Department of Commerce Innovation is in our nature. commerce.wa.gov/eia	**Washington State** **Energy Independence Act** **Application for Advisory Opinion and Renewable Energy Facility (WREGIS) Certification**

All information provided in this application or any supplemental or additional materials is subject to public disclosure.

FACILITY NAME: **Lookout Point Dam** WREGIS Generating Unit ID (if already registered): **W5086 - W5088**	A separate Washington application is required for each generating unit with a separate WREGIS GU ID. Applicant must select Washington in WREGIS generating unit registration.

Section 1: Agency Action Requested

☒ Advisory Opinion and WREGIS Certification ☐ Advisory Opinion Only

Section 2: Applicant Information

Applicant Contact: **Deb Malin**	Title: **Account Executive**
Applicant Phone: **503-230-5701**	
Applicant E-mail: **djmalin@bpa.gov**	
Applicant Company Name: **Bonneville Power Administration**	
Company Address: **P.O. Box 3621**	
City: **Portland**	State/Province: **OR**
Zip Code: **97208**	Country: **US**

Section 3: Facility Information

Facility Owner		
Name of Facility Owner: **US Army Corps of Engineers** **OR** ☐ The Facility Owner is the same as the Applicant.		
Address: **1125 NW Couch St., Suite 500**		
City/State/ZIP: **Portland/OR/97209**		
Contact Name, Phone, and Email: **Francis (Beth) Coffey, Francis.E. Coffey@usace.army.mil, 503-909-3880**		
Facility Identification and Location		
Unit Name: **Unit 1 -3**		
Facility Name: **Lookout Point Dam**		
Unit location (street address, legal description, or GPS coordinates):		
City: **near Lowell**	County: **Lane**	
State/Province: **OR**	Zip: **97452**	Country: **US**
Provide a description of the facility. **Lookout Point Dam is a concrete gravity dam with a spillway, constructed primarily for flood control. It's hydropower facility is composed of one powerhouse containing three main generating units. The turbine runner replacement that was undertaken between 2011 and 2014 affected all units.**		
Facility Identification Numbers		

WREGIS Generating Unit ID: **5086-5088**	Other External ID:
EIA Utility Code:	EIA Plant Code: **3083**

Section 4: Facility Eligibility

A. Facility Profile

Nameplate Capacity (MW): **138.6**

If this value will change, please explain:

Commercial Operation Date (COD): **4** / **25** / **1954 for final unit**

Is your facility considered repowered by WREGIS? ☒ Yes ☐ No

If yes, please explain: **Generating units 1-3 were turned off during replacement.**

B. Facility Fuel

Indicate each energy source used by the facility. For definitions, refer to RCW 19.285.030. For multi-fuel generating facilities indicate all fuels used.

☐	Wind	☐	Wave power
☐	Solar energy	☐	Ocean power
☐	Geothermal energy	☐	Tidal power
☐	Landfill gas	☐	Gas from sewage treatment facility
☐	Biomass energy (must complete Section 5)	☐	Biodiesel fuel (must complete Section 6)
☒	Water (must complete Section 7)	☐	Other (please specify):

Will the facility use any fossil fuel or other non-qualifying fuel? ☐ Yes ☒ No

- Type of fossil fuel or other non-qualifying fuel:
- Average annual amount of non-qualifying fuel used (percent of net heat input):

Section 5: Biomass Energy Supplement (complete only if "biomass energy" is checked in Section 4)

Allowed Fuel Sources. Indicate each source of biomass energy used by the facility.

☐	Organic by-products of pulping and the wood manufacturing process	☐	Food waste and food processing residuals
☐	Animal manure	☐	Liquors derived from algae
☐	Solid organic fuels from wood	☐	Dedicated energy crops
☐	Forest or field residues	☐	Yard waste
☐	Untreated wooden demolition or construction debris		

Prohibited Fuel Sources. The following materials will NOT be used as a source of biomass energy by the facility.

☐	Wood pieces that have been treated with chemical preservatives such as creosote, pentachlorophenol, or copper-chrome-arsenic	☐	Wood from old growth forests
		☐	Municipal solid waste

Legacy Biomass. The Washington Energy Independence Act allows a biomass energy facility commencing operation before March 31, 1999 to qualify as an eligible renewable resource in certain circumstances. Contact Commerce to obtain application requirements.

Section 6: Biodiesel Fuel Supplement (complete only if "biodiesel fuel" is checked in Section 4)	
The biodiesel fuel used by the facility meets each of the identified conditions:	
☐	The fuel (a) is a mono alkyl ester of long chain fatty acids derived from vegetable oils or animal fats for use in compression-ignition engines and (b) meets the requirements of the American society of testing and materials specification D 6751 in effect as of January 1, 2003.
☐	The fuel is NOT from crops raised on land cleared from old growth or first-growth forests where the clearing occurred after December 7, 2006.

Section 7: Water/Hydroelectric Power (complete only if "water" is checked in Section 4)		
The facility uses water as a fuel in the following manner:		
☒	**Incremental Hydro.** Incremental electricity produced as a result of efficiency improvements completed after March 31, 1999, to hydroelectric generation projects owned by a qualifying utility and located in the Pacific Northwest where the additional generation does not result in new water diversions or impoundments.	
	Date efficiency improvement completed: **Unit 1 - 8/19/2013, Unit 2 - 9/25/2012, Unit 3 - 6/6/2014**	
	Method of measuring incremental generation:	
	☐	Incremental generation is separately metered or measured.
	☐	Incremental generation is modeled each year based on actual stream flows.
	☒	Incremental generation is modeled as a fixed percentage of total generation. Fixed percentage: **6.1%**
	☐	Incremental generation is modeled as a fixed generation amount. Fixed amount: megawatt-hours
	Note: If any box but the first is checked, the facility must register in WREGIS as a multi-fuel facility. Non-incremental generation will be classified as Large Hydro (LHN) and excluded from certificate creation.	
☐	**Canal or pipe.** Hydroelectric generation from a project completed after March 31, 1999, where the generation facility is located in irrigation pipes, irrigation canals, water pipes whose primary purpose is for conveyance of water for municipal use, and wastewater pipes located in Washington where the generation does not result in new water diversions or impoundments.	

Section 8: Eligibility for Washington Multipliers (Optional)	
The facility qualifies for the following multipliers under the Washington Energy Independence Act:	
☐	**Distributed Generation.** The facility has a generating capacity of 5 MW or less and is not part of any integrated cluster of facilities with an aggregate generating capacity of 5 MW or more.
☐	**Apprentice Labor.** The facility commenced operation after December 31, 2005 and in construction used an apprenticeship program approved by the Washington State Apprenticeship and Training Council.
NOTE: Commerce requests optional multiplier eligibility from facility owners for informational purposes only. Owners seeking certification of a facility as eligible for a multiplier should contact Commerce for application requirements.	

Section 9: Reservation
The Washington Department of Commerce makes a determination of resource eligibility under the Washington Energy Independence Act based on the information provided by the applicant and does not independently verify that information. An applicant must promptly notify Commerce of any changes to the information submitted for certification that may affect the facility's eligibility. Commerce reserves the right to modify or withdraw a designation if it determines that the information supplied by the applicant was incomplete or inaccurate.

Section 10: Attestation

I declare that the information provided in this application and any supplemental forms and attachments are true and correct to the best of my knowledge, that the information contained in this submission is consistent with information on file with WREGIS unless otherwise indicated, that no information materially affecting the facility's eligibility has been withheld, and that I am authorized to file this submission on the facility owner's behalf.

Signature: DMalin
Date Signed: 7/12/2019
Authorized Officer/Agent: **Deb Malin**
Officer Title and Company: **Account Executive and Bonneville Power Administration**
Name of Facility: **Lookout Point Dam**

Application Checklist for Submission

Applicants must select the Washington program administrator in the generating unit's WREGIS static data.
Applicants should ensure that the following documents are provided:

1. Electronic copy of entire application, including a signed attestation page.
2. WREGIS "static data" if the facility is already registered in WREGIS. A printout of your generator account profile screen in WREGIS.
3. Optional project background documentation. Background documentation can be submitted or published in regulatory settings (FERC or state commission filings) or informal forums (websites, articles or factsheets).
4. Payment of advisory opinion fee of **$1,250**. A separate application and application fee are required for each generating unit. However, if a facility owner has multiple WREGIS generating unit IDs for a single facility and all the static characteristics of the facility (other than the generating capacity) are identical, it may request that Commerce treat the combined generating units as a single application. The owner must document at the time of application that all GU IDs are part of a single facility in a single location. If GU IDs are added later, a separate application will be required.

To submit your facility for certification, e-mail the application and any supplemental materials listed above to (wregis@commerce.wa.gov). Submit payment of the advisory opinion fee to:

Department of Commerce
Attn: State Energy Office
P.O. Box 42525
Olympia, WA 98504-2525

Commerce will post each application on its website. Applications are subject to a public comment period.

Lookout Point Powerhouse Runner Replacement

Calculation of Incremental Efficiency Improvements for Renewable Energy Credits

Contents

Summary

Bonneville Power Administration (BPA) is seeking Renewable Energy Credits (RECs) for the three new turbines installed at the Lookout Point Powerhouse (LOP) which is owned and operated by the United States Army Corps of Engineers (USACE). Under federal law, BPA markets power produced by the USACE at federal power projects within the Federal Columbia River Power System. This report provides documentation of the calculation of incremental efficiency improvement for the new turbine runners for submission to the Oregon Department of Energy.

These three turbines were recently rehabilitated between 2011 and 2014 with new high efficiency Francis runners; and the General Electric generators had been rewound in 1995. Calculations were performed by BPA to compare efficiency of the original units vs. the new rehabilitated units and are described herein. Unit rehabilitations have the potential to change operations and this was considered in the analysis. This analysis uses both historical (before rehabilitation) and recent (after rehabilitation) operations data for the calculation of efficiency gains. The total weighted average incremental efficiency improvement is estimated at 6.1% for the plant (January 2008 – January 2016 data). Data is rounded to the nearest 1/10th of a percent to reflect reasonable accuracy in testing and analysis methods. BPA proposes that Units 1, 2 and 3 be registered in the Western Renewable Energy Generation Information System (WREGIS) as a group and that the weighted average incremental efficiency given above be multiplied by the cumulative monthly unit generation (MWh) to arrive at incremental generation for each month.

Table 1: Incremental Efficiency Results

Unit #	1	2	3
Weighted avg. incremental efficiency	6.1%	6.1%	6.2%

Background

Project Description

Lookout Point Dam is located on the Middle Fork of the Willamette River, it is an earth and gravel filled dam with concrete spillways and length totaling 3,381 feet. The project's three 157 inch diameter Francis turbines were originally manufactured by the Pelton Waterwheel Company. They were initially placed into service over the period from December 1954 through April 1955. The turbine runners began to develop cracks as early as 1963. In 2008 Voith was awarded the contract to replace the turbine runners. Voith performed successful testing using their scale model by the end of 2009 and the rehabilitation of the turbine components took place between October 2011 and June 2014, with one unit being rehabilitated at a time. Since the generators had been previously rewound, they already had the ability to operate at higher power outputs than could be achieved by the original runners.

Unit Online Dates

The three units at Lookout Point originally went online beginning in 1954. Each unit's runners were replaced at different times, with the replacement process starting on October 17, 2011 and ending on June 6, 2014.

The original online dates of the original units, unit outage start dates, and new unit online dates are listed below for each turbine. These dates are used in this analysis to establish the pre-rehab and post-rehab time periods for each unit.

Table 2: Online Dates

Unit	Original Unit Online Dates*	Unit Outage Start Dates**	New Unit Online Date**
1	December 16, 1954	September 25, 2012	August 19, 2013
2	February 16, 1954	October 17, 2011	September 25, 2012
3	April 25, 1954	August 20, 2013	June 6, 2014

*Source: Original online dates from "Turbine Runner Replacement Evaluation Study", USACE Hydroelectric Design Center (HDC).
**Source: Unit outage start dates and new unit online dates from Sondra Ruckwardt, USACE-NWP Large Capital Program Manager and Lookout Point Project Manager.

Unit Ratings

The generators for all three units were rewound in 1995 to a capacity of 63.6 MVA (60.4 MW at 0.95 power factor). However, limitations in the generator cooling system and other minor generator parts restrict the maximum generator rating to approximately 60 MVA.

Table 3: Unit Ratings Pre Turbine Rehabilitation & Post Generator Rewind

Unit	Rated Net Head (ft)	Turbine rated power (hp)	Turbine rated power (MW)	Generator max power (MW) at 0.95 Power Factor
1	185	52,500	39.1	60.4
2	185	52,500	39.1	60.4
3	185	52,500	39.1	60.4

Source: "Turbine Runner Replacement Evaluation Study", Hydroelectric Design Center,
and Nameplate photos from USACE,
and Tabulation of Generator and Turbine Data rev 2 from USACE.

Table 4: Unit Ratings Post Turbine Rehabilitation & Post Generator Rewind (2011-2014 Voith)

Unit	Rated Net Head (ft)	Turbine rated power (hp)	Turbine rated power (MW)	Generator max power (MW) at 0.95 Power Factor
1	185	63,219	47.1	60.4
2	185	63,219	47.1	60.4
3	185	63,219	47.1	60.4

Source: Nameplate photos from USACE.

The transformers are 51 years old and limit generator output to their rated capacity of 48 MVA (45.6 MW at 0.95 PF). Additionally, the existing 0.21 mile-long transmission line from the powerhouse to the switchyard limits total plant output to 170 MVA which is insufficient to handle the full output of three 63.6 MVA (191 MVA total) generators.

Performance

The new turbine runners were the sole source of efficiency gains calculated herein. Data used to calculate the efficiency gains is from 2008 to the present, so it does not include years before the generators were rewound, therefore the rewinds did not affect the efficiency gains calculated for the purposes of this REC submission.

Refer to the calculation spreadsheets provided along with this report for additional detailed information. The pre and post-rehabilitation turbine performance curves are shown below and are identical for all three units. In the case of both the 1954 – 1955 Pelton units (pre-rehab) and 2011 – 2014 Voith units (post-rehab) the curves were developed starting with model tests that were performed in the manufacturer's laboratory on a scaled models of the turbines from just upstream of the spiral case to the discharge.

These model tests are the primary basis for the performance curves shown below, but a field performance test was also performed by the HDC to confirm and adjust the model data. The original units were field tested in 1992, and one new runner (Voith Unit 2) was field tested in 2014 by the HDC. The field test results are used to estimate penstock losses, prove power output and efficiency guarantee and correct net head to gross head for both the pre and post rehab Voith units. The field test was also used to establish overall actual operating characteristics.

The performance curves (flow tables) were provided by the Hydroelectric Design Center of the U.S. Army Corps of Engineers (HDC) for both the pre and post rehab units. The detailed tables can be found in the calculation spreadsheet. The 1992 field testing of the original units resulted in an adjustment to the model developed tables of -1.2% efficiency, applied evenly to all performance curves. This included a -0.2% difference in measured values when compared to the model test and an estimated -1% efficiency loss due to the age of the runner.

The field test for the 2014 Voith unit showed that the model predicted prototype performance was very close to the performance test results, within 0.4% efficiency. This validated the model predicted prototype because the difference was minor and was within the test uncertainty of 1.37% so no adjustment was made based on the field test.

The generator efficiency assumed for the flow table development by HDC was 98% for both the pre and post rehab units, which is typical for generators of this size and design. This REC analysis focused on turbine efficiency improvements so the generator efficiency was backed out of the flow tables to arrive at turbine efficiency. This analysis used assumptions consistent with those used by HDC.

Pre-rehabilitation and Post-rehabilitation model curves are shown in Figures 1 and 2, respectively. Note that each colored line represents an operating head (ft.) ranging from 125 ft. to 235 ft. The turbine curves were cut off at the generation limit of 46 MW due to transformer and transmission limitations, although these runners are capable of producing above 46 MW. In the event that the transformers and transmission line are upgraded, these calculations will need to be revised for turbine operations at higher power output.

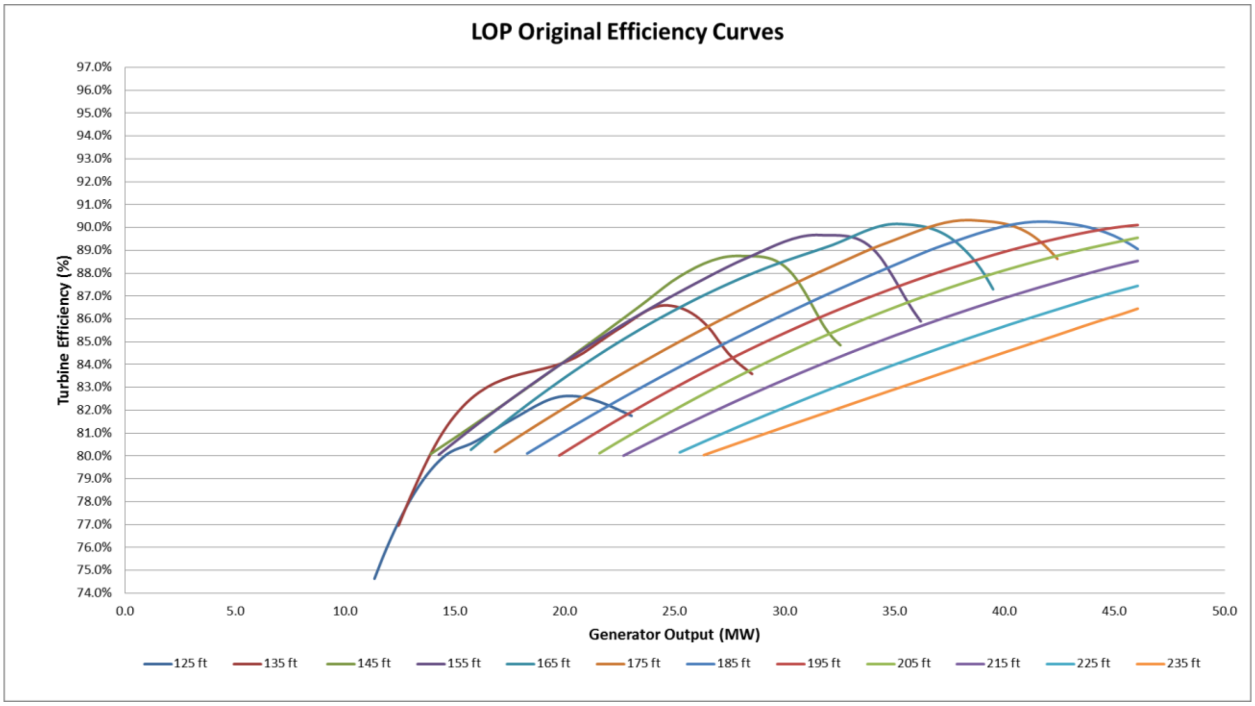

Figure 1: Pre-Rehab Curves. Refer to calculation spreadsheets for additional detail.

Figure Redacted

Figure 2: Post-Rehab Curves. Refer to calculation spreadsheets for additional detail.

The field performance test results are shown below. The pre rehabilitation information is taken from the 1992 Unit 2 test and the post rehabilitation information is taken from the 2014 Unit 2 test.

Figure Redacted

Figure 3: Field Test Pre and Post-Rehab Comparison. Source: the USACE Hydroelectric Design Center.

REC Calculation Method

Method Description

The calculation spreadsheets will be made available to Oregon DOE reviewers; they contain additional detailed information. Pre and post rehabilitation hourly operations data was collected for the plant from January 1, 2008 to January 1, 2016 . Since an 8 year time span was considered, it can be assumed that we are covering a broad range of water years which represent a sufficient range of operating conditions to accurately model the overall efficiency change with the new runners. This data was available in the BPA PI Data System and is believed to be representative of the historical, current and expected operating regime.

The data used included hourly forebay elevation (ft), hourly tailwater elevation (ft) and hourly plant total generation (MW). Unfortunately, PI data is limited to total plant generation and unit specific generation data is not available for Lookout Point.

Calculations were performed to estimate the average annual change in efficiency given the turbine runner replacement. Typically after a turbine runner upgrade each unit would be operated differently in order to maintain peak efficiency with their new flow curves. Thus one would expect to see different operations when comparing the span of pre-rehab and post-rehab operating data. In this case, however, we are making assumptions on how each unit is operated throughout the entire span. This assumption should yield a conservative result since the new turbine operating point would most likely shift slightly for a new peak efficiency location.

For the purposes of this analysis, assumptions were made to distribute the total plant generation between the three units. The unit-specific operating condition follows a logic table defined by the original unit constraints that is established by gross head (forebay elevation – tailwater elevation) and generator output for each hour. These tables were developed by BPA as part of this analysis based on the turbine curves provided by the HDC and on historical generation data. Typically, operating curves are provided by the HDC to maximize generation based on head and flow (or power). It is BPA's understanding that the units at Lookout Point are operated from the flow tables (provided within the calculation spreadsheet) to provide a given discharge; with power being a secondary consideration (facility was designed primarily for flood control). Formal operating tables were not provided by HDC for this facility. Therefore, BPA developed the table provided in Figure 5 to back-calculate the number of units in operation based on a given total plant generation (combined generation at the meter for all three units).

Turbine Efficiency for Original Units Installed 1954-1955												
Turbine Efficiency	125 ft	135 ft	145 ft	155 ft	165 ft	175 ft	185 ft	195 ft	205 ft	215 ft	225 ft	235 ft
GrossHd (ft) → MW ↓	125	135	145	155	165	175	185	195	205	215	225	235
11.3	74.6%	77.0%	80.1%	80.1%	80.3%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
11.7	75.5%	77.0%	80.1%	80.1%	80.3%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
12.1	76.4%	77.0%	80.1%	80.1%	80.3%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
12.4	77.1%	77.0%	80.1%	80.1%	80.3%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
12.8	77.8%	77.8%	80.1%	80.1%	80.3%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
13.2	78.4%	78.6%	80.1%	80.1%	80.3%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
13.5	78.9%	79.4%	80.1%	80.1%	80.3%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
13.9	79.4%	80.1%	80.1%	80.1%	80.3%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
14.3	79.8%	80.7%	80.3%	80.1%	80.3%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
14.6	80.1%	81.3%	80.6%	80.3%	80.3%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
15.0	80.3%	81.8%	80.8%	80.6%	80.3%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
15.3	80.4%	82.2%	81.0%	80.9%	80.3%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
15.7	80.5%	82.5%	81.3%	81.2%	80.3%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
16.1	80.7%	82.8%	81.5%	81.4%	80.6%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
16.4	80.9%	83.0%	81.8%	81.7%	80.9%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
16.8	81.2%	83.2%	82.0%	82.0%	81.1%	80.2%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
17.2	81.4%	83.3%	82.2%	82.2%	81.4%	80.4%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
17.5	81.6%	83.5%	82.5%	82.5%	81.7%	80.6%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
17.9	81.8%	83.6%	82.7%	82.7%	82.0%	80.9%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
18.3	82.0%	83.7%	83.0%	83.0%	82.2%	81.1%	80.1%	80.0%	80.1%	80.0%	80.2%	80.0%
18.6	82.2%	83.7%	83.2%	83.2%	82.5%	81.3%	80.3%	80.0%	80.1%	80.0%	80.2%	80.0%
19.0	82.4%	83.8%	83.5%	83.5%	82.8%	81.5%	80.5%	80.0%	80.1%	80.0%	80.2%	80.0%
19.4	82.5%	83.9%	83.7%	83.7%	83.0%	81.7%	80.7%	80.0%	80.1%	80.0%	80.2%	80.0%
19.7	82.6%	84.0%	84.0%	84.0%	83.3%	82.0%	81.0%	80.0%	80.1%	80.0%	80.2%	80.0%
20.1	82.6%	84.1%	84.2%	84.2%	83.5%	82.2%	81.2%	80.2%	80.1%	80.0%	80.2%	80.0%
20.5	82.6%	84.3%	84.5%	84.4%	83.7%	82.4%	81.4%	80.5%	80.1%	80.0%	80.2%	80.0%
20.8	82.6%	84.5%	84.7%	84.7%	84.0%	82.6%	81.6%	80.7%	80.1%	80.0%	80.2%	80.0%

Figure 4: Partial screenshot of a performance table, rows = power (MW), columns = gross head (ft), from the calculation spreadsheet. Note that red text is conservatively extrapolated estimates of turbine efficiency where data was not available.

The operation logic used to find the total MW for each unit is shown in Figure 5. An example of the logic operation would be if the gross head is 179 ft., and the total power is 65 MW, then the logic operator would divide the total MW equally between two units. In order to conservatively analyze the efficiency increase we assume the units are operating within the pre-rehab constraints and weighted average incremental efficiency is calculated for the entire time span.

Logic for lookup operation is based on the total MW of the plant and gross head. Selection of unit operation is based on the conditions of the table below.			
Operation → Gross Hd. ↓	Divide Total MW by 3	Divide Total MW by 2	Divide Total MW by 1
>185	Total MW>92.01	92>Total MW>46.01	Total MW<46
>175	Total MW>84.81	84.8>Total MW>42.41	Total MW<42.4
>165	Total MW>79.01	79>Total MW>39.01	Total MW<39
>155	Total MW>72.41	72.4>Total MW>36.21	Total MW<36.2
>145	Total MW>65.01	65>Total MW>32.51	Total MW<32.5
>135	Total MW>57.01	57>Total MW>28.51	Total MW<28.5
>125	Total MW>46.01	46>Total MW>23.01	Total MW<23
Unit 2 and 3 logic check unit 1 gen against the total. If the total is divisible by 1 according to Unit 1 Lookup then Units 2 and 3 are not populated. If the total is divisible by 2 according to Unit 1 Lookup then Unit 2 is also populated. If the total is divisible by 3 according to Unit 1 Lookup then Unit 2 and 3 are also populated.			

Figure 5: Logic Lookup Table for unit operation following Pre-Rehab Constraints

After the unit-specific generation is determined per the operating table shown in Figure 5, the pre and post-rehab turbine efficiency tables are used to look up turbine efficiency of the original turbines and new turbines at the same operating condition for each hour of operation. The performance tables are defined by generator output or power (MW) in the left most column, gross head (ft) in the top row, and turbine efficiency in the body (as seen in Figure 4). Interpolation was utilized to calculate the efficiency if the operating condition fell between rows and columns in the table. A bi-linear interpolation macro was utilized to perform the look up function.

Graphs of the data and detailed annual results can be found in the calculation spreadsheets.

Summary of Governing Equations

The following equations are used within the calculations spreadsheets to determine the unit specific incremental efficiency and generation.

Hourly generation (MW) = calculated from hourly plant generation data from BPA's PI database. Per unit dispatch estimate achieved by applying turbine operating limits of original units as summarized in the previous section.

Gross head (ft) = forebay elevation (ft) – tailwater elevation (ft)

Original turbine efficiency (%) = value interpolated from the original turbine efficiency table(s)

New turbine efficiency (%) = value interpolated from the new turbine efficiency table(s)

Generator efficiency (%) = generator efficiency was assumed to be 98% in both the original and new flow tables.

Total efficiency (%) = turbine efficiency (%) X generator efficiency (%)

Delta total efficiency (%) = new total efficiency (%) – original total efficiency (%)

Delta generation (MW or MWh) = delta total efficiency (%) X generation (MW or MWh)

Average annual delta efficiency (weighted avg. %) = 100% X Sum of all hourly delta generation / Sum of all hourly generation

Total Weighted Avg. Incremental Efficiency (avg. for all years of study) = sum of: (Average annual delta generation) / sum of: (Average annual total generation)

Metering Discussion

Only aggregate hourly generation data for the three units at Lookout Point is available to BPA through the PI database. However, units 1-3 at Lookout Point are individually metered for gross generation. The meters measure the gross generation from each unit with no unmonitored paths around the meters. The meter data is collected by the plant SCADA system. The Watt-hour data is periodically uploaded to the Corps of Engineers Operations and Maintenance

Business Information Line (OMBIL) database and monthly gross generation reports are extracted from OMBIL by BPA. Hourly data is not available in OMBIL.

The unit gross generation meters measure total generation from each unit, and do not account for station service loads. The generation values measured by the meters are gross values and are not reduced for any station service load. However, in the case of renewable energy generation for incremental hydro projects, the station service loads are irrelevant to the calculation of incremental energy. The station service loads will not change as a result of the unit efficiency improvement, while the unit gross generation will increase due to the efficiency improvement.

WREGIS agrees that in this case the station service load should not be included in the calculation of incremental generation. The station service load did not change as a result of the efficiency upgrade, so all of the incremental generation reaches the grid. The following example explains why station service load is irrelevant to the calculation of incremental generation.

<u>Gross Generation</u>
Before runner replacement:
-Let's say that the *gross* generation is 500 MWh
-Let's say the station service and pumping load is 50 MWh.
After runner replacement:
-With an incremental efficiency gain of 6.1%,
-The *gross* generation would be 500 MWh X 106.1% = 530.5 MWh.
So the incremental generation measured against the gross would be: (530.5 – 500 MWh) X 99.22% (transformer efficiency)* = 30.3 MWh.

<u>Net Generation</u>
Before runner replacement:
-The *net* generation is (500 MWh – 50 MWh) X 99.22% transformer efficiency* = 446.5 MWh.
After runner replacement:
-Assuming the same station service load of 50 MWh, the *net* generation would be (530.5 MWh – 50 MWh) X 99.22% (transformer efficiency)* = 476.8 MWh.
So the incremental generation measured against the *net* would be the same as if it were measured against the *gross*: 476.8 MWh – 446.5 MWh = 30.3 MWh.

* Note: The efficiency of the transformers is estimated by BPA to be 99.22%, energy weighted average based on experience with equipment of this size and design. The incremental generation that reaches the grid for each unit will be equal to the incremental gross generation measured on the low side of the transformer multiplied by transformer efficiency or loss factor.

Meter Information:

There is one meter on each of the units at Lookout Point Power Plant. All three are JEMSTAR units. The accuracy of the JEMSTAR units is approximately +/- 0.07%. Individual information about each meter is listed below in Table 7.

Table 6: Detailed Generation Meter Information

LOOKOUT POINT UNITS 1-3 WATT HOUR METERS			
UNIT	**MODEL**	**MODEL NUMBER**	**SERIAL NUMBER**
1	JEMSTAR	JS-05R6010-15	02 18 01275
2	JEMSTAR	JS-05R6010-15	02 18 01286
3	JEMSTAR	JS-05R6010-15	02 18 01285

Summary of Results

The following Figure 6 provides a tabular summary of results for the entire study period, extracted from the calculation spreadsheet.

Pre-Rehab (red)	Post-Rehab (white)		
	Unit #		
Delta Efficiency (weighted avg)	1	2	3
2008	6.5%	6.4%	6.3%
2009	6.2%	6.2%	6.2%
2010	5.5%	5.6%	6.0%
2011	6.2%	6.1%	5.7%
2012	6.0%	5.9%	5.5%
2013	5.8%	5.6%	5.3%
2014	6.3%	6.3%	6.8%
2015	6.1%	6.1%	6.2%

	Unit #		
Delta Generation (MWh)	1	2	3
2008	11,586	8,647	3,476
2009	9,865	7,204	2,532
2010	10,371	4,041	742
2011	12,223	7,055	906
2012	10,528	7,435	317
2013	6,903	4,224	940
2014	11,167	9,749	2,957
2015	4,930	4,741	3,762

	Old Unit		
Weighted Avg Efficiency	1	2	3
2008	85.7%	85.7%	85.3%
2009	85.7%	85.8%	86.2%
2010	86.9%	86.5%	86.9%
2011	86.4%	86.2%	86.2%
2012	86.5%	86.5%	83.2%
2013	86.3%	85.9%	83.9%
2014	86.3%	86.2%	84.7%
2015	85.3%	85.3%	85.4%

	New Unit		
Weighted Avg Efficiency	1	2	3
2008	92.1%	92.1%	91.6%
2009	92.0%	92.0%	92.3%
2010	92.4%	92.1%	92.9%
2011	92.5%	92.3%	91.8%
2012	92.5%	92.4%	88.7%
2013	92.1%	91.5%	89.2%
2014	92.6%	92.6%	91.5%
2015	91.4%	91.4%	91.6%

	Unit #		
Total Generation (MWh)	1	2	3
2008	178989	134730	54896
2009	158055	116133	41140
2010	188166	72761	12432
2011	197850	115134	16001
2012	174617	125382	5760
2013	119170	75350	17613
2014	176963	153715	43491
2015	81177	78014	60839

Total gen for entire study period (MWh)	1,274,986	871,218	252,171
Incremental gen for entire study period (MWh)	77,574	53,096	15,633
Avg. annual incremental gen. (MWh)	9,697	6,637	1,954
Avg. incremental gen. (aMW)	1.11	0.76	0.22
Avg. annual total gen. (MWh)	159,373	108,902	31,521
Per Unit Weighted avg. incremental effic. (avg annual incremental gen/avg annual total gen)	6.1%	6.1%	6.2%
Total weighted avg. incremental efficiency (all units 1-3 combined)	6.1%		

Figure 6: Screenshot of Results, extracted from the Summary tab within the calculation spreadsheet

Below is a sample screenshot (Unit 3, 2015) from the 2015 calculation spreadsheet that shows all of the input parameters and calculation results. Note that each row represents an hour of unit operation.

New Unit - Weighted Average Efficiency	91.6%
Old Unit - Weighted Average Efficiency	85.4%
Delta Generation (MWh)	3762.2
Weighted Average Delta Efficiency	6.2%

Note - data zeroed for zero generation (<5MW)or generator output that is text, ie. "shutdown"

Lookout Point Hourly Ops Data			New Unit				Old Unit				Incremental Improvement			
Timestamp	Gross Head (ft)	Gen. Output (MW)	Turbine Efficiency (%)	Generator Efficiency (%)	Total Efficiency (%)	Weighted Gen. Output (MW)	Turbine Efficiency (	Generator Efficiency (%)	Total Efficiency (%)	Weighted Gen. Output (MW)	Delta Turbine Efficiency (%)	Delta Generator Efficiency (%)	Delta Total Efficiency (%)	Delta Generation (MWh)
1/1/15 0:00	172.4	40.7	95.0%	98.0%	93.1%	37.9	89.3%	98.0%	87.5%	35.6	5.7%	0%	5.6%	2.3
1/1/15 1:00	172.3	40.0	95.1%	98.0%	93.2%	37.3	89.4%	98.0%	87.6%	35.0	5.8%	0%	5.6%	2.3
1/1/15 2:00	172.2	41.0	94.9%	98.0%	93.0%	38.1	89.1%	98.0%	87.3%	35.8	5.8%	0%	5.7%	2.3
1/1/15 3:00	172.1	40.7	95.0%	98.0%	93.1%	37.8	89.2%	98.0%	87.4%	35.5	5.8%	0%	5.7%	2.3
1/1/15 4:00	172.0	40.7	95.0%	98.0%	93.1%	37.8	89.1%	98.0%	87.4%	35.5	5.8%	0%	5.7%	2.3
1/1/15 5:00	171.8	41.0	94.9%	98.0%	93.0%	38.1	89.0%	98.0%	87.2%	35.8	5.9%	0%	5.8%	2.4
1/1/15 6:00	171.6	41.0	94.8%	98.0%	92.9%	38.1	88.9%	98.0%	87.2%	35.7	5.9%	0%	5.8%	2.4
1/1/15 7:00	171.4	39.7	95.1%	98.0%	93.2%	37.0	89.2%	98.0%	87.4%	34.7	6.0%	0%	5.9%	2.3
1/1/15 8:00	171.2	40.0	95.1%	98.0%	93.2%	37.3	89.1%	98.0%	87.3%	34.9	6.0%	0%	5.9%	2.3
1/1/15 9:00	171.0	40.7	94.9%	98.0%	93.0%	37.8	88.9%	98.0%	87.1%	35.4	6.0%	0%	5.9%	2.4
1/1/15 10:00	170.7	40.7	94.9%	98.0%	93.0%	37.8	88.8%	98.0%	87.0%	35.4	6.1%	0%	5.9%	2.4
1/1/15 11:00	170.5	39.3	95.1%	98.0%	93.2%	36.7	89.0%	98.0%	87.2%	34.3	6.1%	0%	6.0%	2.4
1/1/15 12:00	170.2	39.7	95.1%	98.0%	93.2%	37.0	88.8%	98.0%	87.0%	34.5	6.2%	0%	6.1%	2.4
1/1/15 13:00	170.0	41.0	94.7%	98.0%	92.8%	38.1	88.5%	98.0%	86.8%	35.6	6.2%	0%	6.0%	2.5
1/1/15 14:00	169.8	39.0	95.2%	98.0%	93.3%	36.4	89.1%	98.0%	87.3%	34.1	6.0%	0%	5.9%	2.3
1/1/15 15:00	169.6	39.7	95.0%	98.0%	93.1%	36.9	88.6%	98.0%	86.9%	34.5	6.4%	0%	6.3%	2.5
1/1/15 16:00	169.4	39.7	95.0%	98.0%	93.1%	36.9	88.6%	98.0%	86.8%	34.4	6.4%	0%	6.3%	2.5
1/1/15 17:00	169.2	39.7	95.0%	98.0%	93.1%	36.9	88.5%	98.0%	86.8%	34.4	6.5%	0%	6.3%	2.5
1/1/15 18:00	169.0	40.0	94.9%	98.0%	93.0%	37.2	88.4%	98.0%	86.7%	34.7	6.5%	0%	6.3%	2.5
1/1/15 19:00	168.8	39.7	95.0%	98.0%	93.1%	36.9	88.4%	98.0%	86.6%	34.4	6.6%	0%	6.4%	2.6
1/1/15 20:00	168.8	40.0	94.9%	98.0%	93.0%	37.2	88.4%	98.0%	86.6%	34.6	6.5%	0%	6.4%	2.6
1/1/15 21:00	168.3	38.3	95.2%	98.0%	93.3%	35.8	89.3%	98.0%	87.6%	33.6	5.9%	0%	5.7%	2.2
1/1/15 22:00	168.1	38.7	95.1%	98.0%	93.2%	36.1	89.1%	98.0%	87.3%	33.7	6.1%	0%	6.0%	2.3
1/1/15 23:00	167.9	39.7	94.9%	98.0%	93.0%	36.9	88.2%	98.0%	86.4%	34.3	6.8%	0%	6.6%	2.6
1/2/15 0:00	167.7	39.3	95.0%	98.0%	93.1%	36.6	88.3%	98.0%	86.5%	34.0	6.7%	0%	6.6%	2.6
1/2/15 1:00	167.5	38.7	95.1%	98.0%	93.2%	36.0	88.9%	98.0%	87.2%	33.7	6.2%	0%	6.0%	2.3
1/2/15 2:00	167.3	39.0	95.0%	98.0%	93.1%	36.3	88.6%	98.0%	86.8%	33.8	6.5%	0%	6.4%	2.5
1/2/15 3:00	167.1	39.0	95.0%	98.0%	93.1%	36.3	88.5%	98.0%	86.7%	33.8	6.5%	0%	6.4%	2.5
1/2/15 4:00	166.9	39.0	95.0%	98.0%	93.1%	36.3	88.5%	98.0%	86.7%	33.8	6.6%	0%	6.4%	2.5
1/2/15 5:00	166.7	38.7	95.1%	98.0%	93.2%	36.0	88.8%	98.0%	87.0%	33.6	6.3%	0%	6.2%	2.4
1/2/15 6:00	166.5	38.7	95.1%	98.0%	93.2%	36.0	88.8%	98.0%	87.0%	33.6	6.3%	0%	6.2%	2.4
1/2/15 7:00	166.3	38.7	95.1%	98.0%	93.2%	36.0	88.7%	98.0%	86.9%	33.6	6.3%	0%	6.2%	2.4

Figure 7: Screenshot of unit-specific detailed results, extracted from 2015 calculation spreadsheet

The graphs below are also an output of the excel calculations and depict Delta Efficiency and Delta Generation for each hour of unit operation throughout the course of a year. It is observed that there is some seasonal variation in both the Delta Efficiency and the Delta Generation. This is primarily due to seasonal head variations and flow at the project. These graphs are generated for each year of the study period and for each unit in the powerhouse. For a complete record of all the graphs, refer to the calculation spreadsheets.

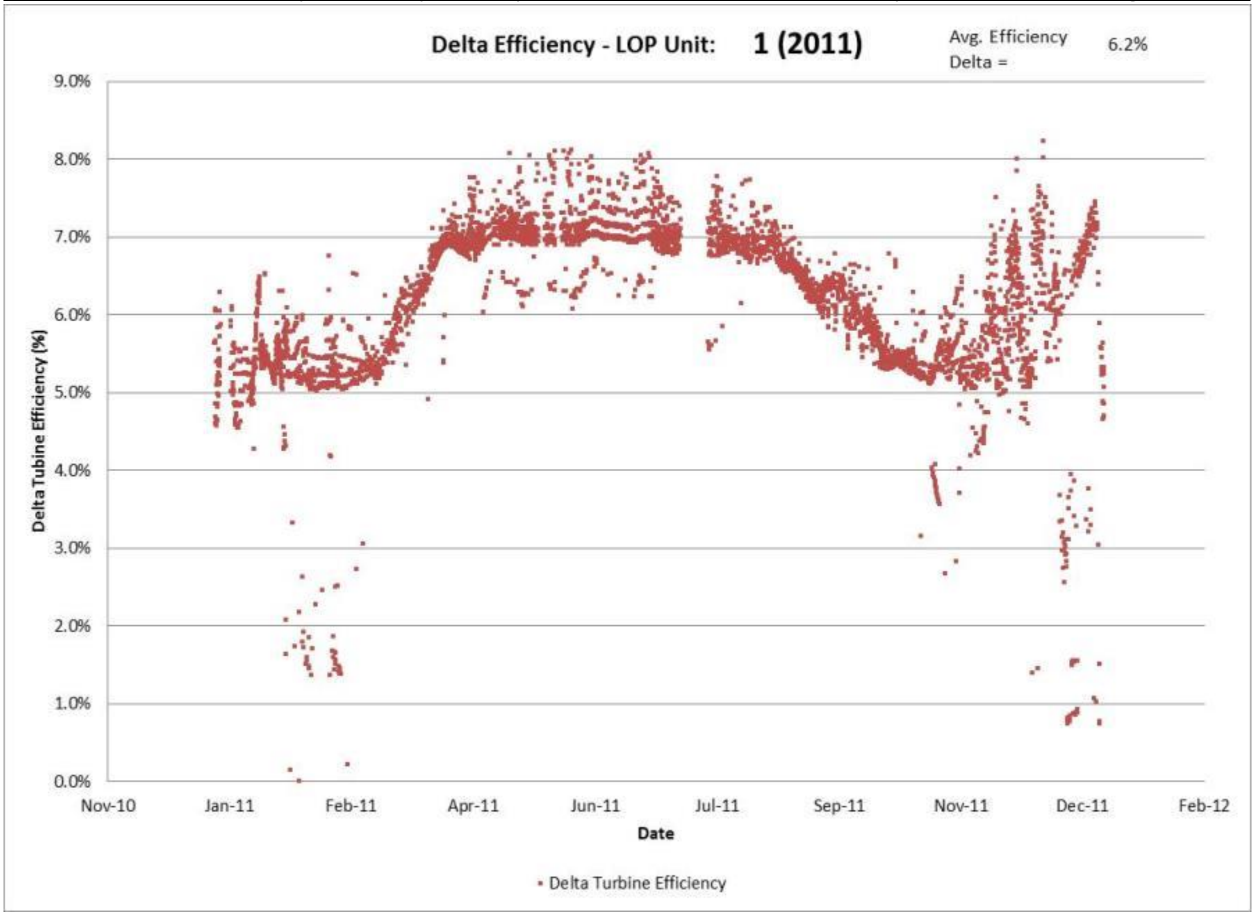

Figure 8: Example of Incremental Efficiency (New Units - Original Units) for each hour of a single year, extracted from 2011 calculation spreadsheet

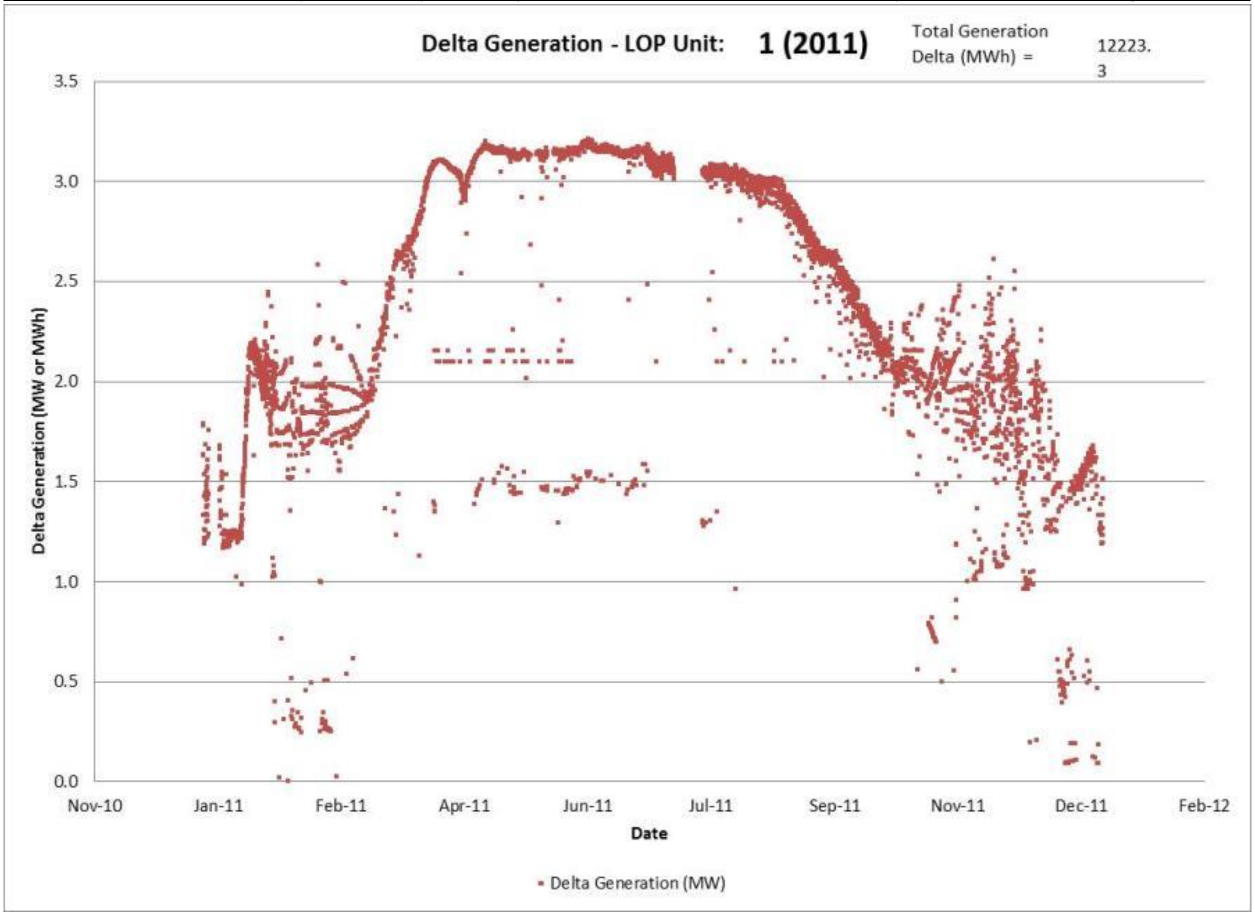

Figure 9: Example of incremental generation (New Units - Original Units) for each hour of a single year, extracted from 2011 calculation spreadsheet

Conclusion

The fundamental method of calculating incremental gains in hydropower efficiencies was developed earlier by BPA, reviewed by HDR and the Oregon DOE, and has now been applied to the USACE's Lookout Point Dam. Based on the methodology, data and analysis presented in this report, BPA has calculated the average plant efficiency improvement for Lookout Point to be approximately 6.1%.

HDR

August 16, 2016

Mr. George Brown
Senior Mechanical Engineer
BPA Generating Assets
Bonneville Power Administration
Portland, Oregon

Dear George,

At the request of the Bonneville Power Administration (BPA), HDR Engineering, Inc. (HDR) has reviewed your report entitled "Lookout Point (LOP) Powerhouse Runner Replacement: Calculation of Incremental Efficiency Improvements for Renewable Energy Credits (REC)" and the accompanying calculations. This letter documents HDR's independent engineering review of the REC Credit report pursuant to requirements of the Oregon DOE (ODOE).

The supporting calculations were performed in a macro enabled spreadsheet and are accompanied by a report documenting critical assumptions and results. HDR has reviewed BPA's calculations and report, provided comments and worked with you to finalize the attached report.

The following comments have been discussed with BPA and have been resolved in the report and spreadsheet.

1. **Efficiency Tables:** Model test data for both the original runners and the modernized runners were used to estimate the increase in turbine efficiency. In both cases, field tests were performed to validate model tests. Since the field test results were very close and confirm the model tests, the model test performance curves were used to estimate turbine efficiency calculations in application.

   During HDR's review of the efficiency curves and charts, it was noted that the new turbines could perform well beyond the limits of the data provided and that the generators are rated higher than the turbines. BPA explained that the efficiency data was limited to power output ranges under 46 MW due to the limit of the generator step up transformers and transmission line. If the transformers are upgraded, these calculations could be resubmitted for a higher turbine and generator output.

2. **Unit Operations:** Head and total plant output were extracted from BPA's Performance Indicators (PI) Database for years 2008 through 2015. These parameters were used with flow tables from the U.S. Army Corps of Engineers (USACOE) Hydroelectric Design Center (HDC) to estimate generation through the plant. Since meter data was only available for the gross plant generation, not for individual units, the individual generation for each unit was back-calculated from the gross using assumptions outlined within the

report and spreadsheet. HDR has reviewed these assumptions and agrees that they are reasonable and that the resulting efficiency increase will be conservative since the same logic was assumed for the original and modernized runners.

HDR also understands that optimized turbine performance tables were not provided by HDC and that plant operations are normally determined to meet flow, not power. Again, the operations assumptions used within this report should yield reasonable results.

HDR has reviewed BPA's final spreadsheet and report, attached, and found these to reasonable and acceptable. This cover letter has now been stamped by an Oregon PE for the purposes of BPA's submittal to the ODOE, documenting that HDR has reviewed and approves BPA's Renewable Energy Credit analysis and results for Lookout Point.

Sincerely,

HDR Engineering, Inc.

Stephen D. Spain, P.E.

Vice-President, Hydropower Services

REGISTERED PROFESSIONAL ENGINEER
12070
OREGON
May 20, 1983
STEPHEN D. SPAIN
EXPIRES: 6/30/2018

Oregon
Kate Brown, Governor

Department of Energy
550 Capitol St NE
Salem, OR 97301-2567
Phone: 503-378-4040
Toll Free: 1-800-221-8035
FAX: 503-373-7806
www.oregon.gov/energy

April 7, 2017

Adrian Allen
Bonneville Power Administration
P.O. Box 3621
Portland, OR 97208

RE: Certificate of Oregon Eligibility and Vintage Date for Lookout Point Dam (W5086, W5087, W5088)

Dear Mr. Allen:

The Oregon Department of Energy has approved your request for Oregon Renewable Portfolio Standard (RPS) eligibility for Lookout Point Dam Units 1-3. The Department has notified WREGIS of this approval and the first eligible vintage date. Any Renewable Energy Certificates (RECs) sourced from generation from your facility from the vintage date described below will be eligible for RPS compliance in Oregon.

Generating Unit	WREGIS ID	Oregon Certification Number	First Eligible Vintage Date	Renewal Date
Lookout Point – Unit 1	W5086	17alt015or	June 2014	April 2022
Lookout Point – Unit 2	W5087	17alt015or	June 2014	April 2022
Lookout Point – Unit 3	W5088	17alt015or	June 2014	April 2022

Please note that the Department routinely requires an evaluation of incremental efficiency evaluation five years. Based on your facility's approval date, Lookout Point Dam Units 1-3 will need to attest to the same incremental efficiency by April 2022 in order to maintain eligibility for the Oregon RPS. If any changes are made to your facility that could affect its eligibility for the Oregon RPS prior to the renewal date listed above, the Department must be notified.

The Department's approval is only for the incremental electricity attributed to efficiency upgrades calculated using the methodology proposed by Bonneville Power Administration and on file with the Department and WREGIS. Any future changes to the methodology in practice or with WREGIS must receive Department approval.

Please contact me with any questions about this letter or approval.

Sincerely,

Jessica Reichers

Jessica D. Reichers
Technology and Policy Manager
Oregon Department of Energy
550 Capitol Street NE
Salem, OR 97301