HYDROPOWER ECONOMIC EXPOSURE METHODS

INTRODUCTION

The economic model in RiverViz quantifies the economic exposure resulting from variable reservoir elevations on hydropower users who receive power from the Colorado River Storage Project (CRSP) units, Hoover, Parker and Davis facilities.

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

Acronym Glossary

CRSP: Colorado River Storage Project
CRSS: Colorado River Simulation System
EIA: U.S. Energy Information Administration
FY: Fiscal Year
ICE: Intercontinental Exchange
WAPA: Western Area Power Administration

HYDRO-ECONOMIC EXPOSURE MODEL FRAMEWORK

The economic impacts are expressed as the change in total cost of fulfilling energy needs designated in the current Western Area Power Administration (WAPA) contracts. The change in cost is a function of the difference between WAPA 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:

$$TC = R_W(G) + [SR][A - G] \text{ (Equation 1)}$$

TC = Total cost ($)
R_W = Rate of electricity ($/MWh) bought from WAPA
G = Total hydropower generation (MWh)
SR = Rate of electricity ($/MWh) on the spot 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 (WAPA 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 operating costs, for example contractors are responsible for Hoover Power Plant operating costs even if it is no longer physically possible to produce hydropower. Colorado River Simulation System (CRSS) data shows this point when Lake Mead is approximately at an elevation of 1,015' (Bureau of Reclamation 2014).

Model Components

The Financial Risk in the Economic Exposure figure is determined by calculating the surplus cost to contractors associated with buying power from the open market as power generation declines. Therefore, the rate of electricity from the open market from Equation 1 was the only rate considered. In other words, if there is a deficit in power generation the supplemental cost (SC) would be calculated as follows:

$$SC = (A - G) \times SR \text{ (Equation 2)}$$

Hydropower Generation (G)

G, measured in MWh, 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 its respective fiscal year (FY):

*Colorado River Storage Project Units (FY 2020)** - Link
Hoover Dam (FY 2023) - Link
Lower Colorado (Parker Dam & Davis Dam, FY 2021) - Link

*The CRSP value comes from the Salt Lake City Area and Integrated Projects (SLCA/IP) unit. CRSP generates roughly 96.5% of the energy from the whole SLCA/IP unit, so to get the Allocated Power number the SLCA/IP number (5,135 GWh) was multiplied by 96.5% to get the CRSP Allocated Power number (4,955 GWh).

Spot Market Rates (SR)

For purposes of assessing economic impacts, the RiverViz 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 are 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. The Intercontinental Exchange (ICE) - a brokerage platform for over-the-counter and futures energy trades- 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 (Mid C Peak), Southwest-Palo Verde (Palo Verde Peak), California-SP15 (SP15 EZ Gen DA LMP Peak), California-NP15 (NP15 EZ Gen DA LMP Peak), MISO-Indiana (Indiana Hub RT Peak).

Spot market rates were obtained from the U.S. Energy Information Administration (EIA). EIA obtains its data through a special agreement with ICE. 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 2022 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 increase 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 the hydropower facilities.

Table 1: Spot market prices by hub, average and average adjusted in $/MWh.

Month	Indiana Hub RT Peak	Mid C Peak	NP15 EZ Gen DA LMP Peak	Palo Verde Peak	SP15 EZ Gen DA LMP Peak	Average	Adjusted Average
Jan	$72.08	$42.08	$58.44	$40.40	$53.17	$53.23	$60.42
Feb	$66.54	$39.90	$47.48	$38.88	$43.30	$47.22	$53.59
Mar		$34.92	$51.13	$35.08	$38.11	$39.81	$45.18
Apr	$70.25	$86.28	$76.77	$65.50	$58.98	$71.56	$81.21
May	$121.75	$60.96	$87.21	$64.61	$60.13	$78.93	$89.59
Jun	$164.96	$36.52	$82.51	$80.83	$72.22	$87.41	$99.21
Jul	$131.25	$77.00	$91.57	$104.15	$86.36	$98.06	$111.30
Aug	$118.00	$153.38	$128.03	$156.61	$126.60	$136.52	$154.95
Sep	$102.93	$129.30	$233.19	$192.86	$130.12	$157.68	$178.97
Oct		$ 72.46	$84.50	$59.94	$67.08	$70.99	$80.58
Nov	$68.00	$101.04	$123.54	$74.83	$89.67	$91.41	$103.76
Dec	$93.50	$269.64	$303.62	$239.05	$245.79	$230.32	$261.41

FINANCIAL RISK

Applying Hydropower Economic Exposure Model to Colorado River Facilities

Hoover Supplemental Hydropower Cost

IF: $(A_H - G_H) > 0$ (deficit)

THEN: $SC_H = (A_H - G_H) \times SR$

IF: $(A_H - G_H) \leq 0$ (even or surplus)

THEN: $SC_H = 0$

SC_H = Supplemental hydropower cost ($) (Hoover)
A_H = Total monthly allocated power (MWh) (Hoover)
G_H = Total monthly hydropower generation (MWh) (Hoover)
SR = Energy rate for spot market power ($/MWh)

Parker-Davis Supplemental Hydropower Cost

IF: $(A_{PD} - G_{PD}) > 0$ (deficit)

THEN: $SC_{PD} = (A_{PD} - G_{PD}) \times SR$

IF: $(A_{PD} - G_{PD}) \leq 0$ (even or surplus)

THEN: $SC_{PD} = 0$

SC_{PD} = Supplemental hydropower cost ($) (Parker-Davis)
A_{PD} = Total monthly allocated power (MWh) (Parker-Davis)
G_{PD} = Total monthly hydropower generation (MWh) (Parker-Davis)
SR = Energy rate for spot market power ($/MWh)

CRSP Supplemental Hydropower Cost

IF: $(A_{CRSP} - G_{CRSP}) > 0$ (deficit)

THEN: $SC_{CRSP} = (A_{CRSP} - G_{CRSP}) \times SR$

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

THEN: $SC_{CRSP} = 0$ (even or surplus)

SC_{CRSP} = Supplemental hydropower cost ($) (CRSP)
A_{CRSP} = Total monthly allocated power (MWh) (CRSP)
G_{CRSP} = Total monthly hydropower generation (MWh) (CRSP)
SR = Energy rate for spot market power ($/MWh)

Cumulative Costs Over CRSS Projection Period

Hydropower Economic Exposure Figure

- For a given hydrology ensemble scenario, the CRSS model outputs multiple traces of data that correspond to energy generation in GWh for a given facility over a projection period -present to 2060.
- The supplemental hydropower cost is calculated on a monthly basis for each of the Colorado River facilities, ensembles, and trace ids, using the formulas outlined in the previous boxes.
- The total annual cost is calculated by adding monthly supplemental costs on a yearly basis for each of the Colorado River facilities, ensembles, and trace ids.
- The cumulative cost through the maximum projection period is calculated for each of the Colorado River facilities, ensembles, and trace ids.
- Lastly, summary statistics per ensemble and trace id for each Colorado River facility are calculated and shown in a box plot (i.e., min, Q1, median, Q3, and max) in billions of $, representing financial risk.