Identifying the total economic value of hydropower at Glen Canyon Dam and implications for adaptive management

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Glen Canyon Dam Adaptive Management Program Annual Reporting Meeting
January 13, 2020   Phoenix, Arizona

Photo Credit: Amy S. Martin
LTEMP EIS Hydropower Resource Goal

Maintain or increase Glen Canyon Dam electric energy generation, load following capability, and ramp rate capability, and minimize emissions and costs to the greatest extent practicable, consistent with improvement and long-term sustainability of downstream resources.
Project N.1

Project N will identify, coordinate, and collaborate with external partners on monitoring and research opportunities associated with operational experiments at GCD designed to meet hydropower and energy resource objectives, as stated in the LTEMP ROD.
Operable utility-scale generating units as of July 2018

Circle area proportional to capacity (MW)

Sources: U.S. Energy Information Administration, Form EIA-860, 'Annual Electric Generator Report' and Form EIA-860M, 'Monthly Update to the Annual Electric Generator Report.'
Economic Cost of Energy

Variable Cost per Unit Energy

- Hydro
- Coal
- Natural gas

Highest Cost

Operable utility-scale generating units as of July 2018
Economic Value of Energy

On-peak Demand

Variable Cost per Unit Energy

$Q$

On-peak Demand

Quantity of Energy

Operable utility-scale generating units as of July 2018

USGS: science for a changing world
Economic Value of Energy, cont.

Variable Cost per Unit Energy

Off-peak Demand

Quantity of Energy
Glen Canyon Dam Hourly Release Pattern AUG 2014

August 1-31, 2014
81 MW reg/res at GCD

August Volume = 800 kaf

Scheduled Hourly Releases
Actual Hourly Releases
Lees Ferry Flow

U.S. Department of Interior, Bureau of Reclamation. August 2014 DOI-DOE
Federal Family Call Glen Canyon Operations Coordination August 19, 2014
Structural Changes in the Electricity Sector

Net generation, Mountain, all sectors, monthly

thousand megawatthours

Data source: U.S. Energy Information Administration
Annual Share of 2024 Generation

California

Colorado River Basin States Excluding California

Preliminary data, do not cite
Natural Gas Prices

U.S. Natural Gas Electric Power Price (Dollars per Thousand Cubic Feet)

https://www.eia.gov/dnav/ng/hist/n3045us3m.htm
Total 2024 Variable Operations Cost by Generation Type

Average Cost per MwH

Coal

Natural Gas

PLEXOS 2024 Variable Operations Cost

Preliminary data, do not cite
Social Cost of Emissions

Average External Marginal Cost per kWh

Total 2024 Variable Operations and Emissions Cost by Generation Type

Average Cost per MwH

Coal
- Regional Cost of NOx Emissions ($2190/ton)
- Regional Cost of SO2 Emissions ($6600/ton)
- Cost of CO2 Emissions ($50/ton)

Natural Gas
- PLEXOS 2024 Variable Operations Cost

Preliminary data, do not cite
Hypotheses

• Using Glen Canyon Dam as baseload generation will reduce total economic costs associated with electricity generation in the Western Interconnect when considering generation mix and fuel and emissions costs.

• Glen Canyon Dam baseload generation would be ‘consistent with improvement and long-term sustainability of downstream resources.’
Methods and Assumptions

• PLEXOS, a production cost model was used to estimate variable costs of generation in 2024 under economic dispatch and flat flows at GCD.

• External CO$_2$ costs and costs by county associated with SO$_2$ and NO$_x$ were estimated following optimization runs.

• This is a short run economic analysis. We are assuming that power capacity requirements are met across scenarios.
2024 Electricity Sector Scenarios

- Business as usual
- Low natural gas price $2/MBtu
- High natural gas price $6/MBtu
- Additional 700 MW solar in Arizona
- Low natural gas price with additional solar
- High natural gas price with additional solar
Modeling Results
# Total Economic Costs

## Western Interconnect Production and Emissions Costs with Flat Flows at Glen Canyon Dam (dollars in thousands)

<table>
<thead>
<tr>
<th>Electricity Sector Scenario</th>
<th>Baseline Production Cost</th>
<th>Change in Production Cost</th>
<th>Change in Emissions Damages</th>
<th>Total Change in Economic Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business as Usual</td>
<td>$22,445,443</td>
<td>$4,698</td>
<td>-$6,611</td>
<td>-$3,725</td>
</tr>
<tr>
<td>High Natural Gas $</td>
<td>$25,699,633</td>
<td>$16,556</td>
<td>$5,681</td>
<td>$22,410</td>
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<tr>
<td>High Natural Gas $ with Solar</td>
<td>$25,636,912</td>
<td>$15,838</td>
<td>-$3,683</td>
<td>$8,865</td>
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<tr>
<td>Low Natural Gas $</td>
<td>$16,693,376</td>
<td>$2,850</td>
<td>$8,917</td>
<td>$19,539</td>
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<tr>
<td>Low Natural Gas $ with Solar</td>
<td>$16,660,672</td>
<td>$4,162</td>
<td>$1,844</td>
<td>$8,167</td>
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<tr>
<td>Solar</td>
<td>$22,396,835</td>
<td>$10,245</td>
<td>-$4,362</td>
<td>$3,341</td>
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</table>

Preliminary data, do not cite
# Total Economic Costs, cont.

## Western Interconnect Production and Emissions Costs with Flat Flows at Glen Canyon Dam (dollars in thousands)

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<td></td>
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<td>Carbon Dioxide</td>
<td>Sulfur Dioxide</td>
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Preliminary data, do not cite
Change in Annual 2024 Generation – Flat Flows Compared to Economic Dispatch

Energy Type
- Coal
- Natural Gas

Change in GWh
- -300
- -20
- -2
- 2
- 20
- 100

Preliminary data, do not cite
Change in Annual 2024 SO₂ Emissions – Flat Flows Compared to Economic Dispatch

-5 to -10,000 tons
-10,000 to -20,000 tons
-20,000 to -30,000 tons
-30,000 to -40,000 tons
-40,000 to -100,000 tons

No Change / <5 tons

Preliminary data, do not cite
Change in Operations and Emissions Costs with Flat Flows at Glen Canyon Dam (dollars in thousands)

Preliminary data, do not cite
Change in Operations and Emissions Costs with Flat Flows at Glen Canyon Dam (dollars in thousands)

Preliminary data, do not cite
Conclusion

• Structural changes in the electricity sector are altering the role of hydropower and how costs associated with experimental flows might accrue.

• Total economic costs of our proxy experimental flow are significantly different when emissions costs are included.

• Decisions we make today in electricity sector expansion will impact the role hydropower plays in the sector and costs associated with environmental and adaptive management of rivers.