Pumped-storage in the USA: A story of IPPs, PPAs and regulated utilities

The USA has historically been one of the leading countries for pumped-storage development, with total capacity totalling about 22 GW, and the largest project (Bath County) having a capacity of 3000 MW. Today a large number of major planned pumped-storage projects are at various stages of planning and development. News Editor Martin Burdett has discussed with a number of developers and consultants both the incentives and the remaining hurdles for new pumped-storage schemes to move forward, and the clear benefits they will provide when they are developed, particularly in the view of the large volume of intermittent renewables coming on line.

The USA has the second largest pumped-storage capacity in operation in the world, with 43 plants totalling 21.9 GW and an estimated storage capacity of 553 GWh, including the world's second largest plant, the 3 GW Bath County facility in Virginia. Built mostly in the 1970s and 1980s to complement nuclear power, pumped-storage has been the 'silent workhorse' of the country's power grid, and the backbone of the generation system, ensuring system reliability, and rarely any significant recognition of its services. But the rapid expansion of intermittent renewables, wind and solar, and the growing variability of weather systems, with more frequent extreme events, has led to the recognition of the value of pumped storage and the understanding that much more is going to be required in the future.

This could be a renaissance for pumped-storage in the USA, and, it is hoped, not another false dawn. With three projects fully licensed by the Federal Energy Regulatory Commission (FERC), numerous projects at advanced stages of permitting, and a pipeline of 49 projects totalling 39.5 GW with preliminary permits as of July 2023, the prospects for new pumped-storage look bright. However, construction has not actually begun on the first new project in more than 30 years. Of equal interest to market followers is whether the first new project will be built by an Independent Power Producer (IPP) or by one of the regional electric utilities. The absence of a signed power purchase agreement (PPA) for any of the three fully licensed IPP projects or by any others IPP projects at advanced stages of development remains a concern, but not for all. "Among utilities interested in pumped storage, some seem to be more interested in acquiring projects partially or wholly, while others would lean more towards signing a PPA", said Matthew Shapiro, CEO of rPlus Hydro, the country's leading pumped-storage developer. "Investor-owned utilities seem to want to own infrastructure assets and rate base them, but that is not the only business case. We are still wating to see which project gets the first offtake agreement with a utility, whether that be one of ours or a different developer, but I believe that it is not too far away now".

The Eagle Mountain pumped storage project, which will be an integral component of California's renewable energy policies, and its goals for reduction of greenhouse gas emissions.

Three closed-loop IPP projects, totalling more than 2 GW of capacity, are now fully licensed by FERC, and are ready for final design and construction, pending the signing of a PPA: the 400 MW/3400 MWh Gordon Butte project in Montana, which is being developed by Absaroka Energy; the 393 MW/3700 MWh Swan Lake North project in Oregon by Copenhagen Infrastructure Partners (CIP); and, the 1300 MW/23 400 MWh Eagle Mountain project in California, by Eagle Crest Energy. The prestige of building the first new pumped-storage scheme could, however, go to rPlus Hydro, which has the largest and one of the most advanced portfolios, with 12 projects in the western USA with a combined capacity of 7100 MW. rPlus has two projects that have moved into the final licence application phase: the 1000 MW/8000 MWh White Pine project in Nevada, and the 900 MW/9000 MWh Seminoe project in Wyoming. Meanwhile, the 600 MW Owyhee scheme in Oregon advanced this year to the Pre-Application Document (PAD) stage. Moreover, rPlus's 500 MW Oquirrh project in Utah and 500 MW Bison Peak project in California can move forward with one less permitting hurdle, as neither requires a FERC licence. Only an estimated 14 pumped-storage projects in the USA have interconnection queue positions. Eight of these belong to rPlus Hydro. Shapiro suggested that construction of the first of its projects could begin as early as 2025, although more likely in 2026, for commissioning in 2030. "We have certainly made progress in terms of discussions with utilities, and this spans both project build transfer type of arrangements, and PPAs. We are open to both, and some of the utilities that we have been talking to seem open to both too".

The current status of pumped-storage development in the USA is similar to the situation in numerous other competitive electricity markets in the world, such as the UK. The capability of the only commercially available long-duration energy storage technology is unquestioned, as is the essential role it plays, and will play, for the stability and resilience of current and future grids. As a result, there is cautious optimism for its future development. There is also a growing acknowledgement of the critical need for increased long duration storage in current and future zero-carbon electricity markets, to allow for the rapid expansion of variable renewables, such as wind and solar, at a time when fossil fuel plant is being retired. Its critical role has long been understood by the hydropower industry, and more generally the power sector, and this recognition has started to flow through in state and federal policy initiatives. Pro-renewable state policies have provided positive policy frameworks for the development of energy storage, while the Biden Administration has introduced important fiscal incentives providing a fillip for developers, in particular IPPs. However, the uncertainty that comes with developing large infrastructure projects, in some cases with multi-billion dollar outlays, lingers without clarity about long-term revenue streams and a return on investment. The major remaining hurdle for IPP projects is the continued reticence of regional utilities, which are by nature more risk averse, to commit either to a long-term PPA or a buy-out.

Tax credits

A number of new developments over the past year have provided encouragement for the prospects of new pumped-storage. The largest development in terms of policy and legislation was the Inflation Reduction Act, which was adopted in August 2022, and which provides an investment tax credit (ITC) of up to 50 per cent for stand-alone energy storage systems, including pumped storage. This comprises a tax credit of 30 per cent if the project meets prevailing wage and apprenticeship requirements, and a so-called Energy Community Bonus, which offers a 10 per cent increase in the ITC if projects are located in an area which has experienced coal plant, coal mine and oil industry retirements. A project can also qualify for an additional 10 per cent credit in the ITC if the it meets a minimum domestic content requirement. The Inflation Reduction Act (IRA) of 2022, which represents the single largest investment in climate and energy in American history, is intended to enable the USA to tackle the climate crisis, secure its position as a world leader in clean energy manufacturing, advance environmental justice, and put it on a pathway to achieve the Biden Administration's climate goals, including a net zero emissions economy by 2050. Together with the Bipartisan Infrastructure Law, these initiatives are designed to help the USA reach President Biden's goal of reducing greenhouse gas emissions by 50-52 per cent in 2030 relative to 2005 levels.

"rPlus Hydro was instrumental in ensuring that pumped storage was clearly identified as an eligible resource for the ITC, and that all components of pumped-storage projects would be included, not just the equipment but also the dams, reservoirs and tunnels", said Shapiro. "We are confident that our projects will meet domestic content thresholds, so we are looking in many cases at a 40 per cent or in some cases a 50 per cent tax credit, which will clearly make a big difference for energy storage finance".

Regarding legislation, Shapiro notes that several bills that would have positive implications for pumped storage have been proposed recently in Congress. One of them has provisions to streamline some of the permitting requirements, while the other has a provision that would remove the requirement for a FERC licence for certain types of projects. At present virtually all pumped-storage projects need a FERC licence. "This legislation, if it is passed, would exempt certain closed-loop projects from requiring a FERC licence, which makes a lot of sense because federal overseeing of pumped-storage projects dates back to a time when a lot of projects were being built on rivers, and were going to need a federal entity to mediate water impacts that may cross state boundaries. A lot of proposed projects today are closed loop in nature, rather than being on rivers. Their water requirements are relatively modest, so it really does not make sense for this agency to have jurisdiction over them particularly, as there are coal and gas plants that use far more water from rivers than these closed-loop projects," he explained.

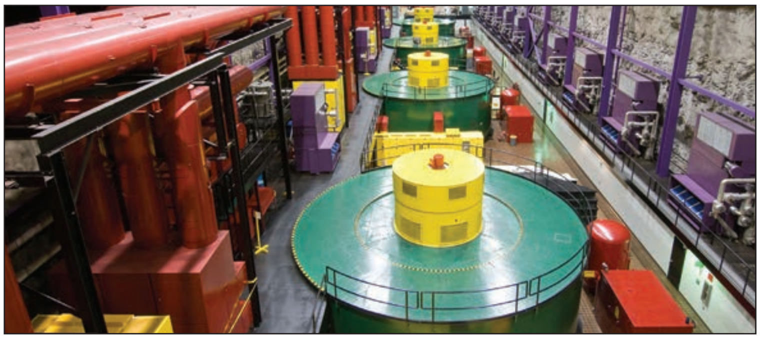
This is already the case for two closed-loop projects that rPlus Hydro is developing: the 500 MW/4000 MWh Oquirrh project near Salt Lake City in Utah and the 500 MW/3500 MWh Bison Peak project in California. "The Oquirrh project is advancing on a different track in terms of permitting, as we obtained a ruling from FERC that it would not require a licence because it does not involve any federal lands, and also because none of the water that naturally flows through the site leads to a river that crosses inter-state borders," explained Shapiro. We also obtained a determination that FERC licensing would not be required for Bison Peak in California, depending on its fill water source. That is fairly rare," he added.

Regulated utilities entering the game

While IPPs have been blazing a trail for new pumped storage for decades, without success to date, perhaps one of the most encouraging developments in recent times has been the growing interest among regulated utilities, notably in the southeast of the USA. Duke Energy, Southern Company and the quasi-governmental Tennessee Valley Authority (TVA) are now all pursuing projects within their power service areas at various levels, filing either preliminary permit applications or in some cases advancing projects in permitting. "That is a very good sign, because if they are doing it themselves, then that shows a lot of interest and value in new pumped storage," said rPlus Hydro's CEO. "All three utilities are large enough to carry out development on a stand-alone basis, and perhaps capable of funding their projects," Vladimir Koritarov, Director of the Center for Energy, Environmental, and Economic Systems Analysis (CEEESA) at Argonne National Laboratory, told *Hydropower & Dams*. "This is encouraging as such utilities do not need to rely on the market, because they are regulated utilities so they see pumped storage as enhancing their own portfolios, providing system savings for their owners, and in addition they have the means to deliver their own projects".

In May this year, TVA announced that, to meet its obligations under the National Environmental Policy Act (NEPA), it is preparing a Programmatic Environmental Impact Statement (PEIS) to evaluate potential new facilities at two locations in Jackson County, Alabama (Rorex Creek near Pisgah and Widows Creek near Fabius) as well the expansion of the existing Raccoon Mountain pumped-storage plant in Marion County, Tennessee. The PEIS will consider potential environmental and economic impacts from the construction and operation at each site. Based on its findings, TVA said it

The Raccoon mountain powerhouse.

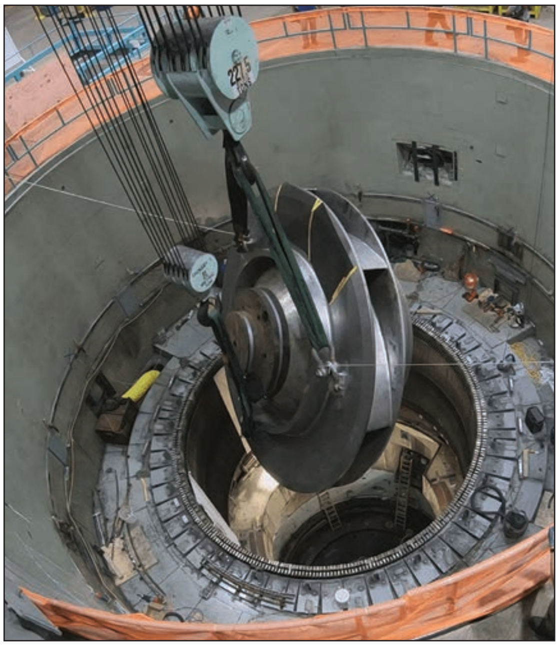


may potentially select one or more sites as the need for long-duration energy storage increases. TVA said as part of its substantial decarbonization effort and aspirations to be carbon neutral by 2050, long-duration storage (8 to 12 hours) will be needed to balance the daily energy cycle. This will enable additional generation from solar, new nuclear, and carbon capture technologies by assisting with load balancing and allowing these technologies to run nearly full time.

"Utilities are seeing a change in the function of pumped storage, with a lot of solar development taking place. For example, they are seeing pumping starting in the morning, which historically was not the case, so there is an additional function of these plants of saving solar generation for afternoon peak," said Shapiro.

Alabama Power, a subsidiary of Southern Company, received in March 2022 a preliminary permit from FERC to study the Chandler Mountain pumped-storage project on Little Canoe, Gulf and Jake creeks near Steele in Etowah and St. Clair counties, Alabama. The proposed scheme is planned to be equipped with reversible pump-turbines, with a capacity of between 800 and 1600 MW.

Duke Energy Carolinas is, meanwhile, considering whether to expand further its 1640 MW Bad Creek pumped-storage project in Salem, South Carolina, to accommodate plans for more solar generation. The original licence for the station expires in July 2027, and the subsidiary plans to submit a new FERC licence application no later than July 2025. As the first step in that process, in 2022 Duke filed a pre-application document (PAD) and notice of intent to relicense Bad Creek for another 40 to 50 years. That notice also included the possibility of building a second 1400 MW four-unit underground power complex at Bad Creek, which could approximately double the currently installed generating and pumping capacity, but would reduce the available run time, according to the filing. The Bad Creek II Complex could also contain variable-speed units, which would have the ability to regulate in both generating and pumping modes, providing frequency regulation to support the integration of Duke Energy's "ever-expanding intermittent renewable energy resources". Duke Energy owns all the property that would be needed to build a second powerhouse, and if the company chooses to pursue the expansion, construction could take six to seven years, with units potentially fully in service as early as 2033. In 2021, Duke announced that it had surpassed 10 GW of wind and solar energy, and is aiming to reach 16 GW by 2025 and 47 GW by 2050.



Removal of the original pump-turbine runner from Unit 2 at Bad Creek.

The company is, meanwhile, set to complete upgrades of all four units at the existing Bad Creek facility this year, to increase its capacity by 280 to 1640 MW, making it one of the largest pumped-storage stations in the USA. The upgrades, carried out by Voith Hydro, Andritz Hydro and ABB since 2019, has provided an additional 70 MW of generating capacity per unit. Each overhauled pump-turbine unit generator output was increased from 340 to 410 MW and the pumping capacities from 310 to 375 MW. The first unit was completed in October 2020, the second in October 2021, the third in September 2022 and the last unit is due to restart this year.

"Regulated utilities are once again becoming very interested in developing new pumped-storage project, especially those that are existing owners of pumped-storage hydro schemes as they know how beneficial these projects can be in their system", said Mike Manwaring, Western US Regional Sector Lead for Energy at the engineering consultancy Stantec. "IPPs have been driving the development of these projects for the last decade and are much further advanced with their projects, but they still must find an offtake agreement with a utility. A regulated utility can make the case to their utility commission and make the decision to build the plant, and then you can have confidence it will be online in the next seven to ten years. Some of these utilities have land they own or bought previously for pumped-storage projects originally envisaged back in the 1970s and 80s, and they are now 'dusting off' these projects to see if they make sense today," said Don Erpenbeck, Vice President and Global Sector Leader, Dams & Hydropower at Stantec. "With rapidly rising renewables penetration in their service areas, they are now recognizing the need for new pumped storage, and can bring a rate case to their utility commission when ready. I believe those are the most likely to go forward," he said. "For them, the offtake agreement is not really an issue", he added.

"I have come to the conclusion that it may take a regulated utility on a rate case basis to build any pumped storage in the USA right now," said Erpenbeck. "Now that rate case could come in the form of an offtake agreement with an IPP, so it is not necessarily ruling out the IPP developers, but it would have a rate case behind the offtake agreement. It is the way the old school utilities used to do it before they were deregulated and split up, and guarantees cost recovery plus a very small profit", Erpenbeck said.

Incorporating pumped storage in resource planning

Increasing numbers of regional utilities are incorporating pumped storage in their long-term resource planning, which Shapiro considers "an encouraging development". Over the past year, at least two utilities have selected new pumped storage capacity in their resource plans. Most utilities have to go through a robust resource planning process and objectively identify the best type of new generation to meet growing demand, particularly as fossil plants are retired. "The fact that Puget Sound Energy and Northwestern Energy in the northwest region has included pumped storage capacity in its new plans is positive news", he said. "As utilities' choices for reliable dispatchable generation resources narrow, because they can no longer build additional fossil fuel sources, then they are going to pick energy storage to integrate wind and solar and there are not a lot of choices. Where there are good pumped-storage options, they should be favoured as part of their generation portfolios," he said.

All these developments are good news for IPPs giving greater confidence to pursue their projects despite the lengthy and costly permitting and development processes. "There is a distinct possibility of some of these regulated utilities buying into some of the IPP projects and taking them forward," said Erpenbeck. "There is a real probability of joint ownership between IPPs and regulated utilities, and that would derisk a lot of the projects from the forward-looking uncertainty over 20 to 25 years. It is a risk management thing, considering a large pumped storage project", said Manwaring. "If you split a billion dollar investment between two or three owners, then the economic risk is reduced considerably. It is much more tolerable for utilities from a risk perspective. There is also no lack of interest from capital institutions to be part of these projects. The capital is there. They are just waiting for the necessary long-term offtake agreements that help reassure them there will be an acceptable return on investment," said Manwaring. "I always say that nothing will get the second pumped-storage project built faster than the first one, finalizing its contract mechanism. Once somebody makes that leap, I suspect other projects will follow pretty quickly," he added.

Decarbonization drives development

Perhaps the most intriguing aspect of pumped-storage development in the US electricity markets is that there is no specific support mechanism in place to monetize fully the grid services provided by pumped storage. Pumped-storage plants can provide dispatchable capacity, energy arbitrage and several ancillary services, but not all markets in the USA have capacity markets, including California, where a mandatory resource adequacy requirement serves to ensure system reliability. There are also decreasing revenues for arbitrage between the sale of peaking power and the purchase of off-peak power for pumping, according to Koritarov, as most markets have price settlement on the marginal price, and with large resources like wind and solar with zero or near zero marginal cost, the marginal cost is very low and there is not much differential between day and night.

Markets for regulating services, spinning reserve, and other supplementary reserve are, moreover, relatively small and easily saturated with existing capacity so revenue streams are limited and prices are very unpredictable, making long-term projections difficult as the basis for financial analysis.

"The best value is the integration of renewables with pumped storage in a hybrid style arrangement," Rhett Hurless, Senior Vice President and COO of developer Absaroka Energy told *H&D*. "With this model, you can increase the capacity factor by 20 to 30 per cent," he noted, "and hit the 'dispatchable' mode for renewables. With the retirement of coal units, the grid needs inertia to ride through 'events', so with pumped-storage we can fill that niche with spinning mass," he said, when asked about the potential for providing ancillary services.

"What is driving most development activity is the decarbonization shift," said Shapiro. "There is no national policy yet, but on a state-by-state and utility-by-utility basis, there are significant shifts towards decarbonization with the retirement of coal-fired generation, changes to plans for new natural gas-fired capacity and renewable energy requirements that are being put in place, ranging from 50 per cent by 2030 to 100 per cent by 2040 and 2050. We are not really waiting for a particular market mechanism, but rather looking at the reality of the situation, which is that we are going to need firm capacity sources to integrate all that wind and solar energy, and for us that points to pumped storage."

"Decarbonization is happening, although maybe not by 2035 as the Biden Administration has proclaimed, but at some point there will be a carbon-free electricity system and then utilities will look at their portfolios and system operators will realize that they will need a lot of storage to operate systems in those conditions," Koritarov observed. "The economics have not changed much, but people now realise that pumped storage will be a necessity. It is the only commercially available technology that can provide long duration storage, which is critical to providing resilience to the system. Other new technologies may emerge over the coming years, such as ion-air batteries, which are being developed by Form Energy, with up to 100 hours of storage, but they will not have the flexibility of pumped storage, or the ability to ramp up and down".

"Regulated utilities are responsible for providing reliable power to their customers. That has always been their main driver, but now they also have environmental and social drivers. As society continues to focus on decarbonization and invest in renewable resources like solar and wind, we need energy storage resources that can provide long duration generation when wind and solar are not available. But, a pumped-storage project also provides a place to store excess renewable energy in the form of mechanical energy in an upper reservoir. We often use the term 'water battery' to describe a pumped-storage project, as people understand the concept of charging or discharging a battery. Communities are also starting to appreciate that pumped storage is more than a typical hydropower project; it is also a critical transmission asset to help manage the grid. And pumped storage can also serve as a water resource project, providing water supply, recreation, flood control and other services that a conventional hydropower may offer. When effectively partnered with renewable resources, pumped storage is not a GHG emitting project and so it fits nicely into a utility's environmental and social justice goals," said Manwaring. "Most utilities are being evaluated by their stakeholders by how much renewable energy they can develop, regardless of individual state policy guidelines. Utilities are investing more and more in renewables, as they are getting more positive credits on the stock markets for being greener, and that is also definitely pushing in favour of pumped storage," said Erpenbeck. "The three-way intersection between state policies, federal incentives, and growth of renewables all are making pumped storage look like a really attractive technology and solution for grid reliability. Grid integration and the understanding of the long-term need for pumped storage is the fourth leg of that stool and that is now becoming a reality", he said. ◊