CLEAN DEVELOPMENT MECHANISM
PROPOSED NEW METHODOLOGY: MONITORING (CDM-NMM)
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CONTENTS

SECTION A. Identification of methodology

A.1. Title of the proposed methodology:

Increased electricity generation from existing hydro power stations through Decision Support System optimization

A.2. List of category(ies) of project activity to which the methodology may apply:

#1- Renewable Energy

A.3. Conditions under which the methodology is applicable to CDM project activities:

The methodology applies:

- Only to existing hydropower generation units and reservoir capacity. The methodology can include multiple units linked in a cascade including both run of the river and reservoir-based units.
- To hydropower systems that lack advanced the Decision Support System optimization controls and modeling required to optimize generation potential
- To electrical power systems where additional hydropower would offset fossil fuel based generation
- Only includes optimization of generation units that were online as of the baseline year
- Only to those power generation units that have not undergone significant upgrades beyond basic maintenance, which would affect the expected operational efficiency levels during the duration of the project.
- Only where accurate data is available to measure and document the additional energy generated by existing hydro stations beyond the baseline case
- Only where no dam height is added as a result of the project to increase reservoir size

A.4. What are the potential strengths and weaknesses of this proposed new methodology?

Strengths
The methodology is simple. It provides a clear transparent overview of the increase in generation due to optimization of the existing generating units. The methodology eliminates the impact of year-to-year generation variability due to changes in water availability. The methodology will

conservatively determine what the generation would have been under the baseline scenario based on how much water is actually available, and compares that base generation to the actual generation that did occur. The difference between the two is a measure of the energy improvement due to the new technology. The methodology is set up to ensure any discrepancies in emissions reduction accuracy err on the conservative side. It also has a heavy reliance on monitoring using very accurate data. To translate the additional electricity generation into CO_2 reductions, the methodology utilizes the combined margin approach, which has already been refined and approved by the CDM Executive Board. Once the methodology calculates what the additional hydro output is, the project essentially becomes like a zero-emission, renewable electricity project, of which there are many examples for the Clean Development Mechanism.

Weaknesses
Because of the complexity of hydro systems, the methodology cannot interpret the project's impact on new generation capacity added during the course of the project. Any new generating units added during the course of the project will be excluded. Also, it cannot hope to quantify any improvement that the Decision Support Software would enable during major abnormal operational situations (blackouts, major equipment repairs, etc.)

SECTION B. Proposed new monitoring methodology

B.1. Brief description of the new methodology:

There is a certain amount of energy embedded in water held in a reservoir or flowing through a river. Hydropower units transfer some portion that energy into an electrical form. The electricity generating units that execute this task perform best under certain operating conditions. The optimal operating conditions for each unit may differ based on design or other variables. By determining the optimal operating conditions for each unit – and trying to match up the actual operation of the units with their optimal operation point – an operator can increase the total electricity generation from the same amount of water flowing under the same conditions. This is especially true when you calculate the optimal generation scenario for multiple generating units using all the available data including likely weather conditions, reservoir capacity, head, and other variables.

Two to ten percent increases in electricity generation have been realized for example in the reasonably well managed operations in Manitoba Hydro (Canada) and Idaho Power (USA) simply by implementation of a Decision Support system to better manage water resource decision making.

Decision Support Tools are designed to calculate the optimal use of the generating capacity of a hydro generating unit or a series of hydro generating units by taking advantage of all the controllable factors (head, reservoir capacity, spillage, time of use, etc.) and best available information. If the Decision Support Tool is able to increase electricity generation from existing hydro units it may be able to displace electricity generated from thermal sources and eliminate the combustion of fossil fuels. This will result in CO_2 emission reductions.

To measure the impact of a Decision Support System, a project developer can look at optimizing the cumulative energy (measured in kwh) generated for each m^3 of water that moves through the generating units and spillways or cascade of generating units and spillways. In order to eliminate the key factor outside the control of the Decision Support System- the timing and quantity of natural water supply – a normalized baseline is established in which the weekly energy output for the system is established for various points corresponding to a total flow index. For example in the baseline year, in a given 1-week period in which the average flow releases are say 20,000 cubic feet per second (CFS) (566 m3/second), the production would be 60,000 MWh. In the post-optimization project year, for a week with the same flow index (20,000 cfs), the actual production would be compared to the baseline production, and the gain quantified.

The total flow index, which in projects with reservoirs includes spillage, can be the flowrate (or total flow volume) from all hydro stations. The total flow index will be measured consistently between the baseline period and the project years.

The baseline generation in kwh at a particular flow index observed during a week in the project year would be compared with the actual kwh generated. The difference would yield the additional electricity generated. This will be converted into CO_2 emission reductions using the combined margin approach to develop a carbon emissions factor.

The Decision Support tool results in increased generation from the same water volume, as a result of many mechanisms. Two examples are as follows:

- the Decision Support Tool might inform an operator currently running all the generating units at between 50-75% of capacity that more electricity can be generated by using fewer units at a higher capacity and higher efficiency, while still meeting reserve requirements
- Since the Tool predicts future inflows from either trend projections and/or quantification of runoff due to weather data monitoring, it can increase current generation and temporarily lower reservoir levels. That could avoid spillage when the increased flows reach the dam, and what would have been spillage can now be used as useful electricity.

In these two cases, this increased level of output could displace fossil-fuel units, reducing CO_2 emissions.

B.2. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario:

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B.2.1. Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

There will be no project emissions.

B.2.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

The project is designed to increase the generation of electricity from existing hydro units by optimizing their operations. There will be no project emissions.

B.2.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of greenhouse gases (GHG) within the project boundary and how such data will be collected and archived:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
A-1	*Generation for each generation unit*	*Measured at each hydro generation unit*	*Kwh*	*m*	*Hourly, cumulated Weekly*	*100%*	*electronic*	*The monitoring system used to inform the Decision Support System will gather and archive this data*
A-2	*Total water flow index*	*Measured as a flow rate, a total flow volume across all generating units including spillage, or total volume at a representative point such as the most downstream plant*	*m3 or m3/second*	*m*	*Weekly (measured both in the baseline year and in the project years)*	*100%*	*electronic*	*The monitoring system used to inform the Decision Support System will gather and archive this data*
A-3	*Carbon emissions factor*	*Calculated using the combined margin approach outlined in ACM002*	*KgCO2/kwh*	*m and c*	*Annually (in project years)*	*100%*	*electronic*	*IPCC data may be used to determine carbon content for fuels.*

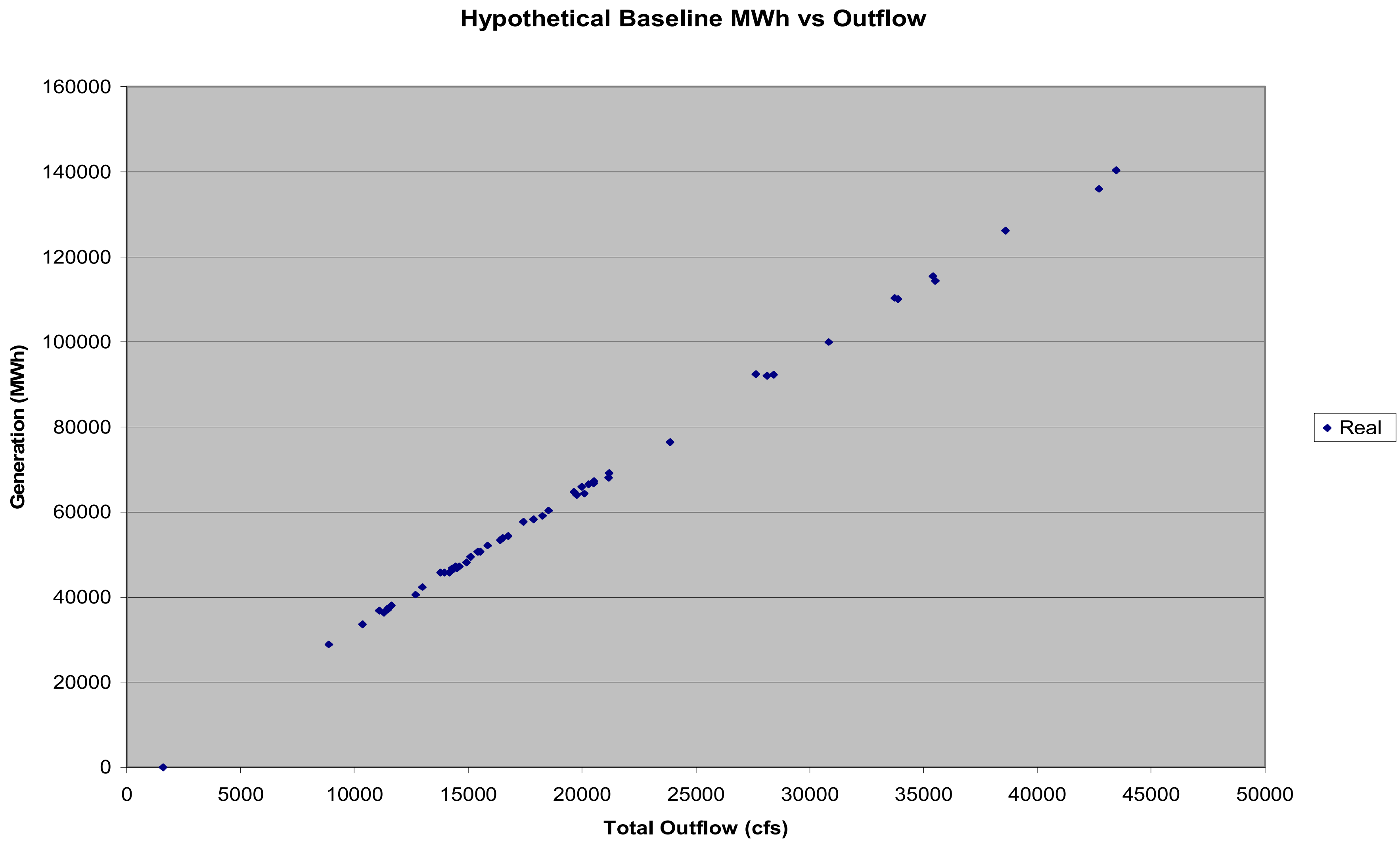
B.2.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

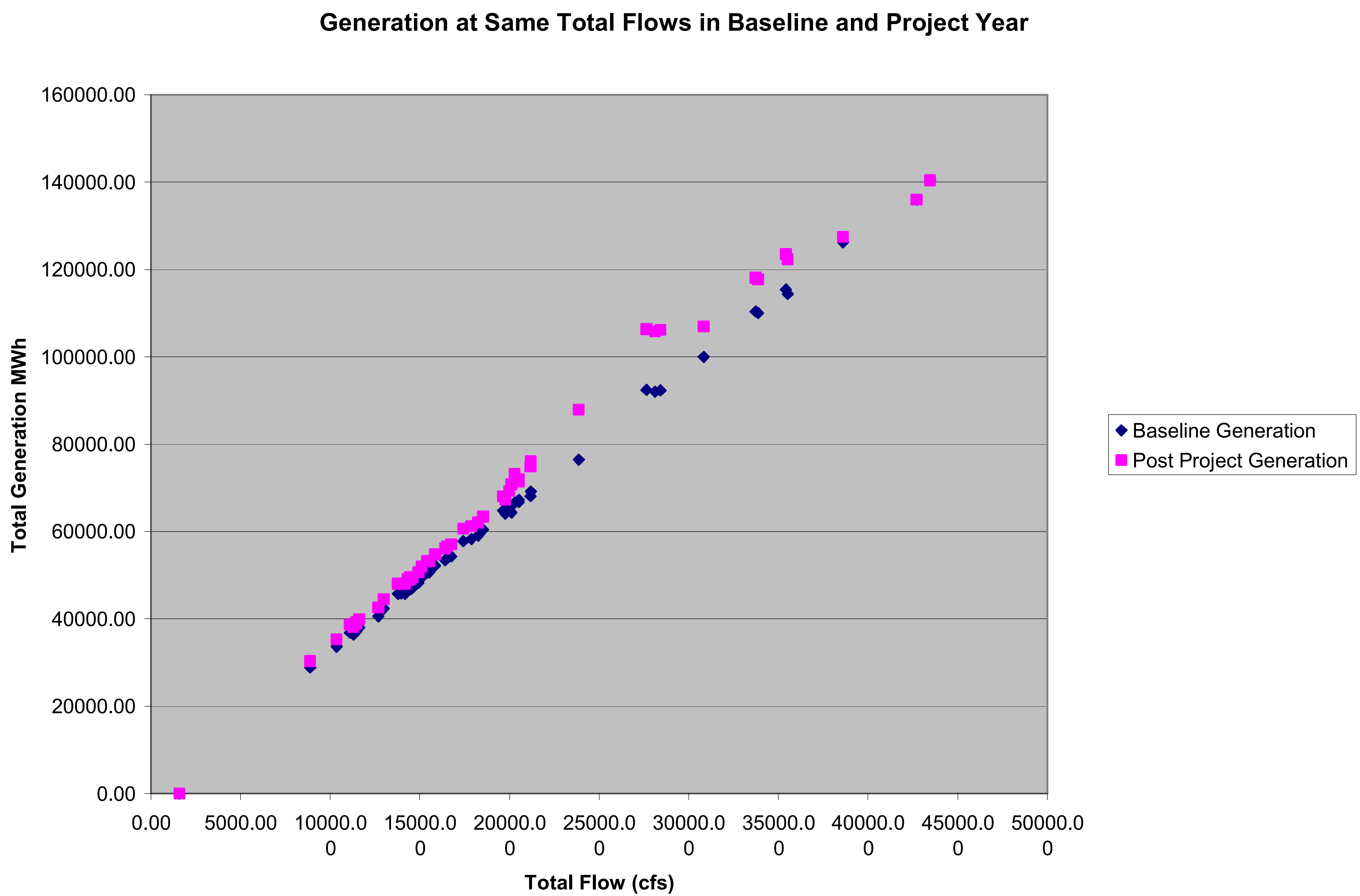
The project is designed to increase the generation of electricity from existing hydro units by optimizing their operations. The formulae are designed to calculate the total increase in generation in MWh from either a single hydro station or a series of hydro stations in a cascade. The project developer will have to calculate separately any geographically separated units (ie on a different unconnected river).

The baseline for year x will be determined by first measuring the pre-project efficiency of generation in the project area in total kwh produced at particular weekly[1] total flow index. This means in practical terms that in the baseline year, for each week, the total flow of water through the project area will be calculated and the total kWh generated will also be recorded. The relationship between the flow index and the actual aggregate generation will be established, as seen graphically below. A best-fit line using a polynomial trend equation (like that typically found using Excel 'TREND' function) will be established. This relationship will be used to define the baseline energy production for a given weekly flow index.

Each project year, the baseline generation and the actual generation will be calculated by determining the actual weekly flow index and using the measured electricity production for that flow index in the baseline year to determine what the generation of electricity would have been for that week if the hydro system had not been optimized. The total baseline electricity generation will simply be a sum of all the weekly figures, and the total actual generation will be the sum of all the weekly figures. These two values will then be compared, to determine the additional electricity generated through optimization.

[1] The time period of a week was selected as the default because unlike a day or hour it should capture all of the various usage peaks that typically fall within a week (weekend versus weekday). It also is preferable to longer periods such as a month, since an average flow over this longer period would mask the hydrologic variability. In specific cases, the project developer can propose a different time period to the DOE by demonstrating and documenting how a different timeframe produces a more accurate result.


Hypothetical Baseline MWh vs Outflow
Generation (MWh)
160000
140000
120000
100000
80000
60000
40000
20000
0
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
Total Outflow (cfs)
Real


Generation at Same Total Flows in Baseline and Project Year
Total Generation MWh
160000.00
140000.00
120000.00
100000.00
80000.00
60000.00
40000.00
20000.00
0.00
0.00
5000.00
10000.00
15000.00
20000.00
25000.00
30000.00
35000.00
40000.00
45000.00
50000.00
Total Flow (cfs)
Baseline Generation
Post Project Generation

For example, in the baseline year the measured outflow in week 18 of 20,000 cubic feet per second produced 60,000 MWh from the hydro generating units in the project boundary. If in the project year after optimization, the same measured outflow produced 62,000 MWh the project developer could claim credit for an additional 2000 MWh produced for that particular week.

Once the total additional electricity generation is determined by subtracting the baseline generation from the actual generation, it will be multiplied by a carbon emissions factor for the entire electricity grid determined using the combined margin approach.

In developing the data set for both the baseline and the project year, the project developer must identify and eliminate outlying data points that represent atypical circumstances such as blackouts, major equipment malfunction and repair. For the baseline, this will simply mean eliminating these data points from the data set. In the project year, the project developer will not be able to claim any emission reductions in weeks where these types of major abnormalities occur since it would be too hard to calculate the baseline generation in those same abnormal conditions.

Additionally, the project developer will measure electricity generation at each generating unit and total the output for the week. This is needed since any major post-project upgrades to existing generating units or any new units added will need to be factored out of the calculations since the optimization project will not be directly responsible for the increase in generation. This means that if two years after the optimization project a 50MW generating unit is overhauled and upgraded to a more efficient 75MW, from that point on the generation output of this unit will be factored out both in the baseline calculation and in the post project calculation.

Baseline Electricity Generation in year x equals or BEgen
(note two caveats listed above which may change slightly the actual formula (i.e. only 51 weeks are tabulated since a major blackout occurred during one week)

$$\sum_{week_x=1}^{52} \left(\sum_{HPU=1}^{\Psi g} kwh_{hpu} \text{ produced in } year_0 \text{ at } Q(index)week_x \right)$$

Where
Year x= given project year being compared to baseline

HPU= Hydro power unit
ψg= total number of hydro power generation units that existed in the baseline year
Q(index)= total of all generation flows and spill flows during the week (see calculations below)
$Week_x$ = week in the year x (1-52)
Year 0= baseline year

The Weekly flow index which is used to identify the corresponding total electricity generation figure from the baseline year , Q(index), is calculated by cumulating all project releases (generation flow and spill flow) during the week, as follows.

$$Q(index) = \sum_{hour_x=1}^{168} \left(\sum_{HPU=1}^{\Psi g} m3_{hpu} \right) + \sum_{hour_x=1}^{168} \left(\sum_{s/w=1}^{\Psi s} Qspill \right)$$

Where
HPU= Hydro power unit index in m3
S/w = spillway
ψg= total number of hydro power generation units that existed in the baseline year
ψs= total number of spillways that existed in the baseline year
Qspill= total m3 of spillage for given time period and spillway

B.3. Option 2: Direct monitoring of emission reductions from the project activity:

N/A – Option 1 selected

B.3.1. Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

N/A – Option 1 selected

B.3.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

N/A – Option 1 selected

B.4. Treatment of leakage in the monitoring plan:

There is no anticipated leakage from this project. The hydro-optimization installation is not a large, capital-intensive project with substantial environmental impacts (like power plant construction). In terms of generation efficiency, the environmental gains should only be positive. It is not expected that generation output increases in the hydro facility would lead to greater fossil fuel use or inefficiencies in any other part of the grid.

B.4.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity:

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

NA – No anticipated leakage from this project.

B.4.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

NA

B.5. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

The CO2 emissions reductions for year x is the difference between Actual electricity generation for year x and the baseline electricity generation for year x which is then multiplied by the carbon emissions factor for the electricity in year x being displaced by the extra generation.[2]

(Actual Electricity Generation$_x$ - Baseline Electricity Generation$_x$) * CEF $_{yearx}$ = Emission Reductions$_x$

CEF= kgCO2/kwh=Carbon emissions factor determined using the combined margin approach outlined in ACM002

Total actual generation energy, Egen is the sum of the generation in all the weeks in year x

$$Egen = \sum_{week_x=1}^{52} E(x)$$

[2] While not likely, it should be noted that if the actual generation is less than the baseline for a certain week, it will be treated as a negative value and deducted from the total annual savings.

To determine the actual electricity generation in week x or, E(x) equals[3]

$$E(x) = \sum_{hour_x=1}^{168} \left(\sum_{HPU=1}^{\Psi g} kwh_{hpu} \right)$$

where
E(x) = total electricity generated in week x
$hours_x$ =total hours in week x
HPU= Hydro power unit
ψg= total number of hydro power generation units that existed in the baseline year
Kwh_{hpu} =total kwh generated by the given hydropower unit (HPU) for a given time frame

B.6. Assumptions used in elaborating the new methodology:

In cases where better data does not exist, the carbon content of the fuel will be determined by IPCC data sources.

[3] Note the following two caveats which may affect the implementation of the formula either reducing the number of weeks or reducing the number of HPUs-

1. In developing the data set for both the baseline and the project year, the project developer must identify and eliminate outlying data points that represent atypical circumstances such as blackouts, major equipment malfunction and repair. For the baseline, this will simply mean eliminating these data points from the data set. In the project year, the project developer will not be able to claim any emission reductions in weeks where these types of major abnormalities occur since it would be too hard to calculate the baseline generation in those same abnormal conditions. This may mean the actual data calculations for the year involves fewer than 52 weeks.

2. Additionally, the project developer will measure electricity generation at each generating unit and total the output for the week. This is needed since any major post-project upgrades to existing generating units or any new units added will need to be factored out of the calculations since the optimization project will not be directly responsible for the increase in generation. This means that if two years after the optimization project a 50MW generating unit is overhauled and upgraded to a more efficient 75MW, from that point on the generation output of this unit will be factored out both in the baseline calculation and in the post project calculation.

B.7. Please indicate whether quality control (QC) and quality assurance (QA) procedures are being undertaken for the items monitored:

Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
A-1	*L*	*The data acquisition system used for the Decision Support Tool will provide highly accurate data.*
A-2	*L*	*The data acquisition system used for the Decision Support Tool will provide highly accurate data.*
A-3	*L*	*If linked to the rest of the grid, the data acquisition system used for the Decision Support Tool will provide highly accurate data.*

B.8. Has the methodology been applied successfully elsewhere and, if so, in which circumstances?

This technology has begun to penetrate the North American and European Market. No CDM project has been attempted using this methodology.

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