DOCKETED	
Docket Number:	19-SB-100
Project Title:	SB 100 Joint Agency Report: Charting a path to a 100% Clean Energy Future
TN #:	232354
Document Title:	The National Hydropower Association Comments - Comments of the National Hydropower Association on SB 100
Description:	N/A
Filer:	System
Organization:	The National Hydropower Association
Submitter Role:	Public
Submission Date:	3/9/2020 3:33:12 PM
Docketed Date:	3/9/2020

Comment Received From: The National Hydropower Association
Submitted On: 3/9/2020
Docket Number: 19-SB-100

Comments of the National Hydropower Association on SB 100

Additional submitted attachment is included below.

March 9, 2020

David Hochschild	Mary Nichols	Liane Randolph
Chair	Chair	Commissioner
California Energy Commission	California Air Resources Board	California Public Utilities Commission
1516 Ninth Street,	1001 I Street	505 Van Ness Avenue
Sacramento, CA 95814	Sacramento, CA 95814	San Francisco, CA 94102

Dear Chair Hochschild, Chair Nichols, and Commissioner Randolph,

The National Hydropower Association (NHA) appreciates the opportunity to comment on California's implementation of S.B. 100. NHA is a non-profit national association dedicated to promoting hydropower as a clean, carbon-free, renewable, and reliable energy resource that serves the Nation's environmental and energy objectives. Our membership consists of more than 240 organizations, including public and investor-owned utilities, independent power producers, equipment manufacturers, and professional organizations that provide legal, environmental, and engineering services to the hydropower industry.

NHA members are excited about the opportunities for hydropower to contribute to a 100% clean energy economy in California. We hope you will find our comments useful in your preparation of an action plan to support the requirements of S.B. 100.

Please feel free to contact us at your convenience if you have any questions or concerns.

Sincerely,

M. Woolf

Malcolm Woolf
President and CEO
National Hydropower Association
601 New Jersey Ave NW
Washington, D.C. 20001
Phone: 202-682-1700

Introduction:

The National Hydropower Association (NHA) believes hydropower is well positioned to play an expanded role in addressing climate change by providing the carbon free flexibility, capacity, energy storage, and other reliability services that are increasing in demand as large amounts of wind and solar replace fossil generation.

Hydropower technologies include run-of-river, reservoir storage, marine (tidal), and pumped storage – with capacity sizes ranging in scale from kilowatts to gigawatts. There are examples of all of these technologies already deployed in California, but there are opportunities for more deployment as the state seeks to meet its carbon free goals.

For more than one hundred years, our nation's hydropower resources have helped optimize river systems to accomplish multiple objectives and provide inexpensive power. These hydropower resources were the catalyst for businesses to succeed and communities to grow. In California, some of the many benefits of hydropower include flood control, drought management, water supply, recreational opportunities, and environmental flows and other mitigation measures to support aquatic species.

As California plans to meet the ambitious emissions reduction goals outlined in S.B. 100, hydropower serves as a reliable, low cost, carbon free resource capable of integrating other renewables on to the electric grid. With the proper policies in place, hydropower, from California and nearby states, can help California meet its emissions reduction goals reliably and at the lowest cost to ratepayers.

As the California Energy Commission, California Public Utilities Commission, and California Air Resources Board prepare the Joint Agency Report, NHA recommends policy makers fully consider how hydropower, in all its forms, can contribute to the S.B. 100 clean energy goals. This analysis should reflect the complete portfolio of hydropower's potential contribution to California's goal while evaluating any potential barriers to fully optimizing hydropower's value.

To that end, NHA provides the following information and recommendations on hydropower's role in a clean energy grid.

Table of Contents:

I. **Summary of NHA's Feedback on the February 24, 2020 "S.B. 100 Modeling Inputs and Assumptions" Workshop**

II. **Resource Diversity and Flexibility: Hydropower's Ability to Integrate Other Renewable Resources**
  a. Hydropower Provides Substantial Carbon Free Flexibility for California
  b. Hydropower and Batteries Provide Different and Complementary Services
  c. Hydropower Prevents Solar Curtailment
  d. International Reliance on Hydropower Resources for Flexible Capacity
  e. Case Studies:
    i. Flexibility from In-State Hydropower: Helms Pumped Storage Project
    ii. Flexibility from Out of State Hydropower: Pelton Round Butte Hydroelectric Project

III. **Reliability: Hydropower Provides Essential Carbon Free Reliability Attributes**
  a. Operating Reserves
  b. Black Start
  c. Flexible Capacity
  d. Long-Term Storage
  e. Inertia and Frequency Response
  f. Frequency Regulation
  g. Firm/Installed Capacity
  h. Annual Energy

IV. **Innovation and Emerging Technologies: There is Potential for Thousands of MWs of Responsible Hydropower Growth in California and Regionally**
  a. Development of Conduit Hydropower in California
  b. Development of Non-powered Dams in California and Regionally
  c. Development of Closed Loop Pumped Storage in California and Regionally
  d. Development of Marine Energy

V. **Resource Shuffling:**
  a. Imports of Hydropower Do Not Increase Carbon Emissions Elsewhere on the Western Grid

VI. **Conclusion**

I. Summary of NHA's Feedback on the February 24, 2020 "S.B. 100 Modeling Inputs and Assumptions" Workshop

- NHA supports a technology neutral approach to achieving carbon emissions reductions and is very supportive of the Commission including large hydropower in the "RPS+" and "No Fossil Fuel Combustion" zero carbon resource options. NHA encourages the Commission to ensure the following resources are included in any policies designed to achieve S.B. 100 goals:
    - New and existing hydropower resources;
    - Privately owned, publicly owned, and federally owned hydropower resources;
    - Large and small hydropower resources;
    - In-state hydropower resources;
    - Out-of-state hydropower resources that can deliver energy into California;
    - The many different types of hydropower resources, including conventional, pumped storage, run of river, and marine energy.

- NHA requests additional information on how hydropower will be modeled in RESOLVE. NHA acknowledges that modeling all forms of hydropower is challenging. NHA would like to work with the Commission to ensure the operational characteristics of hydropower are captured accurately in order to produce the highest quality results for S.B. 100 implementation.

- NHA recommends inclusion of hydropower conduit growth potential in resource build scenarios (Pages 13-14).

- NHA recommends the Commission consider a study to analyze feasibility of hydropower development at non-powered dams in California to inform the resource build scenarios (Pages 14-16).

- NHA is supportive of the scenarios the Commission is planning to run in RESOLVE, but suggests the Commission consider running an additional scenario that looks to 2045, instead of 2030. In addition, NHA recommends consideration of the lifetime of storage resources and replacement costs (Page 17).

- NHA recommends the Commission consider a scenario with lower cost assumptions for pumped storage hydropower. Under this scenario, planners could better ascertain how cost relates to the deployment of pumped storage and consider the extent to which regulatory improvements or alternate financing or markets may stimulate pumped storage development. NHA members could provide information as necessary (Pages 17-18).

- When considering resource shuffling, NHA requests the Commission consider that hydropower integrates and prevents curtailment of other renewables and is surplus in the Pacific Northwest. In addition, many neighboring states have their own carbon free goals (page 19).

II. Resource Diversity and Flexibility: Hydropower’s Ability to Integrate Other Renewable Resources

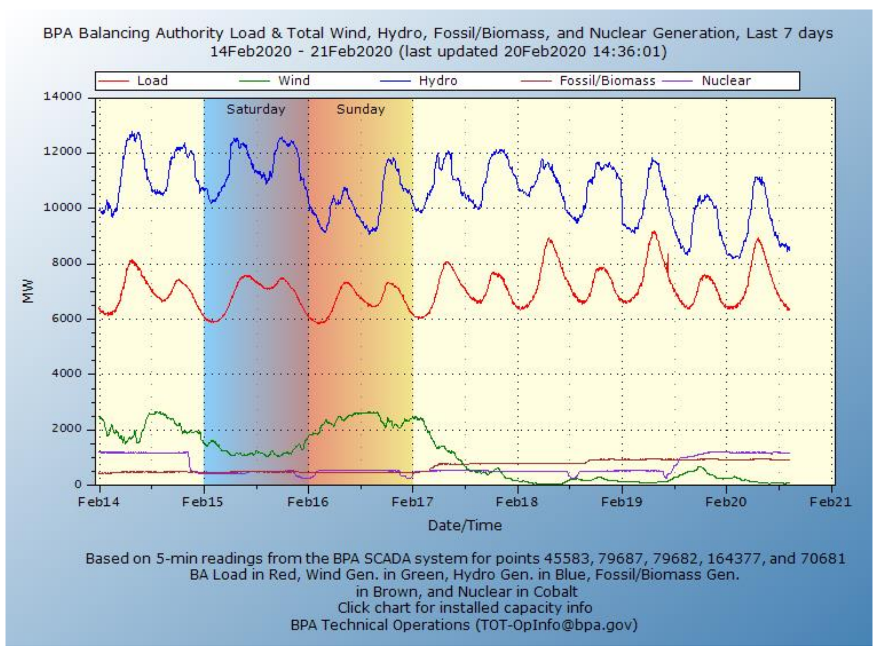
A. Hydropower Provides Substantial Carbon Free Flexibility for California

The continued growth of renewable resources like wind and solar is critical to meeting California’s energy goals. While the power system has always needed flexibility to adapt to changes in demand or generator failures, high penetration of wind and solar resources creates additional need for flexibility by increasing power system variability and uncertainty.

At higher penetrations of wind and solar, energy becomes less valuable, while capacity and flexibility become more important. As recent modeling from Lawrence Berkeley National Laboratory demonstrated, “We find a general decrease in average annual hourly wholesale energy prices with more variable renewable energy penetration, increased price volatility and frequency of very low-priced hours, and changing diurnal price patterns. Ancillary service prices rise substantially…”[1]

Given its ability to shift among providing energy, capacity, and flexibility, hydropower is uniquely positioned to meet the evolving needs of the power system. Shifting from primarily providing energy to providing capacity and flexibility will require changes in how hydropower resources are operated, and in their revenue streams. Markets should be designed to appropriately value these services, not just for ensuring the economic viability of this resource, but also to ensure that enough of these services will be provided to maintain electric reliability.

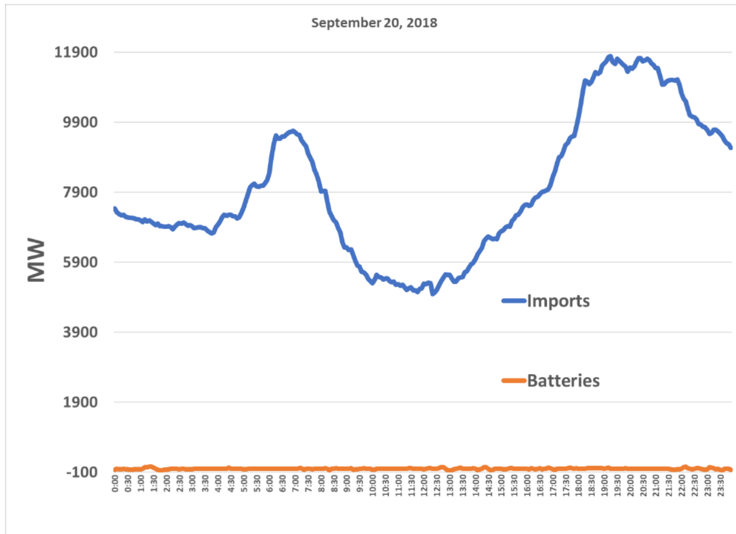
Hydropower is already providing the flexibility to accommodate the significant growth of wind and solar. As an example, data from the main grid operator in the Pacific Northwest show that the region’s hydropower resources ramp up and down to meet demand and accommodate fluctuations in wind, as well as solar imports from California.[2] Whereas other regions of the country rely heavily on fossil fuels to provide ramping and flexibility, California has an adundance of carbon free hydropower resources both in state and regionally that can help balance supply and demand.



[1] https://emp.lbl.gov/publications/impacts-high-variable-renewable

[2] https://transmission.bpa.gov/business/operations/wind/

California grid operator data confirms that electricity imports, made up chiefly of hydropower from the Pacific Northwest, are the primary tool used to accommodate solar output, ramping up in the morning and down in the evening. As shown in the following chart for a typical day, imports are dialed back midday when California solar generation is abundant, and then ramped back up as solar output wanes and electricity demand peaks in the evening.



A new report from the Western Interstate Energy Board confirms that imports of hydropower will continue to play a key role in providing flexibility to the Western power system, concluding that "Regions will rely heavily on imports/exports to meet flexibility needs, and transfers between regions will increase significantly in the coming years."[3]

B. Hydropower and Batteries Provide Different and Complementary Services

The state's grid-connected batteries are almost exclusively used to accommodate fast intra-hour fluctuations in electricity supply and demand, often switching from charging in one 5-minute period to discharging in the next 5-minute period, as shown in the chart above.[4] As battery costs continue to decline and their penetrations increase, they will likely play a larger role in helping to accommodate these multi-hour ramps in electricity supply and demand. However, given its low fuel cost, ability to store energy for long durations, and large scale, hydropower, particularly hydropower with reservoir storage and pumped storage hydropower, is likely to continue playing the primary role in shifting daytime solar output to meet nighttime demand.

C. Hydropower Prevents Solar Curtailment

Energy consulting firm Energy and Environmental Economics (E3) examined a host of potential solutions to reduce solar curtailment under a 50% Renewable Portfolio Standard (RPS) in California in 2014. The study found that some of the most effective solutions were regional coordination and access to a diverse mix of resources.[5] The study found that around 5,000 MW of energy storage, several times greater than the level envisioned under current policy, would be necessary to reduce solar curtailment as much as using regional coordination or a diverse mix of resources. Other analysis from E3 confirms

[3] https://nwenergy.org/wp-content/uploads/2019/12/WIEB-Flexibility-Study-Short-Summary-Presentation-191201-get-permission-before-posting.pdf
[4] http://www.caiso.com/TodaysOutlook/Pages/supply.aspx
[5] https://www.ethree.com/wp-content/uploads/2017/01/E3_Final_RPS_Report_2014_01_06_with_appendices.pdf

the importance of obtaining flexibility through imports and geographic aggregation,[6] which entails strong coordination with the region's hydropower projects.

A study from the National Renewable Energy Lab (NREL) found that a package of flexible resources, including expanded imports and exports, would reduce renewable curtailment in California by nearly 95%.[7] The analysis found that among the "flexibility" solutions in the package, removing restrictions on electricity imports and exports from California and removing requirements for local generation would be major drivers that could reduce curtailment of renewable resources. The primary role of imports and exports in providing flexibility was confirmed in the study's ramping analysis, which found that "the primary resources ramping to meet the 11 GW hourly ramp include physical imports (4.5 GW ramp), storage (3.2 GW), the gas fleet (3.2 GW), and demand response (0.2 GW)."[8]

The development of advanced pumped storage hydropower projects can provide significant portions of the 5,000 MWs of storage recommended by E3, whether developed within California or imported from the Pacific Northwest. In addition, the existing conventional hydropower fleet in the Pacific Northwest can also adjust operations to more closely align with generation needs across California.

D. International Reliance on Hydropower Resources for Flexible Capacity

Many European countries use hydropower resources across their systems to balance new renewable energy resources. A German energy official recently noted that Germany's investment in larger transmission ties to access larger amounts of Scandinavian hydropower is "the cheapest flexibility you can think of."[9] As he further explained, "I don't know whether the demand for storage will increase. What I know is the demand for flexibility will increase, will increase dramatically... and if storage proves to be the cheapest flexibility, and the market chooses storage, then of course storage will increase… It's always coming down to flexibility. That's what we need and storage is one sort of that." To enable its transition to large amounts of wind energy, the U.K. is also building undersea high-voltage direct current transmission ties to access the flexibility provided by Scandinavian hydropower.[10]

E. Case Studies:

1. Flexibility from In-State Hydropower: Helms Pumped Storage Project

The Helms Pumped Storage Project (Helms), constructed in 1984 by Pacific Gas and Electric in the Sierra Nevada Mountains primarily to provide flexibility for the Diablo Canyon nuclear station, is increasingly being used to provide flexibility for renewable energy resources, especially solar.

---

[6] https://www.ethree.com/wp-content/uploads/2017/02/WECC_Flexibility_Assessment_Report_2016-01-11.pdf
[7] https://www.nrel.gov/docs/fy16osti/64884.pdf, pages v-vii
[8] *Ibid.*, page viii
[9] http://www.eesi.org/briefings/view/060818germany, https://www.forbes.com/sites/jeffmcmahon/2018/06/10/baseload-is-poison-and-5-other-lessons-from-germanys-energy-transition/
[10] http://northsealink.com/

Helms can provide between 84 – 1,212 MWs of energy, depending on what the grid needs at any given moment. Helms can sustain maximum capacity of 1,212 MW for multiple days in a row. In addition, Helms can provide 930 MW of pumped load when needed, which is currently used on a daily basis to prevent curtailment of solar in the middle of the day. Helms can go from 0 MW to 1,212 MW of generation in less than 8 minutes and 0 MW to 930 MW of pumping load in less than 10 minutes.

Pumped Storage: from day/night arbitrage to fast response

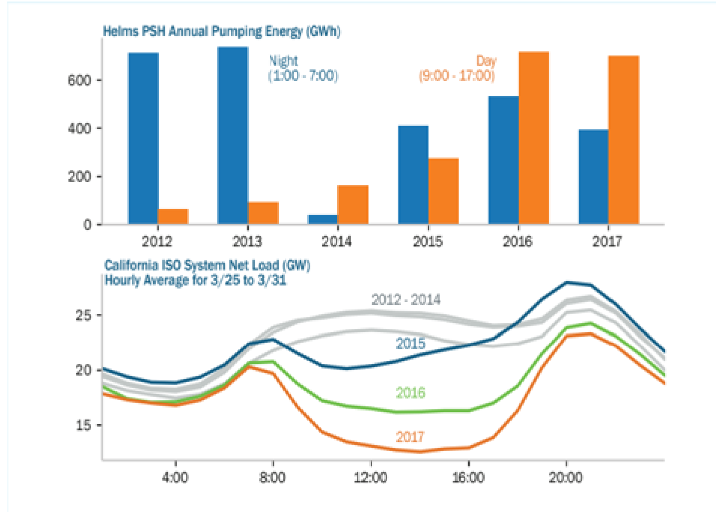


Figure 34. Annual pumping energy consumption by Helms PSH versus CAISO net load in the last week of March (2012-2017)

In the past, Helms typically cycled one time per day. It pumped during the night and generated during the day. However, Helms now completes between two to five cycles per day, due to the need to balance generation from solar and wind resources.

The additional cycling increases wear and tear on the plant's equipment associated with more frequent stops and starts. This is a field of ongoing research at PG&E, the Department of Energy, and other research organizations.

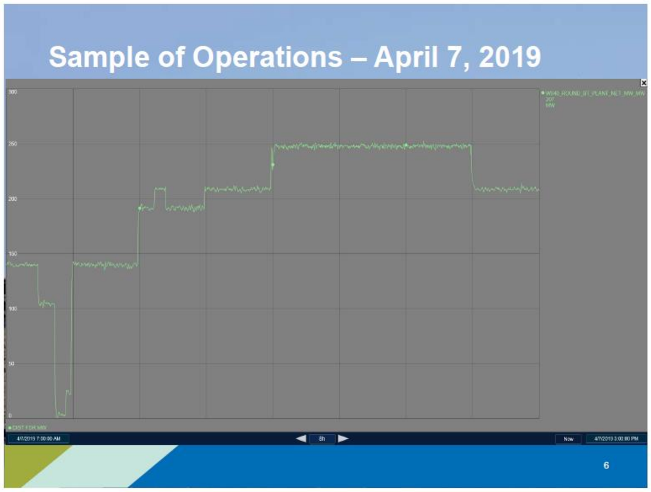
For projects changing their operations to meet the growing need for grid flexibility, the value of carbon free electricity (or the services associated with storage and delivering it to support load) needs to increase to improve the economic outlook for reinvestment in equipment maintenance and upgrades. As California regulators and system operators conduct energy market initiatives, NHA asks them to consider the effects of proposed rules on hydropower resources needed under S.B. 100.

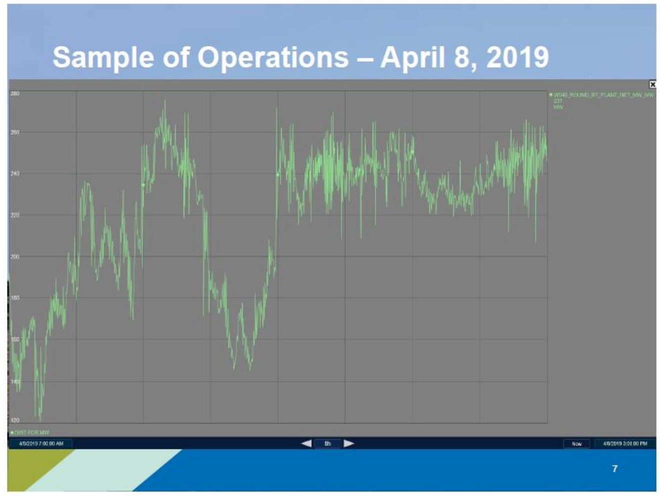
The Helms Pumped Storage Project, along with other existing and new pumped storage facilities under development, are critical resources that can help California efficiently meet its clean energy goals.

2. Flexibility from Out of State Hydropower: Pelton Round Butte Hydroelectric Project

Portland General Electric's Pelton Round Butte hydroelectric project, located on the Deschutes River in Oregon, is increasingly being used to integrate California based renewable resources. The conventional hydropower project consists of three dams: Round Butte Dam (372.5 MWs), Pelton Dam (110 MWs), and the Pelton ReRegulating Dam (19 MWs). Together the projects provide a suite of energy, capacity, and ancillary services in the CAISO administered EIM, which helps integrate California's renewable resources.

No two days of operations are ever exactly the same. For example, on two consecutive days in April, operations at the project varied significantly by providing slow and fast response as needed based on the output of other renewable resources.





The increase in variable operations increases maintenance and operations costs of the project. PGE is currently studying the costs of increased cycling and making substantial reinvestments in equipment, including: generator rewinds, wicket gate pin redesign, upgrades to the governors and exciters, and more.

NHA suggest that policy makers conduct energy market initiatives and implement regulations with an eye toward the potential effect on the availability of hydropower imports. Imported hydropower should be treated on a fair and equitable basis with in-state resources.

Market rules should send a strong signal that these long-life carbon free resources, like the Pelton Round Butte Project and other regional hydropower projects, are important resources to integrate renewable energy resources.

PGE's Pelton Round Butte hydropower project is one example of many regional hydropower projects that are adjusting operations to integrate intermittent renewable resources within its geography and across state borders. These regional hydropower projects are essential resources that will help California achieve its clean energy goals.

III. Reliability: Hydropower Provides Essential Carbon Free Reliability Attributes

Hydropower is unique among generating resources because it is both renewable and can provide nearly all the attributes necessary for a reliable and resilient electric grid, from dependable capacity to black start capability. Importantly, the ability of many hydropower facilities to ramp up or down quickly to complement wind and solar resources is valuable in a rapidly evolving electric system. As the grid integrates more wind and solar to replace fossil fuels, hydropower's ability to provide firm capacity, frequency response, voltage support, load following and long-term storage is increasingly critical. While no two hydropower projects are the same and some have greater capabilities than others, many hydropower projects have characteristics necessary to affordably help meet the nation's reliability and emissions requirements.

A. Operating Reserves:

As the fast-acting component of flexibility, operating reserves are used to keep power system frequency stable by keeping electricity supply and demand in balance over the timeframe of seconds to minutes. Categories of operating reserves include frequency regulation, following reserves, spinning reserves, and non-spinning reserves, which cover time periods ranging from seconds to half an hour. While modest amounts of wind and solar can be accommodated with the reserves that are already held to accommodate fluctuations in electricity demand, large penetrations of solar and wind significantly increase the need for operating reserves.

Conventional hydropower and pumped storage hydropower are well-positioned to meet that increased need for operating reserves. In Colorado, the utility Xcel Energy found that doubling its 324 MW Cabin Creek pumped hydropower plant would reduce the cost of integrating 2 and 3 GW of wind energy by $0.48/MWh and $1.12/MWh, respectively.[11] Other analysis has demonstrated the value of reservoir storage hydropower for providing flexibility and operating reserves to accommodate wind and solar.[12]

B. Black Start:

If the power system experiences widespread blackout, hydropower can help restart the power system, enabling other generators to come online. Units can become operational very quickly (within minutes); their output can be quickly ramped up as electric service is restored to customers; and they can provide more stable system restoration than many other types of generators. Grid operators turn to hydropower for black start because it is a proven resource – one that has been undervalued and yet played this critical role time and again, most recently during the East Coast blackout of 2003. The U.S.-Canada Power System Outage Taskforce that examined the East Coast blackout noted specifically that hydropower plants in western New York formed the basis for restoration of power throughout New York and Ontario.[13]

Excerpted from the Department of Energy's "Hydropower Plants as Black Start Resources" from May 2019:[14]

> **"Hydroelectric** power plants meet all the desired attributes for black start:
>
> - Except in the most extreme drought conditions, the reservoirs impounded by dams store enough water to power, without any special preparation, turbines for black start operation.

---

[11] https://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/PSCo-ERP-2011/Attachment-2.13-1-2G-3G-Wind-Integration-Cost-Study.pdf at 24

[12] https://in.nau.edu/wp-content/uploads/sites/156/2018/08/Integration-of-Wind-and-Hydropower-Systems-Simplified-Modeling-ek.pdf

[13] U.S.-Canada Power System Outage Task Force: "Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations" (April 2004). Available at: https://www.energy.gov/sites/prod/files/oeprod/DocumentsandMedia/BlackoutFinal-Web.pdf

[14] DOE "Hydropower Plants as Black Start Resources" (Ma 2019). Available at: https://www.energy.gov/sites/prod/files/2019/05/f62/Hydro-Black-Start_May2019.pdf

- Minimal station power is needed, since fuel preparation and cooling are not required.
- The plants that have backup power (e.g., small diesel generators) to manage spillway gates can also use this resource for black start.
- Hydro plants can restart quickly, with minimal internal preparation and buswork switching.
- Hydropower generators tend to be more tolerant of frequency excursions than large steam generators, and they also have significant inertia and high enough ramp rates (for changing power output) to help stabilize system frequency.
- Many hydropower generators are large enough to supply adequate power to energize the transmission system, provide station power to start up other generating plants, and pick up loads.
- Hydropower connections to the transmission network usually enable direction of their output to restart other power plants with minimal transmission line switching.

Pumped storage hydropower (PSH) units have almost all the advantages of conventional hydro units. However, economical dispatch may deplete the upper ponds of PSH systems, so PSH units are not sure to have adequate energy available for black start unless some water is always held in reserve for it."

C. Flexible Capacity:

Many hydropower projects are flexible enough to adjust generation during the day to assure loads and resources stay in balance. This flexibility is critical in integrating wind and solar, especially during steep ramping events, such as those experienced in California and other regions.

Hydropower is one of the lowest-cost sources of flexibility on the "flexibility supply curve" created by the National Renewable Energy Laboratory (NREL).[15] Due to its flexibility, hydropower can provide energy, capacity, flexibility, or other reliability services when needed and shut down when not, while most fossil and nuclear generators cannot start up or shut down quickly.

D. Long-Term Storage:

Many conventional hydropower projects with large reservoirs, such as Lake Shasta or Lake Oroville, provide storage capability, which can be used to balance loads and generating resources. Some storage projects have reservoirs that can store water for months at a time to release when needed. In addition, run-of-river hydropower projects can often be coordinated with reservoir storage projects to optimize generation from stored water, using the same water to generate at multiple facilities along the same watercourse. In addition, pumped storage hydropower provides significant energy storage capacity, representing 95 percent of all energy storage capacity in the U.S. today. It is the most proven, cost-effective, durable, and reliable utility-scale energy storage innovation available.

[15] Cochran et al., "Flexibility in 21st Century Power Systems," May 2014, p. 11, at https://www.nrel.gov/docs/fy14osti/61721.pdf.

E. Inertia and Frequency Response:

Hydropower units are a source of inertia that help avoid widespread blackouts when the electrical grid is stressed by providing large rotating mass to maintain system frequency. Inertia can stabilize the grid by slowing frequency declines or increases and damping the oscillations that can occur when there is a sudden loss of a large generator or load.

Hydropower also provides fast frequency response by increasing output in the seconds following the loss of a large generator. The control systems used on hydropower units (governor controls) quickly increase output to stabilize power system frequency, protecting consumer equipment and preventing a widespread outage. Supply and demand for inertia and frequency response is set across an entire electrical Interconnection, so hydropower plants within California or in the Pacific Northwest can help provide inertia and frequency response for the entire Western Interconnect.

F. Frequency Regulation:

Many hydropower projects can provide frequency regulation within the electric grid by responding to grid operator signals within 4 seconds of system disturbances. To meet these reliability needs, hydropower resources can increase or decrease output merely by allowing more or less water to pass through turbines using automatic generation control — or simply by relying on large rotating machine inertia. Fast load ramping rates provide rapid frequency regulation without generating any carbon emissions.

G. Firm/Installed Capacity:

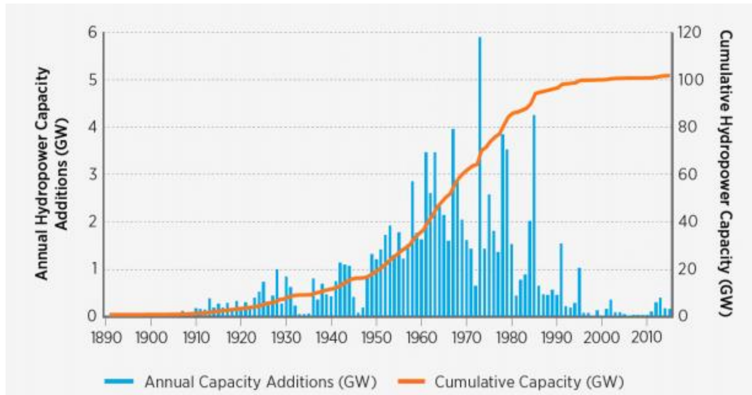
Most hydropower systems can store water in their reservoirs and hence can provide electricity when called upon to meet energy demand, while also providing flood protection and environmental flows to support aquatic systems.

H. Annual Energy:

Even though stream flows can vary, hydropower is a reliable resource that produces energy throughout the year. Hydropower generation can be forecasted with a high degree of accuracy months in advance. Reservoir storage at individual dams, and systemwide, can facilitate the best coordinated use of water releases, meeting a diverse need of resources, including recreation, aquatic flows, water and irrigation supplies, as well as carbon free generation.

IV. Innovation and Emerging Technologies: There is Potential for Thousands of MWs of Responsible Hydropower Growth in California and Regionally

From the 1990s to mid-2000s, hydropower growth was relatively flat. Total hydropower growth from 2006 to 2016 in the United States was 2,030 MW, including 1,435 MW (70%) coming from refurbishments and upgrades[16] and 113 new hydropower resources built on non-powered dams (40) or existing conduits (73), including several in California.



There are many opportunities for continued responsible growth of hydropower in California, including conduit hydropower, development of non-powered dams, and closed loop pumped storage. NHA works with its members and across the environmental stakeholder community to develop projects with minimal adverse impacts that can provide the greatest benefit to the citizens of California and across the country.

A. Development of Conduit Hydropower in California

NHA encourages the Commission to include conduit hydropower in its assessment of new resource builds.

In March 2019 the California Energy Commission's Final Project Report titled "California's In-Conduit Hydropower Implementation Guidebook: A Compendium of Resources, Best Practices, and Tools" found that "414 MW of maximum untapped in-conduit hydropower potential is available in the State of California."[17]

The Federal Energy Regulatory Commission defines conduits as projects that are located on a water feature used for agricultural, municipal, or industrial consumption, are not an integral part of a dam, and have an installed generating capacity of 40 MW or less.[18] These projects are eligible for exemptions from relicensing, as FERC recognizes their uniquely low-impact nature. Their environmental impact is insignificant because they are located on man-made structures with minimal aquatic life.

While some of these projects have limitations with respect to dispatchability and ramping, they often meet other needs. Because their generation often coincides with related consumption, they are

[16] DOE 2017 Hydropower Market Report Executive Summary (April 2018). Available at: https://www.energy.gov/sites/prod/files/2018/04/f51/Hydropower%20Market%20Report%20-%20Executive%20Summary.pdf
[17] CEC's states this report will be made available in the Spring. For more information please visit: https://www.energy.ca.gov/programs-and-topics/topics/research-and-development/research-tools
[18] FERC "Hydropower Primer" (February 2017). Available at: https://www.ferc.gov/legal/staff-reports/2017/hydropower-primer.pdf

uniquely situated to meet specific needs at the times they are generating. For example, hydropower projects on irrigation conduits generate when irrigation water is in the canal. This is precisely the time that there is peak pumping demand as farmers pump the same water to their fields below the project.

B. Development of Non-powered Dams in California and Regionally:

The greatest potential for small hydropower development is at a portion of the 80,000 existing non-powered dams in the United States.

The purpose of most non-powered dams is to provide one or more of the following benefits: flood control, irrigation, navigation, recreation, and water supply.

Hydropower development at non-powered dams is an attractive option because there are fewer environmental impacts and lower capital costs because the impoundment is already in place for other purposes.

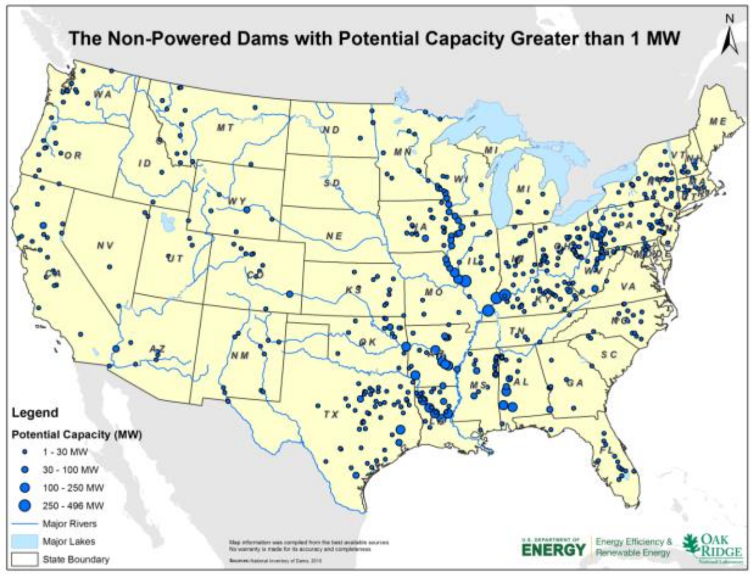


Figure ES-1: Locations of the top non-powered dams with potential hydropower capacities greater than 1 MW

The abundance of non-powered dams throughout the country are an attractive option for states like California to develop in order to help meet their carbon reduction goals. Several non-powered dams have been developed in the past decade, the largest of which by American Municipal Power on the Ohio River with total capacities of 105 MW, 88 MW, and 45 MW.

Several different federal agencies have studied the potential of hydropower development at existing non-powered dams. For example, the U.S. Bureau of Reclamation (BOR) determined that there are 28 BOR owned non-powered dams in California with potential for hydropower development.[19] Both the DOE and FERC went one step further and analyzed non-powered dams with the greatest potential for development. The DOE estimates there is 195 MW of potential hydropower capacity at existing non-powered dams in California, including the following projects:

[19] Bureau of Reclamation "Resource Assessment Sites Available for Development" (2018). Available at: https://www.usbr.gov/power/ResourceAssessment/2018_Available_Sites_8-17-18.pdf

DOE "An Assessment of Energy Potential at Non-Powered Dams in the United States"

State	Name of Non-Powered Dam	River	Potential Capacity MWs
CA	Palo Verde Diversion	Colorado River	54.3
CA	Fish Barrier Dam (Oroville Facilities)	Feather River	35.2
CA	Morelos Diversion	Colorado	25.2

FERC "Nonpowered Federal Dams with Potential for Non-federal Hydropower Development"

State	Name of Non-powered Dam	River	Potential Capacity MWs
CA	Morelos Diversion	Colorado River	25.2
CA	North Fork Dam	North Fork American River	6.2
CA	Hidden Dam	Fresno River	2.6
CA	Boca Dam	Little Truckee River	1.2
CA	Imperial Dam	Colorado River	1.1
CA	Casitas Dam	Coyote Creek	1.0

In addition, there are several non-powered dams in neighboring states with the potential to sell carbon free energy into California as the electric grid continues to increase regional coordination:

DOE "An Assessment of Energy Potential at Non-Powered Dams in the United States"

State	Name of Non-powered Dam	River	Potential Capacity MWs
WA	Howard Hanson	Green River	26.3
OR	Gold Ray Dam	Rogue River	20.4

FERC "Nonpowered Federal Dams with Potential for Non-federal Hydropower Development"

State	Name of Non-powered Dam	River	Potential Capacity MWs
AZ	Horseshoe Dam	Verde River	13.7
AZ	Bartlett Dam	Bartlett Lake	7.5
AZ	Alamo Dam	Williams River	4.0
OR	Applegate Dam	Applegate River	11.5
OR	Fern Ridge Dam	Tom River	5.1
OR	Blue River Dam	Blue River	5.0
OR	McKay Dam	McKay Creek	3.4
OR	Warm Springs Dam	Malheur River	1.2
OR	Agency Valley	Malheur River	1.2
MT	Huntley Diversion Dam	Yellowstone River	2.4
MT	Crow Dam	Crow Creek	2.3
MT	Sun River Diversion Dam	North Fork Sun River	2.0
MT	Hubbart Dam	Little Bitterroot	1.8
MT	Fresno Dam	Milk River	1.7
WA	Howard Hanson	Green River	26.3

WA	Hiram Chittenden Lock and Dam	Cedar River	12.0
WA	Cle Elum Dam	Cle Elum River	7.3
WA	Keechelus Dam	Yakima River	2.4
WA	Sunnyside Dam	Yakima River	1.4
WA	Kachess Dam	Kachess River	1.2
WA	Easton Diversion Dam	Yakima River	1.1

If developed, most of these projects are eligible for the California RPS, which currently limits eligible hydropower resources to 30 MW or less. The few projects above 30 MW could help fulfill the remaining 40% of California's Clean Energy Standard.

NHA recommends California pursue a feasibility assessment similar to the "Maine Hydropower Study" conducted by the Maine State government in 2015.[20] The primary goals of the study were to "(1) develop an inventory of existing and potential hydropower resources, and (2) identify potential regulatory changes to facilitate development of these resources." The study also examined projects economics and environmental impacts for development of specific hydropower sites. A similar study in California could help analyze the best hydropower development projects to help California meet its clean energy goals.

C. Development of Closed Loop Pumped Storage in California and Regionally

Energy storage is a critical component of California's clean energy goals. As more wind and solar replace fossil fuel generators, the electric grid demands more storage to accommodate the intermittency of renewable resources. There are multiple forms of energy storage resources that all provide critical attributes necessary for a clean electric grid.

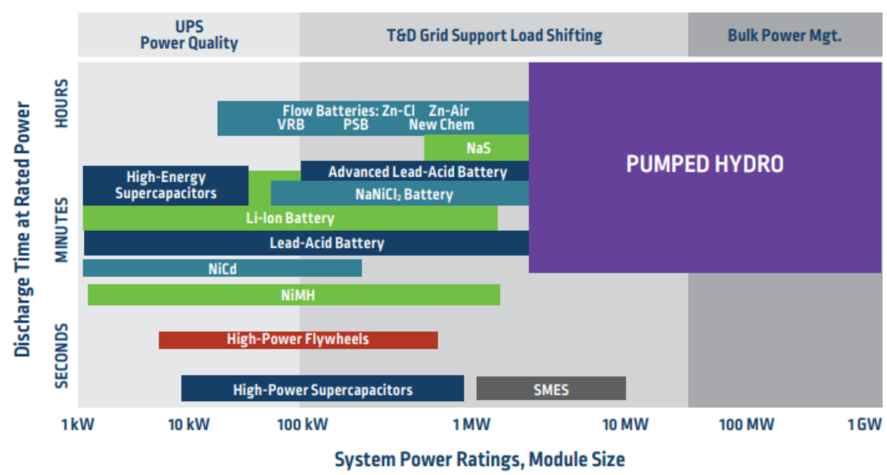


FIGURE ILLUSTRATING VARIOUS CAPABILITIES OF DIFFERENT ENERGY STORAGE TECHNOLOGIES, FROM THE ENERGY STORAGE ASSOCIATION (ESA), UPDATED WITH PUMPED STORAGE CHARACTERISTICS.

Pumped storage is a proven, long duration bulk storage option with exceptionally long lifetimes. The existing pumped storage fleet and new pumped storage developments, both in California and nearby states, are critical resources to help California meet its clean energy goals.

Although California has several existing pumped storage projects, most are associated with multipurpose reservoirs and on naturally flowing rivers, and therefore may have some operation restrictions (i.e. restricted flow release rates). These projects are not able to unlock their full potential to

[20] Maine Governor's Energy Office "Maine Hydropower Study" (2015). Available at: https://www.maine.gov/energy/publications_information/001%20ME%20GEO%20Rpt%2002-04-15.pdf

help integrate renewable energy resources. It is important to recognize the full suite of services existing projects provide to the electric grid, and to incentivize new advanced pumped storage project development. This will help the existing projects continue to invest in modernizing their operations and equipment and help justify the economic investment in new projects that are critical to help California meet its carbon free energy goals.

New, advanced pumped storage hydropower will create additional markets for California renewables to prevent curtailment while also providing important reliability services. As more fossil fuel resources retire, these pumped storage projects are a long term, proven option to help integrate more renewable resources.

Despite the Pacific Northwest National Laboratory (PNNL) 2019 report which found pumped storage to be one of the lowest cost energy storage resources, one of the primary obstacles to deployment of new, advanced pumped storage is obtaining long term financing.[21] At least three projects in California and nearby states, with a combined 2,100 MW of capacity, have satisfied environmental conditions and received federal and state permits to construct.[22] FERC has also issued preliminary permits for an additional 1,544 MWs of pumped storage in California.[23]

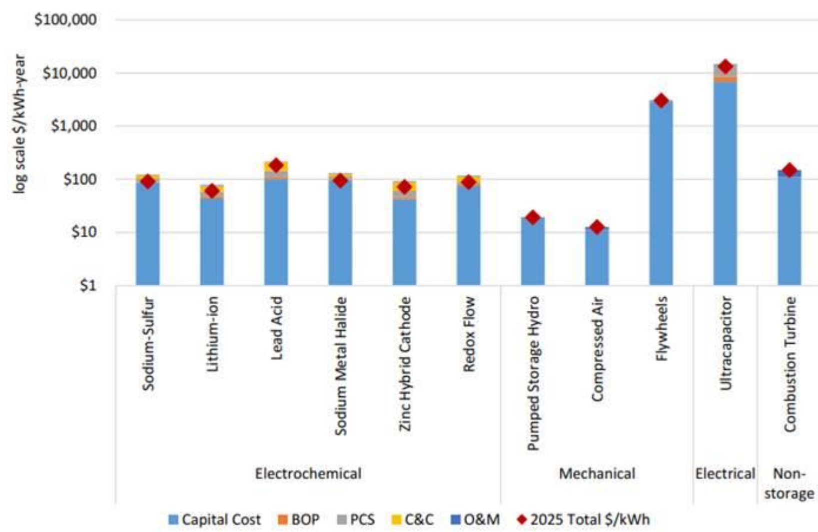


Figure 5.6. Annualized $/kWh cost of all technologies.

However, the difficulty of obtaining long term financing is preventing their development. Most existing pumped storage projects were built prior to electricity market deregulation and were able to be financed into the rate base of vertical owned utilities over 30 years. Because these projects are capital intensive, it requires time to repay investors, which is challenging given today's low wholesale market prices. Making it clear that new, advanced pumped storage is part of California's future energy resource mix will send a clear signal to investors.

[21] PNNL "Energy Storage Technology and Cost Characterization Report" (July 2019). Available at: https://energystorage.pnnl.gov/pdf/PNNL-28866.pdf

[22] 1. Eagle Mountain Pumped Storage Hydroelectric Project (1,300 MW), Riverside County, California.
2. Swan Lake North Pumped Storage Project (393 MW), Klamath County, Oregon.
3. Gordon Butte Pumped Storage Project (400 MW), Meagher County, Montana.

[23] Including the San Vicente Energy Storage Facility (500 MW) in San Diego County, California. For a full list of FERC issued preliminary permits, click here: https://www.ferc.gov/industries/hydropower/gen-info/licensing/pump-storage/issued-permits.pdf

NHA is supportive of the scenarios the Commission is planning to run in RESOLVE, but suggests the Commission consider running an additional scenario that looks to 2045, instead of 2030. In addition, NHA recommends consideration of lifetime of storage resources and replacement costs.

Another option for an additional scenario is to consider a scenario with lower cost assumptions for pumped storage hydropower. Under this scenario, planners could better ascertain how cost relates to the deployment of pumped storage and consider the extent to which regulatory improvements or alternate financing or market may stimulate pumped storage development. NHA members could provide information as necessary.

D. Development of Marine Energy

Marine energy utilizes advanced water power generation technologies to tap into vast amounts of globally available wave, tidal, current and riverine resources. For example, CalWave, which was founded at UC Berkeley, is an emerging marine energy technology and has won several awards from the Department of Energy.

Marine energy represents the next generation of renewable power and can provide significant amounts of clean electricity while creating high-value employment within California. Marine energy is also reliable, predictable and environmentally friendly. The resource is close to population centers which reduces transmission costs and environmental impacts. In addition, marine energy can provide power to many different maritime markets, including newly emerging Blue Economy opportunities such as remote vehicle charging, autonomous sensors and deep-water aquaculture. For example, the U.S. Navy is actively pursuing the development of marine energy systems for national security applications related to at-sea persistent surveillance and communications as well as tactical shore energy production for forward deployed assets.

The International Energy Agency Ocean Energy Systems, of which the U.S. is a member country, predicts that by 2050 over 300 GW of marine energy capacity will be installed globally. This would represent $35 billion in investment, 680,000 direct jobs and a savings of 500 million tons of CO_2 emissions. The U.S. Department of Energy has estimated that ten percent of electricity demand along the Pacific Coast could be met by 2050 with just a fraction of the available wave energy resource. This is equivalent to powering five million homes and would create 30,000 jobs.

Marine energy technologies have large promise, but present unique engineering and operational challenges that are significantly greater than those for other renewable energy technologies. In addition, individual marine energy technologies are at an early stage of development and dominated by small companies with limited sources of external funding. Advancement of marine energy technologies in a globally competitive marketplace is greatly enhanced by significant and consistent levels of public sector support that augments R&D efforts underway in the private sector. These funds provide risk mitigation, technical advancement and review, and early market growth opportunities and are key to attracting private capital and igniting commercialization of the marine energy industry.

A growing U.S. marine energy industry will support efforts to address climate change, assist in grid reliability and resiliency, while also advancing our national economic goals. These benefits are enhanced by the potential for increased local economic growth for coastal and water-side communities, along with revitalization of our nation's ports and shipyards as devices can be built and maintained near generation sites. Marine energy development will also help create thousands of high-quality engineering, manufacturing and related jobs in California and across the United States.

V. Resource Shuffling:

A. Imports of Hydropower Do Not Increase Carbon Emissions Elsewhere on the Western Grid

One of the guiding principles of S.B. 100 implementation is that it "Shall not increase carbon emissions elsewhere in the western grid and shall not allow resource shuffling." NHA understands there is concern that hydropower imports from the Pacific Northwest may result in resource shuffling and increased carbon emissions. However, it is important to note that increased regional coordination can increase renewable generation without adding additional hydropower capacity. During the day, California exports solar energy throughout the region to prevent solar curtailment. During this time, hydropower generation decreases and water is stored in reservoirs. When the solar production decreases, hydropower production increases by calling on the stored water. Even though there is no net gain in hydropower generation, regional coordination increases total carbon free generation by preventing the curtailment of solar during the day.

The risk to California load serving entities of procuring Northwest hydropower, that is "backfilled" with market purchases sourced from dispatchable fossil fuel resources to serve local demand, is minimal because the Northwest is generally surplus and the majority of Pacific Northwest hydropower is Asset Controlling Supply (ACS).

In addition, many nearby states with abundant hydropower resources have carbon free goals, such as Washington State, which intends to be carbon free by 2045. The Clean Energy Transformation Act requires a carbon free electricity portfolio by 2045, with interim goals in 2030. Because of such state commitments, the risk of so-called "resource shuffling" from Northwest imports has been minimized.

VI. Conclusion

California is in a unique position to take a leadership role in combating climate change. California can and will set a strong example for other states, the federal government, and the international community to follow. Again, NHA offers the following recommendations at this time:

- NHA supports a technology neutral approach to achieving carbon emissions reductions and is very supportive of the Commission including large hydropower in the “RPS+” and “No Fossil Fuel Combustion” zero carbon resource options. NHA encourages the Commission to ensure the following resources are included in any policies designed to achieve S.B. 100 goals:
    - New and existing hydropower resources;
    - Privately owned, publicly owned, and federally owned hydropower resources;
    - Large and small hydropower resources;
    - In-state hydropower resources;
    - Out-of-state hydropower resources that can deliver energy into California;
    - The many different types of hydropower resources, including conventional, pumped storage, run of river, and marine energy.

- NHA requests additional information on how hydropower will be modeled in RESOLVE. NHA acknowledges that modeling all forms of hydropower is challenging. NHA would like to work with the Commission to ensure the operational characteristics of hydropower are captured accurately in order to produce the highest quality results for S.B. 100 implementation.

- NHA recommends inclusion of hydropower conduit growth potential in resource build scenarios (Pages 13-14).

- NHA recommends the Commission consider a study to analyze feasibility of hydropower development at non-powered dams in California to inform the resource build scenarios (Pages 14-16).

- NHA is supportive of the scenarios the Commission is planning to run in RESOLVE, but suggests the Commission consider running an additional scenario that looks to 2045, instead of 2030. In addition, NHA recommends consideration of the lifetime of storage resources and replacement costs (Page 17).

- NHA recommends the Commission consider a scenario with lower cost assumptions for pumped storage hydropower. Under this scenario, planners could better ascertain how cost relates to the deployment of pumped storage and consider the extent to which regulatory improvements or alternate financing or markets may stimulate pumped storage development. NHA members could provide information as necessary (Pages 17-18).

- When considering resource shuffling, NHA requests the Commission consider that hydropower integrates and prevents curtailment of other renewables and is surplus in the Pacific Northwest. In addition, many neighboring states have their own carbon free goals (page 19).