MONTES DEL PLATA PROJECT
Punta Pereira – Uruguay

THE PUNTA PEREIRA CDM PROJECT - CALCULATION OF RECOVERY BOILER EFFICIENCY FOR THE BASE LINE CASE

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1.0 INTRODUCTION

The ACM0006 (Version 11.1) baseline methodology and the "Tool to determine the baseline efficiency of thermal or electric energy generation systems (Version 01)" do not specify a proper default efficiency factor or give any guidelines on how the efficiency should be calculated for a pulp mill recovery boiler. In the case of the Punta Pereira CDM project activity (located inside a pulp mill facility); an efficiency value for the recovery boiler that would be used in the baseline scenario must be defined. Therefore, this document has been prepared to establish this efficiency value, ensuring the consistency with the baseline pulp mill design of the Punta Pereira project activity, a conservative emission reduction calculation of the project activity and that the proposed efficiency value complies with the normal standards of the Pulp and Paper industry in the relevant geographical region defined for the Punta Pereira project activity. It must be noted that because of these reasons, the proposed efficiency value has been designed for the specific Punta Pereira CDM project activity baseline context, and thought it could eventually be used in other contexts; it has not been designed as a general default efficiency factor.

More specifically, this document has been prepared to:

1. Present how the recovery boiler efficiency has been established for the baseline scenario of the Punta Pereira CDM project activity.

2. Demonstrate that the proposed recovery boiler efficiency for the baseline scenario of the Punta Pereira CDM project activity is appropriate and consistent with the results that other calculation methods would have generated.

3. Demonstrate that the proposed recovery boiler efficiency for the baseline scenario is comparable with the efficiencies observed in other modern pulp mills in the relevant geographical region.

4. In all, show that the proposed recovery boiler efficiency for the baseline scenario of the Punta Pereira CDM project activity is conservative, as it leads to a lower emission reduction calculation associated to the proposed project activity.

References to support the information provided in this memo are given, whenever possible.

2.0 DEFINITION OF RECOVERY BOILER EFFICIENCY

Normally within the Kraft pulping industry efficiency based on the Higher Calorific Heating value HCV value is used. However, in CDM methodologies the efficiency is based on the Net Calorific Value, NCV. The difference is the vaporization heat of at the combustion formed water. The efficiency based on NCV is higher, about 4% units, than the efficiency based on HCV.

The boiler efficiency based on the NCV can be expressed as:

Efficiency = Use full heat from boiler / (fuel flow * fuel NCV)

The use full heat is the summary of the heat in steam to the net and heat in steam for soot blowing.

Heat in steam is (steam enthalpy – feed water enthalpy)

The efficiency can be established by using different software. In the Punta Pereira case a software developed by KSH-CRA has been used and is described below.

3.0 RECOVERY BOILER MASS AND HEAT BALANCE

The Recovery Boiler's mass and heat balance for the base line case can be found in appendix A.

As can be seen from the balance the efficiency based on NCV has been calculated to 76,2%. This value has been used in the emission calculations.

The combustion calculations in the balance are based on normal chemistry taking into account specific inputs that are described below in the item inputs.

The balance program is using a commercial software WinSteam from Techware Engineering Applications, Inc for calculations of steam and water enthalpies, vaporization heat etc. The same values could be found in hand books, etc. but calculated values are used for practical reasons. Detailed description of the software can be found on http://www.techwareeng.com/

In addition, the balance program is using @air and @gas both also from Techware Engineering Applications, Inc for calculation of air and flue gas enthalpies.

Below is the balance as well as the inputs described more in detail.

4.0 INPUTS

Inputs to the Recovery Boiler Mass and Heat balance program can be divided into three groups depending on how they are established:

4.1 Inputs that are not related to the design of the boiler

Below are listed inputs to the calculations that are not related to the design of the boiler but to the design of the pulp mill in general.

- ✓ Black liquor analysis, including moister content and temperature
- ✓ Black liquor HCV
- ✓ Black liquor flow
- ✓ Methanol analysis, including moister content and temperature
- ✓ Methanol HCV
- ✓ Methanol flow
- ✓ CNCG analysis, including moister content and temperature
- ✓ CNCG HCV

- ✓ CNCG flow

The values used are in the normal range for the industry.[1] It is important to remember that identical set of data, except the black liquor moister content which is higher in the base line case than in the project case, have been used for the two cases.

In the contract with with Andritz[2] for the project case boiler the design data can be found. The corresponding data from Metso's[3] can be found in the proposal. Please note that all flows are for design conditions, slightly higher than MCR, and not for average conditions for which the energy / mass balances have been done.

4.2 Input of for this project specific design data

Input data of this category are:

- ✓ Steam pressure and temperature (86 bar(a) and 480 C): The data has been chosen as suitable ones and are in the normal range used in the industry for a plant not optimized for power generation. However the values are only slightly lower than the ones used in two of CDM project activities (86 bar(a) and 485 C) in the region, Nueva Aldea and Valdivia. The values could have been chosen both higher and lower. ***It should be noted that the pressure and temperature level has no impact on the calculation of the recovery boiler efficiency.***
- ✓ Feed water temperature. The situation is the same as for steam pressure and temperature. See below.
- ✓ Flue gas temperature. This has been chosen to 190 °C for the base line case as a recovery boiler with high efficiency is of less importance as the mill in any case will be self-sufficient with electrical energy and no alternative use of the heat is available. The temperature could be theoretically higher but at one point problems with the design temperature for the Electrostatic Precipitator would occur. If boiler efficiency is of important the flue gas temperature is normally 30 °C higher than the feed water temperature.

4.3 Input of type guaranteed or predicted performance

Input data of this category are:

- ✓ Consumption of soot blowing steam, see item 5.7 below.
- ✓ Ejector steam flow.

[1] The heating values and analysis used are more or less the same as used in similar projects in Brazil, Chile and Uruguay. The statement can be verified by Andritz and Metso, the two major suppliers in the region of recovery Boilers.
[2] The contract is available for review at the Montes del Plata project office in Montevideo
[3] The proposal is available for review at the Montes del Plata project office in Montevideo

- ✓ Excess combustion air or O2 content in dry flue gas: The normal level is in the range 2,0 – 3,0% O2 in dry flue gas. Andritz[4] has for project case recovery boiler predicted 2,0% which is low. On the other hand Metso[5] in their bid predicted 2,8%. It has been assumed that the same level would have been achieved in the base line case as in the project case. In the balance calculations has by mistake 3,0% been used. The impact on the boiler efficiency is 0,15% between 2,0 and 3,0 oxygen content in the flue gas. However the resulting efficiency is well within what would have been achieved using other sources of information etc, see item 6 below.
- ✓ Smelt reduction efficiency. 96% has been guaranteed by Andritz[6] for the project case recovery boiler. The same level has been assumed to be achieved also for the base line recovery boiler.
- ✓ Blow-down, see 5.13 below
- ✓ Heat loses due to radiation, unburned, etc. See item 5.14 below.

5.0 HEAT BALANCE

Below are the different parts of the heat balance summary described in some detail.

5.1 Chemical energy in Black Liquor Dry Solids

This term describes the heat input from black liquor using the HCV and the actual black liquor flow.

5.2 Sensible heat in Black Liquor

This is the black liquor sensible heat. The sensible heat for the liquors water content is taken into account.

5.3 Chemical energy in Aux fuels:

The term is the heat input from methanol and CNCG using the HCVs and the actual flows.

5.4 Sensible heat in ejector steam

A steam ejector is used for the CNCG, the sensible heat from the ejector steam is not included in the sensible heat in Aux fuels above.

[4] Can be checked in the contract documents with Andritz. The contract is available at the MdP project office in Montevideo, Uruguay.

[5] Can be checked in the proposal documents from Metso. The proposal is available at the MdP project office in Montevideo, Uruguay.

[6] Can be checked in the contract documents with Andritz. The contract is available at the MdP project office in Montevideo, Uruguay.

5.5 Sensible heat in cold air:

This term is the sensible heat above the reference temperature for the combustion air before preheating. The air flow is calculated from the fuel analysis (design values, see item fuel specifications below) and the excess air factor (normally achieved value, see item below).

5.6 Sensible heat in air after SCAH

This term is the sensible heat above the cold air temperature for the combustion air after the preheating. As described above the air flow is calculated from the fuel analysis (design values, see item fuel specifications below) and the excess air factor (normally achieved value, see item below).

5.7 Soot blowing steam

The recovery Boiler is using steam to keep the superheater, boiler bank and economizer clean. It should be noted that the consumption of soot blowing steam in most cases is independent on the boiler load within a reasonable range. The consumption of soot blowing steam is in different references specified to be in the range 6 – 3% of the feed water flow.

The table below presents the soot blowing steam consumptions from different sources summarized. Please note that the percentages refer to the feed water flow to the boiler.

Andritz [7]	Metso [8]	Performance test procedure [9]	Alkaline Pulping [10]	FAPET [11]	**Base line balance**
3,4%	3,8%	4,8%	5,7%	3,6%	**4,1%**

The soot blowing steam consumption used in the base line case calculations might be a little bit on the high side. However, taking all inputs into account the total difference in calculated efficiency is very small. Please see item 6 below.

[7] Can be checked in the contract documents with Andritz. The contract is available at the MdP project office in Montevideo, Uruguay.
[8] Can be checked in the proposal documents from Metso. The proposal is available at the MdP project office in Montevideo, Uruguay.
[9] CA Report No. 84041601 March 1996, TAPPI Atlanta Georgia, USA. Calculated from flows in form 1 and 4.
[10] Pulp and Paper Manufacture volume 5 Alkaline Pulping, Canadian Pulp and Paper Association 1989. Calculated from flows on page 546.
[11] volume 6 “Chemical Pulping” of FAPET (Finnish American Engineers’ Text Book). Calculated form flows in item 13.2.2.

5.8 Sensible heat in the flue gases

The flue gas flow is calculated from the fuel analysis (design values, see item fuel specifications below) and the excess air factor (normally achieved value, see item below).

5.9 Evaporation heat

As the black liquor contains water in liquid phase heat is consumed for this. The black liquors water content is a design criterion.

5.10 Sensible heat in smelt

As the recovered chemicals leave the boiler as a smelt the heat in the smelt can be seen as a loss from a steam generation point of view. The smelt flow is calculated from the fuel composition. Also in this case different values can be found in different sources. The different sources not only have different Cp (specific heat) for the smelt, the smelt temperature is also different. Below are summarized the smelt enthalpy from different sources. Note that the enthalpies are recalculated to black liquor DS (dry solids) as reference and the specific smelt flows is also taken into account.

Andritz [12]	Metso	Performance test procedure [13]	Alkaline Pulping [14]	FAPET [15]	**Base line balance**
608 kJ/kgDS	Not spec.	584 kJ/kgDS	578 kJ/kgDS	577 kJ/kgDS	**603 kJ/kgDS**

As can be seen in the table above, all sources give specific heat losses with smelt quite close to each other.

As the heat loss with smelt is less than 4% of the total heat input and the difference between the values is small, the difference in boiler efficiency is very small (<0,2%) using the different values above.

[12] Can be checked in the contract documents with Andritz. The contract is available at the MdP project office in Montevideo, Uruguay.
[13] CA Report No. 84041601 March 1996, TAPPI Atlanta Georgia, USA. Calculated from form 2 and 3.
[14] Pulp and Paper Manufacture volume 5 Alkaline Pulping, Canadian Pulp and Paper Association 1989. Calculated from info on page 539 and 546.
[15] volume 6 “Chemical Pulping” of FAPET (Finnish American Engineers’ Text Book). Calculated form information item 13.2.1 and 2.

5.11 Correction for H_2O formation from H_2

The heating value HCV is determined for the combustion products at 25 °C. With other words, from H_2 formed water is in liquid phase. Therefore the heat of evaporation of the formed water needs to be deducted from the useful heat as the water leaves the boiler in vapor phase.

5.12 Reduction heat

In the determination of the heating values HCV and NCV all sulfur is oxidized to SO_2. However, in the Kraft Pulping process one of the active substances is Na_2S.

Therefore corrections are necessary to be made. In the balances this is expressed as reduction heat. As for the smelts sensible heat a number of different formulas with slightly different results are available.

Below are listed values from the same sources as above:

Andritz [16]	Metso	Performance test procedure [17]	Alkaline Pulping [18]	FAPET [19]	**Base line balance**
1 477 kJ/kgDS	Not specified	1 459 kJ/kgDS	1 458 kJ/kgDS	1 382 kJ/kgDS	**1 433 kJ/kgDS**

As can be seen the different sources of reference values give both lower and higher value on the specific reduction heat than the calculated one in the base line balance.

5.13 Blow-down losses

As the feedwater to the boiler contains some salts, minerals and other chemical compounds that are only vaporized partly as a function of the concentration and therefore not leaving the boiler with the steam this chemicals will accumulate in the boiler water if no measures are taken to avoid this. There are a number of reasons not to let the salt levels be too high, one is that with higher salt levels more salt leaves the boiler with the steam, in

[16] Can be checked in the contract documents with Andritz. The contract is available at the MdP project office in Montevideo, Uruguay.
[17] CA Report No. 84041601 March 1996, TAPPI Atlanta Georgia, USA. Calculated from form 2 and 3.
[18] Pulp and Paper Manufacture volume 5 Alkaline Pulping, Canadian Pulp and Paper Association 1989. Calculated from info on page 539 and 546.
[19] volume 6 "Chemical Pulping" of FAPET (Finnish American Engineers' Text Book). Calculated form information item 13.2.1 and 2.

vaporized form or in solid form. These salts and minerals can and will damage the turbo generator if the levels are too high.

To keep the salt and mineral levels under control some boiler water needs to be removed continuously from the boiler, blow-down.

For a mill with a new modern and well functioning feed water and condensate treatment the blow-down can be kept at a low level. 0.5% is not uncommon in practice.

Andritz [20]	Metso	Performance test procedure [21]	Alkaline Pulping [22]	FAPET [23]	**Base line balance**
0,8%	Not specified.	Not specified.	5%	Not specified.	**0,5%**

The reason why the blow-down is not specified in some of the sources is that recovery boiler performance test normally are done without blow-down. It shall be noted that Andritz in the heat balance is calculating without blow-down.[24]

The value used in the base line balance is on the low side but as mentioned above this level can be achieved in practice. A low blow-down results in higher steam generation with higher efficiency as a result. This will give a higher power generation in the base case than a high blow-down. Therefore a low blow-down result in less reduction of the emissions than a high blow-down and can be considered conservative for an emission reduction point of view.

5.14 Radiation losses, unburned, unaccounted for and manufactures margin.

The different sources specify these values in a different way as will be shown below. It shall be noted that these items are very difficult, if possible to establish before hand. The only term is the radiation losses that could be calculated knowing insulation thickness etc.

Below are listed the different reference sources' inputs for the sum of these terms.

[20] Can be calculated from data in the contract documents with Andritz. The contract is available at the MdP project office in Montevideo, Uruguay.
[21] CA Report No. 84041601 March 1996, TAPPI Atlanta Georgia, USA. Calculated from form 2 and 3.
[22] Pulp and Paper Manufacture volume 5 Alkaline Pulping, Canadian Pulp and Paper Association 1989. Calculated from info on page 539 and 546.
[23] volume 6 "Chemical Pulping" of FAPET (Finnish American Engineers' Text Book). Calculated form information item 13.2.1 and 2.
[24] Can be checked in the contract documents with Andritz. The contract is available at the MdP project office in Montevideo, Uruguay.

Andritz [25]	Metso	Performance test procedure [26]	Alkaline Pulping [27]	FAPET [28]	**Base line balance**
65 kJ/kgDS	Not specified	234 kJ/kgDS	373 kJ/kgDS	245 kJ/kgDS	**91 kJ/kgDS**

As can be seen the values for theses losses are quite different from the different sources.

The values used by Andritz and in the base line case are quite close to each other. It might be that the used 91 kJ/kgDS is on the high side. However the impact from this on the efficiency would be very small, <0,2%. Also taking all inputs into account the total difference in calculated efficiency is very small, see item 6 below.

5.15 Heat balance summary

From what is described above the mass and heat balance as well as the efficiencies for the base line case has been calculated and is summarized in the table below:

ENERGY BALANCE					
IN	kJ/kgDS	kW	**OUT**	kJ/kg DS	kW
Chemical energy in BL DS	14.000	822.938	Sensible heat in flue gas	1.172	68.896
Sensible heat in BL	417	24.541	Evaporation heat	871	51.197
Chemical energy in Aux fuels	268	15.731	Smelt sensible heat	603	35.456
Sensible heat in Aux fuel	2	98	Reduction energy	1.433	84.242
Sensible heat in ejector steam	1	66	Corr. for H_2O formation from H_2	818	48.104
Sensible heat in cold air	75	4.434	Blowdown loss	17	988
Sensible heat in air afer SCAH	414	24.320	Radiation, unburnt etc	91	5.349
Sootbl. steam	81	4.757	**Total heat losses**	**5.006**	**294.233**
			Steam generation	kJ/kgDS	kW
			Energy to HP-steam generation	9.806	576.423
			Energy to sootblowing steam	446	26.228
Total energy to boiler	**15.258**	**896.884**	**Total energy from boiler**	**15.258**	**896.884**
Net steam generation	kg/kgDS	3,45			
Efficiency on HHV	%	71,86	on total fuel input and including soot blowing steam		
Efficiency on NCV	%	76,23			

[25] Can be checked in the contract documents with Andritz. The contract is available at the MdP project office in Montevideo, Uruguay.
[26] CA Report No. 84041601 March 1996, TAPPI Atlanta Geor, USA. Calculated from form 3.
[27] Pulp and Paper Manufacture volume 5 Alkaline Pulping, Canadian Pulp and Paper Association 1989. Info on page 546.
[28] volume 6 "Chemical Pulping" of FAPET (Finnish American Engineers' Text Book). Calculated form information item 13.2.2

The efficiency 76,2% on a NCV basis is what can be expected from a mill with the base line case liquor properties and base line case boiler configuration.

6.0 CROSSCHECK OF THE EFFICENCY CALCULATION WITH INFORMATION FROM OTHER SOURCES

A cross check cannot be made for the ***base line*** recovery boiler as this boiler never has been designed by a manufacturer or any other third party except for the calculations described above.

However a cross-check can and has been made for the ***project case*** recovery boiler using the balance program described above and the same inputs when relevant as above. The result has been compared with Andritz predicted performance for the purchased ***project case*** recovery boiler. In addition, the efficiency for a recovery boiler proposed by Metso for the ***project case*** is available. The results are summarized in the table below.

Predicted performance by	Andritz	Metso	Average Andritz and Metso	**Project case balance**
Recovery boiler efficiency based on NCV	82,5%	82,2%	82,4%	**82,4%**

The three results are surprisingly close especially considering the large amount of inputs that are difficult to establish exactly and also the large amount of calculations involved as well as necessary simplifications made.

Furthermore, the ***project case*** balance and the average value of the two main suppliers of recovery boilers out side North America is more or less the same.

Note that the only differences in input between the base line case and the project case are:

- ✓ Steam data, which do not have an impact on the efficiency.
- ✓ Black liquor moister content. The moister content has an impact on the black liquor sensible heat, the evaporation losses and the flue gas flow due to different moister content.
- ✓ Flue gas temperature.

As the calculations of the heat inputs and heat losses for these terms are quite simple, it can on good grounds be assumed that the calculated efficiency would be very close to the one the boiler suppliers would have calculated as shown for the base line case.

The difference in efficiency between the base line case and project case recovery boiler is not related to the quality of the recovery boiler itself, but more to the definition parameters of the pulp mill. In other words, the efficiency of 76,2% is what can be expected for a recovery boiler operating with the base line black liquor moister content and flue gas temperature.

In the definition above, item 2, of the recovery boiler efficiency, the soot blowing steam is included as useful heat. However from a power generation point of view this is not the case as the soot blowing steam is internal boiler steam and in this case can not pass though the turbo generator and produce electrical power. The impact on the efficiency is about 0,15 percentage units.

This definition of recovery boiler efficiency in the baseline scenario is conservative as it results in more heat available for power generation in the baseline, which translates into less emission reductions associated to the Punta Pereira CDM project activity.

7.0 RECOVERY BOILER EFFICIENCIES FOUND IN MODERN PULP MILLS LOCATED IN THE RELEVANT GEOGRAPHICAL REGION

The table below shows recovery boiler efficiencies of modern pulp mills located in the relevant region listed and compared with both the baseline and project case recovery boiler efficiency of the Punta Pereira CDM project activity[29]. The corresponding supporting information is available at Arauco's office in Santiago or at KSH-CRA's office in São Paulo.

Company		Montes del Plata		Arauco	Arauco	CMPC	Klabin	UPM
Mill		Punta Pereira		Valdivia	Nueva Aldea	Santa Fe 2	Monte Alegre	Frey Bentos
Wood species		Eucalyptus		Eucalyptus	Mix Euca. & Pine	Eucalyptus	Mix Eucalyptus & Pine	Eucalyptus
Source of information		Base Line Case	Project case	Metso	Metso	KSH files	Klabin	Andritz
Black liquor analysis								
Carbon C	w%	35,5	35,5	-	-	33,0	34,3	N/A
Hydrogen H	w%	3,6	3,6	-	-	3,6	3,1	3,6
Sulfur S	w%	4,55	4,55	-	-	4,6	4,2	N/A
Sodium Na	w%	18,5	18,5	-	-	19,9	19.8	N/A
Potasium K	w%	2,1	2,1	-	-	1,8	2,2	N/A
Chlorine Cl	w%	0,4	0,4	-	-	0,5	1,12	N/A
Nitrogen	w%	0,09	0,09	-	-	0,1	0,15	N/A
Inerts	w%	0,15	0,15	-	-	0,4	0,01	N/A
Oxygen O	w%	35,11	35,11	-	-	36,1	35,12	N/A
Dry Solids (DS) content	%	76	80	74	80	78	80	80
Calorific heating value	MJ/kgDS	14.268	14.268	14.322	13.909	13.450	13.540	14.316
Net calorific heating value	MJ/kgDS	13.449	13.449	13.519	13.099	12.662	12.862	13.528
Heat utilized	MJ/kgDS	10.252	11.081	10128,8	9957,0	9.742	9.714	10.759
Efficiency on NCV basis	%	**76,23**	**82,39**	**74,92**	**76,01**	**76,94**	**75,53**	**79,53**

[29] It must be noted that specific technical information of pulp mills is not publicly available in the region. Nevertheless, the information presented in the table above is enough to provide the necessary support for the argument presented in this section of this technical report.

Comparing the recovery boiler efficiencies it should be noted that the following has an impact on the efficiency as defined without changing the over-all boiler efficiency:

- ✓ Combustion air temperature, higher combustion air temperature increases the efficiency but also increases the heat consumption out side the boilers battery limit.
- ✓ Black liquor dry solids, higher dry solids content to the boiler gives a higher efficiency but also a somewhat higher heat consumption in the evaporation plant.
- ✓ Black liquor sulfur content, ah higher sulfur content gives a lower efficiency at constant green liquor reduction degree.

These factors explain some of the differences between the boilers in the table above.

From the table above the following conclusions can be made:

- ✓ The efficiency for the base line case recovery boiler is in the same range as the efficiency for the Santa Fe 2 and Monte Alegre recovery boilers and as well as for the CDM project boilers in Valdivia and Nueva Aldea.
- ✓ The efficiency for the CDM-project boiler in Fray Bentos is higher than the base line case recovery boiler efficiency, but lower than the project case recovery boiler efficiency.

The conclusion is that the efficiency for the base line case recovery boiler is what could be expected for a non CDM-project boiler in the region. More so**, in three of the five cases the proposed base line recovery boiler efficiency is higher than the ones of the other pulp mills shown above (some of them registered as CDM project activities)**. The estimated project case recovery boiler efficiency is in the range or even higher than what is observed in other modern pulp mills under the CDM in the relevant geographical region.

Altogether, it has been demonstrated that the proposed recovery efficiency of 76,2% will result in a base line steam generation that would be in line or higher than for other non CDM-project recovery boilers in the region. As a result of this, also the power generation would be in line or higher than what could be expected from other non CDM-project installations in the region. **Therefore the used approach is conservative as it results in less potential for emission reductions for the Punta Pereira CDM project activity.**

8.0 SUMMARY

The recovery boiler efficiencies are normally not presented in proposals or in other recovery boiler documentation but can be determined easily from the steam generation and

the fuel inputs. Doing so, it has in this document been ***clearly demonstrated*** that the used methodology to establish the efficiency ***is in line*** with what ***the two major recovery boiler manufacturers***, outside North America presents indirectly in different documentation.

It has also ***been demonstrated*** that the ***inputs*** to the efficiency calculations are ***in line with the common practice of the Pulp and Paper industry***.

From a methodological point of view, the used definition of the recovery boiler efficiency includes the soot blowing steam (4,1% of total) as the useful heat from the boiler. However, in the Punta Pereira base line case the soot blowing steam is internal. In other words, the soot blowing steam would not be able to pass through a turbo generator. With the definition of the boiler efficiency and the methodology to establish emission reductions the result is that the project case emission reductions will be lower than if an efficiency based on only the steam through the turbo generator was used. The resulting ***emission reduction will be conservative*** (low).

It has also been shown that the recovery boiler efficiency is in line with what could be expected for a non CDM-project boiler in the region. Furthermore, the efficiency is in line with the efficiency of CDM-project boilers in two cases out of three. In other words, the proposed recovery boiler efficiency results in a ***conservative emission reduction calculation (low) for the proposed project activity.***

Considering all the above, the calculated boiler efficiency of 76,2% is in line with what other sources would have provided and leads to a conservative emission reduction calculation for the Punta Pereira CDM project activity.

APPENDIX A

BASE LINE CASE RECOVERY BOILER MASS AND HEAT BALANCE

Client:	MONTES DEL PLATA	
Mill:	CDM	
Case:	Base Case	

RECOVERY BOILER MASS AND HEAT BALANCE

DEFINITIONS

Reference temperature	ºC	20

BLACK LIQUOR

Elemental analysis							
Carbon	C	%DS	35,50	**Boiler load**		tDS/d	5.079
Hydrogen	H_2	%DS	3,60	**Black Liquor HHV**		kJ/kgDS	14.000
Nitrogen	N	%DS	0,09				
Sulphur	S	%DS	4,55	**Dry solids content from evaps.**		%	74,0
Sodium	Na_2	%DS	18,50	**Temperature at guns**		ºC	140,0
Potassium	K_2	%DS	2,10				
Chlorine	Cl	%DS	0,40	**HHV for analysis C,S,H,Na**		kJ/kgDS	14.412
B	B	%DS	0,00				
Inerts	-	%DS	0,15	**Make-up**	t/d	kg/kgDS	mol/kgDS
Oxygen, as difference	O_2	%DS	35,11	as Na2SO4	0,00	0,0	0,00

ADDITIONAL FUELS

		Methanol	Turpentine	LVHC	Aux. Fuel 1	Aux. Fuel 2	Aux. Fuel 3	Sum aux
Fired fuel, DS	t/h	1,84	0,00	2,25	0,00	0,00	0,00	4,09
Dry solids content	%	80,00	95,00	87,55	0,00	0,00	0,00	84,15
HHV (cal.)	MJ/kg DS	22,30	41,56	6,97	0,00	0,00	0,00	13,86
Fuel temperature	°C	40,00	40,00	60,00	0,00	0,00	0,00	51,01

SMELT AND GREEN LIQUOR

Smelt	Green liquor			Weak wash		Remarks	
Specific flow	Flow	Sulphidity	TTA	Flow	TTA	Flows at 25 C	
kg/tDS	m3/d	%	g/l	m3/d	g/l	Green liquor density at 25 C	
428	10.835	39	162	10.804	5	1.201	kg/m3

FLUE GASES

Flue gas	nm^3/s	$nm^3/h \times 10^3$	kg/s	t/h	kg/tDS	nm^3/tDS	kg/nm^3	Air factor
Dry	214,1	770,9	295,8	1065	5.032	3.643	1,38	1,16
Wet	284,9	1025,8	352,7	1270	6.000	4.847	1,24	-
Flue gas compostion				**Emissions in dry gas**				
	%-dry	%-wet		at	8%	at actual-O2		
O_2	3,00	2,25		ppm	mg/nm^3	ppm	mg/nm^3	kmol/tDS
CO_2	16,54	12,43	CO	104	304	144	422	0,00800
N_2	79,47	59,72	TRS	2	3	3	4	0,00063
Ar	0,94	0,71	SO_2	25,0	73	35	101	0,01998
H_2O	-	24,85	NO_X	105	131	146	182	0,07608
			Ash		60		83	
	From	After demin	Dew point					
Temperature	Eco.	preheat	H2O	Acid est.				
°C	190	190	65	128				

COMBUSTION AIR

Air moisture g/kg dry air	12	Primary	Secondary	HVLC	Vent gas	Tertiary	Quartiary	Leakage
Cold air temperature	°C	20	20	43	43	20	20	20
Temperature after SCAH	°C	150	150	80	80	20	150	20
Distribution	%	23	38	8	3	28	0	0
Flow, dry	nm^3/s	50,0	82,6	17,5	6,4	60,9	0,0	0,0
Flow, dry	kg/s	64,7	106,8	22,6	8,3	78,7	0,0	0,0
Specific flow, dry	nm^3/tDS	851	1.406	297	110	1.036	0	0
Specific flow, dry	kg/tDS	1.100	1.818	385	142	1.339	0	0
Flow, wet	nm^3/s	51,0	84,2	17,8	6,6	62,1	0,0	0,0
Flow, wet	kg/s	65,5	108,1	22,9	8,4	79,7	0,0	0,0
Specific flow, wet	nm^3/tDS	867	1.433	303	112	1.056	0	0
Specific flow, wet	kg/tDS	1.113	1.839	389	144	1.356	0	0
TOTAL AIR	nm^3/s	$nm^3/h \times 10^3$	kg/s	t/h	kg/tDS	nm^3/tDS	kg/nm^3	
Dry	217,5	782,8	281,2	1.012,3	4.784	3.699	1,29	
Wet	221,7	798,1	284,6	1.024,5	4.841	3.771	1,28	

	Client:	MONTES DEL PLATA
	Mill:	CDM
	Case:	Base Case

RECOVERY BOILER MASS AND HEAT BALANCE

STEAM AND FEEDWATER

		HP-steam to mill	Sootblow steam internal	Blow-down	Sootblow steam external	Feed-water
Flow	t/h	730,7	39,6	3,9	0,0	774,1
Pressure	bar(a)	86,0	99,0	103,0	23,5	112,0
Temperature	°C	480	340	313	350	120,0
Enthalpy	kJ/kg	3.342	2.886	1.421	3.130	501,6
		MP2-steam	MP1-steam	LP-steam		
Flow	t/h	0,0	9,5	36,0		
Pressure	bar(a)	23,5	12,5	5,3		
Temperature	°C	350,0	199,8	164,0		
Enthalpy	kJ/kg	3130,2	2812,4	2774,4		

ENERGY BALANCE

IN	kJ/kgDS	kW	OUT	kJ/kg DS	kW
Chemical energy in BL DS	14.000	822.938	Sensible heat in flue gas	1.172	68.896
Sensible heat in BL	417	24.541	Evaporation heat	871	51.197
Chemical energy in Aux fuels	268	15.731	Smelt sensible heat	603	35.456
Sensible heat in Aux fuel	2	98	Reduction energy	1.433	84.242
Sensible heat in ejector steam	1	66	Corr. for H_2O formation from H_2	818	48.104
Sensible heat in cold air	75	4.434	Blowdown loss	17	988
Sensible heat in air afer SCAH	414	24.320	Radiation, unburnt etc	91	5.349
Sootbl. steam	81	4.757	**Total heat losses**	**5.006**	**294.233**
			Steam generation	kJ/kgDS	kW
			Energy to HP-steam generation	9.806	576.423
			Energy to sootblowing steam	446	26.228
Total energy to boiler	**15.258**	**896.884**	**Total energy from boiler**	**15.258**	**896.884**
Net steam generation	kg/kgDS	3,45			
Efficiency on HHV	%	71,86	on total fuel input and including soot blowing steam		
Efficiency on NCV	%	76,23			

TOTAL POWER CONSUMPTION incl. 10% contingense	kW	9.788

SUMMARY CONSUMPTIONS, GENERATIONS AND SPECIFIC FIGURES

	t/h	t/tDS	GJ/tDS	Remarks
Steam to net	731	3,453	9,806	
Steam for sootblowing	40	0,187	0,586	
Blow-down	4	0,018	0,026	
MP2 for air preheating	0	0,000	0,000	Condensate return at saturated temp LP
MP1 for air preheating	5	0,024	0,052	Condensate return at saturated temp LP
LP for air preheating	36	0,170	0,363	Condensate return at saturated temp LP
LP for CNCG ejector	1,0	0,005	0,013	
MP1 for smelt shatering	4,4	0,021	0,058	0,55 t/h and smelt spout, max ~650 tDS/d and spout