

Increasing energy storage capacity in North America

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Pumped storage will be an essential component in the North American energy transition, helping to deliver a sustainable and reliable energy supply from renewable and intermittent forms of power generation. It is the most effective way of storing large amounts of energy and provides significant reliability benefits to the electric grid. This article gives a brief overview of the current focus on current and planned pumped-storage development in the USA and Canada.

Pumped storage is increasingly being recognized worldwide for its current and future potential to support renewable energy integration and grid stability. As the world transitions towards renewable energy sources, pumped storage will increasingly help to address the intermittent nature of renewable sources like solar and wind.

This article focuses on existing pumped-storage plants in the USA and Canada, and future planned developments in this field. In both countries, there is increasing interest in developing new pumped-schemes and upgrading existing plants to meet the energy needs of each nation, and to support the reliability of power supply across North America. Pumped-storage projects are seen as vital in both reducing greenhouse gas emissions from conventional plants and providing a stable energy supply. The recent resurgence of pumped storage is also supported by favourable federal and provincial policies, grants, and investment incentives, all aimed at promoting sustainability and reliability for consumers.

Current pumped-storage development in the USA

Pumped storage hydropower is experiencing a resurgence in project development across the globe. In the USA, this is especially driven by the increasing need for renewable energy integration, new generation capacity to offset generation for thermal plant retirements, and improved grid stability.

A total of 69 proposed pumped-storage projects are currently at various stages of design and planning across 22 states in the USA. These projects represent more than 60 GW of new storage capacity. Seven of these projects are at an advanced stage of design, with an investment having been made in them of almost US\$ 1 billion; they represent more than 6 GW of new installed generating capacity. Several of these projects

could be online between 2033 and 2037. Stantec continues to be a leader in new pumped-storage developments in the USA, from an engineering, design, and regulatory perspective. At present the company is serving as the lead designer or owner's engineer on multiple new projects in the development pipeline.

Recent USA federal policies and presidential executive orders have established favourable tax and investment conditions for new pumped-storage developments, in recognition of their contributions to grid reliability and energy security. The Inflation Reduction Act of 2022 introduced substantial clean energy tax credits and incentives which are resulting in a significant rise in pumped-storage investments. More recently, the so-called 'One Big Beautiful Bill Act' was signed into law on 4 July 2025, which extended investment tax credits (ITC), including the elective pay provisions, for hydropower, pumped storage, and marine energy through to 2033.

A consistent concern with developing new pumped-storage projects is the difficulty of forecasting future revenue of the new facility once it has been constructed, particularly as large pumped-storage projects often take 10 or more years from conception to operation, when they begin to generate revenue. With many parts of the country operating in competitive electricity markets, forecasting revenue ten or more years head represents significant uncertainty. This is especially true when there are limited revenue sources within these competitive markets for the ancillary services that pumped-storage projects can provide to the grid, including load following, frequency and voltage regulation, and system inertia.

At present, pumped-storage projects are being advanced by public utilities in the southern USA. This takes advantage of the vertically integrated organizations. In these scenarios, the projects will not only be used for energy storage to complement new intermittent renewables projects, but will also be used to provide additional stability to the grids. These projects, and many others under development across the USA, are also incorporating variable speed pump-turbines. These can provide even greater load following capabilities, faster response times to increased load, frequency regulation, and pumping at less than full load. The new variable speed units will provide frequency regulation and load following in the pumping mode, which the conventional units installed at all of the operating pumped-storage plants in the USA have not been able to do. In addition to taking advantage of the ancillary services these pumped-storage projects will provide to the grids, the public utilities could also be in a position to take advantage of the ITC using the elective pay provision. That will provide credits to the util-

Conceptual rendering of the pit-style powerhouse facilities for the planned 1000 MW Salt River pumped-storage project in Arizona, USA.



ities in the form of a rebate-like payment after a plant begins service.

One of the projects currently under design is a 1200 to 1600 MW pumped storage scheme being proposed by the Tennessee Valley Authority (TVA) along the Rorex Creek near Pisgah, Alabama. The TVA is aiming to be carbon neutral by 2050 and is planning for this pumped-storage project to provide 8 to 12 hours of storage. This will help them to balance the energy cycle and allow for additional generation from solar, nuclear, wind, and other renewable energy projects.

The Salt River pumped-storage project is also planned at Apache Lake on the Salt river in Arizona. The objective is to support grid reliability, boost renewable energy supply, and reduce carbon intensity. The planned project will have a capacity of 1000 MW with more 10 hours of energy storage, and with provision for a possible 1000 MW upgrade in the future.

Outlook for pumped storage upgrades, refurbishments, and life extensions

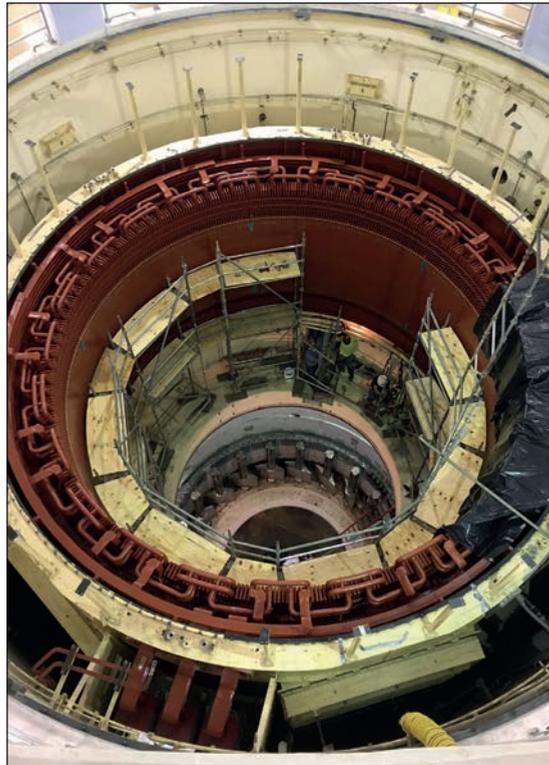
The USA has the third largest pumped-storage hydropower fleet in the world, with more than 23 000 MW of capacity which was mostly installed between 1960 and 1994. While a few plants were constructed in the 1960s, and one major project in the early 1990s, most of the US plants were built during the 1970s and early 1980s. These plants have not been sitting idle: they have been operating to support the changing power grid since they were commissioned.

But running these powerplants so hard has resulted in challenges. First, at almost every pumped-storage project, the original equipment has worn out. These have had to, or will have to, go through major life extension programmes. In some cases, the plants might require a second life extension programme. Almost every project has had pump-turbines, generator-motors or their components, and main inlet valves replaced, and there are some such projects ongoing. At least one plant is on its fourth set of pump-turbine runners.

While it may sometimes seem that the US pumped-storage market has 'dried up', this is far from being the case. Most of the existing pumped-storage projects have had major life extensions to increase outputs, sometimes in stages, typically by 20 per cent, and in some cases, by 30 per cent.

One example is the Rocky Mountain plant, the newest utility-scale pumped storage project to be implemented in the USA. Built in 1994, Rocky Mountain was upgraded after only 12 years. This increased its capacity from 845 to 1030 MW. Another example is Duke Energy's Bad Creek plant in North Carolina. An upgrade has just been completed there, which increased its capacity from 1360 to 1640 MW. In fact, the USA has added more than 3000 MW of new pumped-storage capacity through upgrades since 1994. And more such schemes are on the way, with major plans in progress at Pacifica Gas & Electric's Helms plant in California and the Grand River Dam Authority's Salina plant in Oklahoma.

These upgrade projects will typically have paid for themselves, including the life extension, by the time the last unit has been upgraded. The pumped-storage refurbishment and upgrade market has averaged more than US\$ 1 billion a year in spending over the last 25 years, and this is continuing today. The will-



View down the dismantled pump-turbine undergoing refurbishment recently at the 1030 MW Rocky Mountain plant in the USA.

ingness of pumped-storage plant owners to reinvest in their projects is the ultimate proof of the value of pumped storage.

Now that much of the pumped storage fleet in the USA has undergone upgrading with advanced technology, little to no further upgrading work is now technically feasible. However, more energy storage capacity is required across North America, and as a result new plants must be constructed. The life extension activities will continue into the foreseeable future, however, as utilities do not plan to retire pumped storage stations at present.

Recent developments in Canadian pumped storage

In its strategic response to the country's net zero emissions targets for 2035 and 2050, Canada is experiencing a renewed focus on pumped storage as a critical component of its clean energy transition.

Pumped storage has historically been underutilized in Canada. This is because of the nation's abundant conventional hydropower resources, equivalent to more than 80 GW in generating capacity. But now, pumped storage is being recognized for its critical role in grid flexibility, renewable integration, and energy security.

The population of Canada is projected to reach 50 million by 2050. But the electrical demand growth is forecast to exceed population growth. This is because of the added effects of electrification of transportation and resource industries, as well as the establishment of major data centres.

According to Waterpower Canada's assessment (led by Stantec, in collaboration with the Australian National University, CEATI, and Power Advisory), more than 8000 GW of technically feasible pumped-storage potential has been identified across nearly 1200 candidate sites in the country. At present, many

utilities and power producers are evaluating this immense potential for development. This is largely concentrated in British Columbia, Québec, and Newfoundland and Labrador, where mountainous terrain naturally provides the highest energy density for the stored water. These regions are also well correlated with the wind atlas of the country, indicating potential co-location of wind and pumped storage hydropower sites.

However, it is Ontario that is emerging as a key province for pumped-storage development. This results from the power market and other economic conditions there. In this context, it is noted that the country's only pumped storage facility is a 175 MW plant, operating since 1957 as part of Ontario Power Generation's (OPG's) Sir Adam Beck Complex in Niagara, Ontario. The Ontario Government has launched its first integrated energy plan, entitled 'Energy for Generations'. This takes the electricity system operator's 'Annual Planning Outlook' into consideration, forecasting net annual energy demand to increase by 75 per cent by 2050. The plan specifically mentions TC Energy's Ontario pumped-storage project. This is a 1000 MW project near Meaford, Ontario. It is expected to be in service in the early 2030s, subject to regulatory and corporate approvals. The Minister of Energy asked TC Energy to advance the project, and announced that the Government would be investing in the pre-development work, including completion of the cost estimate and environmental assessments.

While Canada's pumped storage potential is vast, and political will is stronger than ever both federally and provincially, challenges still remain. These relate to the permitting process, community support, ground risk, scarcity in expertise, supply chain support, cost escalation, and uncertainty in revenue stream for energy arbitrage and grid services. Generally, these are no different than those presented in the international context by an IHA Guidance note on de-risking pumped-storage investments.

The promising future for pumped storage in North America

In both the USA and Canada, progress in pumped storage development and upgrading is testament to the resilience and adaptability these projects can provide.

In the USA, the significant focus on upgrading existing facilities is extending both the life and capacity of pumped-storage plants. Projects like the Rocky Mountain and Bad Creek have led the way. They showcase how strategic investments can yield substantial returns for operators embracing upgrades. But as there are only so many upgrades that can take place, the emphasis is now set to shift back to designing and building new projects. This is essential to meet the increasing demand for grid reliability and the commissioning of more intermittent renewables into the mix.

In Canada, the underutilization of pumped storage is starting to change. This is in response to the nation's ambitious net zero emissions targets for both 2035 and 2050. The significance of WaterPower Canada's identification of more than 8000 GW of pumped-storage potential cannot be overstated. It marks a monumental opportunity for Canada's energy infrastructure. Lately, Ontario has been emerging as a key candidate location

because of its actively increasing power market. The province's proactive energy planning underscores the strategic importance of pumped storage in achieving its energy targets.

Addressing the challenges mentioned in this article requires a concerted effort from policymakers, industry stakeholders, and host communities.

Clearly the future of pumped storage in providing flexibility, integrating renewable energy, and enhancing energy security offers too many benefits to discount. Future developments will require significant further investment, planning, and as always, innovation. This technology will remain a flagship of the energy future in the USA and Canada, as in many other parts of the world. ◇



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