BP-18 Rate Proceeding

Initial Proposal

Power Loads and Resources Study

BP-18-E-BPA-03

November 2016

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COMMONLY USED ACRONYMS AND SHORT FORMS

ACNR	Accumulated Calibrated Net Revenue
ACS	Ancillary and Control Area Services
AF	Advance Funding
aMW	average megawatt(s)
ANR	Accumulated Net Revenues
ASC	Average System Cost
BAA	Balancing Authority Area
BiOp	Biological Opinion
BPA	Bonneville Power Administration
Btu	British thermal unit
CDQ	Contract Demand Quantity
CGS	Columbia Generating Station
CHWM	Contract High Water Mark
CNR	Calibrated Net Revenue
COE	U.S. Army Corps of Engineers
COI	California-Oregon Intertie
Commission	Federal Energy Regulatory Commission
Corps	U.S. Army Corps of Engineers
COSA	Cost of Service Analysis
COU	consumer-owned utility
Council	Northwest Power and Conservation Council
CP	Coincidental Peak
CRAC	Cost Recovery Adjustment Clause
CSP	Customer System Peak
CT	combustion turbine
CY	calendar year (January through December)
DD	Dividend Distribution
dec	decrease, decrement, or decremental
DERBS	Dispatchable Energy Resource Balancing Service
DFS	Diurnal Flattening Service
DNR	Designated Network Resource
DOE	Department of Energy
DOI	Department of Interior
DSI	direct-service industrial customer or direct-service industry
DSO	Dispatcher Standing Order
EE	Energy Efficiency
EIS	Environmental Impact Statement
EN	Energy Northwest, Inc.
ESA	Endangered Species Act
ESS	Energy Shaping Service
e-Tag	electronic interchange transaction information
FBS	Federal base system
FCRPS	Federal Columbia River Power System

FCRTS	Federal Columbia River Transmission System
FELCC	firm energy load carrying capability
FORS	Forced Outage Reserve Service
FPS	Firm Power and Surplus Products and Services
FPT	Formula Power Transmission
FY	fiscal year (October through September)
G&A	general and administrative (costs)
GARD	Generation and Reserves Dispatch (computer model)
GMS	Grandfathered Generation Management Service
GSR	Generation Supplied Reactive
GRSPs	General Rate Schedule Provisions
GTA	General Transfer Agreement
GWh	gigawatthour
HLH	Heavy Load Hour(s)
HOSS	Hourly Operating and Scheduling Simulator (computer model)
HYDSIM	Hydrosystem Simulator (computer model)
IE	Eastern Intertie
IM	Montana Intertie
inc	increase, increment, or incremental
IOU	investor-owned utility
IP	Industrial Firm Power
IPR	Integrated Program Review
IR	Integration of Resources
IRD	Irrigation Rate Discount
IRM	Irrigation Rate Mitigation
IS	Southern Intertie
kcfs	thousand cubic feet per second
kW	kilowatt
kWh	kilowatthour
LDD	Low Density Discount
LLH	Light Load Hour(s)
LPP	Large Project Program
LPTAC	Large Project Targeted Adjustment Charge
Maf	million acre-feet
Mid-C	Mid-Columbia
MMBtu	million British thermal units
MRNR	Minimum Required Net Revenue
MW	megawatt
MWh	megawatthour
NCP	Non-Coincidental Peak
NEPA	National Environmental Policy Act
NERC	North American Electric Reliability Corporation
NFB	**N**ational Marine Fisheries Service (NMFS) **F**ederal Columbia River Power System (FCRPS) **B**iological Opinion (BiOp)
NLSL	New Large Single Load

NMFS	National Marine Fisheries Service
NOAA Fisheries	National Oceanographic and Atmospheric Administration Fisheries
NORM	Non-Operating Risk Model (computer model)
Northwest Power Act	Pacific Northwest Electric Power Planning and Conservation Act
NP-15	North of Path 15
NPCC	Pacific Northwest Electric Power and Conservation Planning Council
NPV	net present value
NR	New Resource Firm Power
NRFS	NR Resource Flattening Service
NT	Network Integration
NTSA	Non-Treaty Storage Agreement
NUG	non-utility generation
NWPP	Northwest Power Pool
OATT	Open Access Transmission Tariff
O&M	operation and maintenance
OATI	Open Access Technology International, Inc.
OS	Oversupply
OY	operating year (August through July)
PDCI	Pacific DC Intertie
Peak	Peak Reliability (assessment/charge)
PF	Priority Firm Power
PFp	Priority Firm Public
PFx	Priority Firm Exchange
PNCA	Pacific Northwest Coordination Agreement
PNRR	Planned Net Revenues for Risk
PNW	Pacific Northwest
POD	Point of Delivery
POI	Point of Integration or Point of Interconnection
POR	Point of Receipt
Project Act	Bonneville Project Act
PS	Power Services
PSC	power sales contract
PSW	Pacific Southwest
PTP	Point to Point
PUD	public or people’s utility district
PW	WECC and Peak Service
RAM	Rate Analysis Model (computer model)
RCD	Regional Cooperation Debt
RD	Regional Dialogue
REC	Renewable Energy Certificate
Reclamation	U.S. Bureau of Reclamation
RDC	Reserves Distribution Clause
REP	Residential Exchange Program
REPSIA	REP Settlement Implementation Agreement

RevSim	Revenue Simulation Model
RFA	Revenue Forecast Application (database)
RHWM	Rate Period High Water Mark
ROD	Record of Decision
RPSA	Residential Purchase and Sale Agreement
RR	Resource Replacement
RRS	Resource Remarketing Service
RSC	Resource Shaping Charge
RSS	Resource Support Services
RT1SC	RHWM Tier 1 System Capability
SCD	Scheduling, System Control, and Dispatch rate
SCS	Secondary Crediting Service
SDD	Short Distance Discount
SILS	Southeast Idaho Load Service
Slice	Slice of the System (product)
T1SFCO	Tier 1 System Firm Critical Output
TCMS	Transmission Curtailment Management Service
TGT	Townsend-Garrison Transmission
TOCA	Tier 1 Cost Allocator
TPP	Treasury Payment Probability
TRAM	Transmission Risk Analysis Model
Transmission System Act	Federal Columbia River Transmission System Act
Treaty	Columbia River Treaty
TRL	Total Retail Load
TRM	Tiered Rate Methodology
TS	Transmission Services
TSS	Transmission Scheduling Service
UAI	Unauthorized Increase
UFT	Use of Facilities Transmission
UIC	Unauthorized Increase Charge
ULS	Unanticipated Load Service
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish & Wildlife Service
VERBS	Variable Energy Resources Balancing Service
VOR	Value of Reserves
VR1-2014	First Vintage Rate of the BP-14 rate period (PF Tier 2 rate)
VR1-2016	First Vintage Rate of the BP-16 rate period (PF Tier 2 rate)
WECC	Western Electricity Coordinating Council
WSPP	Western Systems Power Pool

1. INTRODUCTION AND OVERVIEW

1.1 Introduction

The Power Loads and Resources Study (Study) contains the load and resource data used to develop Bonneville Power Administration's (BPA's) wholesale power rates. This Study illustrates how each component of the loads and resources analysis is completed, how the components relate to each other, and how they fit into the rate development process. The Power Loads and Resources Study Documentation (Documentation), BP-18-E-BPA-03A, contains details and results supporting this Study.

This Study focuses on fiscal years (FY) 2018–2019 and has two primary purposes: (1) to determine BPA's monthly and annual energy load and resource balance (load-resource balance); and (2) to provide specific results that are used as inputs in other rate case study processes and calculations. To ensure that BPA has sufficient firm generation to meet its firm load obligations, BPA bases its resource planning on hydro generation estimates under 1937 critical water conditions. *See* § 3.1.2.1.3.

This Study provides inputs for various other studies, processes, and calculations in the ratemaking process. The results of this Study provide data to (1) the Power Rates Study; (2) the Power Revenue Requirement Study; and (3) the Power and Transmission Risk Study.

1.2 Overview of Methodology

This Study includes three main components: (1) load data, including a forecast of the Federal system loads and contract obligations; (2) resource data, including Federal system generating resource and contract purchase estimates, total Pacific Northwest (PNW) regional hydro resource estimates, and the estimated power purchases that are eligible for section 4(h)(10)(C) credits under the Pacific Northwest Electric Power Planning and Conservation Act (Northwest Power Act), 16 U.S.C. §§ 839–839h; and (3) the Federal system load-resource balance, which compares Federal system loads, contract obligations, and sales to the Federal system generating resources and contract purchases.

The first component of the Power Loads and Resources Study, the Federal system load obligation forecast, estimates the firm energy that BPA expects to serve during FY 2018–2019 under firm requirements contract obligations and other BPA contract obligations. The load estimates are discussed in Chapter 2 of this Study and are detailed in the Documentation.

The second component is resource data, which includes the forecast of (1) Federal system generating resources; (2) PNW regional hydro generating resources; and (3) power purchases eligible for 4(h)(10)(C) credits. The Federal system resource forecast includes hydro and non-hydro generation estimates plus power deliveries from BPA contract purchases. The Federal system resource estimates are discussed in section 3.1 of this Study and are detailed in the Documentation. The PNW regional hydro resources include all hydro resources in the Pacific Northwest, whether federally or non-federally owned. The regional hydro estimates are discussed in section 3.2 of this Study and are detailed in the Documentation. The resource

estimates used to calculate the 4(h)(10)(C) credits are discussed in section 3.3 of this Study, and the estimated power purchases eligible for 4(h)(10)(C) credits are detailed in the Documentation.

The third component of this Study is BPA's load-resource balance, which is calculated on an annual average energy basis for each year of the rate period, FY 2018 and FY 2019. BPA's firm energy load-resource balance is calculated using the sum of BPA's total generating resources under 1937 critical water conditions and contract purchases. Then BPA's load and contract obligations are subtracted from the generation. The load-resource balance is discussed in Chapter 4 of this Study and is detailed in the Documentation.

Throughout the Study and Documentation, the load and resource forecasts are shown using three different measurements. The first, energy in average megawatts (aMW), is the average amount of energy produced or consumed over a given time period, in most cases a month. The second measurement, heavy load hour energy in megawatthours (MWh), is the total MWh generated or consumed over heavy load hours. Heavy load hours (referred to as either Heavy or HLH) can vary by contract but generally are hours 6 a.m. to 10 p.m. (or Hour Ending (HE) 0700 to HE 2200) Monday through Saturday, excluding North American Electric Reliability Corporation (NERC) holidays. The third measurement, light load hour energy in MWh, is the total MWh generated or consumed over light load hours. Light load hours (referred to as either Light or LLH) can vary by contract but generally are hours 10 p.m. to 6 a.m. (or HE 2300 to HE 0600) Monday through Saturday, all day Sunday, and all day on NERC holidays. These measurements are used to ensure that BPA will have adequate resources to meet the variability of loads.

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2. FEDERAL SYSTEM LOAD OBLIGATION FORECAST

2.1 Overview

The Federal System Load Obligation forecasts include (1) BPA's projected firm requirements power sales contract (PSC) obligations to consumer-owned utilities (COUs) and Federal agencies (together, for purposes of this Study, called Public Agencies or Public Agency Customers); (2) PSC obligations to investor-owned utilities (IOUs); (3) contract obligations to direct-service industries (DSIs); (4) contract obligations to the U.S. Bureau of Reclamation (USBR); and (5) other BPA contract obligations, including contract obligations outside the Pacific Northwest region (Exports) and contract obligations within the Pacific Northwest region (Intra-Regional Transfers (Out)). This section includes summaries of BPA's forecasts of these obligations.

2.2 Public Agencies' Total Retail Load and Firm Requirement Power Sales Contract (PSC) Obligation Forecasts

In December 2008, BPA executed PSCs with Public Agencies under which BPA is obligated to provide power deliveries from October 1, 2011, through September 30, 2028. These contracts are referred to as Contract High Water Mark (CHWM) contracts. Three types of CHWM contracts were offered to customers: Load Following, Slice/Block, and Block (with or without Shaping Capacity). Of the 135 BPA Public Agency CHWM customers, currently 118 have Load Following contracts, 16 have Slice/Block contracts, and one has a Block contract.

BPA's obligation to serve Public Agency customers under their CHWM contracts incorporates the following: updated Tier 1 System Capability; updated forecasts of each customer's total load obligation; individual customers' dedicated resource amounts; and individual customers' elections for Above-Rate Period High Water Mark (Above-RHWM) load service. The Tier 1 System Capability is determined for each rate period in the RHWM Process (see Power Rates Study, BP-18-E-BPA-01, §1.4.2).

Under the CHWM contracts, BPA's load obligation to each customer can consist of RHWM load and Above-RHWM load. The RHWM Process sets the maximum amount of power that a customer may purchase each year of the rate period under Tier 1 rates, subject to that customer's calculated Net Requirement net of its New Large Single Loads (NLSLs). *See* Tiered Rate Methodology (TRM), BP-12-A-03, § 4.2. Above-RHWM load for each year of the rate period is calculated by subtracting the customer's RHWM from the difference between its forecast Total Retail Load (TRL) (less NLSLs) and its existing resources.

Each customer elects how to serve Above-RHWM load by (1) adding new non-Federal dedicated resources; (2) buying power from sources other than BPA; and/or (3) requesting BPA to supply all or a part of this power. *See* TRM § 4.3. Under the terms of the CHWM contract and the TRM, the first two options are identified as self-supply and result in a change in the dedicated resource amounts for that customer. If a customer elects for BPA to serve all or part of its Above-RHWM load, BPA will purchase power or acquire the output from generating resources to meet that customer's elected Above-RHWM load, which is supplied at Tier 2 rates. Federal power purchased or acquired to serve Tier 2 load is separate and distinct from BPA's Tier 1

System Capability. Therefore, customers' Above-RHWM load service elections are not included in, nor do they affect, BPA's annual firm energy load-resource balance in this Study.

2.2.1 Load Following PSC Obligation Forecasts

The Load Following product provides firm power to meet the customer's total retail load, less the dedicated power from the customer's non-Federal resource generation and purchases from other suppliers used to serve the customer's total retail load.

The total monthly firm obligation forecast for Public Agency customers that purchase the Load Following product is based on the sum of the utility-specific firm requirements PSC load obligation forecasts, which are customarily produced by BPA analysts. The method used for preparing the load obligation forecasts is as follows.

First, using BPA's Agency Load Forecast (ALF) model, utility-specific forecasts of total retail load are produced by applying least-squares regression-based models on historical monthly energy loads. These models may include several independent variables, such as a time trend, heating degree days, cooling degree days, and monthly indicator variables. Heating and cooling degree days are measures of temperature effects to account for changes in electricity usage related to temperature changes. Heating degree days are calculated when the temperature is below a base temperature, such as 65 degrees; similarly, cooling degree days are calculated when the temperature is above a base temperature. The results from these computations are utility-specific monthly forecasts of total retail energy load. The energy value for total retail load is split into HLH and LLH time periods using recent historical relationships.

The monthly peak loads are forecast similarly, including the use of historical data for the customers' peaks.

Second, estimates of customer-owned and consumer-owned dedicated resource generation and contract purchases dedicated to serve retail loads are subtracted from the utility-specific total retail load forecasts to produce BPA's firm load obligation forecast for each utility. These load obligation forecasts provide the basis for the Load Following product sales projections incorporated in BPA ratemaking.

A list of the 118 Public Agency customers that have purchased the Load Following product appears in Documentation Table 1.1.1. BPA's total PSC load obligation forecast including Federal Agencies is summarized in Documentation tables 1.2.1 for energy, 1.2.2 for HLH, and 1.2.3 for LLH, on line 3 *(Load Following)*. The components of this forecast are also included in the calculation of the load-resource balance, Documentation tables 9.1.1 for energy, 9.1.2 for HLH, and 9.1.3 for LLH, on line 1 *(Load Following)*.

2.2.2 Block PSC Obligation Forecasts

The Block product provides a planned amount of firm requirements power to serve the customer's total retail load up to its planned net requirement. The customer is responsible for using its own non-Federal resources or unspecified resources to meet any load in excess of its planned monthly BPA purchase.

The single Block customer is identified in Documentation Table 1.1.2. BPA's forecast of the total Block Obligation is summarized in Documentation tables 1.2.1 for energy, 1.2.2 for HLH, and 1.2.3 for LLH, on line 15 *(Tier 1 Block).* This forecast is also included in the calculation of the load-resource balance, Documentation tables 9.1.1 for energy, 9.1.2 for HLH, and 9.1.3 for LLH, on line 6 *(Tier 1 Block).*

2.2.3 Slice/Block PSC Obligation Forecasts

The Slice/Block product provides firm requirements power to serve the customer's total retail load up to its planned net requirement. For each fiscal year, the planned annual Slice/Block amounts are adjusted based on BPA's calculation of the customer's planned net requirement under the contract. The Block portion of the Slice/Block product (Slice Block) provides a planned amount of firm requirements power in a fixed monthly shape, while the Slice Output from the Tier 1 System (Slice Output) portion provides planned amounts of firm requirements power in the shape of BPA's generation from the Tier 1 System.

The annual Slice Block forecast and monthly shape of the Slice Block product for FY 2018–2019 are calculated by multiplying (1) the Tier 1 Block Monthly Shaping Factors in the customer's CHWM contract by (2) the customer's planned annual net requirement in aMW less its annual forecast Critical Slice Amounts, as defined in the CHWM contract. Critical Slice Amounts are forecast to equal the customer's Slice Percentage, as adjusted as described in TRM section 3.6, multiplied by the applicable annual RHWM Tier 1 System Capability.

BPA's Slice Output obligation for the Slice/Block customers is forecast by multiplying the monthly forecast of Tier 1 System output by the sum of the individual customers' Slice Percentages as listed in the Slice/Block CHWM contracts. The Tier 1 System output is comprised of specific Federal system resources and contracts identified in the TRM. *See* § 3.4.

A list of the 16 Slice/Block customers appears in Documentation Table 1.1.3. BPA's forecast of the total Slice/Block PSC Obligation is summarized in Documentation tables 1.2.1 for energy, 1.2.2 for HLH, and 1.2.3 for LLH, on line 9 *(Slice Block)* and line 12 *(Slice Output from Tier 1 System)*. This forecast is also included in the calculation of the load-resource balance, Documentation tables 9.1.1 for energy, 9.1.2 for HLH, and 9.1.3 for LLH, on line 8 *(Slice)*.

2.2.4 Sum of Load Following, Slice/Block, and Block PSC Obligation Forecasts

The sum of the projected firm requirements PSC obligations for customers with CHWM contracts comprises the Public Agencies Preference Customers' portion of the Priority Firm Public (PFp) load obligation forecast. Each customer's load obligation forecast accounts for the reported amount of conservation the customer plans to achieve during the FY 2018–2019 rate period. These forecasts do not include additional BPA-funded conservation beyond what the customers have reported they plan to achieve. As individual customers achieve conservation measures in addition to what they already committed to, the customers will receive credits on their power bills reflecting lower loads due to the additional conservation measures. The annual average energy Priority Firm Power (PF) load obligations, by product, for FY 2018–2019 are presented in Table 1 of this Study.

2.3 Investor-Owned Utilities Sales Forecast and Other Load Served at the NR Rate

The six IOUs in the PNW region are Avista Corporation, Idaho Power Company, NorthWestern Energy Division of NorthWestern Corporation, PacifiCorp, Portland General Electric Company, and Puget Sound Energy, Inc. Most of the IOUs have signed BPA power sales contracts for FY 2011 through 2028; however, no IOUs have chosen to take service under these contracts. If requested, BPA would serve any net requirements of an IOU at the New Resource Firm Power (NR-18) rate. No net requirements power sales to regional IOUs are forecast for FY 2018–2019 based on BPA's current contracts with the regional IOUs.

In addition, BPA makes power available at the NR-18 rate to any public body, cooperative, or Federal agency to the extent such power is used to serve any new large single load as defined by the Northwest Power Act, 16 U.S.C. §§ 839–839h. BPA also offers products at the NR-18 rate for customers electing to serve their NLSLs with their own dedicated resources. No sales at the NR-18 rate are forecast in the FY 2018–2019 rate period.

2.4 Direct Service Industry Sales Forecast

Currently BPA is making power sales deliveries to two direct service industry customers, Port Townsend Paper Corporation (Port Townsend) and Alcoa, Inc. (Alcoa).

Port Townsend's current contract with BPA runs through September 30, 2022. BPA's deliveries under this contract will provide Port Townsend a maximum contract demand of 15.75 MW through September 30, 2022. Jefferson County PUD serves Port Townsend's wheel turning load (load not integral to the industrial process) and Port Townsend's Old Corrugated Containers

(OCC) recycling plant load, totaling 8.5 aMW. Jefferson County PUD's load forecast reflects this service arrangement. BPA assumes in this Study that it will continue to serve the remainder of Port Townsend's load during the FY 2018–2019 rate period, approximately 12.6 aMW.

Alcoa's current contract with BPA also runs through September 30, 2022. Deliveries began on December 7, 2012, with BPA delivering 300 aMW per month, flat across all hours. BPA and Alcoa negotiated a contract demand reduction that began May 1, 2015, decreasing deliveries to 75 aMW per month. Alcoa filed a notice with BPA to curtail load further in November 2015. In response to this notice, BPA and Alcoa negotiated a load curtailment that reduced deliveries under this contract to 10 aMW per month through February 14, 2018, at which time contract delivery to Alcoa will increase to 75 aMW per month through the remainder of the contract. This Study assumes annual DSI power sales to Alcoa of 48.1 aMW in FY 2018 and 75 aMW in FY 2019.

BPA's DSI contract obligations are detailed in Documentation tables 1.2.1 for energy, 1.2.2 for HLH, and 1.2.3 for LLH, on line 1 *(DSI Obligation)*. This forecast is also included in the calculation of the load-resource balance, Documentation tables 9.1.1 for energy, 9.1.2 for HLH, and 9.1.3 for LLH, on line 11 *(DSI Obligation)*.

2.5 USBR Irrigation District Obligations

BPA is obligated to provide power from the Federal system to several irrigation districts associated with USBR projects in the Pacific Northwest. These irrigation districts have been congressionally authorized to receive power from specified Federal Columbia River Power

System (FCRPS) projects as part of the USBR project authorization. BPA does not contract directly with these irrigation districts; instead, there are several agreements between BPA and USBR that provide details on the power deliveries.

A list of USBR irrigation district obligation customers appears in Documentation Table 1.1.4. BPA's forecast of the total USBR customer load is summarized in Documentation tables 1.2.1 for energy, 1.2.2 for HLH, and 1.2.3 for LLH, on line 35 *(USBR Obligation)*. This forecast is also included in the calculation of the load-resource balance, Documentation tables 9.1.1 for energy, 9.1.2 for HLH, and 9.1.3 for LLH, on line 4 *(USBR Obligation)*.

2.6 Other Federal System Contract Obligations

BPA provides Federal power to customers under a variety of contract arrangements not included in the Public Agencies, IOU, DSI, or USBR forecasts. These contract obligations are categorized as (1) power sales; (2) power or energy exchanges; (3) capacity sales or capacity-for-energy exchanges; (4) power payments for services; and (5) power commitments under the Columbia River Treaty. These arrangements, collectively called "Other Contract Obligations," are specified by individual contract provisions and can have various delivery arrangements and rate structures. BPA's Other Contract obligations are considered to be firm and are assumed to be served by the Federal system resources regardless of weather, water, or economic conditions. These contracts include obligations delivered to entities outside the Pacific Northwest region (Exports) and obligations delivered to entities within the Pacific Northwest region (Intra-Regional Transfers (Out)). These contract obligations are modeled individually and are specified or estimated for monthly energy in aMW, HLH, and LLH.

BPA's Export contract obligations are detailed in Documentation tables 2.1.1 for energy, 2.1.2 for HLH, and 2.1.3 for LLH. BPA's Intra-Regional Transfers (Out) contract obligations are detailed in Documentation tables 2.3.1 for energy, 2.3.2 for HLH, and 2.3.3 for LLH. These forecasts are also included in the calculation of the load-resource balance, Documentation tables 9.1.1 for energy, 9.1.2 for HLH, and 9.1.3 for LLH, on line 14 *(Exports)* and line 15 *(Intra-Regional Transfers (Out))*.

BPA's load-resource balance in this Study is used to help set the firm Tier 1 rates for BPA's PSC customers. Trading floor sales are not included in BPA's load-resource balance because they are not included in the Tier 1 rate calculation. Revenue impacts of trading floor contracts are reflected as presales of secondary energy and are included as secondary revenues credited to non-Slice customers' rates. These trading floor contracts are accounted for as committed sales in the Power and Transmission Risk Study Documentation, BP-18-E-BPA-05A.

3. RESOURCE FORECAST

3.1 Federal System Resource Forecast

3.1.1 Overview

BPA is charged with the responsibility of marketing power and providing transmission services to serve the firm electric load needs of its customers. BPA does not own generating resources; rather, BPA markets power from Federal and specific non-Federal generating resources to meet BPA's Federal load obligations. In addition, BPA purchases power through contracts that add to the Federal system resource capability. These resources and contract purchases are collectively called "Federal system resources." Federal system resources are classified as hydro resources (regulated, independent, and small hydro projects); other resources (large thermal and renewable resources); and contract purchases. The Federal system resources are adjusted to take into account reserves and transmission loss estimates on the Federal system, which reduces the Federal system resource capability.

3.1.2 Hydro Generation

The Federal system hydro resources are comprised of the generation from regulated, independent, and small hydro projects. Regulated hydro projects and the process used for estimating the generation of regulated hydro projects are detailed in section 3.1.2.1. Independent hydro projects and the methodology for forecasting generation of independent hydro projects are described in section 3.1.2.2. BPA also purchases the output from two small hydro projects. The generation estimates for these small hydro projects were provided by the individual project

owners and are assumed not to vary by water year. Small hydro projects are described in section 3.1.2.3.

3.1.2.1 Regulated Hydro Generation Forecast

BPA markets the generation from the Federal system hydro projects. These projects are primarily owned and operated by either the U.S. Army Corps of Engineers (USACE) or USBR.

This Study uses BPA's hydrosystem simulator model (HYDSIM) to estimate the Federal system energy production that can be expected from specific hydroelectric power projects in the Columbia River Basin when operating in a coordinated fashion and meeting power and non-power requirements for 80 historical water years (October 1928 through September 2008). The hydro projects modeled in HYDSIM are called regulated hydro projects.

The hydro regulation study uses individual project operating characteristics and conditions to determine the energy production expected from each individual project. Physical characteristics of each project come from annual Pacific Northwest Coordination Agreement (PNCA) data submittals from regional utilities and government agencies involved in the coordination and operation of regional hydro projects. The HYDSIM model provides project-by-project monthly energy generation estimates for the regulated hydro projects for each water year modeled. HYDSIM incorporates and produces data for 14 periods per year: 10 calendar months and two periods each for April and August. April and August are modeled differently because the hydro system generation can differ significantly between the beginning and end of these months due to

changes in streamflows and operating constraints. This 14-period data set is referred to as monthly data for simplicity.

There are three main steps of the hydro regulation studies that estimate regulated hydro generation. First, the Canadian operation is set based on the best available information from the Columbia River Treaty (Treaty) planning and coordination process. The Treaty calls for an Assured Operating Plan (AOP) to be completed six years prior to each operating year and a Detailed Operating Plan (DOP) to be completed if necessary the year prior to the operating year. The DOP reflects modifications to the AOP if agreed to by the U.S. and Canada and is usually completed a few months prior to the beginning of the operating year. These official DOP studies from the Columbia River Treaty process are not available in time for use in BPA's ratesetting process. As a result, the 2018 and 2019 AOP studies are used with a few modifications to reflect updates expected in the official DOP studies. These are referred to as "surrogate DOP" studies and represent the best estimate available for Canadian operations for the rate period. The surrogate DOP studies include the official AOP study assumptions plus the most recent plant data available from project owners through the PNCA planning and coordination process.

Second, an Actual Energy Regulation study (AER step) is run in HYDSIM to determine the operation of the hydro system under each of the 80 years of historical water conditions while meeting the Firm Energy Load Carrying Capability (FELCC) produced in the PNCA final hydro regulation. In this step, the Canadian operation is fixed to the surrogate DOP studies. Also in this step, the U.S. Federal, U.S. non-Federal, and Canadian reservoirs draft water to meet the

Coordinated System FELCC while meeting individual reservoir non-power operating requirements.

Third, an 80-year operational study (OPER step) is run in HYDSIM with the estimated regional firm loads developed for each year of the study and with any deviations from the PNCA data submittals necessary to reflect expected operations during the rate period. In the OPER step the non-Federal projects are fixed to their operations from the AER step, and the Federal projects operate differently based on the deviations from PNCA data and the estimated regional firm load.

In summary, a surrogate DOP is used to determine the Canadian operations, an AER step is run based on PNCA data to determine the operation of the non-Federal projects, and an OPER step is run to determine the operation of the Federal projects based on PNCA data plus additional assumptions needed to reflect expected operations. The end result of these three steps is generally referred to as the hydro regulation study. *See* Documentation section 8.1.

For the Power Loads and Resources Study, separate hydro regulation studies are performed for each year of the rate period. Completing hydro regulation studies for each year allows the hydro generation estimates to capture changes in the variables that characterize yearly variations in hydro operations due to firm loads, firm resources, markets for hydro energy products in better-than-critical water conditions, and project operating limitations and requirements. These variables affect the amount and timing of energy available from the hydro system and are updated annually to reflect current expectations. Study sections 3.1.2.1.1 through 3.1.2.1.4

contain additional details on the process of producing the regulated hydro generation estimates used in this Study.

Documentation tables 3.1.1 for energy, 3.1.2 for HLH, and 3.1.3 for LLH, lines 1–14, list the hydro projects included in BPA's Regulated Hydro Generation forecast. The regulated hydro HLH and LLH split is based on the aggregated Federal system regulated hydro generation estimates produced by BPA's Hourly Operating and Scheduling Simulator (HOSS) analyses, which utilize the HYDSIM hydro regulation studies as their base input. *See* section 3.1.2.1.4. This forecast is also included in the calculation of the load-resource balance, Documentation tables 9.1.1 for energy, 9.1.2 for HLH, and 9.1.3 for LLH, on line 19 *(Regulated Hydro – Net)*.

The net regulated hydro energy generation is provided to the Power and Transmission Risk Study, BP-18-E-BPA-05, and the Power Market Price Study and Documentation, BP-18-E-BPA-04. The HLH and LLH Federal system regulated hydro generation estimates are later combined with the Federal system independent hydro HLH-LLH split, also in the Power and Transmission Risk Study.

3.1.2.1.1 Assumptions in the HYDSIM Hydro Regulation Study

The HYDSIM studies incorporate the power and non-power operating requirements expected to be in effect during the rate period, including those described in the National Oceanic and Atmospheric Administration (NOAA) Fisheries FCRPS Biological Opinion (BiOp) regarding salmon and steelhead, published May 5, 2008; the NOAA Fisheries FCRPS Supplemental BiOp, published May 20, 2010; the NOAA Fisheries FCRPS Supplemental BiOp, published

January 17, 2014; the U.S. Fish and Wildlife Service (USFWS) FCRPS BiOp regarding bull trout, published December 20, 2000; the USFWS Libby BiOp regarding bull trout and Kootenai River white sturgeon, published February 18, 2006; relevant operations described in the Northwest Power and Conservation Council's (NPCC) Fish and Wildlife Program; and other mitigation measures. Each hydro regulation study specifies particular hydroelectric project operations for fish, such as seasonal flow objectives, minimum flow levels for fish, spill for juvenile fish passage, reservoir target elevations and drawdown limitations, and turbine operation efficiency requirements.

Additionally, HYDSIM uses hydro plant operating characteristics in combination with power and non-power requirements to simulate the coordinated operation of the hydro system. These operating requirements include but are not limited to storage content limits determined by rule curves, maximum project draft rates determined by each project owner, and flow and spill objectives described in the NOAA Fisheries and USFWS BiOps listed above and as provided by the 2016 PNCA data submittals. Some deviations from the 2016 PNCA data submittals are necessary to more accurately model anticipated operations for the rate period, such as fine-tuning the study to reflect typical in-season management decisions that are not reflected in the 2016 PNCA data submittals.

The hydro regulation studies include sets of power and non-power requirements for each year of the rate period. Specific assumptions for the HYDSIM hydro regulation studies are detailed in Documentation section 8.

Several hydro modeling changes have been made since the BP-16 Loads and Resources Study. These changes have been made as part of BPA's continuous efforts to incorporate the most recent available data in the model and to improve hydro regulation modeling to reflect operations more accurately. The following are the more significant updates to the HYDSIM hydro regulation studies included in this Study:

- All projects have been updated according to 2016 PNCA data with additional updates included based on the 2017 PNCA data known at the time of this study. These updates are too numerous to list in their entirety and tend to be minor. The following are some of the more noteworthy PNCA data updates:
  - Grand Coulee's plant data was updated to better reflect actual storage estimates based on data submitted by the USBR.
  - Hungry Horse's plant data was updated to better reflect actual generation estimates based on data submitted by the USBR.
  - Grand Coulee irrigation pumping was updated based on data submitted by the USBR.
- Canadian project operations have been updated based on the surrogate 2018 DOP and 2019 DOP described earlier. Because the 2018 and 2019 AOP studies include identical Canadian operations, the surrogate DOP studies are the same for the FY 2018 and FY 2019 HYDSIM studies.
- The regional residual hydro loads (RRHL) used in HYDSIM were updated and include current forecasts of loads, contract sales and purchases, and non-hydro generation. The RRHL are calculated by subtracting the regional firm non-hydro resources from the total regional firm load. Additionally, the

independent hydro generation forecasts used in the study were updated. The RRHL in the BP-18 HYDSIM study are several hundred megawatts higher than in the BP-16 HYDSIM study when averaged over the two-year rate period.

- Miscellaneous updates have been made to better reflect expected actual operations:
  - The assumed start date of Libby's sturgeon pulse operation has been updated based on the most recent information available.
  - Updated modeling has been incorporated to include forced drafts for drum gate maintenance at Grand Coulee during FY 2018 and FY 2019.
- There have been a few spill updates since the BP-16 Loads and Resources Study based on the most recent information available:
  - The spring maximum transport operation in dry years at Lower Granite, Little Goose, and Lower Monumental assumed in the BP-16 HYDSIM study for FY 2017 is not included in the BP-18 HYDSIM study.
  - The summer spill end dates for Lower Granite, Little Goose, Lower Monumental, and Ice Harbor have been updated based on the most recent data available.
  - Spill priorities and total dissolved gas caps have been updated based on the most recent data available.
- Federal powerhouse availability factors have been updated using a combination of planned outages, forced outages (based on historical data and current forecasts of equipment condition), and more recent balancing and

operating reserve requirement assumptions. These components are incorporated into the availability factors in HYDSIM and reduce powerhouse generating capability.

- The lack of market spill has been updated based on estimates from the AURORAxmp® model.

Overall, these HYDSIM study changes generally decrease firm annual average generation during 1937 critical water conditions and slightly increase the 80-year annual average generation when averaged over the two-year rate period. The BP-18 rate period annual average Federal generation decreases about 100 aMW in 1937 critical water conditions compared to the BP-16 rate period. The BP-18 rate period 80-year annual average Federal generation increases about 15 aMW compared to the BP-16 rate period. The separate effects of each modeling change have not been analyzed. However, the generation decrease under 1937 critical water conditions is largely attributable to the updates to the Canadian Treaty operations and the removal of the spring maximum transport operation in dry years.

The assumptions in the hydro regulation studies are the same for both years of the rate period, FY 2018 and FY 2019, except for the following:

- The hydro availability factors used to model anticipated unit outages and the standard reserve requirements are estimated for each study year and are different in the FY 2018 and FY 2019 studies.
- The RRHL forecasts are calculated for each study year. The loads incorporated in the FY 2019 hydro regulation study are higher than the loads

projected for the FY 2018 hydro regulation study on an annual average basis, mainly due to load growth but also due to changes in regional thermal resources.

- The amounts of spill due to lack of market are different in the two hydro regulation studies. These differences come from the AURORAxmp® model, which simulates the different anticipated market conditions in FY 2018 and FY 2019.

3.1.2.1.2 80-Year Modified Streamflows

The HYDSIM model uses streamflows from historical years as the basis for estimating power production of the hydroelectric system. The HYDSIM studies are developed using the 2010 modified streamflow dataset. Historical streamflows are modified to reflect the changes over time due to the effects of irrigation and consumptive diversion demand, return flow, and changes in contents of upstream reservoirs and lakes. These modified streamflows were developed under a BPA contract funded by the PNCA parties. The modified streamflows are also adjusted in this study to include updated estimates of Grand Coulee irrigation pumping using data provided by USBR in its 2017 PNCA data submittal.

Eighty years of streamflow data are used because hydro is a resource with a high degree of variability in generation from year to year. The study uses an 80-year hydro regulation study to forecast the expected operations of the regulated hydro projects for varying hydro conditions. Approximately 80 percent of BPA's Federal system resource stack is comprised of hydro generation, which can vary annually by about 5,000 aMW depending on water conditions.

HYDSIM estimates regulated hydro project generation for varying water conditions and takes into account specific flows, volumes of water, elevations at dams, biological opinions, and many other aspects of the hydro system.

Additionally, BPA has generation estimates for other hydro projects that are based on 80 years of historical water conditions, October 1928 through September 2008. These regional projects are called independent hydro projects because their operations are not regulated in this HYDSIM study, primarily because they have much less storage capability than the hydro projects in the Columbia River Basin regulated in the HYDSIM study. The regional independent hydro projects usually have generation estimates for each of the 80 water years of record. Most of these hydro projects are not federally owned, and their generation estimates are updated with the cooperation of each project owner. For those independent hydro projects that did not have data for all 80 water years, generation estimates were expanded using the project's median generation to estimate generation for the additional water years.

3.1.2.1.3 1937 Critical Water for Firm Planning

To ensure that the agency has sufficient generation to meet load, BPA bases its resource planning on critical water conditions. Critical water conditions are when the PNW hydro system would produce the least amount of power while taking into account the historical streamflow record, power and non-power operating constraints, the planned operation of non-hydro resources, and system load requirements. For operational purposes, BPA considers critical water conditions to be the critical period of August 16, 1936, through April 30, 1937, as determined in the PNCA planning process. For planning purposes and to align with the fiscal years used in this study,

however, the study uses the historical streamflows from October 1936 through September 1937 water conditions as the critical period. These streamflows are designated "1937 critical water conditions." The hydro generation estimates under 1937 critical water conditions determine the critical period firm energy for the regulated and independent hydro projects. This is called the FELCC, or firm energy load carrying capability.

3.1.2.1.4 Regulated Hydro HLH/LLH Split Calculation Using HOSS

The monthly energy produced by HYDSIM for each regulated hydro project is split between heavy and light load hours for input to RevSim in the Power and Transmission Risk Study, section 4.1.1.1.1. To calculate the HLH/LLH regulated hydro splits, BPA completes an hourly simulation of the regulated hydro projects' operation using HOSS. The hourly outputs of HOSS are not directly used for ratesetting purposes. Rather, the hourly HOSS outputs are used to derive monthly Federal system regulated hydro energy relationships. These monthly relationships provide monthly HLH energy and LLH energy shapes used in ratemaking.

To simulate hourly Federal regulated hydro generation, the HOSS model uses HYDSIM monthly project flows, beginning and ending conditions, and other power and non-power constraints discussed in section 3.1.2.1. HOSS studies also incorporate current forecasts of monthly Regulating Reserve, Operating Reserve, Load Following Reserve, Dispatchable Energy Resource Balancing Service (DERBS) Reserve, and Variable Energy Resource Balancing Service (VERBS) Reserve.

The resulting HOSS studies shape the monthly energy from HYDSIM into HLH and LLH Federal hydro generation for each of the 80 water conditions of the study period. These projections are the basis for the Federal system hydro energy relationships that provide the monthly HLH and LLH energy splits that are shown in Documentation tables 3.1.2 and 3.1.3 and are inputs to Power and Transmission Risk Study section 2.4.

3.1.2.2 Independent Hydro Generation Forecast

Federal independent hydro includes hydro projects whose generation output typically varies by water condition; however, the generation forecasts for these projects are not modeled or regulated in the HYDSIM study. BPA markets the power from independent hydro projects that are owned and operated by USBR, USACE, and other project owners. Federal independent hydro generation estimates are provided by individual project owners for 80 water years (October 1928 through September 2008). These estimates include power purchased from hydro projects owned by Lewis County Public Utility District (Cowlitz Falls) and Mission Valley (Big Creek). Documentation tables 3.2.1, 3.2.2, and 3.2.3, lines 1–22, list the hydro projects included in BPA's Independent Hydro Generation forecast.

The energy estimates for Federal independent hydro generation used in this Study are summarized in Documentation section 3.2, tables 3.2.1 for energy, 3.2.2 for HLH, and 3.2.3 for LLH, line 24. This forecast is also included in the calculation of the load-resource balance, Documentation tables 9.1.1 for energy, 9.1.2 for HLH, and 9.1.3 for LLH, on line 20 *(Independent Hydro – Net).*

The HLH/LLH splits for the independent hydro generation estimates are developed based on historical generation data. This Study provides the monthly HLH and LLH generation for the Federal system independent hydro resources to the Power and Transmission Risk Study.

3.1.2.3 Small Hydro Generation Forecast

Small hydro resources include the Dworshak/Clearwater Small Hydro project and Rocky Brook hydro project. Generation estimates for these small hydro projects were provided by each individual project owner and are assumed not to vary by water year. Small hydro resources are detailed in Documentation tables 3.3.1 for energy, 3.3.2 for HLH, and 3.3.3 for LLH. This forecast is also included in the calculation of the load-resource balance, Documentation tables 9.1.1 for energy, 9.1.2 for HLH, and 9.1.3 for LLH, on line 21 *(Small Hydro Resources)*.

3.1.3 Other Federal Generation

Other Federal generation includes the purchased output from non-federally owned projects and project generation that is directly assigned to BPA. Other Federal system generation estimates are detailed for monthly energy in aMW and HLH and LLH megawatthours as follows:

(1) Large thermal resources include the Columbia Generating Station project, whose forecast includes a two-year refueling cycle. The generation forecast incorporates facility improvements made since the BP-16 Loads and Resources Study. The generation forecast for Columbia Generating Station is shown in Documentation tables 4.1.1 for energy, 4.1.2 for HLH, and 4.1.3 for LLH. This forecast is also included in the calculation of the load-resource balance, Documentation

tables 9.1.1 for energy, 9.1.2 for HLH, and 9.1.3 for LLH, on line 25 *(Large Thermal Resources)*.

(2) Renewable resources include wind and solar resources (Federal purchases of shares of the Condon Wind Project; Foote Creek 1 and 4 Wind Projects; Klondike I Wind Project; Klondike III Wind Project; Stateline Wind project; Ashland Solar; and White Bluffs Solar). These projects are detailed in Documentation section 4.2, tables 4.2.1 for energy, 4.2.2 for HLH, and 4.2.3 for LLH. This forecast is also included in the calculation of the load-resource balance, Documentation tables 9.1.1 for energy, 9.1.2 for HLH, and 9.1.3 for LLH, on line 26 *(Renewable Resources)*.

3.1.4 Federal Contract Purchases

BPA purchases or receives power under a variety of contractual arrangements to help meet Federal load obligations. The contracts are categorized as (1) power purchases; (2) power or energy exchange purchases; (3) capacity sales or capacity-for-energy exchange contracts; (4) power purchased or assigned to BPA under the Columbia River Treaty; and (5) transmission loss returns under Slice/Block contracts. These arrangements are collectively called "Contract Purchases." BPA's Contract Purchases are considered firm resources that are delivered to the Federal system regardless of weather, water, or economic conditions. The transmission loss returns category captures the return of Slice transmission losses to the Federal system by Slice customers as part of their Slice/Block contracts. These returns act as a Federal system resource.

BPA's expected Contract Purchases are detailed in the Documentation as follows. Power purchases from delivery points outside the Pacific Northwest Region are termed Imports, which are found in Documentation tables 2.2.1 for energy, 2.2.2 for HLH, and 2.2.3 for LLH. Non-Federal Canadian Entitlement Return (CER) deliveries are found in Documentation tables 2.4.1 for energy, 2.4.2 for HLH, and 2.4.3 for LLH. Power purchases from delivery points within the Pacific Northwest Region are called Intra-Regional Transfers (In) and are found in Documentation tables 2.3.1 for energy, 2.3.2 for HLH, and 2.3.3 for LLH. Slice Transmission Loss Returns to BPA do not have their own detailed table but are included in the Federal system load-resource balance, in forecast other contract purchases. While BPA has made trading floor purchases that continue into FY 2018 and FY 2019, such as to meet anticipated Tier 2 obligations and the Southeast Idaho Load Service (SILS), these contracts are not included in the calculation of BPA's firm annual load-resource balance in this Study. *See* Documentation tables 9.1.1 for energy, 9.1.2 for HLH, and 9.1.3 for LLH, on line 29 *(Imports)*, line 30 *(Intra-Regional Transfers (In))*, line 31 *(Non-Fed CER)*, and line 32 *(Slice Transmission Loss Returns)*.

For Tier 2 load service, the load and contract purchase amounts match and therefore would not impact load-resource balance. *See* Power Rates Study sections 2.1.3.2 and 3.2.2. Purchases to meet SILS are for the purpose of providing transfer services to meet specific Southern Idaho loads and are not used to offset the need for system augmentation. Therefore, these purchases are excluded from the computation of system augmentation necessary to achieve annual load-resource balance. Any additional Federal system surplus over the 80-year water conditions

due to these purchases would be sold as secondary energy or used to reduce balancing purchases. *See* Power and Transmission Risk Study section 4.1.1.2.3.

Contract Purchases do include estimates of system augmentation purchases to meet any annual deficits of the Federal system load-resource balance. Calculation of system augmentation purchases is discussed in section 4.3.

3.1.5 Federal System Transmission Losses

Federal system transmission loss estimates are treated as generation reductions in this Study. These losses are calculated monthly and vary by water conditions.

The loss factors used have several components that combine to give the estimate of losses typically associated with Federal system generation: (1) step-up transformers from generation to the high-voltage transmission network; (2) high-voltage network transmission; (3) transfers to Federal loads over non-Federal transmission systems; and (4) step-down transformers from high-voltage transmission to low-voltage delivery.

The Federal system transmission loss factor used in this Study is 2.97 percent for energy, HLH and LLH, when averaged over the year.

The estimated magnitude of each loss factor component for energy is as follows:

(1) Step-up transformers between the Federal generation and the transmission network: average losses of 0.31 percent.

(2) High-voltage network: average losses of 1.90 percent.

(3) Transfer service to Federal system loads over non-Federal transmission systems: average losses of 0.49 percent.

(4) Step-down transformer: average losses of 0.27 percent.

These transmission loss factor components were developed in 1992 and reaffirmed by Transmission Services in 1994, 2000, and 2011. In 2014, BPA updated the transmission loss factor for component (3), transfer service to Federal loads over non-Federal transmission systems; this update was first included in studies for the BP-16 rate case. BPA has not changed any of the transmission loss components for the BP-18 Initial Proposal.

The Power and Transmission Risk Study uses the same transmission loss factors as this Study. The Power Rates Study uses the same transmission loss factors, but they are mathematically converted and applied to loads.

3.2 Regional Hydro Resources

3.2.1 Overview

This study produces total PNW regional hydro resource estimates for FY 2018 and FY 2019 to provide inputs for the AURORAxmp® model used in the Power and Transmission Risk Study and the Power Market Price Study.

3.2.2 PNW Regional 80 Water Year Hydro Generation

PNW regional hydro resource estimates are one of the inputs to the AURORAxmp® model and are comprised of all PNW regulated, independent, and small hydro resources for FY 2018 and FY 2019. Regulated hydro generation estimates for this study are developed for each of the 80 water years (October 1928 through September 2008) using the HYDSIM study described in section 3.1.2.1. Independent hydro generation estimates are provided by the project owners for the same 80 water years; *see* section 3.1.2.2. Small hydro generation estimates are provided by the project owners and are assumed not to vary by water year. Small hydro projects are described in section 3.1.2.3.

The total regional regulated, independent, and small hydro energy is summarized for each of the 80 water years for FY 2018–2019 and is shown in Documentation section 5.1.

3.3 4(h)(10)(C) Credits

3.3.1 Overview

The Northwest Power Act directs BPA to make expenditures to protect, mitigate, and enhance fish and wildlife affected by the development and operation of Federal hydroelectric projects in the Columbia River Basin and its tributaries. These expenditures are to be made in a manner consistent with the Power Plan and Fish and Wildlife Program developed by the NPCC and consistent with other purposes of the Northwest Power Act. 16 U.S.C. §§ 839–839h.

Section 4(h)(10)(C) of the Northwest Power Act requires that the costs of mitigating these impacts be properly accounted for among the various purposes of the hydroelectric projects by

making sure that when BPA funds mitigation on behalf of both power and non-power project purposes, ratepayers can recoup the non-power share. The non-power purposes include flood control, irrigation, recreation, and navigation. The percentage of costs attributable to non-power purposes is 22.3 percent. This percentage is the systemwide average of cost allocations for non-power purposes of the FCRPS provided by the USBR and USACE for their hydropower projects.

Following the Northwest Power Act's requirement for appropriate cost allocation, BPA annually recoups the non-power portion of costs associated with fish measures through "4(h)(10)(C) credits" against BPA's payments to the U.S. Treasury. This study estimates the replacement power purchases resulting from changes in hydro system operations to benefit fish and wildlife. These power purchases are part of the calculation of 4(h)(10)(C) credits in Power and Transmission Risk Study section 4.1.1.2.1. The operations to benefit fish and wildlife are described in this Study, section 3.1.2.1.1.

3.3.2 Forecast of Power Purchases Eligible for 4(h)(10)(C) Credits

The power purchases eligible for 4(h)(10)(C) credits are estimated by comparing power purchase estimates between two HYDSIM hydro regulation studies. The first hydro regulation study, termed the "with-fish" study, models hydro system operations using current requirements for fish mitigation and wildlife enhancement under 80 historical water year conditions (October 1928 through September 2008). The HYDSIM study completed for this Study serves as the "with-fish" study for the power purchase estimates. The second hydro regulation study, called

the "no-fish" study, models the hydro system operation assuming no operational changes were made to benefit fish and wildlife using the same 80 historical water year conditions.

BPA estimates the power purchases that would be required to meet a specific firm load (described below) under the with-fish study and the power purchases that would be required to meet the same firm load under the no-fish study. The 4(h)(10)(C) credits do not pertain to the entire generation difference between the with-fish study and the no-fish study; instead, the credits pertain to only a portion of the additional power purchases in the with-fish study. BPA receives section 4(h)(10)(C) credits for the non-power portion (22.3 percent) of the additional power purchases it must make in the with-fish study relative to the no-fish study.

The specific firm load used in the calculation of 4(h)(10)(C) credits was a part of the original negotiated arrangement between the Department of Energy and the U.S. Treasury allowing BPA to claim the credits. A fundamental principle of this arrangement for claiming section 4(h)(10)(C) credits is that the calculation is not to be affected by BPA's marketing decisions. In order to separate the credit calculation from BPA marketing decisions, 4(h)(10)(C) credits are calculated using the load that could have been served with certainty while drafting the system from full to empty without fish operations under the worst energy-producing water conditions in the 80-year record (referred to as the critical period, which is 1929–1932 in the no-fish study). This FELCC is the amount of firm energy that BPA would have been entitled to sell without fish operations and is used as the firm load in the section 4(h)(10)(C) power purchases analysis.

The differences between the Federal FELCC and the Federal generation in the with-fish study determine the power purchases under the with-fish study. Similarly, the differences between the Federal FELCC and the Federal generation in the no-fish study determine the power purchases under the no-fish study. The instances where power purchases are greater in the with-fish study compared to the no-fish study result in power purchases eligible for section 4(h)(10)(C) credits. Alternatively, when power purchases are less in the with-fish study than in the no-fish study, the difference constitutes a negative section 4(h)(10)(C) credit.

The differences in energy purchase amounts between the with-fish and no-fish hydro studies are calculated for each period and water condition of the 80 water year studies. The differences are shown for the rate period in Documentation section 6.1, tables 6.1.1 and 6.1.2. These power purchases are used as inputs to the Power and Transmission Risk Study, where, combined with AURORAxmp® market price estimates, they are used to calculate the 4(h)(10)(C) credits for power purchases. The non-power portion (22.3 percent) of the average expense for these purchases is used as the forecast of section 4(h)(10)(C) credits for Federal hydro system fish operations.

3.4 Use of Tier 1 System Firm Critical Output Calculation

The forecasted Tier 1 System Firm Critical Output (T1SFCO) for use in the ratesetting process was calculated for the FY 2018–2019 rate period in the 2016 RHWM Process. Power Rates Study, BP-18-E-BPA-01, § 1.4.2. The T1SFCO is part of the calculation of the Tier 1 System Capability used for this Study. The Tier 1 System Capability is the sum of the T1SFCO and RHWM Augmentation. TRM, BP-12-A-03, page xxi. The 2018 RHWM Process rescaled the

CHWMs to an augmented Tier 1 System (RHWM Tier 1 System Capability). These rescaled CHWMs are the RHWMs for the FY 2018–2019 rate period.

Resource and contract forecasts for this Study have been updated since BP-16. These updates changed the Tier 1 System output. The 2016 RHWM Process assumed an adjusted Slice Output of 26.5953 percent of the Tier 1 System.

Supporting tables for the T1SFCO used in this Study for the calculation of the updated Tier 1 System output are provided in Documentation section 7.1. The Tier 1 System output is estimated to be 6,879 aMW when averaged over the two-year rate period, FY 2018–2019.

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4. FEDERAL SYSTEM LOAD-RESOURCE BALANCE

4.1 Overview

For BPA to conduct operational planning and set power rates, the Federal system must be in load and resource balance. That is, BPA must forecast that it has enough resources available to serve its forecast firm loads under critical water conditions. The load-resource balance is composed of the monthly energy amounts of BPA's resources, which include hydro, non-hydro, and contract purchases, less BPA's load obligations, which are comprised of BPA's power sales contract obligations and other contract obligations.

4.2 Firm Load-Resource Balance

To determine whether the Federal system is in load-resource balance, the forecast amount of BPA's annual firm energy resources under 1937 critical water conditions is estimated and compared to BPA's annual firm energy loads. If BPA's expected firm energy resources are equal to BPA's expected load obligations, then BPA is considered to be in load-resource balance. If the load-resource balance is not zero, BPA calculates adjustments to its loads or resources to maintain BPA in load-resource balance.

If BPA's annual firm energy resources are estimated to be greater than the forecast of BPA load obligations, BPA is considered to be annual firm energy surplus. If surplus, BPA would calculate the amount of surplus sales needed to increase load obligations to keep the Federal system in load-resource balance. Conversely, if BPA's annual firm energy resources are estimated to be lower than the forecast of BPA load obligations, BPA is considered to be annual

firm energy deficit. If deficit, BPA would calculate the amount of system augmentation purchases or resource acquisitions needed to keep the Federal system in load-resource balance.

Annual firm surplus sales and system augmentation purchases may not fully balance monthly Federal system HLH or LLH energy surpluses or deficits. Purchases made to meet individual monthly HLH or LLH energy deficits are called balancing purchases and are not included in this Study.

4.3 Firm Federal System Energy Load-Resource Balance

Table 2 shows a summary of the Federal system annual energy load-resource balance for FY 2018–2019. Under 1937 critical water conditions, the Federal system is expected to be in firm annual energy load-resource balance for the rate period. To maintain a firm annual energy load-resource balance, BPA calculates annual system augmentation purchases for times when the Federal system has annual energy deficits and annual firm surplus sales for times when the Federal system has annual energy surpluses.

For FY 2018, the Federal system is forecast to be firm annual energy surplus, thereby requiring 167 aMW of firm surplus sales to achieve load-resource balance. In FY 2019, the Federal system is forecast to be firm annual energy deficit, thereby requiring 45 aMW of system augmentation purchases to achieve load-resource balance. The individual components that make up the Federal system annual energy load-resource balance for FY 2018–2019 are shown in Table 3 and are presented monthly in Documentation section 9, tables 9.1.1 for energy, 9.1.2 for HLH, and 9.1.3 for LLH.

4.4 Federal System 80 Water Year Load-Resource Balance

To determine the load-resource balance for the Federal system under each of the 80 historical water years, the forecasted amount of resources for each year of the 80 historical water years is estimated and compared to loads. The monthly Federal System surplus/deficits for FY 2018 and FY 2019 under each of the 80 water years are found in Documentation tables 10.1.1 for energy, 10.1.2 for HLH, and 10.1.3 for LLH. These are used by RevSim in the calculation of secondary energy revenues. *See* the Power and Transmission Risk Study, section 3.1.2.1.

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SUMMARY TABLES

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Table 1
Regional Dialogue Preference Load Obligations
Forecast By Product
Annual Energy in aMW
(Sums may not be exact due to rounding)

A	B	C
	FY 2018	**FY 2019**
Preference Customer Load Obligations		
1. Load-Following Customers *(Including Federal Agencies and does not include AHWM loads not served by BPA)*	3,295	3,311
2. Block	0	0
3. Slice Block	1,759	1,812
4. Slice Output from Tier 1 System	1,868	1,826
5. Total Preference Load Obligations *(Sum of lines 1 through 4)*	**6,922**	**6,949**

Table 2
Loads and Resources – Federal System Summary
Annual Energy in aMW
(Sums may not be exact due to rounding)

A	B	C
	FY 2018	**FY 2019**
Firm Obligations		
1. Load Following	3,295	3,311
2. Tier 1 Block	0	0
3. Slice	3,627	3,638
4. Direct Service Industries	61	88
5. Contract Deliveries *(Not including Firm Surplus Sale)*	566	540
6. Firm Surplus Sale	167	0
7. Total Net Obligations *(Sum lines 1 through 6)*	**7,715**	**7,576**
Net Resources		
8. Net Hydro Resources	6,592	6,588
9. Other Resources	1,158	995
10. Contract Purchases *(Not including System Augmentation)*	203	182
11. System Augmentation Purchases	0	45
12. Federal System Transmission Losses	-238	-234
13. Net Total Resources *(Sum lines 8 through 12)*	**7,715**	**7,576**
Surplus/Deficit		
14. Firm Surplus/Deficit *(Line 13 – line 7)*	**0**	**0**

Table 3
Loads and Resources – Federal System Components
Annual Energy in aMW
(Sums may not be exact due to rounding)

A	B	C
	FY 2018	**FY 2019**
Firm Obligations		
1. Load Following *Total*	**3,295**	**3,311**
2. Preference Customers	2,998	3,000
3. Fed. Agencies	113	128
4. USBR Obligation	183	183
5. Federal Diversity	0	0
6. Tier 1 Block *Total*	**0**	**0**
7. Tier 1 Block Obligation	0	0
8. Slice *Total*	**3,627**	**3,638**
9. Slice Block	1,759	1,812
10. Slice Output from Tier 1 System	1,868	1,826
11. Direct Service Industries *Total*	**61**	**88**
12. DSI Obligation	61	88
13. Contract Deliveries *Total*	**733**	**540**
14. Exports	505	478
15. Intra-Regional Transfers (Out)	162	62
16. Firm Surplus Sale	167	0
17. Total Firm Obligations *(Line 1 + line 6+ line 8+ line 11+ line 13)*	**7,715**	**7,576**

Table 3 - continued
Loads and Resources – Federal System Components
Annual Energy in aMW
(Sums may not be exact due to rounding)

A	B	C
	FY 2018	**FY 2019**
Net Resources		
18. Hydro Resources *Total*	**6,592**	**6,588**
19. Regulated Hydro – Net	6,250	6,245
20. Independent Hydro – Net	339	339
21. Small Hydro – Net	2.9	2.9
22. Other Resources *Total*	**1,158**	**995**
23. Cogeneration Resources	0	0
24. Combustion Turbines	0	0
25. Large Thermal Resources	1,100	937
26. Renewable Resources	60	60
27. Small Thermal & Misc. Resources	0	0
28. Contract Purchases *Total*	**203**	**227**
29. Imports	1	1
30. Intra-Regional Transfers (In)	30	10
31. Non-Federal CER	136	137
32. Slice Transmission Loss Return	36	35
33. Augmentation Purchases	0	45
34. Reserves & Losses	**-238**	**-234**
35. Contingency Reserves (Non-Spinning)	0	0
36. Contingency Reserves (Spinning)	0	0
37. Generation Imbalance Reserves	0	0
38. Load-Following Reserves	0	0
39. Federal Transmission Losses	-238	-234
40. Total Net Resources *(Sum of lines 18+22+28+34)*	**7,715**	**7,576**
41. Total Firm Surplus/Deficit *(Line 40 – line 17)*	**0**	**0**

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BONNEVILLE POWER ADMINISTRATION
November 2016