

Hydropower Economic Exposure Methods

The economic model in CRRIM quantifies the economic exposure resulting from variable reservoir elevations on hydropower users who receive power from the CRSP units, Hoover, Parker and Davis facilities.

The methods for calculating the economic exposure for hydropower users in CRRIM are extracted and adapted from The Bathtub Ring by Ning et al (2015). While Ning et al. applied these methods only to Hoover, the approach used in CRRIM applies the same methodology to the CRSP facilities, Parker and Davis.

Hydropower Economic Exposure Model Framework

The economic impacts are expressed as the change in total cost of fulfilling energy needs designated in the current WAPA contracts. The change in cost is a function of the difference between WAPA and spot market energy rates and the amount of energy purchased on the spot market due to reductions in Colorado River facility generation. The relationship and parameters of the cost is outlined below:

$$TC = R_w (G) + [SR][A - (G)]$$

TC = Total cost (\$)

R_w = Rate of electricity (\$/MWh) bought from WAPA

G = Total hydropower generation (MWh)

SR = Rate of electricity (\$/MWh) on the open market

A = Total power allocated (MWh)

The model outputs the total cost (TC) for each hydropower facility. Based on contract conditions, it is assumed that contractors will purchase spot market power to supplement hydropower when their full allocation is not available (Western Area Power Administration 2014), and that contractors will continue to pay for Colorado River hydropower for the duration of the modeling horizon regardless of the amount of hydropower received. WAPA contracts bind contractors to Hoover hydropower purchases through 2067, despite the amount of hydropower produced and relative hydropower rate. Theoretically, contractors are still financially responsible for their portion of Hoover Powerplant operating costs even if is no long physically possible to produce hydropower. CRSS data shows this point when Lake Mead is approximately at an elevation of 1,015' (Bureau of Reclamation 2014).

Model Components

Hydropower Generation (G)

G, measured in MWh's, is the total amount of hydropower generated at each Colorado River hydropower facility. Monthly energy data from CRSS is used as the foundation for determining the total cost at each facility.

Allocated Power (A)

A, is the full amount of hydropower, measured in MWh, allocated in total to all contractors. Monthly power allocations for each of the Colorado River facilities were obtained from the following sources for 2018:

Colorado River Storage Project Units

<https://www.wapa.gov/regions/CRSP/PowerMarketing/Documents/FY2009andafterseasonalsuimary.pdf>

Hoover Dam

https://www.wapa.gov/regions/DSW/PowerMarketing/Documents/FY18%20Billing_Final.pdf

Lower Colorado (Parker Dam & Davis Dam)

https://www.wapa.gov/regions/DSW/Rates/Pages/PDP_FY17_RateDesign_Final.pdf

Hydropower (R_w)

R_w is the rate a contractor pays for hydropower from a Colorado River facility. Western Area Power Association (WAPA), the entity in charge of marketing Hoover hydropower, determines the rate of hydropower through a specific rate-setting methodology.

WAPA's rates are a function of the amount of generated hydropower sold and operational costs on an annual basis. At the beginning of WAPA's Fiscal Year, WAPA determines the amount of revenue required to fulfill all fiscal expenses for the year related to hydropower production. The annual revenue requirement is total operational and maintenance expenses for the year less water sales, previous year revenue carry-over, and additional miscellaneous revenues anticipated for the year. WAPA calculates annual rates by dividing the total annual revenue by total annual generation.

In the analysis, the price of hydropower, measured in dollars per MWh, is based on WAPA's current rate setting methodology.

$$\text{Rate } (R_w) = \frac{RR_{2018}}{G}$$

RR_{2018} = WAPA's Annual Revenue Requirement in 2018

G = Total annual hydropower generation

WAPA's actual 2018 base charge was used for the Annual Revenue Requirement (RR_{2018}) because 2018 is baseline year for the analysis.

Annual revenue requirements for each of the Colorado River facilities were obtained from the following sources for 2018:

Colorado River Storage Project Units (pg. 94)

<https://www.wapa.gov/regions/CRSP/rates/Documents/FY2018%20CRSP-MC%20SLIP-AP%20Customer%20Binder%20Draft%20Final%20with%20Slides.pdf>

Hoover Dam

https://www.wapa.gov/regions/DSW/PowerMarketing/Documents/FY18%20Billing_Final.pdf

Lower Colorado (Parker Dam & Davis Dam)

https://www.wapa.gov/regions/DSW/Rates/Pages/PDP_FY17_RateDesign_Final.pdf

Spot Market Rates (SR)

For purposes of assessing economic impacts, the CRRIM model assumes that contractors will replace hydropower shortfalls from their WAPA contracts with energy from the spot market. SR is the rate a

contractor would pay, measured in dollars per MWh, for supplemental energy from the spot market. The spot market figures is used as an analogue for replacement cost based on an assumption that supplemental power needs would vary enough inter-annually to prohibit contractors from entering into long-term power purchase agreements as a cheaper alternative, although this obviously might vary from user to user depending on the nature of their individual portfolios.

In the United States, energy markets are regionally delineated. International Exchange (ICE) records energy trades through a few central hubs in each region. Since spot market rate data is often utilized in futures energy trading, the rate data needed for the analysis was considered sensitive proprietary information. Data available for the analysis was limited to one energy-trading hub per region: Northwest-Mid Columbia, Southwest-Palo Verde, California-SP15, California-NP15, Texas-ERCOT North, MISO-Indiana.

Spot market rates were obtained from the U.S. Energy Information Administration (EIA). EIA obtains its data through a special agreement with ICE, a brokerage platform for over-the-counter and futures energy trades. EIA’s spot market rate data is composed of weighted daily averages of traded electricity prices at the specified trading hub. All hubs reflect Day-Ahead, Peak Load pricing. Off-peak load rates were not utilized because a majority of hydropower is delivered during peak hours.

To simplify the rate analysis, the 2018 monthly average across all the trading hubs is used as the spot market price for all Colorado River hydropower facilities (Table 1). The spot market rates obtained from EIA were further adjusted in order to reflect the added value of hydropower being delivered during core peak hours. Electricity rates change on an hourly basis. Core peak load occurs from 4-11 PM when the most electricity is demanded, and electricity prices are the highest. However, peak rates are the average of hourly rates over the 16-hour peak load time period (8 AM-11 PM). Accordingly, spot market rates were increased by 13.5% to reflect core peak load prices. This rate increased should be viewed as a lower bound since it does not reflect the value added by flexibility and ramping, regulation, and reserve power unique to hydropower produced at Hoover Powerplant.

Table 1: Spot market prices by hub, average and average adjusted.

Month	ERCOT North	Indiana Hub		NP15 EZ Gen	Palo Verde	SP15 EZ Gen		Adjusted Average
	345KV Peak	RT Peak	Mid C Peak	DA LMP Peak	Peak	DA LMP Peak	Average	
Jan	\$ 35.74	\$ 46.60	\$ 21.72	\$ 34.00	\$ 26.95	\$ 36.69	\$ 33.62	\$ 38.16
Feb	\$ 25.27	\$ 32.45	\$ 21.85	\$ 47.11	\$ 27.37	\$ 40.14	\$ 32.36	\$ 36.73
Mar	\$ 27.86	\$ 32.38	\$ 20.68	\$ 34.13	\$ 24.69	\$ 32.35	\$ 28.68	\$ 32.55
Apr	\$ 28.40		\$ 18.66	\$ 35.65	\$ 25.64	\$ 28.98	\$ 27.46	\$ 31.17
May	\$ 34.53		\$ 12.57		\$ 22.58	\$ 25.01	\$ 23.67	\$ 26.87
Jun	\$ 40.50		\$ 18.01	\$ 36.42	\$ 33.32	\$ 33.80	\$ 32.41	\$ 36.78
Jul			\$ 79.09	\$ 157.34	\$ 115.18	\$ 113.21	\$ 116.21	\$ 131.89
Aug		\$ 36.13	\$ 72.72	\$ 95.96	\$ 88.14	\$ 93.06	\$ 77.20	\$ 87.62
Sep		\$ 44.20	\$ 29.04		\$ 30.27	\$ 38.86	\$ 35.59	\$ 40.40
Oct		\$ 46.71	\$ 45.24	\$ 48.94	\$ 31.09	\$ 42.71	\$ 42.94	\$ 48.73
Nov		\$ 42.93	\$ 56.16	\$ 69.27	\$ 39.67	\$ 60.59	\$ 53.73	\$ 60.98
Dec			\$ 49.55	\$ 82.61	\$ 40.24	\$ 60.17	\$ 58.14	\$ 65.99

Applying the Hydropower Economic Exposure Model to the Colorado River Facilities**Hoover Total Hydropower Cost**

$$\text{IF: } (A_H - G_H) \geq 0$$

$$\text{THEN: } TC_H = \left[\left(\frac{RR_H}{G_H} \times G_H \right) + (A_H - G_H) \times SR_{LB} \right]$$

$$\text{IF: } (A_H - G_H) \leq 0$$

$$\text{THEN: } TC_H = \frac{RR_H}{G_H} \times G_H$$

TC_H = Total hydropower cost (\$) (Hoover)

RR_H = Revenue requirement for WAPA (\$) (Hoover)

A_H = Total monthly allocated power (MWh) (Hoover)

G_H = Total monthly hydropower generation (MWh) (Hoover)

SR_{LB} = Energy rate for spot market power (\$/MWh)

Parker-Davis Total Hydropower Cost

$$\text{IF: } (A_{PD} - G_{PD}) \geq 0$$

$$\text{THEN: } TC_{PD} = \left[\left(\frac{RR_{PD}}{G_{PD}} \times G_{PD} \right) + (A_{PD} - G_{PD}) \times SR_{LB} \right]$$

$$\text{IF: } (A_{PD} - G_{PD}) \leq 0$$

$$\text{THEN: } TC_{PD} = \frac{RR_{PD}}{G_{PD}} \times G_{PD}$$

TC_{PD} = Total hydropower cost (\$) (Parker-Davis)

RR_{PD} = Revenue requirement for WAPA (\$) (Parker-Davis)

A_{PD} = Total monthly allocated power (MWh) (Parker-Davis)

G_{PD} = Total monthly hydropower generation (MWh) (Parker-Davis)

SR_{LB} = Energy rate for spot market power (\$/MWh)

CRSP Total Hydropower Cost

$$\text{IF: } (A_{CRSP} - G_{CRSP}) \geq 0$$

$$\text{THEN: } TC_{CRSP} = \left[\left(\frac{RR_{CRSP}}{G_{CRSP}} \times G_{CRSP} \right) + (A_{CRSP} - G_{CRSP}) \times SR_{UB} \right]$$

$$\text{IF: } (A_{CRSP} - G_{CRSP}) \leq 0$$

$$\text{THEN: } TC_{CRSP} = \frac{RR_{CRSP}}{G_{CRSP}} \times G_{CRSP}$$

TC_{CRSP} = Total hydropower cost (\$) (CRSP)

RR_{CRSP} = Revenue requirement for WAPA (\$) (CRSP)

A_{CRSP} = Total monthly allocated power (MWh) (CRSP)

G_{CRSP} = Total monthly hydropower generation (MWh) (CRSP)

SR_{UB} = Energy rate for spot market power (\$/MWh)

Total Annual Hydropower Economic Exposure

$$EE = TC_H + TC_{PD} + TC_{CRSP}$$