Draft baseline methodology AM00XX

"Increased electricity generation from existing hydropower stations through Decision Support System optimization"

Source

This baseline methodology is based on the NM0112-rev methodology "Increased electricity generation from existing hydropower stations through Decision Support System optimization" submitted by Quality Tonnes of the World Bank Carbon Unit.

For more information regarding the proposals and their consideration by the Executive Board please refer to http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html.

This methodology also refers the approved methodology ACM0002, ¨*Consolidated baseline methodology for grid-connected electricity generation from renewable sources*¨ and to the latest version of the "*Tool for the demonstration and assessment of additionality*".[1]

The selected approach from paragraph 48 of the CDM modalities and procedures is:

"Existing actual or historical emissions, as applicable"

Applicability

This methodology is applicable to existing grid-connected hydropower systems that may include multiple hydro generation units linked in a cascade, including both run of the river and reservoir-based units, where the project activity increases annual electricity generation through the introduction of a Decision Support System (DSS)[2] that optimizes the operation of the existing facility/facilities.

The methodology is applicable under the following conditions:

1. Where the operation of hydropower systems is not currently optimized using a DSS, with optimization controls or modeling;
2. Where, at a minimum, one complete year of recorded data is available to establish the baseline relationship between water flow and power generation;
3. Where power generation units covered under the CDM project activity have not undergone, and will not undergo during the crediting period, significant upgrades beyond basic maintenance (e.g., replacement of runners) that affects the generation capacity and/or expected operational efficiency levels during the crediting period;
4. Where no major changes to reservoir size (e.g. due to increased dam height) or to other key physical system elements (e.g. canals, spillways) that would affect water flows within the project boundary, have been implemented during the baseline data period or will be implemented during the crediting period;
5. Where the project activity only includes the optimization of generation units that were online during the year(s) for which historical data for the baseline was collected;

[1] Please refer to: < http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>
[2] A DSS is an integrated set of computer programs (modules) that use forecasting methods and both optimization and simulation techniques to optimize the long-term and short-term benefits of power system operation.

6. Where either no additional hydro power units are located down river from the last hydro unit within the project activity, or the first hydro unit downstream of the project activity, has the capacity to regulate at least 24 hours of maximum flow from upstream.[3]

Identification of the baseline scenario

The methodology determines the baseline scenario through the following steps:

Step I: Identify all alternatives to the proposed CDM project activity that deliver a similar level of additional generation to the grid;

Step II: Determine the most likely scenario (the baseline scenario) from the alternatives identified in Step I using the investment and barriers analysis steps (Step 2 and Step 3, respectively), as defined in the most recent version of the *"Tool for the demonstration and assessment of additionality*¨, together with additional guidance provided for these steps in Additionality section below.

Step I: Identify alternatives to the project activity

Project participants shall identify realistic and credible alternatives(s) to the project activity including the following possible alternatives:

Alternative #1: Status Quo. Continuation of the current water management practices.

Alternative #2: Changes to hydro system operation or facilities (other than the project), including dam height, turbine replacement, spillway dimensions, and other changes that would materially affect the flow-output relationship.

Alternative #3: The proposed project activity, not undertaken as a CDM project activity.

The alternatives proposed in this Section are only indicative. Project proponents should propose other possible alternatives that are reasonably foreseeable.

Step II: Determine the most likely scenario (the baseline scenario) from the identified alternatives

Project participants, after identifying the alternatives to the project activity shall apply the barrier analysis and investment analysis as outlined in Steps 2 and 3 of the most recent version of the *"Tool for the demonstration and assessment of additionality*¨ as further elaborated in the Additionality section below.

The baseline scenario should be the alternative that faces the fewest barriers among the identified alternatives in Step I. If more than one alternative remains subsequent to barrier analysis, then the baseline scenario will be identified using investment analysis. The baseline scenario is then the alternative that is economically most viable as estimated using Step II of additionality assessment tool. Supporting documentation and evidence demonstrating the barriers and financial constraints of each of the non-baseline alternatives faces shall be presented to the DOE.
National/Sectoral Policies: In cases where actively enforced laws mandating the use of Decision Support Tools are in place, the project activity not undertaken as a CDM project (Alternative 3) will be considered the baseline scenario.

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[3] 24 hour capacity in m^3 = Maximum observed annual flow m^3/s *24 hr*3600 s/hr * 0.5. Note that factor 0.5 reflects that the storage must be 50% of the flow volume to re-regulate the inflow to the average daily value.

This methodology is only **applicable if Alternative 1**, i.e., continuation of current water management practices, is the most likely baseline scenario.

Additionality

The project should be demonstrated as additional using the most recent version of the *"Tool for the demonstration and assessment of additionality*, together with additional guidance provided below:

Sub-step 3a. Identify barriers that would prevent the implementation of type of the proposed project activity:

Establish that there are barriers that would prevent the implementation of proposed project activity from being carried out if the project activity was not registered as a CDM activity. Such barriers may include, among others:

Investment barriers:

- Financing capacity of the project proponent vis-à-vis other investment opportunities;
- Debt funding may not be available for innovative project activity;
- Lack of access to international capital markets due to real or perceived risks associated with domestic or foreign direct investment in the country where the CDM project activity is to be implemented;
- Subsidies may exist that inhibit investments in energy efficiency;
- The electric utility may not have cost recovery, and this could inhibit major investments;
- Potential lack of access to credit due to poor revenues; or,
- Inability of the management to dedicate resources, etc for implementation of the CDM project activity.

Technological/lack of familiarity barriers:

- Lack of familiarity or first-of-its-kind project significantly hinders the ability to implement the proposed project activity;
- Skilled and/or properly trained labor to operate and maintain the technology is not available;
- Education/training institution for training operators are not present in the host country leading to equipment disrepair and malfunctioning; or,
- Lack of infrastructure such as appropriate meters and communications links for implementation of the technology.

Step 4. Common practice analysis:,

The project developer may interview electricity utilities, in the selected country or region, and the manufacturers of the DSS software/optimization technology to assess how common is the CDM project activity.

The CDM project activity is not a common practice if:

- the project type has not been implemented in the country (or region for large countries); and
- companies that provide the technology, used in the CDM project activity, have minimal business in the country where the CDM project is being implemented; and
- utility managers are unfamiliar with this type of project.

If the optimization has taken place somewhat frequently elsewhere in the country or region, the project developer would need to show the extenuating circumstances that made that project happen and how it would not be replicable.

With respect to Steps 2, 3 and 4:
For the investment, barrier and common practice analyses, project participants should provide the following evidence to the DOE:

- Letters from the electricity utility implementing the proposed CDM project activity indicating their unfamiliarity with the hydro-optimization technology.
- Letters from one or more technology providers/developers that indicate average penetration rates in developed markets and whether similar projects have been developed in the country or region.
- Financial statements indicating the revenue losses and overall financial health of the electricity utility implementing the CDM project activity.
- Least-cost capacity expansion planning or feasibility studies, if available, that show that electricity utility implementing the proposed CDM project activity has not considered the CDM project activity as an option in these studies. This could include a list of priority investments for the utility. If the list does not include hydro-optimization but includes other projects, it shows that the CDM enables bringing the proposed project forward.
- Existing tariff rates or other information that show the income received from additional hydropower generation from implementing the CDM project activity would not translate into additional income, thus making the investment not cost-effective (for the investment analysis).

Project Boundary

The project site includes all of the hydroelectric generating units for which DSS tool will be installed. The **spatial** extent of the project boundary includes the project site and all power plants connected physically to the electricity system to which the project activity is connected.

For the baseline determination, project participants shall only account for CO_2 emissions from electricity generation in fossil fuel fired power plants that are displaced due to the CDM project activity. The grid emission coefficient will be calculated according to approved methodology ACM0002 "Consolidated baseline methodology for grid-connected electricity generation from renewable sources". The grid boundary for the project is as described in the latest version of approved methodology ACM0002.

Emissions sources included in or excluded from the project boundary

	Source	Gas	Included?	Justification / Explanation
Baseline	Electricity generated from the grid	CO_2	Yes	CO_2 is emitted when fossil fuels are burned to generate electricity. This project activity would displace those fossil fuels with enhanced hydropower output.
		CH_4	No	
		N_2O	No	
Project Activity	Emissions from the CDM project	CO_2	No	In terms of project emissions, the project is enhancing the use of existing hydropower capacity to generate additional hydropower. No fossil fuel emissions will be used to generate this additional electricity and thus there will be no project emissions.
		CH_4	No	
		N_2O	No	

Baseline Emissions

The following six steps are used to estimate baseline emissions. If generating units within the project site, where DSS is implemented, do not share a connected water source, the estimation of the baseline emissions will be sum of the baseline emissions estimated through Steps 1 through 6 for each water course separately.
A Data Book shall be prepared prior to the implementation of the DSS that contains all functional relationships (charts) for each generating unit, including the flow-generation functions.

Step 1: Collect data for estimating the baseline flow-output relationship

The flow-output relationship is developed from baseline data collected for each generating unit and spillway within the project boundary, as described in the steps below. All data available within the most recent three calendar years must be collected and applied to the methodology below. In cases where less than three full years is used, the DOE must verify the unavailability of data. A minimum of one calendar year's data must be used, as required by the applicability conditions.

Step 2: Estimate weekly baseline flow for each week (generating units and spill)

The weekly flow (Q_x) is sum of the flow through generating unit(s) and the spillway(s), estimated on an hourly basis, as follows:

$$Q_x = \sum_{hpu=1}^{N} \sum_{h=1}^{168} Q_{hpu,h} + \sum_{SW=1}^{M} \sum_{h=1}^{168} Q_{SW,h} \qquad (1)$$

where:
Q_x is flow during week x for each generation site.
$Q_{hpu,h}$ is flow through generation unit hpu during hour 'h' in week x estimated using relationship provided in equation 2.
$Q_{SW,h}$ is flow over the spillway SW for hour 'h' during week x, estimated using equation 3.
N is the total number of hydro power generation units (hpu) within the project site on the same water course.
M is the total number of spillways within the project site on the same water course.

<u>Step 2a: Deduce Flow through Generating Units.</u> The hourly flow through each generating unit is determined using the records of measured power output for that hour and the characteristic specifications of the generating unit. A curve for each HPU known as a "Hill Diagram" [4] will be constructed that accurately pinpoints its *power* versus *flow* and *head*. The form of the flow-generation curve for each generating unit is represented by a third order, polynomial equation that relates measured power output to measured head and flow, as follows.

$$EG_{hpu,h} = a + b * Q_{hpu,h} + c * Q_{hpu,h}^{2} + d * Q_{hpu,h}^{3} \qquad (2)$$

where:
$EG_{hpu,h}$ is the observed power output of hpu unit in MW for week x

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[4] Design of Small Dams, US Bureau of the Interior, Bureau of Reclamation, Chapter IX, Spillways

a, b, c, d are coefficients that are a function of head, as noted below:

$$a = a_1 + a_2 * H + a_3 * H^2 \quad (2.1)$$

$$b = b_1 + b_2 * H + b_3 * H^2 \quad (2.2)$$

$$c = c_1 + c_2 * H + c_3 * H^2 \quad (2.3)$$

$$d = d_1 + d_2 * H + d_3 * H^2 \quad (2.4)$$

where:

a_i, b_i, c_i and d_i	are the power polynomial coefficients for each generating unit based on ¨*hill diagram*¨ information provided by the owner or manufacturer.
H	is the head acting on the generating unit (headwater level less tail water level) for each hour 'h'
$Q_{hpu,h}$	is the estimated discharge (flow) in m^3/s for power h.

Step 2b: Calculate Spillway Flows. Spillway flows are calculated with the application of a "rating equation" which relates the flow through the spillway gate opening to monitored parameters - the water level and the gate opening.[5] Rating equation provided by the owner and/or equipment manufacturer shall be used for estimating the spillway flows. For example, a typical equation for spillway overflow with a radial gate partially open is:

$$Q_{SW,h} = C_0 * L_e * O * [WL_h - E_{sill}]^E * 3600 \quad (3)$$

where:

$Q_{SW,h}$	is the hourly spillway flow in m^3/hour
C_o	is a known coefficient taken from manufacturer/owner data
L_e	is the length of the gate, in m, measured as built
O	is the vertical opening, in m
WL_h	is the water level in week x
E_{sill}	is the elevation of the sill measured as built
E	is a known coefficient taken from manufacturer/owner data

Spillway flows will be calculated for each hour and aggregated by week over the year. These values are used in Step 3.

Step 3: Establish the flow-output (generation) relationship

Tabulate weekly total flow (generation flow and spill) estimated in the previous step along with recorded power generation during the corresponding week of the baseline period. Estimate the relationship between *total weekly flow* and *total weekly generation* for the baseline through regression analysis using polynomial equation form, taking into account guidance provided by the Board.[6] The estimated equation should be of the form

$$EG_x = f(Q_x) = a + b_1 Q_x + b_2 (Q_x)^2 + ... + b_n (Q_x)^n \quad (4)$$

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[5] Design of Small Dams, US Bureau of the Interior, Bureau of Reclamation, Chapter IX, Spillways Water Resources Engineering, Linsley and Franzini, McGraw Hill

[6] Please see Annex 7 of EB21 meeting report.

where:

EG_x is the recorded value of power generation for x^{th} week estimated as sum of recorded observation of power generation in each of the units 'hpu' in the week x, as in equation (5):

Q_x is the estimated value of flow in the week 'x', as per Step 2.

$$EG_x = \sum_{hpu=1}^{N} \sum_{h=1}^{168} EG_{hpu,h} \quad (5)$$

The criteria for determining the degree of polynomial 'n' is as follows

(i) The value 'n' for which the adjusted R^2 of the equation is highest.
(ii) Estimates of parameters a, b_1, …,b_n are significant at the 5% confidence level.

Step 4: Determine Baseline power generation

Use the flow-output relationship defined in Equation 4 to estimate baseline electricity output during each week of the project period ($EG^{Bl}_{,x}$), and sum this for each week of the year (y).

$$EG_{BL,y} = \sum_{x=1}^{52} EG_x^{Bl} \quad (6)$$

$$EG_x^{Bl} = f(Q_x^{Pr}) + 1.96 * SE(EG_x^{Bl}) \quad (7)$$

where:

$EG_{BL,y}$	is the estimated electricity that would have been generated corresponding to flow during the project activity in period y.
EG^{Bl}_x	is the estimated electricity that would have been generated corresponding to flow Q^{Pr}_x estimated in the week x of project crediting period y.
Q^{Pr}_x	is the flow for week x estimated using the procedure provided in Step 2
$SE(EG_{Bl,x})$	standard error of the estimate EG^{Bl}_x . The procedure for estimating SE is given in Annex I.

To be conservative, the project developer will not seek to claim credit for any weekly project results in which the flow (Q^{Pr}_x) falls outside the recorded boundaries of the baseline data.[7]

Exclusion of any outlier data points should be documented with a clear rationale (atypical circumstances such as blackouts, major equipment malfunction and repair) and validated and/or verified by the DOE. In the project year, the project developer will not be able to claim any emission reductions in weeks where major atypical circumstances occur.

Step 5: Calculation of Project Electricity Generation

[7] This gives the project developer incentives to use as many years of baseline data as possible. It also allows the baseline to conservatively and accurately normalize data in changing climates and in different withdrawal regimes.

The total electricity generation for the project in year y ($EG_{Pr,y}$) is calculated as follows:

$$EG_{\mathrm{Pr},y} = \sum_{x=1}^{52} \sum_{hpu=1}^{N} EG_{\mathrm{Pr},hpu,x} \qquad (8)$$

where:

$EG_{Pr,y}$	is electricity generated during the project in year y.
$EG_{Pr,hpu,x}$	is total electricity generated by unit 'hpu' in week x of year y

Step 6: Baseline emissions

$$BE = (EG_{Pr,y} - EG_{Bl,y}) * EF_y \qquad (9)$$

where:

EF_y is the CO_2 emissions factor estimated using ACM0002 ($kgCO_2/kWh$)

CO_2 emissions factor for the entire electricity grid determined using the combined margin approach approved in ACM0002.

Project Emissions

Project emissions are zero.

$$PE_y = 0 \qquad (10)$$

Leakage

There is no leakage expected from the installation of a Decision Management System. The installation of software and meters will not lead to additional emissions.

Emission Reduction

$$ER_y = BE_y - PE_y \qquad (11)$$

It should be noted that if the actual generation is less than the baseline generation for a given week, it will be treated as a negative value and deducted from the total annual savings. If in the unlikely event a project activity temporarily results in a negative emission reduction, i.e. baseline emissions minus project emissions are negative, any further CERs will only be issued when the emissions increase has been compensated by subsequent emission reductions by the project activity. (See EB 21, item 18)

Draft monitoring methodology AM00XX

"Increased electricity generation from existing hydropower stations through Decision Support System optimization"

Source

This monitoring methodology is based on the NM0112-rev methodology "Increased electricity generation from existing hydropower stations through Decision Support System optimization", whose baseline methodology and monitoring plan were prepared by Kevin James of Quality Tonnes and Lasse Ringius of the World Bank Carbon Unit.

For more information regarding the proposals and their consideration by the Executive Board please refer to http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html.

This methodology also refers the approved methodology ACM0002 ¨*Consolidated baseline methodology for grid-connected electricity generation from renewable sources*¨ and to the latest version of the "Tool for the demonstration and assessment of additionality".[8]

Applicability

This monitoring methodology shall be used in conjunction with the approved baseline methodology AM00XX ¨Increased electricity generation from existing hydropower stations through Decision Support System optimization¨. The same applicability conditions as in the baseline methodology apply.

Monitoring Methodology

All data collected as part of monitoring should be archived electronically and be kept at least for 2 years after the end of the last crediting period. 100% of the data should be monitored if not indicated otherwise in the comments in the tables below.

The following data for estimating the baseline relationship between power generation and flow shall be archived

1. All the water courses and corresponding hydro power generating units, included within the project site.
2. Relevant parameters of each hydro power generation unit, reservoir dam and the spill way characteristic to verify the applicability conditions.
3. Weekly power generation of each hydro power generation unit within the project site.
4. Parameters for Rating equation to estimate flow over the spill ways.
5. Estimated parameters of power generation and flow relationship, as estimated in Step 3 of Baseline Section in Baseline methodology.

[8] Please refer to: < http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>

The following data for estimating the baseline relationship between power generation and flow index shall be archived:

1. Estimated flow for each week of the crediting period.
2. Projected estimate of baseline power generation corresponding to the project flow index.
3. Project power generation.

In addition, various elements of the hydro system (changes to turbines, dams, etc.) need to be monitored to ensure continued adherence to applicability conditions.

Baseline and Project emission parameters

The following table illustrates the data to be collected or used in order to estimate emissions from the baseline activity.

ID number	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
A-1 ($EG_{Pr,hpu,x}$)	Generation for each generation unit	Measured at each hydro generation unit	KWh	m	Hourly, cumulated Weekly	100%	Electronic	The monitoring system installed with the DSS will gather and archive this data
A-2 (Q_x)	Total water flow	Calculated as sum of flow rate across all generating units and flow over all spillage	m^3 or m^3/second	c	Weekly*(based on hourly data)* (measured both in the baseline *period* and in the project years)	100%	Electronic	Flow through each generating unit is determined for each hour, based on the unit performance “hill diagrams”. Flows are aggregated at all units and all plants in the cascade to yield the flow index. The monitoring system that is used for the DSS will gather and archive this data.
A_3	Hill diagram	Manufacturer/ owner	Diagram which defines the three dimensional relationship between power	m, c	Once	100%	Electronic	A ‘hill diagram’ will be included in the data book for every generating unit in the project boundary. This essentially provides information derived in equation 0.

ID number	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
			output, head and flow					
A-4	Headwater level	Measured in meters at head water entering generating unit	m	m	Hourly	100%	Electronic	The monitoring system used by the Decision Support System will gather and archive this data
A-5	Tail water level	Measured in meters at tail water leaving generation units	m	m	Hourly	100%	Electronic	The monitoring system used by the DSS will gather and archive this data
A-6	Gross Head	Difference between head and tail water	m	c	Hourly	100%	Electronic	The monitoring system used by the DSS will gather and archive this data
A-7	Rating equation for spillway and pertinent Coefficients	Design and or testing information for spillway	equation	c	Once	100%	Electronic	For each spillway in the project boundary
A-8	Spillway dimensions, elevation of the sill and other given parameters as per equation in A-6	Design and or testing information for spillway	m	m	Once	100%	Electronic	For each spillway in the project boundary

ID number	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
A-9	Opening size of spillway as per equation in A-6	Measured during operations	m	m	Constantly	100%	Electronic	For each spillway in the project boundary
A-10	Electricity grid emissions factor	Calculated using the combined margin approach outlined in ACM0002	$kgCO_2$/kwh	m and c	Annually (during project years)	100%	Electronic	See ACM0002.

Leakage

No source of leakage needs to be monitored.

Quality Control (QC) and Quality Assurance (QA) Procedures

All measurements should use calibrated measurement equipment that is maintained regularly and checked for its functioning. QA/QC procedures for the parameters to be monitored are illustrated in the following table.

Data	Uncertainty Level of Data (High/Medium/Low)	Are QA/QC procedures planned for these data?	Outline explanation how QA/QC procedures are planned
A-1, A-2, A-4, A-5	*L*	*Y*	The data acquisition system used for the Decision Support Tool will provide highly accurate data. Meters will be tested annually and calibrated as recommended by the manufacturer. Meters are typically accurate to plus or minus a tenth or hundredth of a percent.
A-3	*L*	*Y*	Hill Diagrams for a generating unit are stationary and do not change measurably within the life of the project. Any changes, however unlikely, would be in the direction of deterioration of the unit and would make the results of the project more conservative (i.e. yield lower generation in project

Data	Uncertainty Level of Data (High/Medium/Low)	Are QA/QC procedures planned for these data?	Outline explanation how QA/QC procedures are planned
			years.)
A-6	*L*	*Y*	The data acquisition system used for the Decision Support Tool will provide highly accurate data
A-7	*L*	*Y*	The equation given by the owner will provide accurate data. More importantly, the equation will give consistent results between baseline measurements and project year measurements.
A-8	*L*	*Y*	These parameters will be easily measured and will not change during the course of the project
A-9	*L*	*Y*	These measurements are very simple to make and accurate. More importantly the measurements will be completely consistent between the baseline year and the project year.
A-10	*L*	*Y*	If linked to the rest of the grid, the data acquisition system used for the Decision Support Tool will provide highly accurate data.

Annex I: Estimation process for standard error (SE)

The estimated value of $EG^{Bl}_{,x}$ is

$$EG_x^{Bl} = f(Q_x^{Pr}) = a + b_1 Q_x^{Pr} + b_2 (Q_x^{Pr})^2 + ... + b_n (Q_x^{Pr})^n \quad (1)$$

In the event that there is only one year in the baseline period, the methodology noted in Section A below will be implemented to determine the standard error of estimate. In the event that two or more years are available, the methodology in Section B below will be implemented.

(I) If the equation is linear, i.e., n=1.

$$SE(EG_x^{Bl}) = \bar{\sigma} * \sqrt{(1 + \frac{1}{N} + \frac{(Q_x^{Pr} - \bar{Q})^2}{\sum_i^N (Q_x - \bar{Q})^2})} \quad (2)$$

where:

σ = is the estimated standard error of the equation. This is reported by the software used to estimate the relationship between power generation and the flow. It can also be estimated as follows:

$$\bar{\sigma} = \frac{1}{N-2} * \sqrt{(1 - R^2) * (\sum_{i=1}^N (EG_x - \bar{EG})^2} \quad (3)$$

$$\bar{EG} = \frac{\sum_{i=1}^N EG_x}{N} \quad (4)$$

N is the total number of observations used in estimating the power generation v/s flow equation. It will be 54 if one full years data is used, without any week being dropped of because of unusual circumstances.

EG_x is the baseline data that was used to estimate the equation form.

$$\bar{Q} = \frac{\sum_{i=1}^N Q_x}{N} \quad (5)$$

Q_x is the flow data in the baseline used to estimated the Equation (1).

(II) If n>1

$$SE(EB_{Bl,x}) = \bar{\sigma} * (1 + [QX]' \{[QI]'[QI]\} [QX]) \quad (6)$$

[QX] is (nx1) vector $[Q_i^{Pr}, (Q_i^{Pr})^2, \ldots, (Q_i^{Pr})^n]$ is vector (1xn) of variables for observation of flow in the power equation for project activity for which power in baseline is being estimated, where n is the degree of polynomial.

$$[QX]' = \begin{bmatrix} Q_x^{Pr} \\ (Q_2^{Pr})^2 \\ \\ \\ (Q_x^{Pr})^n \end{bmatrix} \text{is (nx1) vector transpose of [QX].}$$

$$[QI] = \begin{bmatrix} Q_1 & Q_1{}^2 & & Q_1{}^n \\ Q_2 & Q_2{}^2 & & Q_2{}^n \\ \\ \\ Q_N & Q_N{}^2 & & Q_N{}^n \end{bmatrix}$$

$$[QI]' = \begin{bmatrix} Q_1 & Q_2 & & Q_N \\ Q_1{}^2 & Q_2{}^2 & & Q_N{}^2 \\ \\ \\ Q_1{}^n & Q_2{}^n & & Q_N{}^n \end{bmatrix} \text{is (nxN) transpose of [QI] matrix.}$$

Q's are the (Nxn) matrix of baseline flow observations used to estimate the equation, where N is total number of observations and n is the degree of polynomial.