<tr><td rowspan="2">Slowly degrading</td><td>Pulp, paper, cardboard (other than sludge), textiles</td><td>0.04</td><td>0.06</td><td>0.045</td><td>0.07</td></tr>
<tr><td>Wood, wood products and straw</td><td>0.02</td><td>0.03</td><td>0.025</td><td>0.035</td></tr>
<tr><td>Moderately degrading</td><td>Other (non-food) organic putrescible garden and park waste</td><td>0.05</td><td>0.10</td><td>0.065</td><td>0.17</td></tr>
<tr><td>Rapidly degrading</td><td>Food, food waste, beverages and tobacco (other than sludge)</td><td>0.06</td><td>0.185</td><td>0.085</td><td>0.40</td></tr>
</table>
</td></tr>
<tr><td>Any comment:</td><td></td></tr>
</table>

<table>
<tr><td>Data / Parameter:</td><td>DOC_i</td></tr>
<tr><td>Data unit:</td><td>-</td></tr>
<tr><td>Value used:</td><td>43</td></tr>
<tr><td>Description:</td><td>Fraction of degradable organic carbon (by weight) in the waste type <i>j</i></td></tr>
<tr><td>Source of data:</td><td>IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)</td></tr>
<tr><td>Justification of the choice of data or description of measurement methods and procedures actually applied :</td><td>

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<tr><th>Waste type <i>j</i></th><th>DOC_j (% wet waste)</th><th>DOC_j (% dry waste)</th></tr>
<tr><td>Wood and wood products</td><td>43</td><td>50</td></tr>
<tr><td>Pulp, paper and cardboard (other than sludge)</td><td>40</td><td>44</td></tr>
<tr><td>Food, food waste, beverages and tobacco (other than sludge)</td><td>15</td><td>38</td></tr>
<tr><td>Textiles</td><td>24</td><td>30</td></tr>
<tr><td>Garden, yard and park waste</td><td>20</td><td>49</td></tr>
<tr><td>Glass, plastic, metal, other inert waste</td><td>0</td><td>0</td></tr>
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</td></tr>
<tr><td>Any comment:</td><td></td></tr>
</table>

Data / Parameter:	**MCF**
Data unit:	-
Value used:	1
Description:	Methane correction factor
Source of data:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Justification of the choice of data or description of measurement methods and procedures actually applied :	Use the following values for MCF: • 1.0 for **anaerobic managed solid waste disposal sites**. These must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) leveling of the waste. • 0.5 for **semi-aerobic managed solid waste disposal sites**. These must have controlled placement of waste and will include all of the following structures for introducing air to waste layer: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system. • 0.8 for **unmanaged solid waste disposal sites – deep and/or with high water table**. This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of greater than or equal to 5 meters and/or high water table at near ground level. Latter situation corresponds to filling inland water, such as pond, river or wetland, by waste. • 0.4 for **unmanaged-shallow solid waste disposal sites.** This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of less than 5 metres.
Any comment:	The methane correction factor (MCF) accounts for the fact that unmanaged SWDS produce less methane from a given amount of waste than managed SWDS, because larger fraction of waste decomposes aerobically in the top layers of unmanaged. The municipal landfill is operated according to permit requirements.

Data / Parameter:	**DOC_f**
Data unit:	-
Value used:	0.5
Description:	Fraction of degradable organic carbon (DOC) that can decompose
Source of data:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default values
Any comment:	

Data / Parameter:	**F**
Data unit:	-
Value used:	0.5
Description:	Fraction of methane in the SWDS gas (volume fraction)
Source of data:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default values
Any comment:	This factor reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, under anaerobic conditions in the SWDS. A default value of 0.5 is recommended by IPCC.

Data / Parameter:	**OX**
Data unit:	-
Value used:	Use 0.1 for managed solid waste disposal sites that are covered with oxidizing material such as soil or compost. Use 0 for other types of solid waste disposal sites.
Description:	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Source of data:	Literature
Justification of the choice of data or description of measurement methods and procedures actually applied :	Solid waste disposal site Use the IPCC 2006 Guidelines for National Greenhouse Gas Inventories for the choice of the value to be applied.
Any comment:	

Data / Parameter:	❸
Data unit:	-
Value used:	0.9
Description:	Model correction factor to account for model uncertainties
Source of data:	Literature
Justification of the choice of data or description of measurement methods and procedures actually applied :	Oonk et el. (1994) have validated several landfill gas models based on 17 realized landfill gas projects. The mean relative error of multi-phase models was assessed to be 18%. Given the uncertainties associated with the model and in order to estimate emission reductions in a conservative manner, a discount of 10% is applied to the model results.
Any comment:	

B.6.3 Ex-ante calculation of emission reductions:

Formulae for calculating emissions from the project activity baseline:

1. **Baseline emissions from fossil fuel combustion in boiler(s) for heat generation ($BE_{HG,y}$)**

$$BE_{HG,y} = \frac{HG_{PJ,biomass,y} \times EF_{FF,CO2,i}}{\eta_{boiler,FF}}$$

To estimate the energy efficiency of the boiler in the baseline scenario, the manufacturer's information on efficiency of the existing boiler is used. As the level of biomass residue use in the absence of the project activity is associated with uncertainty, the conservative approach will be followed in determining $HG_{PJ,biomass,y}$. As a conservative approach, the **minimum value for $HG_{PJ,biomass,y}$** is calculated and used for the following two options:

1. The difference between the total quantity of heat generated from biomass residues in all boilers at the project site in the year *5* ($HG_{PJ,biomass,total,y}$) and the highest annual historical heat generation with biomass residues among the most recent three years prior to the implementation of the project activity, as follows (refer to table Table 10: Heat generated from biomass residues):

$$HG_{PJ,biomass,5} = HG_{PJ,biomass,total,5} \quad - \quad MAX\left\{HG_{biomass,historic,n}; HG_{biomass,historic,n-1}; HG_{biomass,historic,n-2}\right\}$$

$$HG_{PJ,biomass,5} = 2145910 \quad - \quad MAX\{578271;689057;752655\}$$

$$HG_{PJ,biomass,5} = 1393255$$

2. The difference between the total quantity of heat generated from biomass residues in all boilers in the year *y* ($HG_{PJ,biomass,total,y}$) and the total heat generation during the year *y* ($HG_{PJ,total,y}$) multiplied with the highest historical fraction of heat generation with biomass residues from the most recent three years. From equation 5 the historical fraction of heat generation with biomass residues can be determined based on the quantities of bark and coal used historically in the boiler(s) at the project site. Equation 5 simplifies to (refer toTable 10: Heat generated from biomass residues):

$$\frac{HG_{biomass,historic,n}}{HG_{total,historic,n}} = \frac{\sum BF_{bark,n} \cdot NCV_{bzrk}}{\sum BF_{bark,n} \cdot NCV_{bark} + \sum FC_{coal,n} \cdot NCV_{coal}}$$

For n-3 (refer to Table 10 Column I): $\frac{HG_{biomass,historic,n-3}}{HG_{total,historic,n-3}} = \frac{752655}{2953267} = 0.25$

For n-2 (refer to Table 10 Column I): $\frac{HG_{biomass,historic,n-2}}{HG_{total,historic,n-2}} = \frac{689057}{2889669} = 0.24$

For n-1 (refer to Table 10 Column I): $\dfrac{HG_{biomass,historic,n-2}}{HG_{total,historic,n-2}} = \dfrac{578271}{2778883} = 0.21$

The difference between the total quantity of heat generated from biomass residues in all boilers in the year *5* ($HG_{PJ,biomass,total,5}$) and the total heat generation during the year *5* ($HG_{PJ,total,5}$) multiplied with the highest historical fraction of heat generation with biomass residues from the most recent three years, as follows (equation 4):

$$HG_{PJ,biomass,5} = 2145910 - 3427200 \cdot MAX\{0.25;0.24;0.21\}$$

$$HG_{PJ,biomass,5} = 1272471 \quad GJ$$

Baseline emissions from fossil fuel combustion in boiler(s) for heat generation ($BE_{HG,y}$) for year 5 can now be calculated:

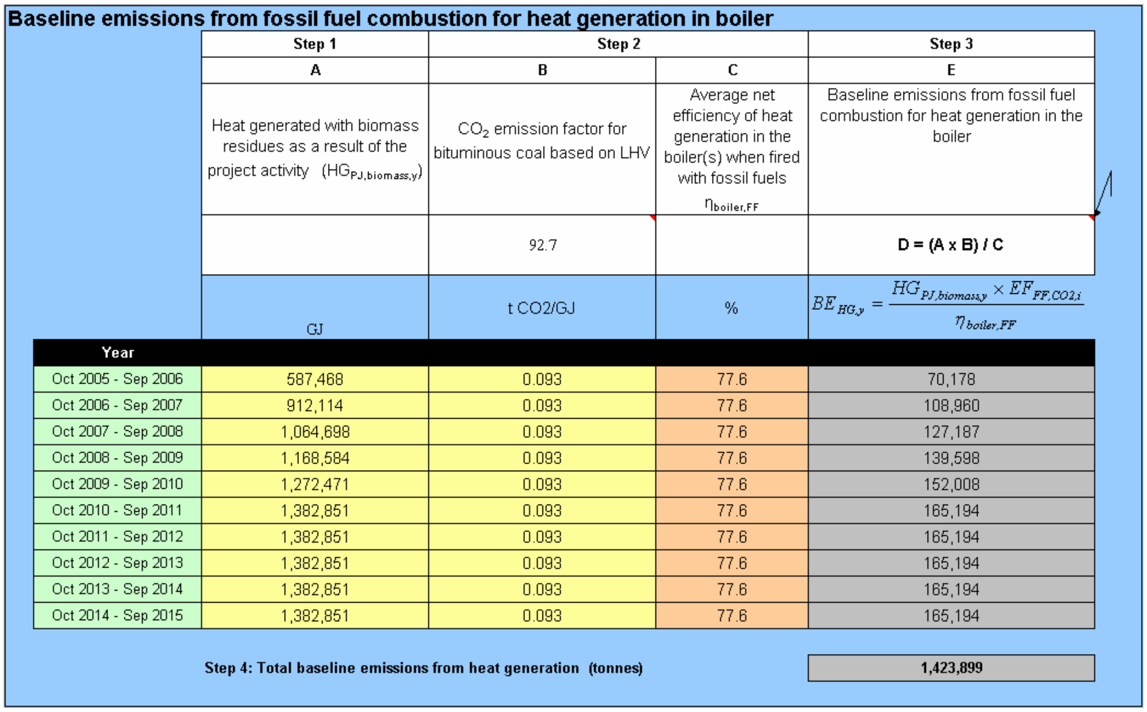
$$BE_{HG,5} = \frac{HG_{PJ,biomass,5} \times EF_{FF,CO2,i}}{\eta_{boiler,FF}}$$

$$BE_{HG,5} = \frac{1272471 \times 0.0927}{0.77}$$

$$BE_{HG,5} = 152008 \; t \; CO_2$$

Table 9 reflects the baseline emissions from fossil fuel combustion over a 10 year period.

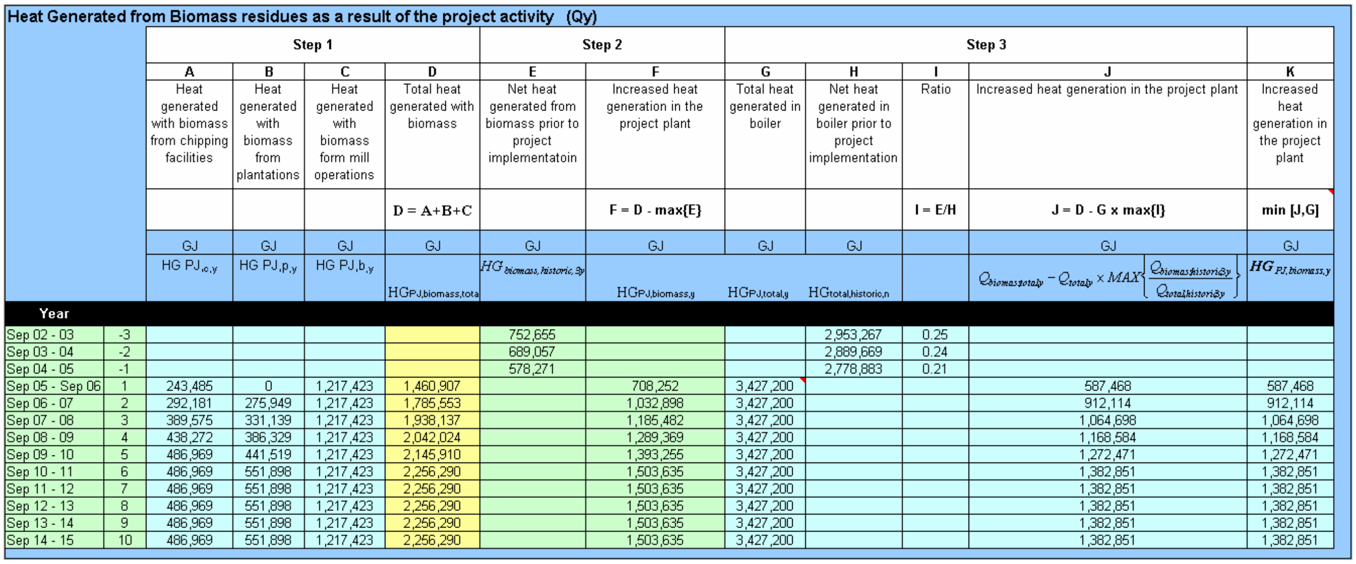
Table 9: Total baseline emissions from fossil fuel combustion



Baseline emissions from fossil fuel combustion for heat generation in boiler

	Step 1	Step 2		Step 3
	A	B	C	E
	Heat generated with biomass residues as a result of the project activity ($HG_{PJ,biomass,y}$)	CO_2 emission factor for bituminous coal based on LHV	Average net efficiency of heat generation in the boiler(s) when fired with fossil fuels $\eta_{boiler,FF}$	Baseline emissions from fossil fuel combustion for heat generation in the boiler
		92.7		D = (A x B) / C
	GJ	t CO2/GJ	%	$BE_{HG,y} = \frac{HG_{PJ,biomass,y} \times EF_{FF,CO2,i}}{\eta_{boiler,FF}}$
Year				
Oct 2005 - Sep 2006	587,468	0.093	77.6	70,178
Oct 2006 - Sep 2007	912,114	0.093	77.6	108,960
Oct 2007 - Sep 2008	1,064,698	0.093	77.6	127,187
Oct 2008 - Sep 2009	1,168,584	0.093	77.6	139,598
Oct 2009 - Sep 2010	1,272,471	0.093	77.6	152,008
Oct 2010 - Sep 2011	1,382,851	0.093	77.6	165,194
Oct 2011 - Sep 2012	1,382,851	0.093	77.6	165,194
Oct 2012 - Sep 2013	1,382,851	0.093	77.6	165,194
Oct 2013 - Sep 2014	1,382,851	0.093	77.6	165,194
Oct 2014 - Sep 2015	1,382,851	0.093	77.6	165,194
		Step 4: Total baseline emissions from heat generation (tonnes)		**1,423,899**

Table 10: Heat generated from biomass residues



Heat Generated from Biomass residues as a result of the project activity (Qy)

		Step 1				Step 2		Step 3				
		A	B	C	D	E	F	G	H	I	J	K
		Heat generated with biomass from chipping facilities	Heat generated with biomass from plantations	Heat generated with biomass form mill operations	Total heat generated with biomass	Net heat generated from biomass prior to project implementatoin	Increased heat generation in the project plant	Total heat generated in boiler	Net heat generated in boiler prior to project implementation	Ratio	Increased heat generation in the project plant	Increased heat generation in the project plant
					D = A+B+C		F = D - max{E}			I = E/H	J = D - G x max{I}	min [J,G]
		GJ	GJ	GJ	GJ	GJ	GJ	GJ	GJ		GJ	GJ
		$HG\ PJ_{,c,y}$	$HG\ PJ_{,p,y}$	$HG\ PJ_{,b,y}$	$HG_{PJ,biomass,tota}$	$HG_{biomass,historic,3y}$	$HG_{PJ,biomass,y}$	$HG_{PJ,total,y}$	$HG_{total,historic,n}$		$Q_{biomass,total,y} - Q_{total,y} \times MAX\left\{\frac{Q_{biomass,historic,3y}}{Q_{total,historic,3y}}\right\}$	$HG_{PJ,biomass,y}$
Year												
Sep 02 - 03	-3					752,655			2,953,267	0.25		
Sep 03 - 04	-2					689,057			2,889,669	0.24		
Sep 04 - 05	-1					578,271			2,778,883	0.21		
Sep 05 - Sep 06	1	243,485	0	1,217,423	1,460,907		708,252	3,427,200			587,468	587,468
Sep 06 - 07	2	292,181	275,949	1,217,423	1,785,553		1,032,898	3,427,200			912,114	912,114
Sep 07 - 08	3	389,575	331,139	1,217,423	1,938,137		1,185,482	3,427,200			1,064,698	1,064,698
Sep 08 - 09	4	438,272	386,329	1,217,423	2,042,024		1,289,369	3,427,200			1,168,584	1,168,584
Sep 09 - 10	5	486,969	441,519	1,217,423	2,145,910		1,393,255	3,427,200			1,272,471	1,272,471
Sep 10 - 11	6	486,969	551,898	1,217,423	2,256,290		1,503,635	3,427,200			1,382,851	1,382,851
Sep 11 - 12	7	486,969	551,898	1,217,423	2,256,290		1,503,635	3,427,200			1,382,851	1,382,851
Sep 12 - 13	8	486,969	551,898	1,217,423	2,256,290		1,503,635	3,427,200			1,382,851	1,382,851
Sep 13 - 14	9	486,969	551,898	1,217,423	2,256,290		1,503,635	3,427,200			1,382,851	1,382,851
Sep 14 - 15	10	486,969	551,898	1,217,423	2,256,290		1,503,635	3,427,200			1,382,851	1,382,851

2. Baseline emissions due to uncontrolled burning or decay of the biomass residues

Different baseline scenarios apply to the plantation residues and the chipping residues and the procedures as outlined below will be applied respectively to the different quantities and types of biomass residues.

Only the use of biomass residues over and above the historical use levels will be attributed to the CDM project activity and consequently be considered when determining $BE_{BF,y}$. The reason is that biomass residues have already been used for heat generation at the project site prior to the implementation of the project activity and the most plausible baseline scenario is that heat will continue to be generated partly with fossil fuels and partly with biomass residues.

The types of biomass residues differ in the baseline scenario, therefore, the total biomass decay emissions in the baseline scenario consist of emissions from two methodologies: 1) *Uncontrolled burning or aerobic decay of the biomass residues* and 2) *Anaerobic decay of the biomass residues*

$$BE_{BF,y} = BE_{Biomass,burning,y} + BE_{Biomass,anaerobic,y} \quad \text{(from equation 6)}$$

Plantation biomass residues

The most likely baseline scenario for the use of the plantation biomass residues is that the biomass residues will be left to decay under mainly aerobic conditions (B1 in table 3) without utilizing it for energy purposes (B3 in table 3). Baseline emissions are calculated for natural decay, and as per the methodology, the emissions are calculated assuming that the biomass residues would be burnt in an uncontrolled manner.

Baseline emissions are calculated by multiplying the quantity of biomass residues that would be left to decay in the absence of the project activity with the net calorific value and an appropriate emission factor, as follows for year 5 (refer to Table 12: Baseline emissions from natural decay of plantation biomass residues):

$$BE_{BF,5} = GWP_{CH4} \times \sum_{k} BF_{PJ,p,5} \times NCV_{p} \times EF_{burning,CH4,p,5} \text{ (from equation 8)}$$

$$BE_{BF,5} = 21 \times \sum_{k} BF_{PJ,p,5} \times NCV_{p} \times EF_{burning,CH4,p,5}$$

$$BE_{BF,5} = 21 \times 19040 \times 17 \times 0.0027$$

$$BE_{BF,5} = 638 \quad t\ CO_2$$

Chipping facility residues

The most likely baseline scenario for the use of the chipping facility residues is case B2 as described in **Table 4: Alternative baseline options and barrier analysis**, i.e. decay under anaerobic conditions. The CH4 emissions avoided by landfill are calculated:

$$BE_{BF,y} = \varphi \times (1-f) \times (1-OX) \times \frac{16}{12} \times F \times DOC_{f} \times MCF \times \sum_{x=1}^{y} BF_{x} \times DOC_{i} \times \left(1-e^{-k_i}\right) \times e^{-k_i.(y-x)}$$

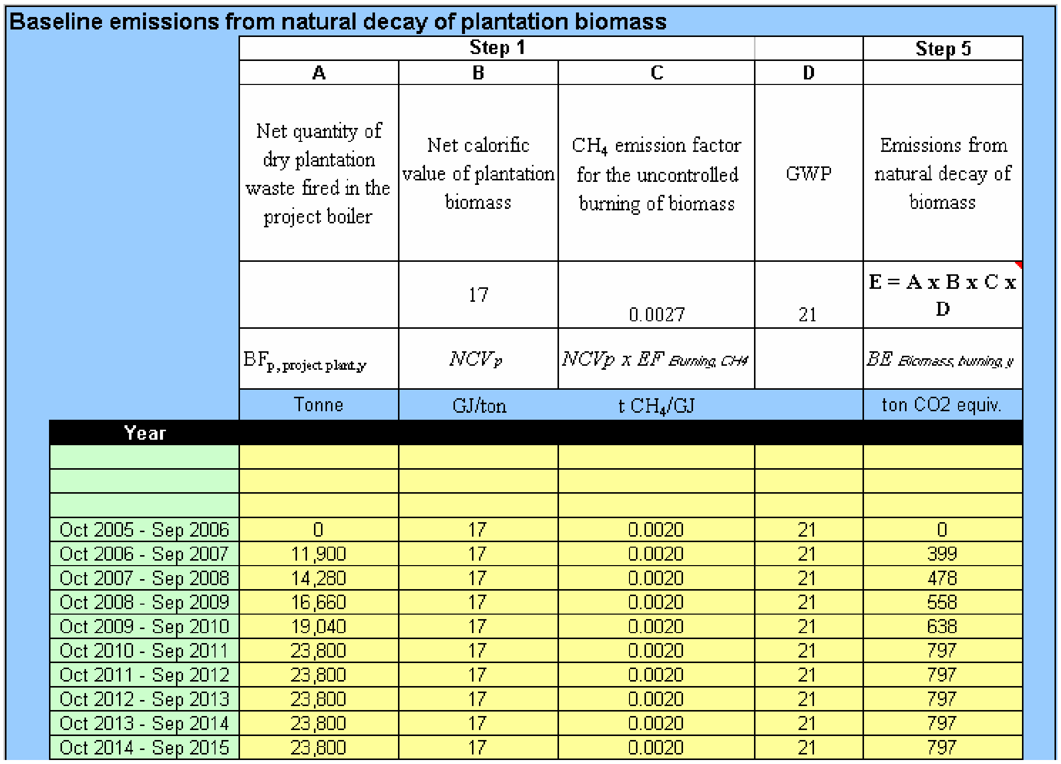
from equation 9

Table 11 **reflects the emissions over a 10 year period.**

Table 11: Calculation of emissions from biomass residue decay in anaerobic conditions

Baseline emissions from biomass in anaerobic conditions (landfill)													
	Step 1							Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
	A			B	C	D	E	F	G	H	I	J	K
	Model correction factor	Fraction of methane flared at the landfill site	Oxidation factor	Fraction of methane in the landfill gas	Fraction degradable organic carbon (DOC) dissimilated to landfill gas	Methane Correction Factor	Decay rate for the biomass waste type	Amount of biomass waste prevented from disposal in the year x	% degradable organic carbon (by weight) in the biomass waste	Year of crediting period		Emissions from biomass under anaerobic conditions	
	Φ	1-f	1-OX	F	DOC_f	MCF	K_i	$BF_{i,x}$	DOC_i	y	$\sum F\times G\times\left(1-e^{-k}\right)\times e^{-k(y-x)}$	$BE_{biomass,anaerobic}$	$BE_{biomass,anaerobic}$
					$BE_{BF,y}=\varphi\times(1-f)\times(1-OX)\times\frac{16}{12}\times F\times DOC_f\times MCF\times\sum_{x=1}^{y}BF_x\times DOC_i\times\left(1-e^{-k_i}\right)\times e^{-k_i(y-x)}$							J = AxBxCxDx16/12xI	K = J x 21
	0.9	f=0	OX=0.1	0.5	0.5	1	0.023	tonne dry	30			t CH4	t CO2 eq
Year													
Oct 2005 - Sep 2006	0.9	1.0	0.9	0.5	0.5	1	0.023	10,500	30	1	7,162	1,934	40,610
Oct 2006 - Sep 2007	0.9	1.0	0.9	0.5	0.5	1	0.023	12,600	30	2	15,562	4,202	88,235
Oct 2007 - Sep 2008	0.9	1.0	0.9	0.5	0.5	1	0.023	16,800	30	3	26,506	7,157	150,290
Oct 2008 - Sep 2009	0.9	1.0	0.9	0.5	0.5	1	0.023	18,900	30	4	38,539	10,405	218,515
Oct 2009 - Sep 2010	0.9	1.0	0.9	0.5	0.5	1	0.023	21,000	30	5	51,604	13,933	292,597
Oct 2010 - Sep 2011	0.9	1.0	0.9	0.5	0.5	1	0.023	21,000	30	6	64,373	17,381	364,994
Oct 2011 - Sep 2012	0.9	1.0	0.9	0.5	0.5	1	0.023	21,000	30	7	76,851	20,750	435,745
Oct 2012 - Sep 2013	0.9	1.0	0.9	0.5	0.5	1	0.023	21,000	30	8	89,045	24,042	504,888
Oct 2013 - Sep 2014	0.9	1.0	0.9	0.5	0.5	1	0.023	21,000	30	9	100,963	27,260	572,458
Oct 2014 - Sep 2015	0.9	1.0	0.9	0.5	0.5	1	0.023	21,000	30	10	112,609	30,404	638,492

Table 12: Baseline emissions from natural decay of plantation biomass residues

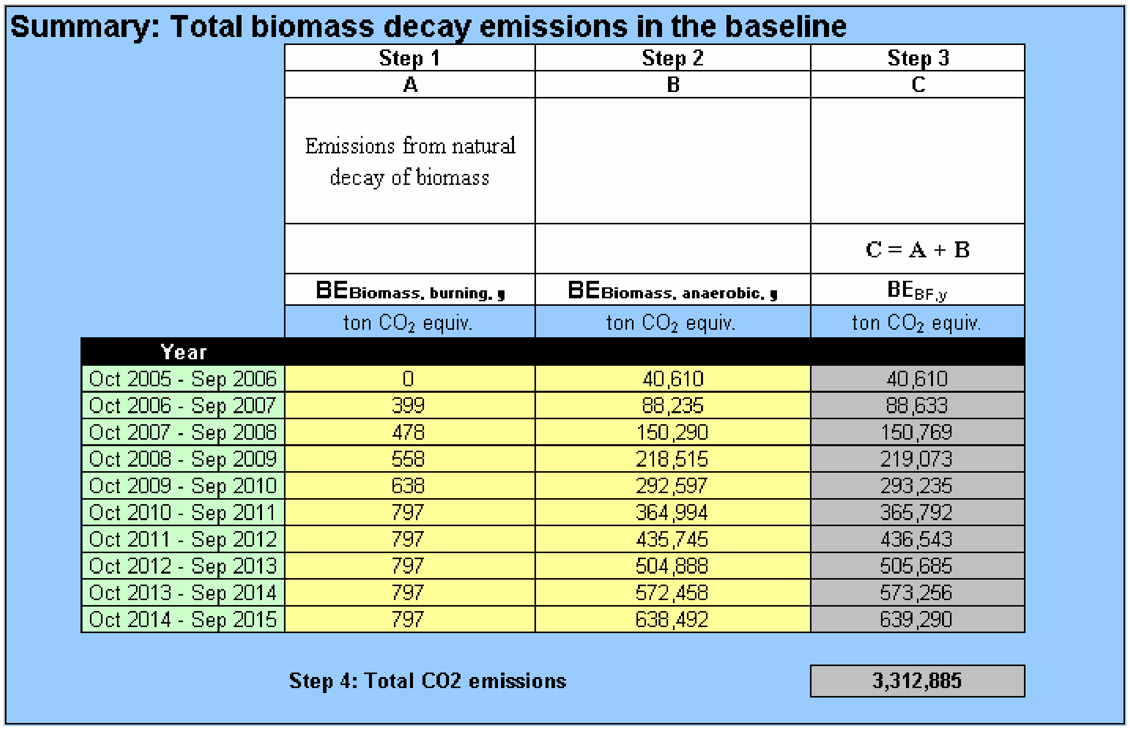


Baseline emissions from natural decay of plantation biomass

	Step 1				Step 5
	A	B	C	D	
	Net quantity of dry plantation waste fired in the project boiler	Net calorific value of plantation biomass	CH_4 emission factor for the uncontrolled burning of biomass	GWP	Emissions from natural decay of biomass
		17	0.0027	21	E = A x B x C x D
	$BF_{p,project\ plant,y}$	*NCVp*	*NCVp x EF Burning, CH4*		*BE Biomass, burning, y*
	Tonne	GJ/ton	t CH_4/GJ		ton CO2 equiv.
Year					
Oct 2005 - Sep 2006	0	17	0.0020	21	0
Oct 2006 - Sep 2007	11,900	17	0.0020	21	399
Oct 2007 - Sep 2008	14,280	17	0.0020	21	478
Oct 2008 - Sep 2009	16,660	17	0.0020	21	558
Oct 2009 - Sep 2010	19,040	17	0.0020	21	638
Oct 2010 - Sep 2011	23,800	17	0.0020	21	797
Oct 2011 - Sep 2012	23,800	17	0.0020	21	797
Oct 2012 - Sep 2013	23,800	17	0.0020	21	797
Oct 2013 - Sep 2014	23,800	17	0.0020	21	797
Oct 2014 - Sep 2015	23,800	17	0.0020	21	797

Table 13 reflects the total forecasted biomass decay emissions in the baseline scenario over a 10 year period.

Table 13: Total baseline emissions from biomass residue decay



Summary: Total biomass decay emissions in the baseline

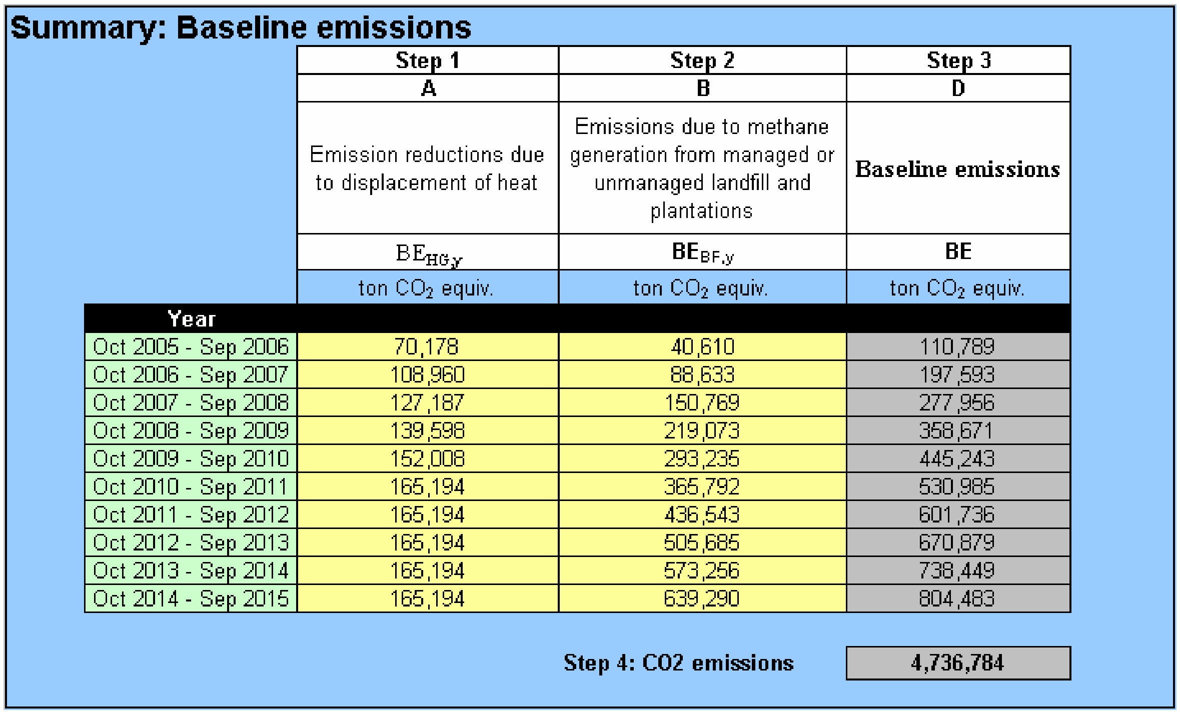
	Step 1	Step 2	Step 3
	A	B	C
	Emissions from natural decay of biomass		
			C = A + B
	BE Biomass, burning, y	**BE** Biomass, anaerobic, y	$BE_{BF,y}$
	ton CO_2 equiv.	ton CO_2 equiv.	ton CO_2 equiv.
Year			
Oct 2005 - Sep 2006	0	40,610	40,610
Oct 2006 - Sep 2007	399	88,235	88,633
Oct 2007 - Sep 2008	478	150,290	150,769
Oct 2008 - Sep 2009	558	218,515	219,073
Oct 2009 - Sep 2010	638	292,597	293,235
Oct 2010 - Sep 2011	797	364,994	365,792
Oct 2011 - Sep 2012	797	435,745	436,543
Oct 2012 - Sep 2013	797	504,888	505,685
Oct 2013 - Sep 2014	797	572,458	573,256
Oct 2014 - Sep 2015	797	638,492	639,290
	Step 4: Total CO2 emissions		**3,312,885**

Total baseline emissions for year 5 are the total baseline emissions from fossil fuel combustion for heat generation in the boiler plus the baseline emissions due to decay of plantation residues and decay of the chipping facility residues:

$$BE_5 = BE_{HG,5} + BE_{BF,5}$$
$$BE_5 = 152008 + 293235$$
$$BE_5 = 1445243 \quad t\ CO_2$$

Table 14 is a summary of baseline emissions for a 10 year period.

Table 14: Total baseline emissions for the project activity



Summary: Baseline emissions

	Step 1	Step 2	Step 3
	A	B	D
	Emission reductions due to displacement of heat	Emissions due to methane generation from managed or unmanaged landfill and plantations	**Baseline emissions**
	$BE_{HG,y}$	$BE_{BF,y}$	BE
	ton CO_2 equiv.	ton CO_2 equiv.	ton CO_2 equiv.
Year			
Oct 2005 - Sep 2006	70,178	40,610	110,789
Oct 2006 - Sep 2007	108,960	88,633	197,593
Oct 2007 - Sep 2008	127,187	150,769	277,956
Oct 2008 - Sep 2009	139,598	219,073	358,671
Oct 2009 - Sep 2010	152,008	293,235	445,243
Oct 2010 - Sep 2011	165,194	365,792	530,985
Oct 2011 - Sep 2012	165,194	436,543	601,736
Oct 2012 - Sep 2013	165,194	505,685	670,879
Oct 2013 - Sep 2014	165,194	573,256	738,449
Oct 2014 - Sep 2015	165,194	639,290	804,483

Step 4: CO2 emissions **4,736,784**

Project activity emissions

The anthropogenic emissions by sources of GHG of the Mondi Biomass project activity in a year y, can be determined as follows:

$$PE_y = PE_{CO2,TR,y} + PE_{CO2,EC,y} + PE_{CO2,FF,y} + GWP_{CH4} \times PE_{CH4,BF,y}$$

Only the additional biomass consumptions will be considered to calculate the net project activity GHG emission savings. Annex 3 shows the additional biomass residue amounts that were used to calculate the net emissions of the proposed project activity. It also shows the biomass mix composition and the weighted average net calorific value that was used for the calculations below.

<u>Assumptions used in the illustrative calculations</u>:

- The biomass residues originate from (1) a mixture of fines, off-cuts and wood chips contaminated with rocks, sand and metal collected from chipping facilities (2) plantation residues transported to the Richards Bay operation and (3) additional bark from the debarking process.
- The quantities biomass residues received from nearby facilities and plantations are monitored.

Table 15: Data/estimates used in illustrative calculations for Project Activity

Parameter		Units	Source of information
Net Calorific Value - Bituminous coal	NCV_c	27.5 MJ/kg or 7.6 MWh/tonne[40] 25.09 TJ/kt	Coal supplier, Mondi laboratory, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories(Table 1-2 on pages 1.16 - 1.22 of the Reference Manual)
Net Calorific Value – Bark (dry)	NCV_b	2.2 MWh/dry tonne 18 MJ/dry kg	Mondi laboratory, IPCC guidelines
Net Calorific Value – bark (wet)	NCV_b	8 MJ/kg or 2.2 MWh/tonne[10]	Mondi laboratory, IPCC guidelines
Net Calorific Value – Sawdust	$NCV_{sawdust}$	5.6 MWh/dry tonne 20 MJ/dry kg	Mondi laboratory, IPCC guidelines
Net Calorific Value - Plantation Waste	NCV_p	5.0 MWh/wet tonne 18 MJ/wet kg	Mondi laboratory, IPCC guidelines where applicable
Default net calorific value, Air-dry, humid zone wood[41]		15.5 MJ/kg	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (Table 1-13 on Page 1.45 of the Reference Manual)
Default net calorific value Air-dry, dry zone[42] wood		16.6 MJ/kg	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (Table 1-13 on Page 1.45 of the Reference Manual)

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[40] Calculated using the conversion factor: 1 MJ/kg = 1/3.6 MWh/tonne

[41] Can be used for reference purposes and quality control of data

[42] Can be used for reference purposes and quality control of data

Parameter		Units	Source of information
Default net calorific value Oven, dry wood[43]		20 MJ/kg	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (Table 1-13 on Page 1.45 of the Reference Manual)
Efficiency of biomass-fired boiler	$\varepsilon_{boiler\ Biomass}$	76.2%	Mondi Co-fired boiler information
Efficiency of coal fired boiler	$\varepsilon_{boiler,\ FF}$	77.6%	Mondi Co-fired boiler information
Plant operation		350 days/year	
CH_4 emission factor for uncontrolled burning	NCV_k x $EF_{burning,CH4,k,y}$	0.0027 t CH4/t biomass used	2006 IPCC Guidelines, Volume 4, Table 2.5, default for agricultural residues
CO_2 emission factor for bituminous coal based on the lower heating value (LHV)[44]	$EF_{CO2,FF}$	92.7 kg CO_2/GJ fuel[45]	Default emission factors from Calculation tools for GHG emissions from pulp and paper mills[46]
CH_4 emission factor for biomass combustion	$EF_{CH4,BF}$	15 kg/TJ biomass fuel converted to 21.55 kg/TJ (see comment).	IPCC default value. A conservativeness factor of 1.37 is applied to the CH_4 emission factor of 15kg/TJ (Table 1-16 on Page 1.54) of the Reference Manual of 1996. Revised IPCC Guidelines), giving a revised CH_4 emission factor of 21.55 kg/TJ used in the calculation.
Weighted average CO_2 emissions for Electricity imported from national grid	$EF_{grid,y}$	0.92kg CO_2/kWh (Eskom)	Eskom publicly reported for the year 2005 that for every kWh it produced, 0.92 kg of CO_2 was emitted (Eskom Annual Report 2006).
Global warming potential of CH_4	GWP	21 tonne CO_2/tonne CH_4	IPCC Emission Guidelines 1996
CO_2 emissions per litre of Diesel	EF_{kmCO2}	2.85 kg CO_2/litre diesel	Table adapted from Kinsky, R. Thermodynamics – advanced applications

*1 TJ = 10^6 MJ
(1 MJ = 1/3.6 kWh) therefore 1 TJ = 10^6/3.6 kWh = 277 777 kWh = 277.8 MWh
So: 21.55 kg/TJ = 21.55/277.8 kg/MWh = 0.077 kg/MWh = 0.00007758 tonne/MWh

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[43] Can be used for reference purposes and quality control of data

[44] Emission factor (LHV) = Emission factor (HHV) / 0.95 for solid/liquid fuels

[45] Applicable to spreader stoker boilers, Emission factors based on lower heating values from EIA, 2001, Appendix B as referenced in Calculation tools for GHG emissions from pulp and paper mills

[46] Sector specific tool developed by NCASI for the Climate Change Working Group of the International Council of Forest and Paper Associations (ICFPA) and is available on www.ghgprotocol.org or www.ncasi.org

Table 16: Transport data/estimates used in illustrative calculations for Project Activity[47]

Project Activity			
Parameter	**TL_i**	**Emissions intensity**	**Return trip Distance**
Plantation i to Mondi operation	6 tonnes	0.56 litre diesel/tonne.km 2.85 kg CO_2/litre diesel	100 km
Nearby chipping facility *i* to Mondi operation	3 tonnes	0.56 litre diesel/tonne.km 2.85 kg CO_2/litre diesel	15 km

Formulae for calculating emissions from the Project Activity

In the project activity, biomass residues are fired in a co-fired boiler under normal operational conditions. Project emissions include CO_2 emissions from transportation of biomass to the project site ($PE_{CO2,TR,y}$) and CO_2 emissions from on-site consumption of electricity due to the processing of the biomass residues by equipment implemented as part of the project activity ($PEFF_y$). CH_4 emissions from the combustion of biomass ($PE_{Biomass,CH4,y}$) are included in the project activity emissions as CH_4 emissions from the decay of biomass are included in the baseline:

Step 1: Determine the quantities biomass residues supplied by plantations, nearby chipping facilities and the additional bark from the wood yard operation used as fuel in the project plant during year *y*

Please refer to Table 17: Biomass residue combustion quantities and emissions

Step 2: Determine CH_4 emissions from the combustion of biomass in the project plant during the year y

$$PE_{CH4,BF,y} = EF_{CH4,BF} \times \sum_k BF_{PJ,k,y} \times NCV_k$$

Equation 16

Step 3: Determine the CO_2 emissions from onsite consumption of electricity due to the use of hoppers and shredders in tonnes

$$PE_{CO2,EC,y} = EC_{PJ,y} \times EF_{grid,y}$$

Equation 15

Step 4: Determine the CO_2 emissions during the year *y* due to transport of the biomass to the project plant in tonnes of CO_2

$$PE_{CO2,TR,y} = \frac{\sum_i BF_{p,y,wet}}{TL_{p,y}} \times AVD_y \times EF_{km,CO2} + \frac{\sum_c BF_{c,y,wet}}{TL_{c,y}} \times AVD_y \times EF_{km,CO2} \quad \text{Equation 5}$$

Step 5: Determine the CO_2 emissions from on-site fossil fuel combustion

$$PE_{CO2,FF,y} = \sum_i FC_{on-site,i,y} \times NCV_i \times EF_{CO2,FF,i}$$

---

[47] This information will be collected during the project activity

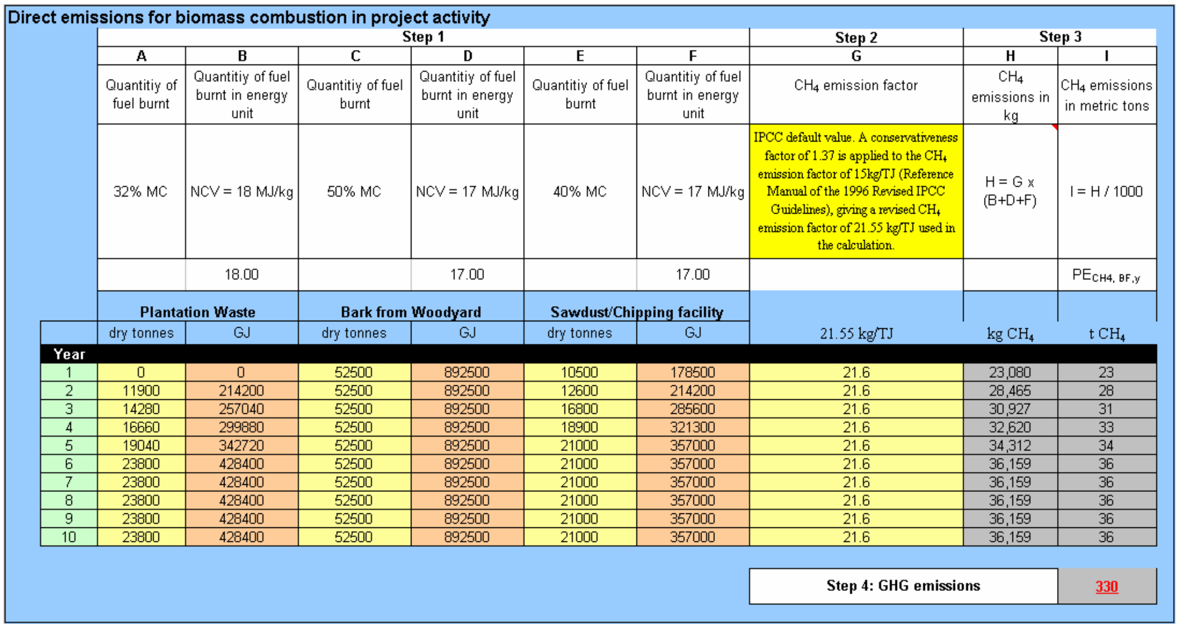
Step 6: Calculate the total tonnes CO_2 emissions during the year *y* due to project activity

$$PE_y = PE_{CO2,TR,y} + PE_{CO2,EC,y} \quad + PE_{CO2,FF,y} + GWP_{CH4} \times PE_{CH4,BF,y}$$

Calculation example for emissions from the Project Activity:

Step 1:
The quantities biomass residues supplied by plantations, nearby chipping facilities and the additional bark from the wood yard operation used as fuel in the project plant are indicated in the following table.

Table 17: Biomass residue combustion quantities and emissions



Direct emissions for biomass combustion in project activity

	Step 1						Step 2	Step 3	
	A	B	C	D	E	F	G	H	I
	Quantitiy of fuel burnt	Quantitiy of fuel burnt in energy unit	Quantitiy of fuel burnt	Quantitiy of fuel burnt in energy unit	Quantitiy of fuel burnt	Quantitiy of fuel burnt in energy unit	CH_4 emission factor	CH_4 emissions in kg	CH_4 emissions in metric tons
	32% MC	NCV = 18 MJ/kg	50% MC	NCV = 17 MJ/kg	40% MC	NCV = 17 MJ/kg	IPCC default value. A conservativeness factor of 1.37 is applied to the CH_4 emission factor of 15kg/TJ (Reference Manual of the 1996 Revised IPCC Guidelines), giving a revised CH_4 emission factor of 21.55 kg/TJ used in the calculation.	H = G x (B+D+F)	I = H / 1000
		18.00		17.00		17.00			$PE_{CH4, BF,y}$
	Plantation Waste		Bark from Woodyard		Sawdust/Chipping facility				
	dry tonnes	GJ	dry tonnes	GJ	dry tonnes	GJ	21.55 kg/TJ	kg CH_4	t CH_4
Year									
1	0	0	52500	892500	10500	178500	21.6	23,080	23
2	11900	214200	52500	892500	12600	214200	21.6	28,465	28
3	14280	257040	52500	892500	16800	285600	21.6	30,927	31
4	16660	299880	52500	892500	18900	321300	21.6	32,620	33
5	19040	342720	52500	892500	21000	357000	21.6	34,312	34
6	23800	428400	52500	892500	21000	357000	21.6	36,159	36
7	23800	428400	52500	892500	21000	357000	21.6	36,159	36
8	23800	428400	52500	892500	21000	357000	21.6	36,159	36
9	23800	428400	52500	892500	21000	357000	21.6	36,159	36
10	23800	428400	52500	892500	21000	357000	21.6	36,159	36
							Step 4: GHG emissions		330

Step 2: Determine biomass combustion CH4 emissions

From equation 5, based on an additional 92540 (dry) tonnes of biomass fired in the co-fired boiler **during year 5**:

$$PE_{CH4,BF,5} = EF_{CH4} \times \sum_k BF_{k,5} \times NCV_k$$

NCV_p for biomass from plantations (k=*p*) equals 18 MJ/kg, and

NCV_c for biomass from nearby chipping facilities (k=*c*) equals 17 MJ/kg. And

NCV_b for dry bark from wood yard operation (k=*b*) equals 17 MJ/kg.

Additional biomass residues from plantations: 19 040 dry tonnes

$$PE_{CH4,BF,5} = 17\left(\frac{GJ}{tonne}\right)\times 19040\ \left(\frac{tonne}{year}\right)\ \times\ \frac{21.5}{10^6}\left(\frac{tonneCH4}{GJ}\right)$$

Additional biomass residues from nearby chipping facilities: 21 000 dry tonnes

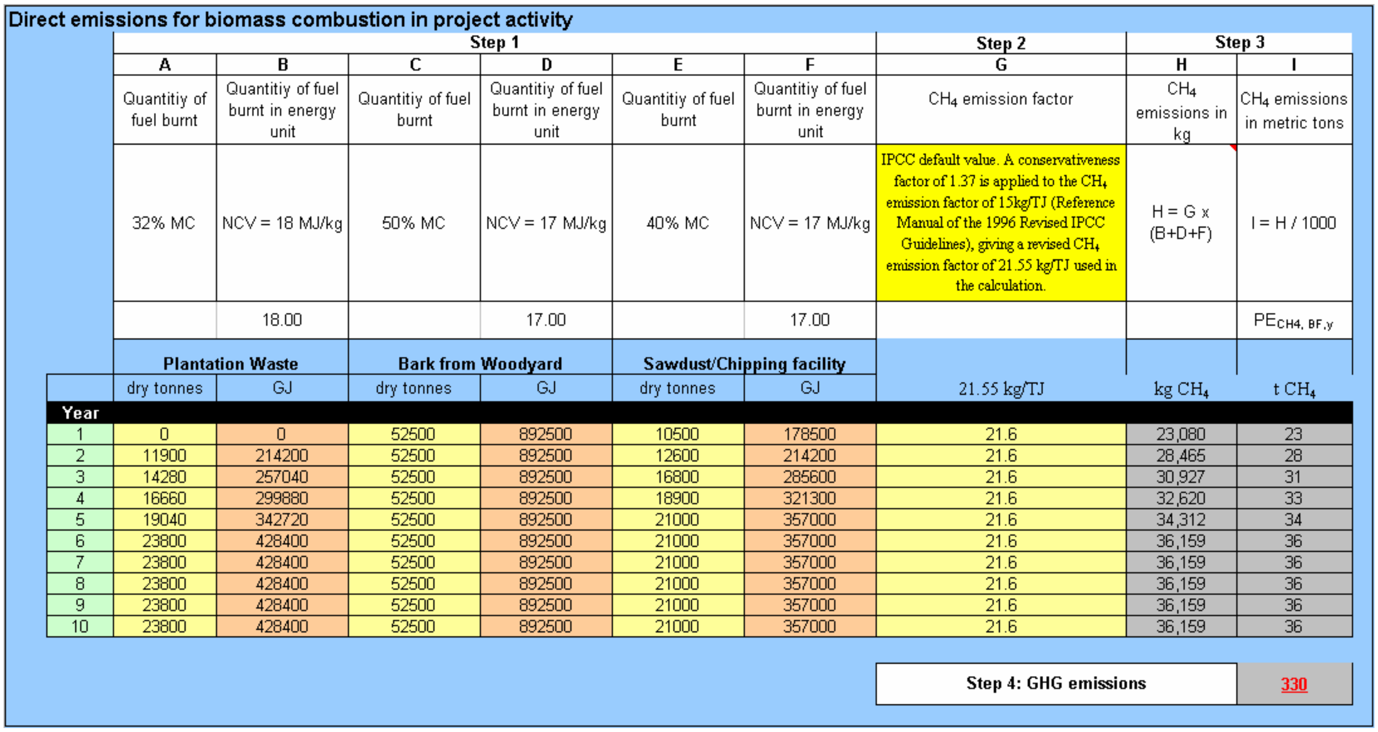
$$PE_{CH4,BF,5} = 17\left(\frac{GJ}{tonne}\right)\times 21000\ \left(\frac{tonne}{year}\right)\ \times\ \frac{21.5}{10^6}\left(\frac{tonneCH4}{GJ}\right)$$

Additional bark from the operation: 52500 dry tonnes

$$PE_{CH4,BF,5} = 17\left(\frac{GJ}{tonne}\right)\times 52500\ \left(\frac{tonne}{year}\right)\ \times\ \frac{21.5}{10^6}\left(\frac{tonneCH4}{GJ}\right)$$

$$PE_{CH4,BF,5} = \quad 34\ tonne \quad CH_4 \quad \text{in year 5}$$

Table 18: Methane emissions from firing biomass residues in the co-fired boiler



Direct emissions for biomass combustion in project activity

	Step 1						Step 2	Step 3	
	A	B	C	D	E	F	G	H	I
	Quantitiy of fuel burnt	Quantitiy of fuel burnt in energy unit	Quantitiy of fuel burnt	Quantitiy of fuel burnt in energy unit	Quantitiy of fuel burnt	Quantitiy of fuel burnt in energy unit	CH_4 emission factor	CH_4 emissions in kg	CH_4 emissions in metric tons
	32% MC	NCV = 18 MJ/kg	50% MC	NCV = 17 MJ/kg	40% MC	NCV = 17 MJ/kg	IPCC default value. A conservativeness factor of 1.37 is applied to the CH_4 emission factor of 15kg/TJ (Reference Manual of the 1996 Revised IPCC Guidelines), giving a revised CH_4 emission factor of 21.55 kg/TJ used in the calculation.	H = G x (B+D+F)	I = H / 1000
		18.00		17.00		17.00			$PE_{CH4,\ BF,y}$
	Plantation Waste		Bark from Woodyard		Sawdust/Chipping facility				
	dry tonnes	GJ	dry tonnes	GJ	dry tonnes	GJ	21.55 kg/TJ	kg CH_4	t CH_4
Year									
1	0	0	52500	892500	10500	178500	21.6	23,080	23
2	11900	214200	52500	892500	12600	214200	21.6	28,465	28
3	14280	257040	52500	892500	16800	285600	21.6	30,927	31
4	16660	299880	52500	892500	18900	321300	21.6	32,620	33
5	19040	342720	52500	892500	21000	357000	21.6	34,312	34
6	23800	428400	52500	892500	21000	357000	21.6	36,159	36
7	23800	428400	52500	892500	21000	357000	21.6	36,159	36
8	23800	428400	52500	892500	21000	357000	21.6	36,159	36
9	23800	428400	52500	892500	21000	357000	21.6	36,159	36
10	23800	428400	52500	892500	21000	357000	21.6	36,159	36
							Step 4: GHG emissions		330

Step 3: Imported electricity emissions

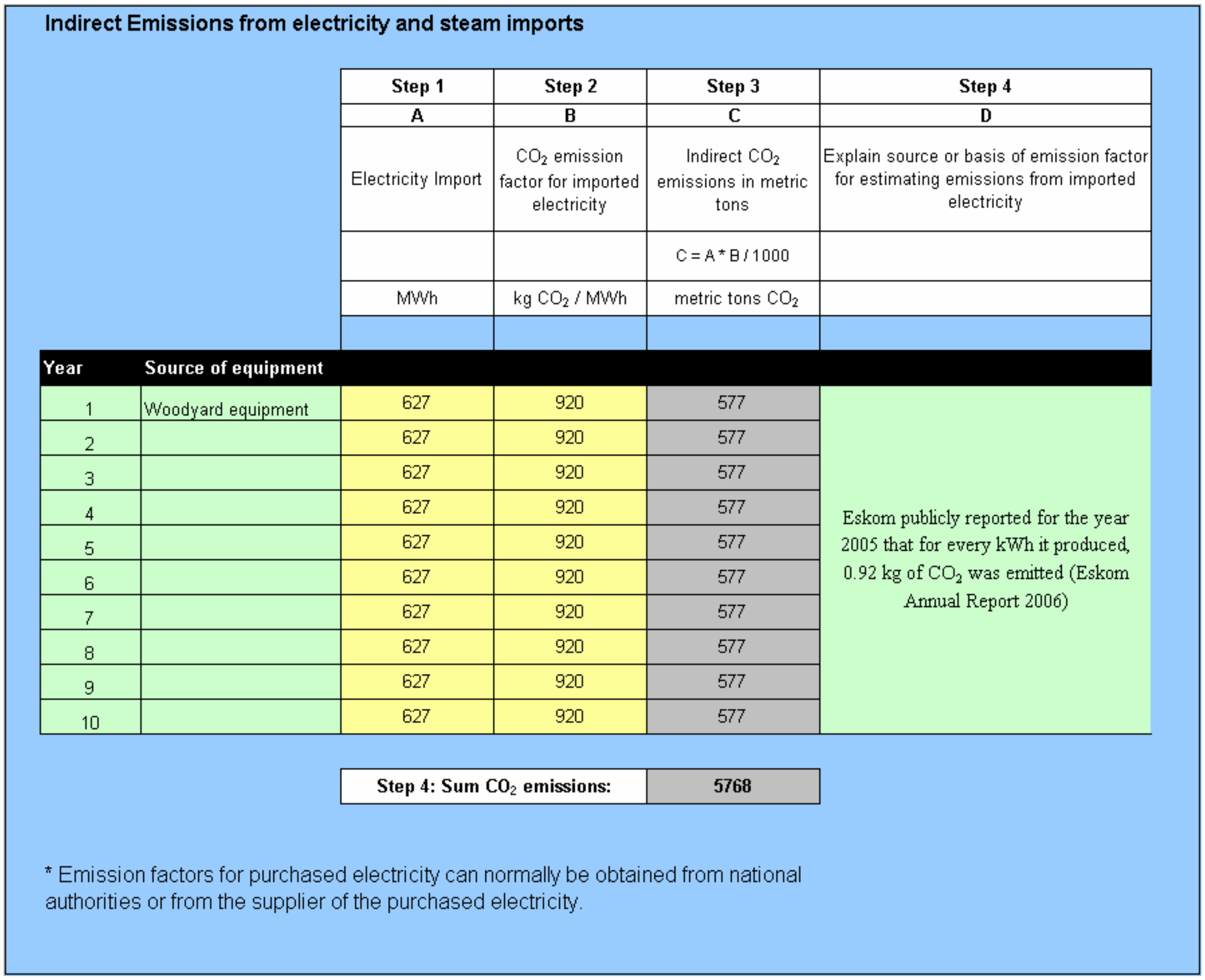
From equation 4 based on an on-site consumption of electricity for the new equipment in the project activity (627 MWh) **in year 5**:

$$PE_{CO2,EC,5} = EC_{PJ,5} \times EF_{grid,5}$$

$$PE_{CO2.EC.5} = 627 \times 0.92$$

$$= 577 \quad tonne \quad CO_2$$

Table 19: Indirect emissions from imported electricity used for equipment implemented in project activity



Indirect Emissions from electricity and steam imports

		Step 1	Step 2	Step 3	Step 4
		A	B	C	D
		Electricity Import	CO_2 emission factor for imported electricity	Indirect CO_2 emissions in metric tons	Explain source or basis of emission factor for estimating emissions from imported electricity
				C = A * B / 1000	
		MWh	kg CO_2 / MWh	metric tons CO_2	
Year	**Source of equipment**				
1	Woodyard equipment	627	920	577	Eskom publicly reported for the year 2005 that for every kWh it produced, 0.92 kg of CO_2 was emitted (Eskom Annual Report 2006)
2		627	920	577	
3		627	920	577	
4		627	920	577	
5		627	920	577	
6		627	920	577	
7		627	920	577	
8		627	920	577	
9		627	920	577	
10		627	920	577	

Step 4: Sum CO_2 emissions:	**5768**

* Emission factors for purchased electricity can normally be obtained from national authorities or from the supplier of the purchased electricity.

Step 4: Transport emissions

Note: For determining transport emissions, the biomass exported from external sources such as the plantations and the chipping facilities are considered.[48]

Project Activity				
Parameter	**Quantity**	**TL_i**	**Emissions intensity**	**Return trip Distance**
$BF_{p,5}$	35 000 tonnes wet	6 tonnes	0.56 litre diesel/tonne.km 2.85 kg CO_2/litre diesel	100 km
$BF_{c,5}$	35 000 tonnes wet	3 tonnes	0.56 litre diesel/tonne.km 2.85 kg CO_2/litre diesel	15 km

From equation 2, based on the transport of 70 000 tonnes biomass in year 5 (35 000 from nearby chipping facilities, 35 000 from plantations), a fuel consumption of 0.56 l/ton.km for biomass and an emission factor of 2.85 kg CO_2/l diesel:

$$PE_{CO2,TR,5} = \frac{\sum_k BF_{PJ,p,5}}{TL_{p,5}} \times AVD_5 \times EF_{km,CO2,5} \quad + \quad \frac{\sum_k BF_{PJ,c,5}}{TL_{c,5}} \times AVD_5 \times EF_{km,CO2,5}$$

Note: For simplicity, we are assuming all the biomass is coming from one plantation and one chipping facility. During the project, the source of biomass will be monitored and associated distances will be applied in the calculations for each individual source.

$$PE_{CO2,TR,5} = \frac{28000}{6} \times 100 \times \frac{1.6}{1000} \quad + \quad \frac{35000}{3} \times 15 \times \frac{1.6}{1000}$$

$$PE_{CO2,TR,5} = 279 \quad + \quad 745$$

$$PET_5 = 1024 \text{ tonne CO}_2$$

where

$$EF_{km,CO2} = \frac{kg\ CO_2}{litre\ diesel} \times \frac{litre\ diesel}{kilometre}$$

$$EF_{km,CO2} = 2.85 \times 0.56$$

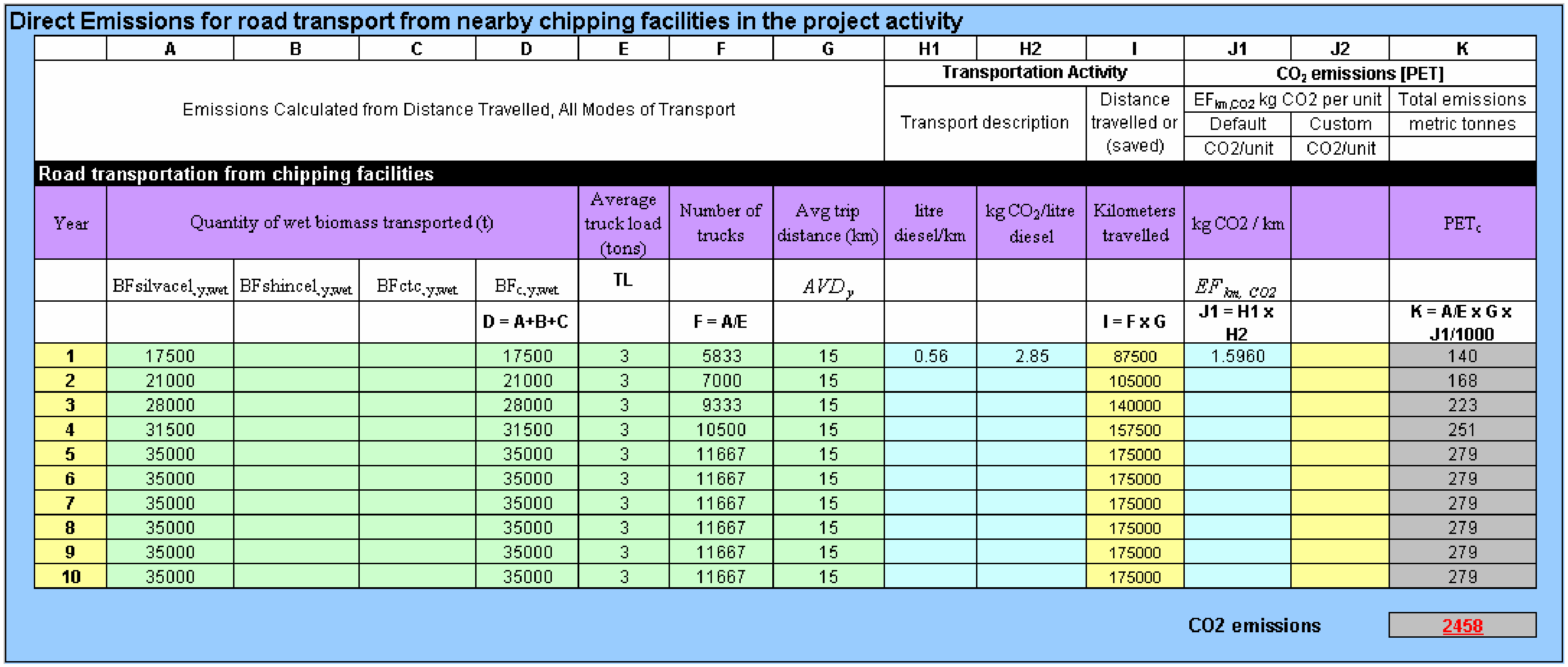
---

[48] The additional biomass from the woodyard is not transported from external sources (for example plantations). Therefore, transport emissions are calculated only for biomass imported to the operation during the project activity.

$$EF_{km,CO2} = 1.6 \frac{kg\ CO_2}{kilometre}$$

Total forecasted estimations for transport emissions as result of the project activity are reflected in **Error! Not a valid bookmark self-reference.**, **Table 21: Emissions from transport from plantations**, **Table 22: Summary of emissions from transport in the project activity**.

Table 20: Transport emissions from chipping facilities

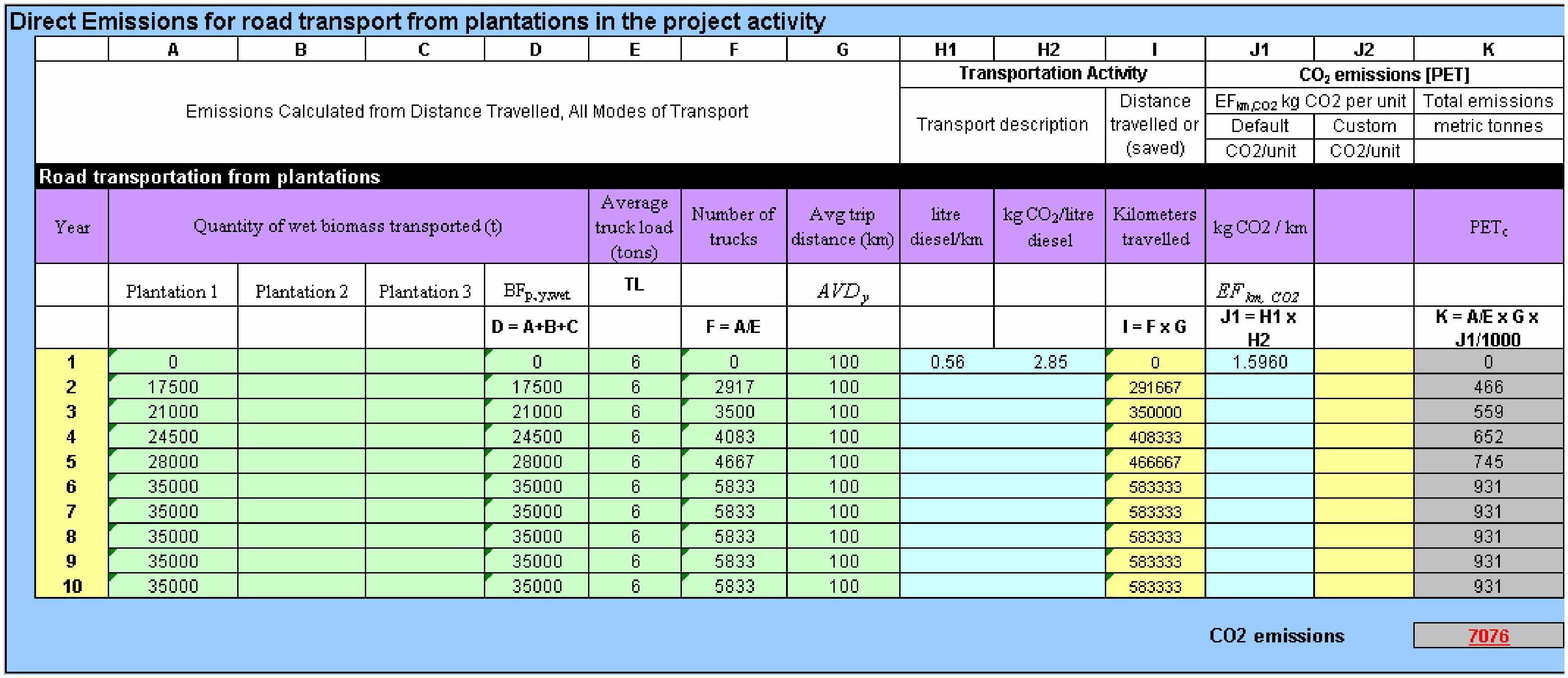


Direct Emissions for road transport from nearby chipping facilities in the project activity

	A	B	C	D	E	F	G	H1	H2	I	J1	J2	K
Emissions Calculated from Distance Travelled, All Modes of Transport								Transportation Activity			CO_2 emissions [PET]		
								Transport description		Distance travelled or (saved)	$EF_{km,co2}$ kg CO2 per unit		Total emissions
											Default	Custom	metric tonnes
											CO2/unit	CO2/unit	
Road transportation from chipping facilities													
Year	Quantity of wet biomass transported (t)				Average truck load (tons)	Number of trucks	Avg trip distance (km)	litre diesel/km	kg CO_2/litre diesel	Kilometers travelled	kg CO2 / km		PET_c
	$BFsilvacel_{y,wet}$	$BFshincel_{y,wet}$	$BFctc_{y,wet}$	$BF_{c,y,wet}$	TL		AVD_y				$EF_{km,\ CO2}$		
				D = A+B+C		F = A/E				I = F x G	J1 = H1 x H2		K = A/E x G x J1/1000
1	17500			17500	3	5833	15	0.56	2.85	87500	1.5960		140
2	21000			21000	3	7000	15			105000			168
3	28000			28000	3	9333	15			140000			223
4	31500			31500	3	10500	15			157500			251
5	35000			35000	3	11667	15			175000			279
6	35000			35000	3	11667	15			175000			279
7	35000			35000	3	11667	15			175000			279
8	35000			35000	3	11667	15			175000			279
9	35000			35000	3	11667	15			175000			279
10	35000			35000	3	11667	15			175000			279

CO2 emissions 2458

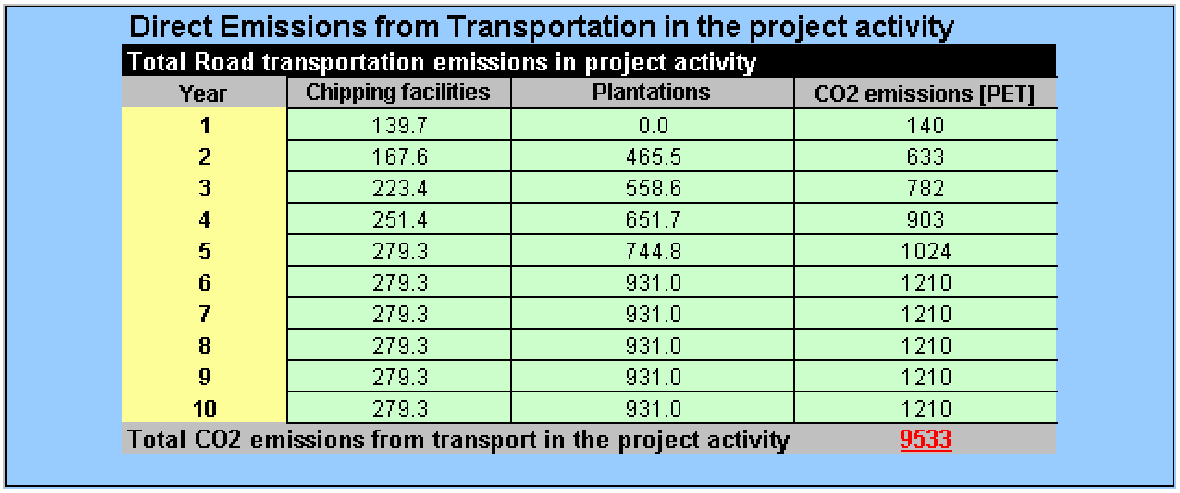
Table 21: Emissions from transport from plantations



Direct Emissions for road transport from plantations in the project activity

	A	B	C	D	E	F	G	H1	H2	I	J1	J2	K
Emissions Calculated from Distance Travelled, All Modes of Transport								Transportation Activity			CO$_2$ emissions [PET]		
								Transport description		Distance travelled or (saved)	EF$_{km,CO2}$ kg CO2 per unit		Total emissions
											Default	Custom	metric tonnes
											CO2/unit	CO2/unit	
Road transportation from plantations													
Year	Quantity of wet biomass transported (t)				Average truck load (tons)	Number of trucks	Avg trip distance (km)	litre diesel/km	kg CO$_2$/litre diesel	Kilometers travelled	kg CO2 / km		PET$_c$
	Plantation 1	Plantation 2	Plantation 3	BF$_{p,y,wet}$	TL		AVD_y				$EF_{km,\ CO2}$		
				D = A+B+C		F = A/E				I = F x G	J1 = H1 x H2		K = A/E x G x J1/1000
1	0			0	6	0	100	0.56	2.85	0	1.5960		0
2	17500			17500	6	2917	100			291667			466
3	21000			21000	6	3500	100			350000			559
4	24500			24500	6	4083	100			408333			652
5	28000			28000	6	4667	100			466667			745
6	35000			35000	6	5833	100			583333			931
7	35000			35000	6	5833	100			583333			931
8	35000			35000	6	5833	100			583333			931
9	35000			35000	6	5833	100			583333			931
10	35000			35000	6	5833	100			583333			931
											CO2 emissions		7076

Table 22: Summary of emissions from transport in the project activity



Direct Emissions from Transportation in the project activity

Total Road transportation emissions in project activity

Year	Chipping facilities	Plantations	CO2 emissions [PET]
1	139.7	0.0	140
2	167.6	465.5	633
3	223.4	558.6	782
4	251.4	651.7	903
5	279.3	744.8	1024
6	279.3	931.0	1210
7	279.3	931.0	1210
8	279.3	931.0	1210
9	279.3	931.0	1210
10	279.3	931.0	1210
Total CO2 emissions from transport in the project activity			9533

Step 5: CO_2 emissions from on-site fossil fuel combustion

Based on fossil fuel in year 5**:**

$$PE_{CO2,FF,5} = \sum_{i} FC_{on-site,i,5} \times NCV_i \times EF_{CO2,FF,i}$$

$$PE_{CO2,FF,5} = 0 \times NCV_i \times EF_{CO2,FF,i}$$

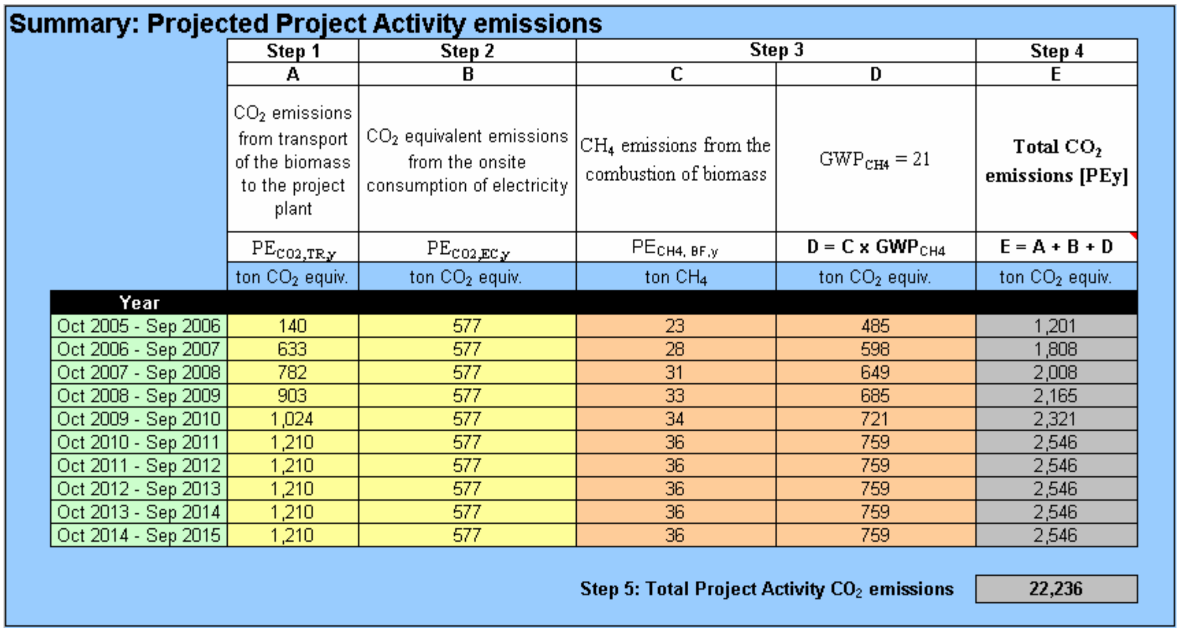
Step 6: From equation 1 the **total project activity emissions**, taken into account that zero fossil fuel will be co-fired **during year 5**:

$$PE_y = PE_{CO2,TR,y} + PE_{CO2,EC,y} \quad + PE_{CO2,FF,y} + GWP_{CH4} \times PE_{CH4,BF,y}$$

$$PE_5 = 1213 + 558 + 21 \times 21.3$$

$$PE_5 = 2218 \text{ tonne } CO_2$$

Table 23: Total project activity emissions for a 10 year period



Summary: Projected Project Activity emissions

	Step 1	Step 2	Step 3		Step 4
	A	B	C	D	E
	CO_2 emissions from transport of the biomass to the project plant	CO_2 equivalent emissions from the onsite consumption of electricity	CH_4 emissions from the combustion of biomass	$GWP_{CH4} = 21$	**Total CO_2 emissions [PEy]**
	$PE_{CO2,TR,y}$	$PE_{CO2,EC,y}$	$PE_{CH4,BF,y}$	$D = C \times GWP_{CH4}$	$E = A + B + D$
	ton CO_2 equiv.	ton CO_2 equiv.	ton CH_4	ton CO_2 equiv.	ton CO_2 equiv.
Year					
Oct 2005 - Sep 2006	140	577	23	485	1,201
Oct 2006 - Sep 2007	633	577	28	598	1,808
Oct 2007 - Sep 2008	782	577	31	649	2,008
Oct 2008 - Sep 2009	903	577	33	685	2,165
Oct 2009 - Sep 2010	1,024	577	34	721	2,321
Oct 2010 - Sep 2011	1,210	577	36	759	2,546
Oct 2011 - Sep 2012	1,210	577	36	759	2,546
Oct 2012 - Sep 2013	1,210	577	36	759	2,546
Oct 2013 - Sep 2014	1,210	577	36	759	2,546
Oct 2014 - Sep 2015	1,210	577	36	759	2,546

Step 5: Total Project Activity CO_2 emissions 22,236

For calculation the emission reductions for year 5, the project activity emissions (PE_y) and leakage emissions (LE_y) are subtracted from the baseline emissions (BE_y):

$$ER_5 = BE_5 - PE_5 - LE_5$$

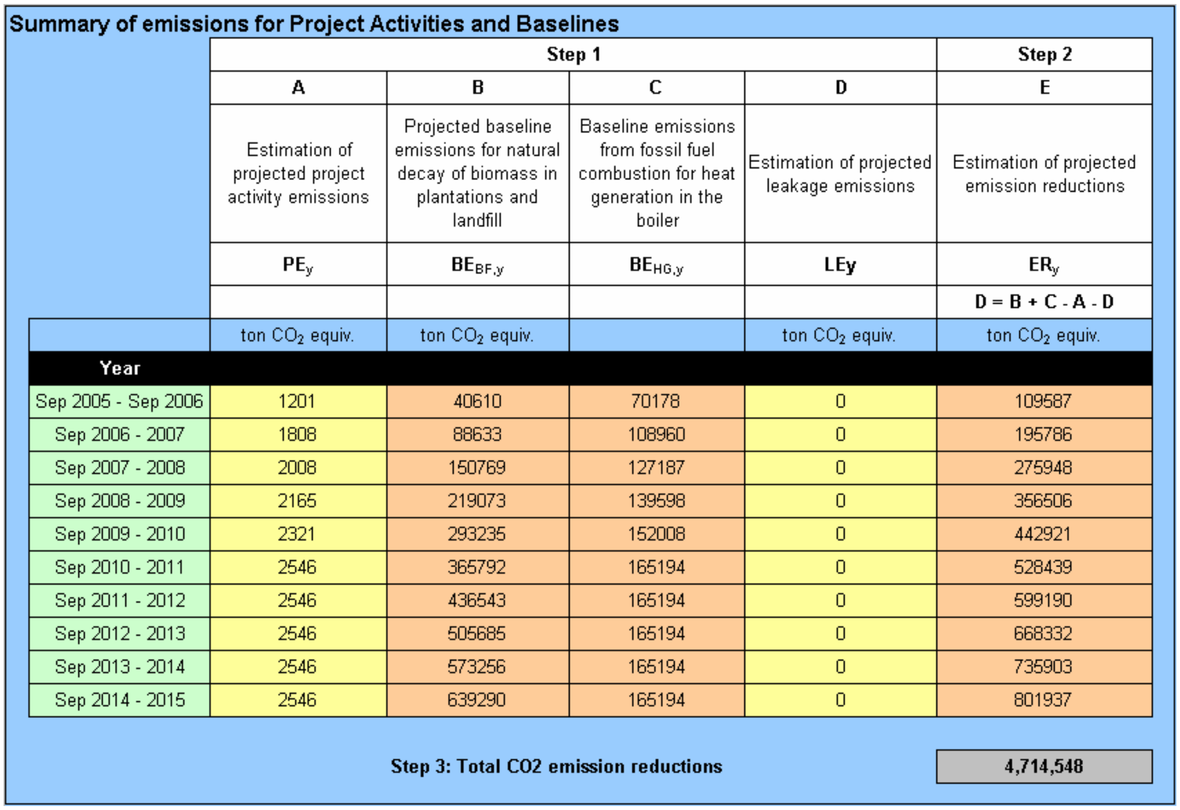
$$ER_y = 445243 - 2321 - 0$$

$$ER_y = 442921 \quad t \quad CO_2$$

Leakage is assumed to be zero over the 10 year period. From the equation above and the emissions calculated for the baseline and the project activity. The total emission reductions over a 10 year period are reflected in **Table 24: Total emission reductions as a result of the project activity**

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

Table 24: Total emission reductions as a result of the project activity



Summary of emissions for Project Activities and Baselines

	Step 1				Step 2
	A	B	C	D	E
	Estimation of projected project activity emissions	Projected baseline emissions for natural decay of biomass in plantations and landfill	Baseline emissions from fossil fuel combustion for heat generation in the boiler	Estimation of projected leakage emissions	Estimation of projected emission reductions
	PE_y	$BE_{BF,y}$	$BE_{HG,y}$	LEy	ER_y
					D = B + C - A - D
	ton CO_2 equiv.	ton CO_2 equiv.		ton CO_2 equiv.	ton CO_2 equiv.
Year					
Sep 2005 - Sep 2006	1201	40610	70178	0	109587
Sep 2006 - 2007	1808	88633	108960	0	195786
Sep 2007 - 2008	2008	150769	127187	0	275948
Sep 2008 - 2009	2165	219073	139598	0	356506
Sep 2009 - 2010	2321	293235	152008	0	442921
Sep 2010 - 2011	2546	365792	165194	0	528439
Sep 2011 - 2012	2546	436543	165194	0	599190
Sep 2012 - 2013	2546	505685	165194	0	668332
Sep 2013 - 2014	2546	573256	165194	0	735903
Sep 2014 - 2015	2546	639290	165194	0	801937
			Step 3: Total CO2 emission reductions		**4,714,548**

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

Data / Parameter:	$BF_{b,y}$
Data unit:	Dry tonne
Description:	Quantity of additional bark from mill used as fuel in the project plant during the year y
Source of data:	Calculated from wet tonnes measured on-site and moisture content
Measurement procedures (if any):	This value will be calculated annually by subtracting the weight of the other biomass residues from the total biomass residue quantity fired.
Monitoring Frequency	Daily, aggregated at least annually
QA/QC procedures to be applied:	Cross check with material balance on softwood on a yearly basis.
Any comment:	

Data / Parameter:	$BF_{c,y}$
Data unit:	Dry tonne
Description:	Quantity of biomass residue from chipping facilities used as fuel in the project plant during the year y
Source of data:	Calculated from wet tonnes measured on-site
Measurement procedures (if any):	The wet tonnes are measured on a weighbridge as biomass residue is transported to the project site. The wet biomass is corrected for moisture.
Monitoring Frequency	Continuously, and aggregated annually
QA/QC procedures to be applied:	Cross check values with purchase/receival receipts
Any comment:	

Data / Parameter:	$BF_{p,y}$
Data unit:	Dry tonne
Description:	Quantity of biomass residue from plantations used as fuel in the project plant during the year y
Source of data:	Calculated from wet tonnes measured on-site
Measurement procedures (if any):	The wet tonnes are measured on a weighbridge as biomass residue is transported to the project site. The wet biomass is corrected for moisture.
Monitoring Frequency	Continuously, and aggregated annually
QA/QC procedures to be applied:	Cross check values with annual energy balance across the boiler.
Any comment:	

Data / Parameter:	$EF_{ff,CO2,y}$
Data unit:	t CO2e/GJ
Description:	CO2 emission factor of the coal displaced by biomass residues for the year *y*
Source of data:	Literature
Measurement procedures (if any):	Use IPCC default emission factors (country-specific, if available) if they are deemed to reasonably represent local circumstances. Use accurate and reliable local or national data where available.
Monitoring Frequency	Review the appropriateness of the data annually.
QA/QC procedures to be applied:	
Any comment:	Bituminous coal has been used in the boiler since 1984. Therefore, $EF_{FF,CO2,y}$ will be determined for bituminous coal in a spreader stoker type boiler.

Data / Parameter:	$HG_{PJ,total,y}$
Data unit:	GJ/yr
Description:	Total heat generated in the co-fired boiler at the project site, firing both biomass residues and fossil fuels, during the year *y*
Source of data:	Calculations based on on-site measurements
Measurement procedures (if any):	The biomass residue feed to the boiler is measured and recorded. The efficiency of the boiler is known and the net calorific value of the biomass feed. Heat generation is determined by an energy calculation.
Monitoring Frequency	Daily, aggregated annually
QA/QC procedures to be applied:	The calculated heat (from the quantity of biomass and/or fossil fuels fired) will be cross-checked with the metered net heat generation (e.g. check whether the net heat generation divided by the quantity of fuel fired results in a reasonable thermal efficiency that is comparable to previous years).
Any comment:	

Data / Parameter:	MC_k
Data unit:	%
Description:	MOISTURE CONTENT OF THE BIOMASS TYPE K For plantation biomass residues k=p For chipping plant residues k=c For bark k=b
Source of data:	Mondi Laboratory
Measurement procedures (if any):	The moisture content of biomass residue reaches equilibrium after exposure to ambient air and therefore, once equilibrium has been reached the moisture fluctuation over time is negligible. The biomass residues used in this project activity are envisaged to include bark, chipping residues and plantation residues. Some variation is expected in the different types of plantation residues (stumps, coppice and off-cuts). Moisture content differs for different types of biomass residues and will therefore be separately analysed. To account for potential monthly variations (albeit small) in moisture content of the delivered batches of plantation biomass, monthly analysis will be performed on the biomass residue received from plantations. The calculations applicable to biomass residue from plantations will utilise monthly moisture content figures.
Monitoring Frequency	On site analysis will be performed monthly on the plantation residues and six monthly on both the bark and chipping plant biomass residues. Mean values will be calculated at least annually.
QA/QC procedures to be applied:	Annually samples of the different types of biomass residues used will be analysed by an accredited external laboratory. This value will be incorporated in the mean annual moisture factor used in the calculations for each type of biomass residue.
Any comment:	

Data / Parameter:	$EC_{PJ,y}$
Data unit:	MWh
Description:	On-site electricity consumption attributable to the project activity during the year *y*
Source of data:	Mondi electricity consumption meters at the wood yard
Measurement procedures (if any):	Continually measured and captured in the Process Information database
Monitoring Frequency	Continually monitored and aggregated annually for the calculations
QA/QC procedures to be applied:	Inconsistencies in the monthly total consumptions will be investigated. Spot checks will be done six monthly
Any comment:	

Data / Parameter:	$FC_{i,y}$
Data unit:	Mass unit (tonnes)
Description:	Quantity of fossil fuel (coal) fired in the co-fired boiler at the project site during the year *y*
Source of data:	On-site measurements
Measurement procedures (if any):	Continually measured and captured in the Process Information database
Monitoring Frequency	Continually monitored and aggregated annually for the calculations
QA/QC procedures to be applied:	Cross check values with annual energy balance across the boiler.
Any comment:	

Data / Parameter:	$EF_{grid,y}$
Data unit:	tCO_2/MWh
Description:	Grid Emission Factor
Source of data:	The average grid emission factor will be used.
Measurement procedures (if any):	The electricity consumption ($EC_{PJ,y}$) is less than 15GWh/yr, therefore the average grid emission factor (including all grid-connected power plants) may be used.
Monitoring Frequency	Annual grid emission factor obtained from Eskom Annual report
QA/QC procedures to be applied:	The Eskom factors are the official government data for electricity in South Africa
Any comment:	

Data / Parameter:	$TL_{k,y}$
Data unit:	Tons
Description:	Average truck load of the trucks used for transportation of biomass type k for the year y
Source of data:	Measured
Measurement procedures (if any):	Mondi Weightometer at the operation, Transport contractor information
Monitoring Frequency	Monitored per truckload, and aggregated for an annual average truck load value
QA/QC procedures to be applied:	Monthly averages will be compared before aggregating towards an annual value Transport contractor information will be used to crosscheck plantation residue truck load information
Any comment:	

Data / Parameter:	AVD_y
Data unit:	Km
Description:	Average return trip distance between biomass fuel supply sites and the project site for the year y
Source of data:	Mondi and biomass transport fleet logs
Measurement procedures (if any):	Distances traveled by trucks will be monitored and recorded. For biomass residue supplied from different sites, this parameter will correspond to the mean value of km travelled by trucks that supply the biomass plant.
Monitoring Frequency	Regularly
QA/QC procedures to be applied:	Check consistency of distance records provided by the truckers by comparing recorded distances with other information from other sources (e.g. maps).
Any comment:	If biomass is supplied from different sites, this parameter should correspond to the mean value of km traveled by trucks that supply the biomass plant.

Data / Parameter:	NCV_i
Data unit:	GJ/ton
Description:	Net calorific value of fossil fuel type i Net calorific value of coal i=coal
Source of data:	Measured
Measurement procedures (if any):	Analysis information from the coal supplier
Monitoring Frequency	Every six months, and aggregated for use in the calculations
QA/QC procedures to be applied:	A coal sample will be send annually to an accredited laboratory.
Any comment:	

Data / Parameter:	NCV_k
Data unit:	GJ/ton of dry matter
Description:	Net calorific value of dry/wet biomass type k Net calorific value of biomass residues from plantations k=p Net calorific value of biomass residues from bark k=b Net calorific value of biomass residues from chipping facilities k=c
Source of data:	Measured
Measurement procedures (if any):	The net calorific value will be determined separately for all types of biomass. Net calorific values will be based on measurements done on at least three samples for each measurement.
Monitoring Frequency	Every six months, and aggregated for use in the calculations
QA/QC procedures to be applied:	A sample from each biomass type will be send annually to an accredited laboratory.
Any comment:	

Data / Parameter:	$EF_{kmCO2,y}$
Data unit:	tCO_2/km
Description:	Average CO_2 emission factor for transportation of biomass with trucks
Source of data:	Literature

Measurement procedures (if any):	IPCC defaults will be used or conservative emission factors for truck types will be sourced from literature until local/national verifiable data is available.
Monitoring Frequency	Annually
QA/QC procedures to be applied:	Cross check between emission factors referred to in the literature
Any comment:	

Data / Parameter:	$EF_{CH4,BF}$
Data unit:	t CH_4/ GJ
Description:	Methane emission factor for combustion of biomass in the boilers
Source of data:	Literature
Measurement procedures (if any):	Values are based on the 2006 IPCC Guidelines, Volume 2, Chapter 2, Tables 2.2 to 2.6. A conservativeness factor is applied as specified in the baseline methodology.
Monitoring Frequency	Annually review if updated values are available
QA/QC procedures to be applied:	The uncertainty of the CH4 emission factor is relatively high. Order to reflect this and for the purpose of providing conservative estimates, a conservativeness factor will be applied as specified in the methodology. Ongoing international research will generate updated estimates, which will be used in the annual calculations
Any comment:	

Data / Parameter:	$EF_{Burning, CH4,y}$
Data unit:	t CH_4/ GJ
Description:	CH_4 emission factor for the uncontrolled burning of plantation biomass in tonnes of CH_4 per MWh
Source of data:	Literature
Measurement procedures (if any):	The IPCC default emission factor will be used in the absence of reliable local/national data.
Monitoring Frequency	Review default values annually.
QA/QC procedures to be applied:	Use of updated default values
Any comment:	

Data / Parameter:	NCV_i
Data unit:	GJ/ton
Description:	Net calorific value of fossil fuel type i Net calorific value of coal i=coal
Source of data:	Measured
Measurement procedures (if any):	Analysis information from the coal supplier
Monitoring Frequency	Every six months, and aggregated for use in the calculations
QA/QC procedures to be applied:	A coal sample will be send annually to an accredited laboratory.
Any comment:	

Data / Parameter:	$EF_{CO2,LE}$
Data unit:	tCO_2/GJ
Description:	CO_2 emission factor of the most carbon intensive fuel used in the country
Source of data:	Literature
Measurement procedures (if any):	Identify the most carbon intensive fuel type from the national communication, other literature sources (e.g. IEA). Possibly consult with the national agency responsible for the national communication / GHG inventory. If available, use national default values for the CO_2 emission factor. Otherwise, IPCC default values may be used
Monitoring Frequency	Review default values annually
QA/QC procedures to be applied:	Use of updated default values
Any comment:	

Data / Parameter:	
Data unit:	
Description:	Demonstration that the biomass residue type k from a specific source would continue not to be collected or utilized, e.g. by an assessment whether a market has emerged for that type of biomass residue (if yes, leakage is assumed not be ruled out) or by showing that it would still not be feasible to utilize the biomass residues for any purposes.
Source of data:	Survey
Measurement procedures (if any):	Information from the local plantation managers.
Monitoring Frequency	Annually
QA/QC procedures to be applied:	
Any comment:	Monitoring of this parameter is applicable if approach L_1 is used to rule out leakage

Data / Parameter:	
Data unit:	tons
Description:	Quantity of biomass residues of type *k* or *m* that are utilized (e.g. for energy generation or as feedstock) in the defined geographical region
Source of data:	Surveys or statistics
Measurement procedures (if any):	Information from local biomass residue producers
Monitoring Frequency	Annually
QA/QC procedures to be applied:	
Any comment:	Monitoring of this parameter is applicable if approach L_2 is used to rule out leakage or if approach L_4 is used in combination with approach L_2 to rule out leakage for the substituted biomass residue type *m*

Data / Parameter:	
Data unit:	Tons
Description:	Quantity of available biomass residues of type *k* or *m* in the region
Source of data:	Surveys or statistics
Measurement procedures (if any):	Information from local biomass residue producers
Monitoring Frequency	Annually
QA/QC procedures to be applied:	
Any comment:	Monitoring of this parameter is applicable if approach L_2 is used to rule out leakage or if approach L_4 is used in combination with approach L_2 to rule out leakage for the substituted biomass residue type *m*

Data / Parameter:	
Data unit:	
Description:	Availability of a surplus of biomass residue type *k* or *m* (which can not be sold or utilized) at the ultimate supplier to the project (or, in case of L_4, the former user of the biomass residue type *k*) and a representative sample of other suppliers in the defined geographical region.
Source of data:	Surveys or statistics
Measurement procedures (if any):	Information from local biomass residue producers
Monitoring Frequency	Annually
QA/QC procedures to be applied:	
Any comment:	Monitoring of this parameter is applicable if approach L_3 is used to rule out leakage or if approach L_4 is used in combination with approach L_3 to rule out leakage for the substituted biomass residue type *m*

Data / Parameter:	**f**
Data unit:	
Description:	Fraction of methane captured at the SWDS and flared, combusted or used in another manner
Source of data:	On-site information
Measurement procedures (if any):	Written information from the operator of the solid waste disposal site and/or site visits at the solid waste disposal site
Monitoring Frequency	Annually
QA/QC procedures to be applied:	
Any comment:	f is zero at the applicable landfill site

Data / Parameter:	**BF_x**
Data unit:	tons
Description:	Total amount of organic waste prevented from disposal in year *x* (tons)
Source of data:	Measured data at Mondi
Measurement procedures (if any):	Collate weighbridge data
Monitoring Frequency	Continuously, aggregated at least annually
QA/QC procedures to be applied:	
Any comment:	

Monitoring involves an annual assessment of the conditions at the solid waste disposal site (SWDS) where the waste would in the absence of the project activity be dumped.

Mondi Business Paper South Africa runs a full Total Quality Management (TQA) system inclusive of all requirements of ISO9001:2000 and ISO14001:1994. All QC/QA controls are documented in the TQM system. The following aspects are addressed in general and for the Biomass project in particular:

- Management Responsibility – Project Document Table 4 in PDD is included in the ISO 14001 System.
- Document Control – D- AADC.001.
- Testing both in terms of Laboratory and Instrument analysis (Test frequencies, Methods and Reporting) – Included in R-EVCR.001.
- Calibration of Equipment (Frequencies, Methods and Reporting) – Included in R-WIEN.001.
- Corrective and Preventative Actions – D-AACA.001.
- Internal Audits as per D-AAQA.001. For the Biomass project, specific audits are scheduled.

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

18/10/2006
Ms Ciska Terblanche, Mondi Business Paper, Richards Bay (project participant)
Mr Steve Thorne, SouthSouthNorth (not a project participant)

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

01/10/2005

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

The operational lifetime of the technology is in excess of 10 years but the crediting period will be limited to a maximum of 10 years.

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

C.2.1. Renewable crediting period

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

N/A

C.2.1.2. Length of the first crediting period:

N/A

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

01/10/2005

C.2.2.2. Length:

10 years

SECTION D. Environmental impacts

D.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:

The Environment Conservation Act requires a project developer to conduct an environmental impact assessment for a proposed project prior to implementation. Mondi Richards Bay conducted a public consultation process whereby comments were invited from stakeholders.

Environmental impacts identified:

1. Reduction in SO_2 emissions from the operation
    - The amount of SO_2 emissions emitted from the operation due to the combustion of coal will be reduced. This is a positive impact on the local air quality in the Richards Bay area.
2. Reduction in GHG emissions from fossil fuel (coal) burning
3. Reduction in fly and coarse ash to landfill resulting in longer lifespan of the landfill site
4. Less biomass to municipal landfill site which will prevent CH_4 emissions from landfill
5. No significant impact on water consumption or wastewater generation in terms of volume or quality is expected.
6. No biotic impacts are anticipated, as the proposed activity will be in an industrial site.
7. The need for rail transport (coal to the facility) and road transport (ash to landfill) will reduce. However, road transport for biomass residue will increase.
8. No impact on land use is associated with the project activity except the reduction of landfill space required for the dumping of ash.
9. Socio-economic aspects – there will not be a reduction in the number of employees at Mondi as a result of this project activity.
10. The project activity will reduce cumulative negative impacts arising from emissions from the surrounding industries thereby furthering the extent of the positive impact associated with health in the area.

Confirmation was received from the Department of Agriculture and Environmental Affairs that in terms of the Environmental Conservation Act Section 21 and Section 22, a full EIA is not necessary. Mondi Richards Bay has embarked on a public participation exercise where stakeholders were invited to attend a presentation on the project and to deliver comments for discussion and follow up. Representatives from the local authorities (including the Health Department and the Air Quality Department), the Richards Bay Clean Air Association and the ratepayers attended the presentation. The scope and technicalities of the project were discussed and questions from the stakeholders were answered. The only comment received was that Mondi should present the impact of the project after implementation to stakeholders to serve as an example to other industries in the area. Mondi agreed to implement this recommendation.

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

No impacts were considered to have a significant negative impact on the environment.
The Department of Agriculture and Environmental Affairs issued a letter of confirmation that a full EIA was not necessary.

SECTION E. Stakeholders' comments

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

An advertisement was placed in the local newspaper to invite stakeholders to participate in a presentation of the biomass project that was held at the Mondi Forum meeting. Comments were invited and recorded. Representatives from the ratepayers association, the local authority including the health department attended. The Department of Agriculture and Environmental Affairs confirmed that the scope of the project is such that a full EIA is not required.

E.2. Summary of the comments received:

The only comment received was from the ratepayers representative who indicated that the project sets an example for industry in the area. A request was received from the local authority that a presentation should be given to the Form members once the project has been implemented. Mondi agreed to deliver a presentation after registration of the project.

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

The comments received were not such that any changes had to be incorporated in either the project activity or the documentation applicable to it.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Mondi Business Paper
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Represented by:	Ciska Terblanche
Title:	Environmental Manager
Salutation:	
Last Name:	Terblanche
Middle Name:	-
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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

There is no public funding involved in the project.

Annex 3

BASELINE INFORMATION

Table 25: Data and information used in calculations

Parameter		Units	Source of information
Net Calorific Value - Bituminous coal	NCV_c	27.5 MJ/kg or 7.6 MWh/tonne[49] 25.09 TJ/kt	Coal supplier, Mondi laboratory, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories(Table 1-2 on pages 1.16 - 1.22 of the Reference Manual)
Net Calorific Value – Bark (dry)	NCV_b	18 MJ/dry kg 2.2 MWh/dry tonne	Mondi laboratory, IPCC guidelines
Net Calorific Value – bark (wet)	NCV_b	8 MJ/kg or 2.2 MWh/tonne[10]	Mondi laboratory, IPCC guidelines
Net Calorific Value – Sawdust	$NCV_{sawdust}$	20 MJ/dry kg 5.6 MWh/dry tonne	Mondi laboratory, IPCC guidelines
Net Calorific Value - Plantation Waste	NCV_p	18 MJ/wet kg 5.0 MWh/wet tonne	Mondi laboratory, IPCC guidelines where applicable
Default net calorific value, Air-dry, humid zone wood[50]		15.5 MJ/kg	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (Table 1-13 on Page 1.45 of the Reference Manual)
Default net calorific value Air-dry, dry zone wood[51]		16.6 MJ/kg	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (Table 1-13 on Page 1.45 of the Reference Manual)
Default net calorific value Oven, dry wood[52]		20 MJ/kg	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (Table 1-13 on Page 1.45 of the Reference Manual)
Efficiency of biomass-fired boiler	$\eta_{boiler\ Biomass}$	76.2%	Mondi Co-fired boiler information – design information

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[49] Calculated using the conversion factor: 1 MJ/kg = 1/3.6 MWh/tonne

[50] Can be used for reference purposes and quality control of data

[51] Can be used for reference purposes and quality control of data

[52] Can be used for reference purposes and quality control of data

Parameter		Units	Source of information
			from supplier
Efficiency of coal fired boiler	$\eta_{\mathrm{boiler,\ FF}}$	77.6%[53]	Mondi Co-fired boiler information - design information from supplier
Plant operation		350 days/year	
CO_2 emission factor for bituminous coal based on the higher heating value (HHV)	$COEF_c$	317.82 kg CO_2/MWh coal[54]	Default emission factors from Calculation tools for GHG emissions from pulp and paper mills
CO_2 emission factor for bituminous coal based on the lower heating value (LHV)[55]	$COEF_c$	334.5 kg CO_2/MWh coal	Default emission factors from Calculation tools for GHG emissions from pulp and paper mills
CH_4 emission factor for biomass combustion	$EF_{CH4,BF}$	15 kg/TJ biomass fuel converted to 21.55 kg/TJ (see comment).	IPCC default value. A conservativeness factor of 1.37 is applied to the CH_4 emission factor of 15kg/TJ (Table 1-16 on Page 1.54) of the Reference Manual of 1996. Revised IPCC Guidelines), giving a revised CH_4 emission factor of 21.55 kg/TJ used in the calculation.
Weighted average CO_2 emissions for Electricity imported from national grid	$EF_{grid,y}$	0.89kg CO_2/kWh (Eskom)	Eskom publicly reported for the year 2002 that for every kWh it produced, 0.89 kg of CO_2 was emitted (Eskom Annual Report 2002 page 133.
Global warming potential of CH_4	GWP	21 tonne CO_2/tonne CH_4	IPCC Emission Guidelines 1996
CO_2 emissions per litre of Diesel	EF_{kmCO2}	2.85 kg CO_2/litre diesel	Table adapted from Kinsky, R. Thermodynamics – advanced applications

*1 TJ = 10^6 MJ

(1 MJ = 1/3.6 kWh) therefore 1 TJ = 10^6/3.6 kWh = 277 777 kWh = 277.8 MWh

So: 21.55 kg/TJ = 21.55/277.8 kg/MWh = 0.077 kg/MWh = 0.00007758 tonne/MWh

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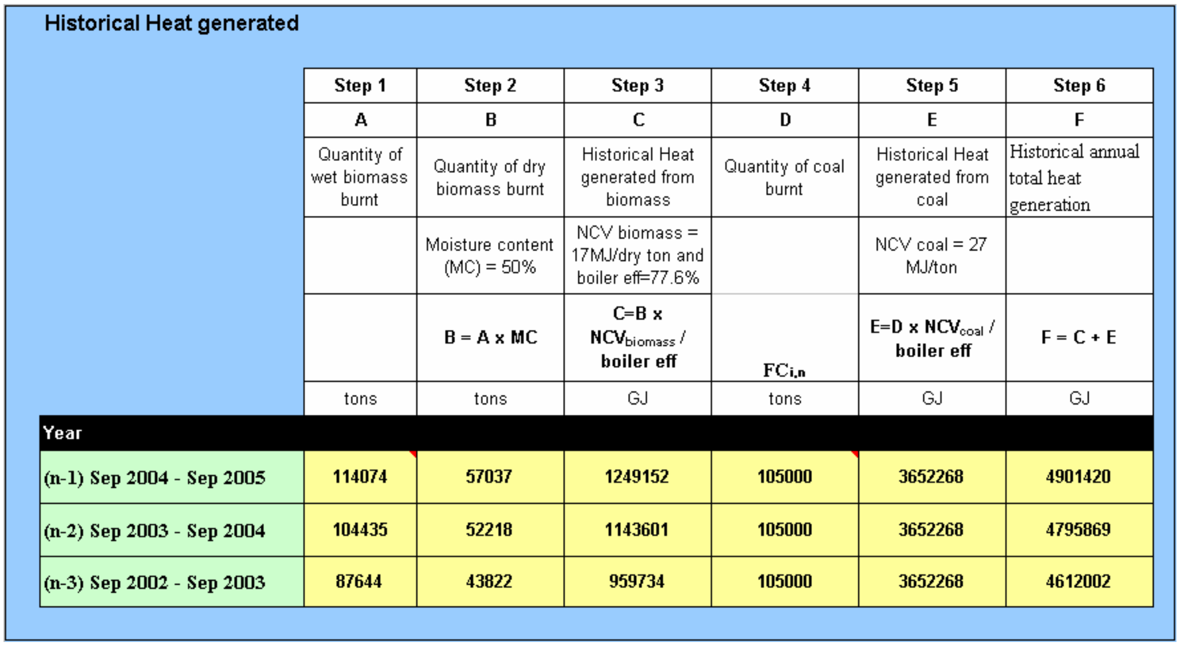
[53] Overall efficiency = combustion efficiency multiplied by thermal efficiency (85.3% x 91%)

[54] Emission factors based on higher heating values from EIA, 2001, Appendix B as referenced in Calculation tools for GHG emissions from pulp and paper mills

[55] Emission factor (LHV) = Emission factor (HHV) / 0.95 for solid/liquid fuels

Table 26: Historical biomass and coal consumption[56]



Historical Heat generated

	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
	A	B	C	D	E	F
	Quantity of wet biomass burnt	Quantity of dry biomass burnt	Historical Heat generated from biomass	Quantity of coal burnt	Historical Heat generated from coal	Historical annual total heat generation
		Moisture content (MC) = 50%	NCV biomass = 17MJ/dry ton and boiler eff=77.6%		NCV coal = 27 MJ/ton	
		B = A x MC	C=B x $NCV_{biomass}$ / boiler eff	$FC_{i,n}$	E=D x NCV_{coal} / boiler eff	F = C + E
	tons	tons	GJ	tons	GJ	GJ
Year						
(n-1) Sep 2004 - Sep 2005	114074	57037	1249152	105000	3652268	4901420
(n-2) Sep 2003 - Sep 2004	104435	52218	1143601	105000	3652268	4795869
(n-3) Sep 2002 - Sep 2003	87644	43822	959734	105000	3652268	4612002

Annex 4

MONITORING INFORMATION

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[56] Table 8 in the Excel sheet: Biomass project emissions forecast. 2006