Name of expert responsible for completing and submitting this form	Barbara Haya
Related F-CDM-NM document ID number	NM0196

Note to reviewers: Please provide recommendations on the proposed new baseline and monitoring methodologies based on an assessment of CDM-NM and of its application in sections A to C of the draft CDM-PDD, desk reviews and public input. Please ensure that the form is completed and that arguments and expert judgements are substantiated.

History of submission *(to be communicated to reviewers by UNFCCC Secretariat):*

Note to reviewers: if the methodology is a resubmission, please read the previous version and associated Meth Panel recommendations.

This methodology is partly based on a previous submission, "Grid connected hydroelectric power generation projects in low-density vegetation areas (NM0130)", which was withdrawn at the request of the Methodology Panel. It was deemed that the project submitted with that methodology submission was applicable to ACM0002 because its power density ratio was above 10 W/m^2.

Title of the proposed new baseline methodology:

Grid-connected hydroelectric power generation projects in low-density vegetation areas where average water temperature is low.

Evaluation of the proposed new methodology by the desk reviewer

A. Changes needed to improve the methodology

(1) Outline any changes needed to improve the methodology:

a) Major changes:

The most important feature of this methodology is its estimate of emissions from hydropower reservoirs that fit the criteria for using this methodology. A review of the published literature on reservoir emissions from boreal and temperate regions does not give a clear indication as to whether the emissions estimate in this methodology is conservative.

- Emissions from reservoirs at the lowest end of the 1-4 W/m2 range could likely have higher emissions according to the data available. The IPCC Good Practice Guidance for LULUCF methods and values result in higher per kWh emissions estimates for dams with power densities close to 1 W/m2 (reservoirs that are very large compared to the amount of power they produce).
- 90 gCO2e/kWh should be conservative for reservoirs at the higher end of the 1-4 W/m2 range.
- The IPCC Good Practice Guidance for LULUCF should serve as a basis for methodologies to assess reservoir emissions.
- Given the scientific nature of the estimation of reservoir emissions and that our understanding keeps improving, scientists performing independent research on reservoir emissions should be involved in creating and evaluating methodologies for estimating reservoir emissions.
- Reservoir emissions estimates used in CDM methodologies should be updated as new research on

the subject is performed and published.

b) Minor changes:

B. Details of the evaluation of the proposed new methodology

Evaluate each section of CDM-NM. Please provide your comments section by section:

(1) Applicability conditions

a) State the applicability conditions as provided in the CDM-NM (simply copy from the submitted CDM-NM)

The methodology is applicable to grid connected hydroelectric power generation projects under the following conditions:

- Applies to grid-connected hydroelectric power generation projects which cause additional land flooding to occur and have a power density ratio of greater than 1 W/m2 but less than or equal to 4 W/m2;
- This methodology is only applicable to projects where the inundated area due to the project can be clearly defined and is dominated by low-density vegetation. The total area cannot consist of over 20% forest cover;
- Average annual water temperature of the project reservoir cannot not exceed 15°C

b) Explain whether the proposed applicability conditions are appropriate and adequate. If not, explain required changes:

I am unable to judge the specific figures: 15 degrees C and 20% forest cover. The analysis below questions the 1 W/m^2 low end of the power density ratio range.

(2) Definition of the project boundary

a) State how the project boundary is defined in terms of:

i) Gases and sources

The methodology provides a single figure – 90 gCO_2e/kWh – to cover the many sources of emissions of three gases (CO_2, CH_4, and N_2O) from reservoirs. I analyse this figure below.

ii) Physical delineation

b) Indicate whether this project boundary is appropriate. If not, outline required changes:

(3) Determining the baseline scenario and demonstrating additionality

a) Explain the methodological basis for determining the baseline scenario, and whether this basis is appropriate and adequate. If not, outline required changes:

A standard procedure is used.

b) Explain whether the application of the methodology could result in a baseline scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases that would occur in the absence of the proposed project activity.

A standard procedure is used.

c) State whether the documentation explains how, through the use of the methodology, it can be demonstrated that a project activity is additional and therefore not the baseline scenario. If so, what are the tools provided by the project participants?

Uses additionality tool.

d) Explain whether the basis for assessing additionality is appropriate and adequate. If not, outline required changes:

Uses additionality tool.

(4) Methodological basis for calculating baseline emissions and emission reductions

a) Explain how the methodology calculates baseline emissions and whether the basis for calculating baseline emissions is appropriate and adequate. If not, outline required changes:

b) Explain how the methodology calculates project emissions and whether the basis for calculating project emissions is appropriate and adequate. If not, outline required changes:

To evaluate if the value of 90g CO_2e/kWh is relatively conservative for hydropower plants that fulfil the criteria for this methodology, I compared this figure to published emissions measurements from reservoirs in temporal and boreal regions.

In sum, it is not clear if this figure is conservative. The per kWh emissions for reservoirs in boreal and temperate regions have been recorded for a small number of reservoirs with low power densities. Most of these are below the 90 gCO_2e/kWh figure (see Table 1). One was not because of its young age (Laforge-1 in Canada). Another, not included in this table, had bubble emissions per area of reservoir around 100 times that of most boreal reservoirs because it was built on peatland (Lokka in Finland) (Duchemin 2002). Also, the figures in Table 1 mostly don't include the relatively high emissions during the first year after inundation.

The IPCC Good Practice Guidance (GPG) for LULUCF (IPCC 2003) provides methods and figures for calculating the emissions from flooded lands including from hydropower reservoirs. I applied the methods and figures for boreal and temperate reservoirs to reservoirs with power densities of 1 W/m^2 and 2 W/m^2 (see Table 2). The IPCC GPG figures suggest that a little less than 50% of boreal reservoirs (with a wide range of power density ratios) would have emissions greater than 90 gCO_2e/kWh if they had power densities of 1 W/m^2 (see columns 3 & 4 in Table 2). A significant percentage of temperate reservoirs would have emissions greater than this figure. A very low percentage of reservoirs would exceed 90 gCO_2e/kWh if they had power densities greater than 2 W/m^2 according to the IPCC guidance (columns 4 & 5 in Table 2).

The IPCC GPG draws substantially on the work of Eric Duchemin. His 2002 article gives average emissions per area of reservoir for boreal and temperate reservoirs based on the set of published measurements. Replacing the IPCC figures with his figures, more than 85% of boreal reservoirs would have emissions below 90 gCO_2e/kWh. But a significant portion, almost 50%, of temperate reservoirs would have emissions higher than that figure. The most important difference between the IPCC and Duchemin values is a different estimate of methane bubbling emissions.

I can not say with confidence that this methodology is or is not conservative. Given its scientific nature of methodologies for assessing emissions from reservoirs and the uncertainties of the science, I would suggest that the independent scientists performing this research be involved in developing methodologies for estimating reservoir emissions. Also, the IPCC GPG guidelines should serve as a basis for any methodology involving reservoir emissions. I question if emissions per kWh is the correct metric for estimating emissions. Instead features of the reservoir including the land-type which it submerges, such as peatland, should factor into emissions estimates. Also, I question if emissions per area submerged or per power density ratio is more appropriate. If this methodology is considered as it is, possibly the cutoff value should be higher than 1 W/m^2.

Table 1 – Published estimates of per kWh emissions from Canadian hydropower reservoirs

Reservoir	Taken from	Reservoir size (km2)	Installed capacity MW	Reservoir age yrs	Power density w/m2	Emissions from reservoir surface gCO2e/kWh	Assumptio
Saint-Marguerite	Duchemin 2002	85	882	varies	10.38	8	
Churchill/Nelson	Duchemin 2002	1,400	3,925	varies	2.8	20.0	
Manic Complex	Duchemin 2002	2,645	5,044	varies	1.91	40.0	
Le Grand Complex	Duchemin 2002	13,000	15,552	varies	1.2	50.0	
Churchill Falls	Duchemin 2002	6,705	5,428	varies	0.81	60.0	
Laforge-1	St Louis 2000	1,288	878	1-5	0.68	264.8	Capacity factor = 60%
Robert Bourassa	St Louis 2000	2,835	5,616	12-19	2.0	52.0	
Revelstoke	St Louis 2000	120	1,980	8	16.5	9.3	Capacity factor = 60%

Table 2 – Results from two reports that provide aggregate estimates for reservoirs in boreal and temperate regions

		1 W/m^2		2 W/m^2	
		mean gCO2e/kWh	1 standard deviation (85% of reservoirs in this category) gCO2e/kWh	mean gCO2e/kWh	1 standard deviation (85% of reservoirs in this category) gCO2e/kWh
IPCC GPG	Boreal, wet	84	155	42	77.5
IPCC GPG	Cold temperate, wet	70	120	35	60
Duchemin (2002)	Avg boreal	50	79	25	39.5
Duchemin (2002)	Avg temperate	85	133	43	67

The figures in Table 2 are based on the emissions averages for boreal and temperate regions given in these two reports, and the following assumptions: 60% capacity factor for the hydropower plant, boreal reservoirs are covered with ice 165 days of the year and temperate reservoirs are covered with ice 40% of the year. For the IPCC figures and I performed a combination of a Tier 1 and Tier 2 assessment. I did a weighted average of ice cover and non-ice cover periods, but did not include degassing emissions.

The *mean* columns show average values, such that 50% of reservoir measurement were lower than this value. The *1 standard deviation* columns use the emissions value under which 85% of measurements lie.

Note of background: The main sources of emissions from hydropower reservoirs in cool climates are CO_2 and CH_4 diffusive and bubbling emissions from the reservoir surface. Diffusive emissions involve exchanges that happen at the water surface/air interface. Bubbling emissions are gas bubbles that float up to the reservoir surface and enter the air. Degassing emissions, released when water flows through the turbines and spillways, are considered negligible for reservoirs in cool climates (Duchemin 2002). Very few measurements have been taken of the N_2O emissions.

(5) Leakage

a) State how the methodology addresses any potential leakage due to the project activity:

b) Indicate whether the treatment for leakage is appropriate and adequate. If not, outline required changes:

(6) Key assumptions

a) List the implicit and explicit key assumptions and rationale for the methodology:

b) Give your expert judgement on whether the assumptions are adequate. Identify those, if any, which are problematic and outline required changes:

(7) Data and parameters NOT monitored *(i.e. data that is determined only once and remains fixed throughout the crediting period)*

a) Indicate for all key data and parameters which data sources or default values are used and how the data or the measurements are obtained (e.g. official statistics, expert judgement):

b) Explain the vintage of data recommended (in relation to the duration of the project crediting period) and whether the vintage of data is appropriate, indicating the period covered by the data. If not, outline required changes:

c) Give your expert judgement on whether the data and the measurement procedures (if any) used are adequate, consistent, accurate and reliable. Identify those, if any, which are problematic and outline required changes:

d) State possible data gaps:

(8) Key data and parameters monitored *(i.e. data that is determined throughout the crediting period)*

a) Indicate for all key data and parameters which data sources (e.g. official statistics, expert judgement) or measurement procedures are used:

b) Give your expert judgement on whether the data sources and measurement procedures (if any) used are adequate, consistent, accurate and reliable. If not, outline required changes:

It is not clear what will happen if the average annual water temperature exceeds 15 degrees C or if the power density ratio goes below 1 W/m2. It is also not clear how the associated time frames are defined.

c) Give your expert judgement on whether the monitoring frequency for the data and parameters is appropriate. If not, outline required changes:

d) Give your expert judgement on whether the QA/QC procedures are appropriate. If not, outline required changes:

e) State possible data gaps:

There is an important typo in the table on page 3. It should be 90 gCO2e/kWh, not kg.

(9) Assessment of uncertainties

Provide an assessment of uncertainties given (e.g. in determining baseline scenario, data sources, key assumptions)

(10) Transparency, "conservativeness" and consistency

a) Explain whether the methodology has been described in an adequate and transparent manner. If not, outline required changes:

Fine.

b) Explain whether the methodology is conservative, and if so, how:

See above.

c) Explain whether the methodology is internally consistent, and if not, highlight which sections are inconsistent:

Fine.

(11) If relevant, state whether the proposed changes required for the methodology implementation on 2nd and 3rd crediting periods are appropriate.

(12) Any other comments

a) State which other source(s) of information (i.e. other than documentation on this proposed methodology available on the UNFCCC CDM web site) have been used by you in evaluating this methodology. Please provide specific references:

Duchemin, É., et al. (2002) 'Hydroelectric reservoirs as an anthropogenic source of greenhouse gases,' *World Resource Review* 14.

IPCC (2003) 'Good Practice Guidance for LULUCF' Appendix 3a.3

St. Louis, V.L. et al. (2000) 'Reservoir Surfaces as Sources of Greenhouse Gases to the Atmosphere: A global estimate,' *BioScience* 50:9.

Email contact with Eric Duchemin

b) Indicate any further comments:

Signature of desk reviewer Barbara Haya
Date: Dec /19 / 2006

Information to be completed by the secretariat	
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