F-CDM-DEV-METH ver 01

CDM: Form for submission of requests for deviation from methodology (Version 01) *(To be used by the DOE, for requesting a deviation)*	
Name of the entity (DOE) submitting this form	DNV Climate Change Services AS
Title of the project activity	Punta Pereira biomass power plant
Title of methodology	ACM0006 – Consolidated methodology for electricity and heat generation from biomass residues (version 11.1)
Title/Subject (give a short title or specify the subject of your submission, maximum 200 characters)	Deviation for determining the baseline efficiencies of heat generator and heat engine
Attach draft CDM-PDD of project activity	☒ Yes, is attached.
Date and signature for the DOE	

Description of the request for deviation

Please use the space below to describe the deviation and substantiate the reason for requesting a deviation from approved methodologies (validation/registration stage).

The deviation requested is related to the way the efficiencies of heat generators and heat-to-power ratio of the heat engines are determined in the baseline. Punta Pereira is a greenfield pulp mill project and the baseline defined in the PDD is: “conventional self-sufficient pulp mill, without surplus power generation capacity”.

For the Punta Pereira baseline determination the efficiency of two equipment, the pulp mill recovery boiler and the turbo generator, should be determined. The deviation of each parameter is described in the sections below:

Efficiency of the turbo generator: According to Step 1.5 “Determine the efficiencies of heat generators, and efficiencies and heat-to-power ratio of heat engines” of the methodology ACM0006 (version 11.1) only Option 1: “Default values should be chosen” is applicable to the project. This option automatically refers to Option F: “Use a default value” of the “Tool to determine the baseline of thermal or electric energy generation system” (version 1).

Table 1 of the referred tool is related to heat generating equipment and is consequently not applicable to the turbo generator. In this case the “Tool to determine the baseline of thermal or electric energy generation system” (version 1) refers to the Annex I: “Default efficiency factors for power plant” of the “Tool to calculate de emission factor for an electricity system” (version 2.2.0), however this Annex only presents efficiencies for fossil fuel power plants (coal, oil and natural gas).

Returning to the “Tool to determine the baseline of thermal or electric energy generation system”

(verison 1), in situations where a specific technology in not include in the table the maximum default efficiency of 100% may be used, as a simple approach.

The value given for efficiency (100%) is impossible to be achieved according to thermodynamical principles. The most efficient heat engine cycle is the Carnot cycle, which consists in an ideal and reversible cycle with two isothermal processes and two adiabatic processes. According to the second law of thermodynamics, Carnot Cycle is given by:

$$\eta_{TG}(\%) = \frac{W_{cycle}}{Q_H} = 1 - \frac{T_C}{T_H} \quad (1)$$

Where:

- η_{TG} is the efficiency of the turbine generator;
- W_{cycle} is the work done during the cycle;
- Q_H is the quantity of heat used in the process, which means the difference between the steam enthalpy to the turbine minus the feed water enthalpy;
- T_C is the outlet temperature of the turbine expressed in Kelvins (cold source);
- T_H is the inlet temperature of the turbine expressed in Kelvins (hot source);

Notice that 100% efficiency is impossible as it would require a T_L equal to zero Kelvin (-273°C) and a T_H near infinite.

Despite that, turbines efficiencies also vary according to the applied technology, the inlet steam conditions, steam extractions and its output conditions.

Considering the presented above the maximum theoretical turbo generator efficiency for the project activity was calculated based on the following configuration:

- one back-pressure turbine with capacity of 116 MW,
- inlet steam of 717 tonnes/h at 83 Bar and 478°C
- one steam medium-pressure extraction of 273 tonnes/h at 12.5 Bar and 200°C
- one steam low-pressure extraction of 444 tonnes/h at 5.3 Bar and 164°C
- outlet flow to the feed water of 717 tonnes/h at 120°C

The turbine efficiency is given by the theoretical formula 1, presented above. In the project case there are two steam extractions that must be considered in the calculation, resulting in:

$$\eta_{TG}(\%) = \frac{\dot{m}_{HP-MP} * (h_{HP} - h_{MP}) + \dot{m}_{MP-LP} * (h_{MP} - h_{LP})}{\dot{m}_{inlet\ steam} * (h_{in} - h_{fw})} \quad (2)$$

Where:

- m_{HP-MP}: flow inside the turbine from the high-pressure to the medium-pressure extraction
- m_{MP-LP}: flow inside the turbine from medium-pressure to the low-pressure extraction
- h_{HP}: high pressure enthalpy
- h_{MP}: medium pressure enthalpy
- h_{LP}: low pressure enthalpy
- h_{in}: enthalpy of the inlet flow
- h_{fw}: enthalpy of the feed water

At the present case and considering the steam conditions as presented above: h_{HP} = h_{in} = 3 342 kJ/kg, h_{MP}

= 2 854 kJ/kg, h_{LP} = 2 687 kJ/kg and h_{fw} = 502 kJ/kg. The flows inside the turbine, $m_{HP\text{-}MP}$ and $m_{MP\text{-}LP}$ will be 717 tonnes/h and 444 (=717-273) tonnes/h, respectively.

Thus applying those values to formula 2, results:

$$\eta_{TG}(\%) = \frac{717*(3342-2854)+444*(2854-2687)}{717*(3342-502)} = \frac{349\ 896+74\ 148}{2\ 036\ 280} = 20.82\% \qquad (3)$$

Considering 100% of isentropic efficiency in order to reflect a maximum theoretical value, the calculated efficiency power-to-heat ratio of the turbo generator results in the efficiency (0.2082), when divided by 3.6 to convert to MWh/GJ this results in 0.05784 MWh/GJ.

Therefore the suggested project specific efficiency for the turbo generator is the maximum isoentropic efficiency of the turbine. In DNV opinion this value can be considered conservative and realistic.

Also when compared to the baseline efficiency of similar pulp mill CDM projects: Nueva Aldea: 0.04525 MWh/GJ (UNFCCC n°0258); Valdivia: 0.04235 MWh/GJ (UNFCCC n°1787); Fray Bentos: 0.03746 MWh/GJ (UNFCCC n°1493)[1], the proposed value for the turbo generator of Punta Pereira project is the highest, assuring conservativeness at the baseline.

Efficiency of the pulp mill recovery boiler: According to Step 1.5 of the methodology ACM0006 (version 11.1) only Option 1: "Default values should be chosen" is applicable to the project. This option automatically refers to Option F: "Use a default value" of the "Tool to determine the baseline of thermal or electric energy generation system" (version 1). At Table 1: "Default baseline efficiency for different technologies" only fossil fuel boilers (natural gas, oil and coal) are listed, and there is no option that could be chosen in order to represent the technology used at a pulp mill recovery boiler.

In cases where no options of Table 1 are applicable the "Tool to determine the baseline of thermal or electric energy generation system" (version 1) indicates the maximum default efficiency of 100% should be used, as a simple and conservative approach.

However if the efficiency of 100% was used in the recovery boiler, once the amount of biomass residues is fixed, the steam production would increase and consequently more heat would be generated in the baseline. This excess of steam would, not be used in the process and would have to be discarded. On the other hand, if a larger turbine was selected in the baseline, more energy would be generated and theoretically, there would be an electricity surplus; consequently the concept of the baseline would be corrupted and the project would not be in line with the common practice of the industry.

Using an efficiency of 100% in the baseline it would not allow the project baseline to be classified as "conventional self-sufficient pulp mill, without surplus power generation capacity", which is the industry common practice.

The suggested project specific efficiency for the recovery boiler was determined as the optimal point for the power plant operation (Case 3.2.4.1 of ACM0006). On the next steps the optimal point for operation, where the balance of biomass-based heat equals the remaining demand for process heat, is presented and justified as the most conservative option:

$$HC_{BL,y} - HC_{BL,BR,CG,y} = \frac{h_{low,y}}{h_{high,y}}.\left(HG_{BL,BR,y} - HG_{BL,BR,CG,y}\right) \qquad (4)$$

And also the electricity generation balance using fossil fuels equals to zero:

[1] "Memo TG efficiency_24-11-2011 (2).pdf"

$$EL_{BL,FF,y} = EL_{BL,y} - EL_{BL,GR,y} - EL_{BL,BR,CG,y} = 0 \quad (5)$$

Below are the scenarios with different efficiencies were simulated according ACM006 steps:

Boiler efficiency *%*	**Baseline emission** *tCO_2*
60,0%	823.241
65,0%	760.772
70,0%	760.792
75,0%	238.501
76,2%	113.001
80,0%	113.017
85,0%	113.038
90,0%	113.059
95,0%	113.079
100,0%	113.100

Table 1 – Efficiencies vs. emissions reductions

The efficiency with lower emission (76.2%) is the point where equations 4 and 5 are satisfied.

Values below 76.2%: For values below the proposed efficiency, the process heat demand would not be achieved using only the biomass residues and fossil fuel would have to be used in order to generate the necessary heat. In this condition the baseline emissions would be higher due to increase in heat generated with fossil fuel in the recovery boiler. (Case 3.2.4.3 of ACM0006).

Values above 76.2%: For values above the proposed efficiency, baseline emissions would be slightly higher due to the increase in heat generated with fossil fuel in the recovery boiler due to technical constrains (start-up and shut-down). According to page 32 of ACM0006 version 11.1 for the consumption of fuel due to technical constraints, the project participants shall: *"(i) clearly identify the fossil fuel type and quantity required due to this technical constraint; (ii) add the identified quantity to the parameter $FF_{BL,HG,y}$; (iii) determine the heat generation from this quantity of fossil fuel based on the efficiency of the heat generator; and (iv) add the calculated heat generation to the parameter $HG_{BL,BR,y}$"*.
Therefore applying formula 14 of ACM0006 for the fossil fuel:

$$HG_{BL,FF,y} = \sum_h (FF_{BL,HG,y} . NCV_{FF,y} . \eta_{BL,HG}) \quad (6)$$

Where:

- $FF_{BL,HG,y}$ is a fixed value (26.62 kg/ADt[2]) based on the annual pulp production (5 097 ADt/yr). Therefore fossil fuel consumption equals to 135.20 tonnes/yr
- NCV_{FF} is a fixed value obtained from 2006 IPCC[3] and equals to 39.80 GJ/tonnes.

Therefore, the heat generated ($HG_{BL,FF}$) is directly proportional to the baseline efficiency ($\eta_{BL,HG}$) and as

[2] ADt: air dryed tonnes of pulp.
[3] From 2006 IPCC Manual, Energy, table 1.2, lower boundary value for baseline emissions.

presented in Table 1 above, the higher the efficiency, higher would be the emission reductions.

In the Punta Pereira project the baseline is defined as "conventional self-sufficient pulp mill, without surplus power generation capacity". The size of the pulp mill was defined based on its processing capacity and this value is limited to 1,300,000 ADt/year (air dry tonnes). The recovery boiler and turbo generator were designed based on the total amount of biomass available and on specific operational conditions of the pulp mill. Therefore it is DNV opinion that the default values available in the methodology ACM0006 (version 11.1) are not applicable to the Punta Pereira project.

Please use the space below to describe and substantiate the assessment of the DOE that the deviation does not require an amendment to the approved methodology used by the proposed project activity.

The presented deviation is proposing project specific values for the efficiencies of the turbo generator and the pulp recovery boiler.

DNV considers that the default values available to determine the efficiency of the turbo generator and the pulp recovery boiler in accordance to the methodology ACM0006 (version 11.1) and respective tools are not sufficient or applicable to the Punta Pereira project.

It is DNV opinion that the baseline efficiencies should be conservative and comply with the pulp and paper industry in the relevant geographical region defined for the Punta Pereira project.

In order to reflect the project conditions and also to be represent a conservative and realistic baseline, project specific efficiencies for the turbo generator and the recovery boiler should be used in the baseline. Thus, being project specific efficiencies, it does not require an amendment to the approved methodology, once an amendment should be applicable to all projects classified under the methodology ACM0006.

Please use the space below to describe the impact of the deviation on the estimates of the emissions reductions for the proposed project activity with the use of approved methodology as existing and with the deviation. Please substantiate the estimations with relevant and verifiable data.

Two scenarios were simulated in order to calculate the impact of the deviation on the estimates of the emission reductions:

Scenario 1 - Efficiencies of the turbo generator:

Considering that there is no applicable efficiency value for biomass steam turbines in the approved methodology and respective tools, it is not possible to evaluate the impact of the deviation in this scenario (green field projects).

Although the proposed turbo generator efficiency was already shown to be more conservative than the average efficiency of similar pulp mill CDM projects. The average efficiency of Nueva Aldea, Valdivia and Fray Bentos equals to 0.04169 MWh/GJ, which is 28% lower than the proposed value (0.05784 MWh/GJ).

Scenario 2 – Efficiencies of the recovery boiler:

Using the 76.2% efficiency instead of the 100% efficiency for the recovery boiler the emission reductions would decrease in 99 tCO_2 per year. This is due to the decrease in the heat generation in the recovery boiler from fuel oil utilization, as explained above in this document.

Project participants are aware that the impact in emission reductions between the proposed (76.2%) and default value (100%) are very low and represents 0.09% of the annual emission reduction. However their main argument is about the conservativeness of the baseline (self-sufficient heat and power generation pulp mill). A baseline boiler with 100% efficiency would generate surplus of heat and power, which is not the common practice of the pulp and paper industry and, consequently does not reflect a conservative baseline scenario.	
Link to the documentation made available at validation stage	http://cdm.unfccc.int/Projects/Validation/DB/UP1L6BL9TJQNEVY94VNGTF949ZVVN0/view.html
If necessary, list attached files containing relevant information which is not available through the above link	• "Memo TG efficiency_24-11-2011 (2).pdf" • "Memo RB efficiency verC_14-12-2011 (2).pdf" • "Punta Pereira em01 (version 10 Chlorate)valid3.xls"

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Version	Date	Nature of revision
01	EB 49, Annex 5 11 September 2009	Initial adoption. This form replaces the form included as part of the *Procedures for request for deviation to the Executive Board* (version 02, EB 24, Annex 30). This form should be used in conjunction with *Procedures for requests to the Executive Board for deviation from an approved methodology.*
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