Methodology for SLCA/IP Resource Analysis

for Consideration in the Development of the

2025 Marketing Plan

Western Area Power Administration

Colorado River Storage Project Management Center

Purpose

The purpose of this report is to provide Western Area Power Administration (Western) management with analyses of the availability of resources from the Salt Lake City Area Integrated Projects (SLCA/IP) for the 2025 Marketing Plan. Further, this report outlines the methods used to project available resources for October 1, 2024, to September 30, 2064, the time period covered by this marketing plan.

This analysis includes information on the following:

- SLCA/IP Sustainable Hydropower (SHP) electrical energy available by season
- SLCA/IP Contract Rate Of Delivery (CROD) Capacity by season

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SLCA/IP Resource Analysis for Consideration in the 2025 Marketing Plan

2025 Marketing Plan

The 2025 Marketing Plan will implement criteria for long-term contracting of Firm Electric Service (FES) of the SLCA/IP power resources to eligible preference customers. These products include Sustainable Hydropower (SHP) energy and a Contract Rate of Delivery (CROD). To accomplish this, Western will determine the amount of SLCA/IP capacity and energy resource available to offer to FES customers for inclusion in a long term contract. Specifically, SHP energy and CROD will be calculated for both the summer and winter seasons.

Seasonal SHP Electrical Energy

The 2025 Marketing Plan is proposed to include a determination of the amount of sustainable electrical energy to be put under FES contract for a 40-year period. The analysis of sustainable energy for winter and summer seasons uses the following equation:

$$\text{Seasonal SHP energy} = \left(\text{Average energy}\right) \text{ or } (\text{Median energy}) - \text{Project use} - \text{Losses}$$

Each of the components of this equation, the input values and assumptions used and the models used are described below.

Hydrology Input Data

The Bureau of Reclamation (Reclamation) uses the Colorado River System Simulation (CRSS) model to simulate the operation of Reclamation's dams on the Colorado River system. This model is used as a tool to provide technical analysis to help inform management, policy makers and the public prior to making important decisions on operation of the Colorado River Storage Project hydroelectric facilities. CRSS model results are the data source for monthly release data and for end-of-month reservoir elevation levels used in the analysis projecting available resources for this marketing plan.

Western received 105 CRSS modeled hydrology outputs, or traces, from Reclamation. Each trace provides hydrological data from October 2024 through September 2064 and includes the monthly water volume released for each CRSP power plant, and end-of-month reservoir elevations for each CRSP reservoir. CRSS modeling assumptions included:

- Initial conditions of each trace were those observed on January 1, 2016.
- Water demands have been projected to 2062, therefore Reclamation extrapolated the 2062 water demands out two additional years to 2064.
- The 2007 shortage criteria guidelines are assumed to be in place through 2064.
- Operating criteria for Glen Canyon Dam were those of the LTEMP EIS Hybrid Alternative (Appendix 3).
- Current operating criteria for the other CRSP power units continue through 2064 (Appendix 3).
- No experiments were included in the CRSS model runs (e.g., High Flow Experiments, Trout Management Flows).

CRSS Model Runs and GT Max Superlite v1 Model

As mentioned above, Reclamation provided CRSS modeling results that included monthly release volume and end-of-month elevation projections for each of the CRSP project power plants. The result of the CRSS modeling are used as the water input data for the GT Max Superlite v1 model.

The GT Max Superlite v1 model uses monthly water release data, operational criteria, end-of-month reservoir elevations, projected hourly energy prices and other information as input values to generate estimates of hourly energy production for one week each month and extrapolates these results out to include monthly and seasonal estimates of SLCA/IP energy for each year of a CRSS trace. The model optimizes generation based on hourly energy prices. Hourly energy prices used for this analysis were real electrical prices as forecasted by the Energy Information Agency (EIA)[1]. See Appendices 1 and 3 for details of assumptions and inputs used in the GT Max Superlite v1 modeling.

Due to the large amount of analysis involved with running all 105 CRSS hydrologic traces, Western needed to use a subsample of these for this assessment. To ensure the subsample included traces representative of the full spectrum of hydrologic scenarios (wet to dry), total release volumes from Glen Canyon from October 2024 to September 2064 were summed for each trace. The summed release volumes were then organized into quartiles and five traces were randomly selected from each quartile using a random number generator for a total of 20 traces.

In summary, the GT Max Superlite v1 model runs provide seasonal SLCA/IP energy for each 40 years, for each 20 hydrology traces. Hourly total SLCA/IP output levels produced by the GT Max Superlite v1 model are available. See Appendices 1 and 3 for more information about the modeling inputs and assumptions used in this analysis.

> **Average and Median Energy:** Seasonal SHP energy values were projected using the GT Max Superlite model and the CRSS traces as described above. Historical form PO&M 59[2] data were used to account for energy generation from the smaller SLCA/IP hydropower resources. Small hydropower resources included Upper and Lower Molina, Rio Grande, Elephant Butte, McPhee, and Towaoc. The modeling results included summer and winter season energy values for each year modeled. These results were then used to calculate average available energy and create an exceedance curve[3] of available energy values for both the summer and winter seasons. From this exceedance curve, AVERAGE and MEDIAN energy available for each season was calculated.
>
> **Project Use**: The projected seasonal project use energy needs of authorized participating projects during the 40-year period beginning on October 1, 2024, were subtracted from the average and median seasonal energy amounts. Project use subtracted for this analysis included 283 GWh in the summer months and 158 GWh in the winter months on an annual basis.

[1] These real electrical prices were also used for power system model impacts in the Glen Canyon Dam Operations Long-term Monitoring and Experimental Environmental Impact Statement (LTEMP EIS)

[2] Form PO&M 59 is the Power Operations and Maintenance 59 form which is produced monthly by Reclamation and includes data on electrical generation.

[3] A cumulative probability curve can be used to derive percentile rankings. An exceedance curve is the opposite of this. It gives the likelihood of a variable being exceeded. In this case – the likelihood of an amount of MWhs being exceeded.

Losses: Transmission losses of 8% were subtracted from the average and median seasonal energy amounts. Losses included transmission and transformation losses on the CRSP transmission system and on the electrical systems of other utilities used for wheeling.

2025 SLCA/IP Seasonal CROD

SLCA/IP capacity commitment levels are an electrical service provided to FES customers and are referred to as the Contract Rate of Delivery or CROD. Western has proposed to extend the existing CROD[4] which was developed for the Post-1989 Marketing Plan. Western calculated the CROD by starting with the nameplate capacity of the SLCA/IP power units and subtracting unavailable capacity, reserves, and project use capacity. The CROD commitment levels developed for the Post-1989 Marketing Plan were carried over, unchanged, for the Post-2004 Marketing Plan and are the current CROD commitment levels described below.

	Summer	**Winter**
Nameplate Capacity	1,737	1,737
Unavailable Capacity	-91	-130
Reserves	-174	-174
Project Use	-176	-39
CROD	**1,296**	**1,394**

Components of the Post-1989 Seasonal CROD

Nameplate Capacity: the sum of the installed or nameplate capacity of the power units that comprise the SLCA/IP at full power head. Power head is the elevation difference between the full power pool (full reservoir elevation) and the tailrace (the water level below the dam).

Unavailable Capacity: the amount of SLCA/IP operating capacity that is estimated to NOT be available because full power head is not always available, e.g. the reservoir is not always full. Since reservoir levels vary constantly and cannot always be predicted, Western set a level of unavailable capacity at the 90% exceedance level.

Reserves: Western participates in the operation of an integrated electrical system. It is required to have reserve capacity available to respond to an electrical emergency.

Project Use: Irrigation projects were authorized in the law that authorized the construction of the CRSP water and power system. These numbers are full project development.

Prior to the final determination of CROD seasonal commitments and electrical energy for the 2025 Marketing Plan, the CRSP electrical system capacities and limitations will be considered by Western.

[4] Federal Register Notice, December 16, 2015 80 FR 78224

Contract Terms and Conditions are NOT Included

This analysis provided seasonal values only. Monthly values and scheduling requirements are provided under contract terms to FES customers. These are identified and described in the table below and do not impact the level of marketable resource. Monthly commitment levels are not included, but will be negotiated following the implementation of the 2025 Marketing Plan between Western and its FES customers.

SLCA/IP Energy and Capacity Delivery Parameters

Name	Time period	Description
Sustainable Hydropower Energy (SHP - energy)	By month	Monthly energy available for scheduling and delivery (MWh). The energy total for each of the 6 months of each season must total the SHP seasonal energy identified in the Marketing Plan.
Sustainable Hydropower Capacity (SHP - capacity)	By month	Maximum amount allowed to be scheduled and delivered during any point in time (MW).
Minimum schedule	By month	Required minimum amount that must be scheduled during the month. This is identified in the FES contract. A lesser amount may be determined by Western each season.
Available Hydropower Capacity & Energy (AHP)	By month	Monthly energy and capacity available for schedule and delivery above SHP as resources permit.

The 2025 Marketing Plan will allocate both seasonal CROD and SHP energy to eligible FES customers. In the Post-1989 Marketing Plan, SLCA/IP FES customers were allocated energy by season and then allowed to determine monthly energy and associated capacity values, up to their proportion of the total identified CROD[5]. Since 1998, Western has determined the monthly capacity values for each customer, based on the seasonal CROD, but did not change the monthly energy pattern selected by the customer. Western has the opportunity, in collaboration with customers, to determine the monthly energy pattern, within the seasonal allocation, as well as the monthly capacity allocation in the 2025 Marketing Plan allocations.

[5] Western allocated energy and allowed customers to choose capacity amounts in order to allow the customer to bundle a Western energy and capacity product that matched the customer's total load factor. However, since operational restrictions were implemented at GCD and with the advent of "contract amendment 4", Western delivers SHP capacity and energy according to the customer's preschedule.

APPENDIX 1
The GT Max Superlite v1 Model[6]

The **Generation and Transmission Maximization Superlite v1 Model** (**GT Max Superlite v1**) is a software tool for electrical energy and power analysis. GT Max is used extensively by power companies, electric utilities, system operators, and merchant companies around the world to address strategic issues, such as regional interconnections, power market studies, market entry analysis, developing optimal spot market and contract portfolios, economic evaluation of renewable resources, etc. With its detailed representation of the power generation and transmission system (hourly simulation, DC optimal power flow, and detailed hydro and renewable resources), the model can track hourly costs, revenues, and profits for each generating unit. For this analysis, we used a modified version of the GT Max model called GT Max Superlite v1. This model uses most of the same optimization function that are in GT Max, but uses Microsoft Excel as the framework for data input and analysis and LINGO software as the solver program. Converting to this format allows for much greater flexibility in the modelling analysis as well as reduces the computation time required to complete analyses of large datasets.

Economic Dispatch Mode vs EMMO Scheduling Goals and Guidelines

The GT Max Superlite v1 model can be used for different purposes and can be run in different modes. The two modes typically identified are:

- **Economic Dispatch Mode**: This formulation of the GT Max model has an objective function of maximizing electrical energy value. It “follows” hourly prices and moves water – within constraints – to hours in which the price or value is highest.

- **EMMO Scheduling Goals and Guidelines**: So named because CRSP MC’s Energy Management and Marketing Office (EMMO) requested that the model assist in formulating the SLCA/IP preschedule. The objective criteria are to schedule water releases to: (1) follow total customer load with CRSP resources, (2) identify purchase energy requirements in on- and off-peak blocks in day-ahead markets, (3) minimize real-time spot purchase, and (4) set the minimum release from Glen Canyon to be identical each night of the week as well as the daily total release from GCD.

For purposes of the marketable resource analysis the GT Max model was run in Economic Dispatch mode. The reasons for using this choice of mode are:

- The proposed 2025 Marketing Plan requires identification of seasonal energy. While daily patterns specified by the GT Max model might differ, the seasonal energy amounts will not differ when the Economic Dispatch is used vs EMMO Scheduling Goals and Guidelines are used.

- Western will be implementing the 2025 Marketing Plan through FES contracts. As discussed above, SHP energy and capacity by month will be negotiated and may be modified. Therefore, it would be inconsistent to model 2025 energy amounts using GT Max Superlite v1 in EMMO mode.

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[6] The GT Max Superlite v1 model was developed for Western by Argonne National Laboratory. It was developed specifically for the 2025 analysis of SHP energy and CROD. The configuration of this model differs from the GT Max and from the GT Max lite models.

APPENDIX 2
The Colorado River System Simulation Model

The Colorado River System Simulation model (CRSS) was developed by Reclamation in the early 1970s. It was implemented in River Ware in 1996. CRSS is a basin-wide, long-term planning and policy model. It is also used to simulate and analyze day-to-day operations. It is Reclamation's primary tool for analyzing the Colorado River Basin operations and analyzing projected development and hydrology.

It simulates the operations at 12 reservoirs and deliveries to over 500 individual water users. It is also used for environmental compliance studies and bi-national negotiation with Mexico. It is updated and maintained continuously by Reclamation's Colorado River Modeling Work Group. Stakeholders who are members of the Colorado River Stakeholder Modeling Work Group run the CRSS model. Members of the Stakeholder Work Group are comprised of technical stakeholders that have the capability to run Reclamation's models or have a vested interest in learning to do so.

Model outputs are a range of future system conditions for:

- End-of-month reservoir levels
- Monthly and annual dam water releases
- Monthly and annual river flows

Two "official" simulations are made each year (January and August). Additional "official" simulations are made at the request of the Work Group, Western or the Basin States.

<u>CRSS Model Inputs</u>

- Initial Reservoir Conditions
- Operating Policy
    - 2007 Interim Guidelines
- Hydrology
- Water Demands
    - Upper Basin Demands are provided by the Upper Colorado River Commission (UCRC)
    - Lower Basin Demands are provided by each Lower Basin state

Appendix 3
Inputs and Assumptions Used in the GT Max Superlite v1 Model Runs for the 2025 Marketing Plan Analysis

The GT Max Superlite v1 model requires a number of inputs and assumptions. Some of these inputs and assumptions apply to the entire system and some are power plant specific. Below is a list of inputs and assumptions used for this analysis:

General inputs/assumptions

1. Hydrology – 20 traces selected from 105 CRSS traces provided by Reclamation that include volumes described in the current preferred alternative for LTEMP. Traces were selected by determining total release volume for each of the 105 traces from Oct, 2024 – September, 2065 and arranging total release volumes into quartiles. From each quartile, 5 traces were randomly selected using a random number generator. Selected traces included: 2, 6, 19, 24, 29, 30, 33, 34, 41, 43, 49, 58, 64, 66, 78, 88, 90, 91, 95, and 104.
2. Transmission loss = 8%.
3. Energy prices – We used the same energy prices used for the LTEMP EIS analysis. However, hourly prices from the LTEMP analysis are only available thru 2035. Hourly energy prices from 2035 were used for the remaining years. The actual price is not important in this modelling exercise since prices are only used to generate a daily pattern.
4. Reserves = 30 MW.
5. Regulation = 40 MW
6. Project use loads – January = 23,439 MW, February = 21,201 MW, March = 33,725, April = 45,017 MW, May = 50,792 MW, June = 49,284 MW, July = 46,530, August = 46,545 MW, September = 45,024 MW, October = 33,708 MW, November = 22,669, and December = 23,440 MW
7. The holidays of New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving, and Christmas are considered "low flow" days, meaning they are treated like a Sunday.
8. Months in which Lake Powell goes below power-pool elevation (3,490 ft) were removed from the analysis.
9. The model was ran for 1 week and results were extrapolated out to produce monthly results.

Glen Canyon specific inputs/assumptions

1. Weekend vs weekday water release volume –Saturday and Sunday have at least 85% of the volume released on a weekday.
2. Assumes operating criteria described in the D4 (hybrid) alternative in the LTEMP EIS.
3. Minimum release is 5,000 cfs 7pm – 5am; 8,000 cfs the remaining hours.
4. Maximum hourly up ramp was 4,000 cfs.
5. Maximum hourly down ramp was 2,500 cfs.
6. Daily flow fluctuation factor was 10 for June – August and 9 the remaining months.
7. Max daily fluctuation of 8,000 cfs.

Flaming Gorge specific inputs/assumptions

1. Minimum release of 800 cfs.
2. Maximum hourly up ramp of 800 cfs.
3. Maximum hourly down ramp of 1,000 cfs.
4. Hourly releases cannot result in more than a 0. 1 m (≈4 inches) stage change at the Jensen gage.
5. Yampa River flows - average monthly flow from the Deerlodge gage for all years. Yampa flow was needed to make sure the 0.1 m stage restriction was not violated.

Aspinall specific inputs/assumptions

1. Maximum drawdown in Morrow Point of 3 ft when elevation was below 7,144 ft.
2. Maximum daily elevation change in Crystal was 4 ft March – June when reservoir elevation was > 6,748 ft and 10 ft for remaining months when reservoir elevation was >6,733 ft.
3. Maximum 3-day elevation change in Crystal was 6 ft March – June when reservoir elevation was > 6,748 ft and 15 ft for remaining months when reservoir elevation is >6,733 ft.
4. Maximum daily elevation change in Crystal was 0.5 ft March – June when reservoir elevation is < 6,748 ft and 5 ft for remaining months when reservoir elevation was < 6,733 ft.
5. Maximum 7-day elevation change in Crystal was 3.5 ft March – June when reservoir elevation is < 6,748 ft and 20 ft for remaining months when reservoir elevation is < 6,733 ft.
6. Weekend vs weekday water release volume –Saturday and Sunday had at least 85% of the volume released on a weekday.
7. Steady releases from Crystal.