Environment

Thomas N. Russo

Reimagining Hydropower and Green Hydrogen

The US, European Union, and other countries that have set net-zero carbon emission targets and participate in the Paris Accord are placing big bets on wind and solar to produce green hydrogen (H_2). Here in the US lawmakers and policy makers seem to have overlooked hydropower as a source of renewable energy even though it accounts for 52 percent of the nation's renewable electricity generation and 7 percent of total electricity generation. For example, indigenous communities and environmental groups are opposed to hydropower because of its impacts on fish, wildlife, and water quality.

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Many hydropower owners are taking a hard look at the economic value of their projects in light of climate change, aging infrastructure, increased operating costs due to environmental compliance, and evolving electricity markets. Many small hydropower projects are especially affected by the above factors since they provide only electric energy and not the peaking capacity and ancillary services valued by the electric grid. Nevertheless, these projects have value since a growing number now contain license conditions to reduce environmental impacts when they were initially built. In a previous column, this author also discussed a way for owners of "low impact hydropower" to fully monetize their project's attributes by seeking renewable energy certificates (RECs).[1]

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This author now also suggests that hydropower can play a significant role in jumpstarting the production and distribution of

[1] Russo, T. N. (2021). Rethinking Low Impact Hydropower and Renewable Energy Certificates. *Climate and Energy, 37*(9), 26–32.

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green hydrogen (H_2). However, this will require all hydropower owners and developers to reimagine how their projects will operate and diversify their revenue streams over the next 20 years. If hydropower projects can produce sufficient quantities of green H_2, they could accelerate efforts to decarbonize natural gas by blending green H_2 in the natural gas grid[2] and help states meet their net-zero emissions. On November 23, 2020, Southern California Gas Co. and San Diego Gas and Electric announced the creation of a Hydrogen Blending Demonstration Program. This program is the first in California and the nation.[3]

One of the biggest challenges with the hydropower industry has been its laser focus of trying to influence Congress and regulators on streamlining the siting process instead of reimaging a non-traditional role for hydropower outside of the electric grid. The National Hydropower Association (NHA) has influenced both Congress and the Federal Energy Regulatory Commission (FERC) to streamline its environmental and regulatory reviews to some degree.[4] The NHA has had some success to date but is still short of what is expected by many hydropower owners and developers. For example, FERC has promulgated an expedited process for issuing original licenses for qualifying facilities at existing nonpower dams and for closed-loop pumped storage[5] projects, pursuant to sections 3003 and 3004 of the America's Water Infrastructure Act of 2018.[6] NHA has also seen progress in extending the time to construct new hydropower projects and set a minimum FERC license term of 40 to 50 years instead of 30 to 50 years.

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Despite the above progress, FERC's regulatory reviews remain some of the most comprehensive and take years for staff to complete, despite the size of the hydropower project. Both small and large hydropower projects that were licensed or constructed prior to passage of the National Environmental Policy Act of 1969 (NEPA) are especially challenged by new environmental conditions included in new licenses and operating conditions.

NEPA REVIEW, POWER PURCHASE AGREEMENTS, AND FINANCING CHALLENGES

Comprehensive NEPA reviews and compliance with environmental laws during the life of a hydropower project are here to stay and are not likely to change. Despite being a form of renewable energy, many hydropower projects are lightning rods for public controversy and duplicative regulation by other federal and state agencies other than

[2] Russo, T. N. (2020). Hydrogen: Hype or Glide Path to Decarbonizing Natural Gas-Part 2. *Climate and Energy, 37(1), 24–32.*

[3] Southern California Gas Company and San Diego Gas & Electric. (2020, Nov. 23). *SoCalGas and SDG&E announce groundbreaking hydrogen blending demonstration program to help reduce carbon emissions*. Retrieved from https://sempra.mediaroom.com/index.php?s=19080&item=137855

[4] Hartman, D. and Russo, T. N. (2017, Aug. 24). *Ebbing the flow of hydropower red tape*. R Street Institute. Retrieved from https://www.rstreet.org/2017/08/24/ebbing-the-flow-of-hydropower-red-tape/

[5] Russo, T. N. (2020, Oct. 26). Pumped Storage Hydro: Reliable Choice for New Electric Storage Era. *Natural Gas & Electricity, 36*(2), 25–32. https://www.russoonenergy.com/content/pumped-storage-hydro-reliable-choice-new-electric-storage-era

[6] Federal Register. (2019, Apr. 24). *Hydroelectric licensing regulations under the America's Water Infrastructure Act of 2018. A Rule by the Federal Energy Regulatory Commission on 04/24/2019. Retrieved from* https://www.federalregister.gov/documents/2019/04/24/2019-08239/hydroelectric-licensing-regulations-under-the-americas-water-infrastructure-act-of-2018

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FERC. The controversy centers on competing use of rivers. Many indigenous communities and environmental groups and environmental agencies want to use water to restore anadromous fish runs and protect fish, wildlife, water quality, and recreation. In contrast, hydropower owners and other communities want to use the project for power generation, water supply, and flood control and other developmental uses, including the prevention of salt-water intrusion on ground water in coastal areas.[7]

Federally-owned hydropower projects, which are fewer in number but usually larger than non-federal hydropower projects, are also challenged by the above factors. Many of these projects are located in the Pacific Northwest, Midwest, and South on large rivers. Changes in operations, new construction, and the presence of federally listed endangered species will trigger NEPA reviews, the Endangered Species Act, and other federal and state laws that will affect the developmental benefits of these projects as well.

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Hydropower projects that successfully undergo FERC relicensing and remain economically viable will likely lose revenue as a result of compliance with environmental conditions in their new licenses. Also the power, flood control, and water supply benefits may be reduced, and cost of electricity will increase as some of those costs are passed on to electricity consumers. Still other hydropower licensees facing relicensing may rethink the value of their projects in terms of changing electricity markets and decide not to pursue relicensing, which may put the existing uses and benefits in jeopardy. The alternative for a hydropower owner is to surrender the project, but that could also entail a range of scenarios including dam removal and other legal obligations.

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New hydropower projects that complete the FERC licensing process must negotiate a power purchase agreement (PPA) and obtain financing for the projects. Alternatively, they could sell their power in the restructured electricity markets. However, most hydropower projects prefer the certainty of a long-term PPA rather than the uncertainty of bidding into restructured electricity markets. Unfortunately, some new hydropower projects don't succeed in signing a PPA and securing funding at all and are never built. Potential power purchasers may find a hydropower project could provide electric energy, but it lacks the peaking capacity and ancillary services that they are seeking. Other reasons could include litigation risks for projects after they are licensed that make risk-adverse purchasers and investors weary of going forward. Finally some investors and power purchasers may not be aware that "low-impact hydro" projects may qualify as "green power" and can generate RECs.

HYDROPOWER REIMAGINED FOR THE NEXT 20 YEARS

Federal and non-federal hydropower project owners or those proposing new projects should

[7] FERC. (2017). *Hydropower Primer. Retrieved from* https://www.ferc.gov/sites/default/files/2020-05/hydropower-primer.pdf

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be exploring ways to monetize their attributes as a renewable energy resource. A key issue for existing hydropower owners is to understand that the market for renewable energy has changed; they are competing with wind and solar projects in the electricity markets. Also, power purchases are not necessarily limited to just electric utilities. Many non-utility businesses are trying to reduce their carbon footprint and may be quite willing to sign a PPA with a hydropower owner. Some non-utility businesses need the assurance that the power they are purchasing is green power. Hydropower owners can apply for RECs to assure purchasers and investors that the project is "low-impact hydro" under a state program or under the US Environmental Protection Agency's (EPA) green power program. Once this is done, the hydropower owner can sell the RECs and monetize the attributes of a hydropower project for years to come.

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The Low Impact Hydropower Institute (LIHI) has certified 178 projects to date, and 18 additional projects are under review (**Figure 1**).

BECOME A GREEN H_2 PRODUCER

According to ClearPath,[8] H_2 is an emerging option for long-duration energy storage.

Like natural gas, it can be stored for long periods of time and can be easily transported by truck to different locations. Since H_2 is a gas, it can be stored in different sized containers, from small tanks to large underground caverns. Large-scale H_2 storage can be especially useful for industry because it provides a steady source of H_2 as a feedstock even if the amount of H_2 being added is irregular during periods of excess hydropower production.

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H_2 is increasingly being discussed across the US. However, the supply of green H_2 is limited and not available to serve new end-users. This presents an opportunity for most hydropower projects to produce green H_2 even if it is only during periods of excessive flows that commonly occur during the spring months from rainfall and snowmelt events. Hydropower owners that want to produce green H_2 must purchase electrolyzers. It's very likely that the electrolyzers at California hydropower projects will be operating all of the time or during low-flow periods. However, they would produce green H_2 during high runoff periods during the spring or other times after meeting all environmental requirements to protect riverine resources. A few examples are provided below:

Douglas County Public Utility District (PUD)

On March 8, 2021, the Douglas County PUD began construction on a 5-megawatt (MW) electrolysis facility at Wells Dam on the Columbia River in Washington. This pilot project was funded initially by a $250,000 grant from the

[8] An entrepreneurial, strategic nonprofit, ClearPath (501(c)(3)) collaborates with public and private sector stakeholders on innovations in nuclear energy, carbon capture, hydropower, natural gas, geothermal, energy storage, and heavy industry to enable private-sector deployment of critical technologies.

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Figure 1. Location of Projects Certified by the Low Impact Hydropower Institute

Source: Low Impact Hydropower Institute

state. Eventually it received a $1.9 million grant from the Centralia Coal Transition Board to fund the Renewable Hydrogen Demonstration Project, which will deliver the first hydrogen fueling station for fuel cell electric vehicles (FCEV) in Washington state.

The Wells Dam often generates power through its turbines even though power prices can be very low or negative during periods of high renewable generation output, such as windy days during the spring snow melt. While the Grant County PUD would prefer to store its water and generate power when power prices are higher, flow requirements for anadromous fish in the Columbia River prevent them from doing so. As a result, power continues to be generated at the Wells Dam.

The new 5-MW proton exchange membrane (PEM) electrolyzer, built by Cummins, will be installed in late 2021 by the Douglas County PUD and can begin turning excess power into green H_2, which can be stored for later use. According to the PUD, the electrolyzer will be capable of producing 2,000 kilograms (kg) per day of green H_2. That amount is consistent with a PEM that is 56 percent efficient but also assumes the electrolyzer runs at 100 percent utilization. In reality, the electrolyzer will not be operating at that rate on some days or during periods of low water. Still, it is an example of a prudent way to utilize excess power while meeting the flow requirements to protect fishery resources.

In the case of the Douglas County PUD, there is no offtake agreement with an entity for the green H_2 at the present time. However, given the various uses of the fuel for blending in natural gas grids and as a transportation fuel this may not be such a critical issue.

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California's Dreaming of Green H_2

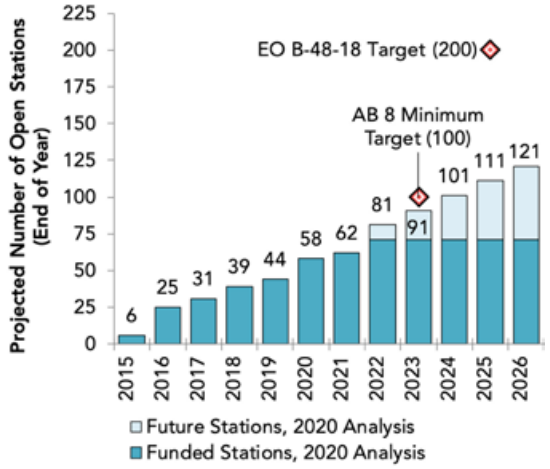
California is spearheading work in blending H2 within the natural gas grid and in the transportation sector.[9] The California Air Resources Board (CARB) is building out an H_2 fueling network for FCEVs (**Figure 2**), but only 36 percent of the fuel is green H2. Assembly Bill 8 (AB 8) set a goal of at least 100 Open-Retail hydrogen fueling stations by January 1, 2024, and Executive Order (EO) B-48-18 expands that goal to 200 stations by 2025.

In 2019 the state's 271 hydropower projects produced nearly 38,494 gigawatt-hours (GWh), or 19 percent of California's in-state generation portfolio. However, this author has found no evidence that any of these projects are directly involved in green H_2 production. It's very noteworthy that 198 of these projects are considered "Low-Impact Hydropower" since each is less than 30 MW. In 2019, these 198 projects had a total installed capacity of 12,282 MW and generated 33,152,894 megawatt-hours (MWh).[10] A large portion of the electricity was likely generated during periods of high runoff and so would produce green H_2 if these projects purchased electrolyzers. Therefore, hydropower could supply green H_2 to at least CARB's H_2 fueling station network that will grow over time. **Figure 3** displays projected hydrogen station network development based on the pace required to meet or exceed the target of 200 stations in 2025 per EO B-48-18 and maintaining a trajectory towards 1,000 stations as early as 2030.

Of course the amount of green H_2 produced by hydropower would vary each year and is largely dependent on snowmelt runoff and rainfall. Nevertheless, if a fraction of California's hydropower projects replicated what the Douglas County PUD is planning to do and purchased a 5-MW PEM electrolyzer capable of producing 2,000 kg per day, the state would increase its green hydrogen supply considerably and help California achieve net-carbon zero emissions.

Producers of H_2 may also be able to obtain a Renewable Identification Number (RIN) under the Renewable Fuel Standard administered by the EPA. Once obtained the RIN could be monetized by selling it. Currently there are no approved pathways for H_2 under RINs, but Air Liquide, Lyte, and FuelCell Energy have filed petitions for them with the EPA.[11]

Figure 2. Projected Station Deployment to Meet AB 8 and EOB-48-18 Compared to Business-As-Usual



Source: California Air Resources Board, 2020 Annual Evaluation of Fuel Cell Electric Vehicle Deployment & Hydrogen Fuel Station Network Development (Report Pursuant to AB 8; Perea, Chapter 401, Statutes of 2013), September 2020. See https://ww2.arb.ca.gov/resources/documents/annual-hydrogen-evaluation

[9] Russo, T. N. (2020). Hydrogen: Hype or Glide Path to Decarbonizing Natural Gas - Part 2. *Climate and Energy, 37(1), 24–32.*

[10] California Energy Commission. (2021). California Hydroelectric Statistics and Data. Retrieved from https://ww2.energy.ca.gov/almanac/renewables_data/hydro/index_cms.php

[11] California Energy Commission. (2021). California Hydroelectric Statistics and Data. Retrieved from https://ww2.energy.ca.gov/almanac/renewables_data/hydro/index_cms.php

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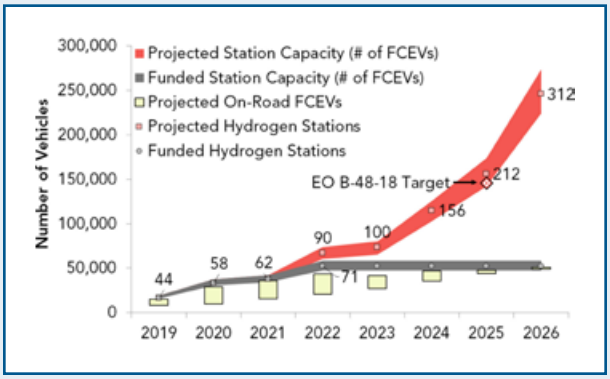
Figure 3. Projected Hydrogen Demand and Fueling Capacity



Hydro-Québec

On January 18, 2021, Hydro-Québec and German industrial giant Thyssenkrupp announced the installation of an 88-MW electrolysis plant for an electric utility, an energy firm backed by the provincial government. This Canadian project will use electricity from hydropower to produce green H_2. According to the Canadian government, hydro is responsible for 59.6 percent of electricity generation in the country. Thyssenkrupp said the new facility will be constructed in Varennes, Québec and will be able to generate 11,100 metric tons of green H_2 per year.

The green H_2 and oxygen produced by the electrolysis plant is set to be used at a biofuel plant to generate biofuels for use in transportation. Commissioning of the green hydrogen facility is slated for the end of 2023.

CONCLUSION

Hydropower owners and developers should rethink their role in the energy sector beyond traditionally producing power for the electric grid. Many hydropower projects produce just energy and not the peaking capacity and ancillary services that the electric grid is demanding today. As a result PPAs and participating in restructured electricity market don't fully reward hydropower for its renewable and non-carbon attributes. If hydropower projects began producing green H_2 and obtained RECs, it's very likely that non-utility power purchasers and/or investors would consider them in their decarbonization programs.

State energy plans and the energy transition are putting a premium on storage and green H_2. Therefore, current owners and developers should consider using a portion of their hydroelectricity to produce green H_2 especially during periods of high seasonal runoff when electricity is oversupplied, and demand is low.

State energy plans and the energy transition are putting a premium on storage and green H_2. Therefore, current owners and developers should consider using a portion of their hydroelectricity to produce green H_2 especially during periods of high seasonal runoff when electricity is oversupplied, and demand is low. Hydropower project owners would have to determine the economic feasibility of purchasing small electrolyzers and also seek support and funding from states that have formal Clean Energy Plans and State Public Utility Commissions. In addition, some projects may also qualify for federal tax credits if Congress passes future legislation to incent green H_2 production.

In addition to the above, hydropower owners should be seeking RECs as low-impact programs from state agencies or from the EPA green power program. The latter approach requires that the project be certified by LIHI. Once the RECs are obtained, they can be used to demonstrate to the public that the project meets the definition of green power and could be monetized by the hydropower owner.

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