Opportunities in Pumped Storage Hydropower:
Supporting Attainment of Our Renewable Energy Goals

By: Rick Miller, P.E., Senior Vice President, Hydropower Division, HDR|DTA and
Maureen Winters, Corporate Consultant, Hydropower Division, HDR|DTA

Abstract

Since its inception in the 1930s pumped storage hydro has provided significant benefits to our energy supply system including storage, load balancing, frequency control and reserve generation. Pumped storage is now being applied to firm the variablity of renewable power sources, such as wind and solar generation. Pumped storage absorbs load at times of high output and low demand, while providing additional peak capacity. With the advent of state by state Renewable Portfolio Standards driving the planning and commissioning of a tremendous amount of variable renewable energy projects across the country, America's electrical energy infrastructure needs storage capacity more than ever. Pumped storage hydro is proving to be an enabling technology for these growing variable renewable power sources' penetration into the United States energy supply system.

While the 31 GW of new pumped storage project proposals now before the Federal Energy Regulatory Commission demonstrates the hydropower industry's commitment to building new pumped storage capacity to support variable renewable sources, developers still face significant obstacles, including an uncertain investment climate and long development timelines. Expanding the current investment and production tax credits, the possible creation of an energy storage credit, coupled with policies that recognize pumped storage as a part of the transmission system for purposes of qualifying for the transmission rate incentives currently afforded to transmission system upgrades and expansions, would encourage investment in pumped storage. This growth would displace the need for additional fossil-fuel based peaking generation, and provide the load management capacity necessary to meet our national renewable energy goals.

Introduction

Pumped storage hydroelectric projects have been providing valuable storage capacity, transmission grid ancillary benefits and renewable energy in the United States and Europe since the 1930s. Today the 40 pumped storage projects operating in the United States (Figure 1) provide more than 20 GW, or nearly 2%, of the capacity for our nation's energy supply system (Energy Information Administration 2007a). Pumped storage and conventional hydroelectric plants combined account for 77% of our nation's renewable energy capacity, with pumped storage alone accounting for approximately 16% of our renewable capacity (Energy Information Administration 2007b).

The contributions of pumped storage hydro to our nation's transmission grid -- by providing stability services, storage capacity needs, and expanding the green job market -- are considerable today. But what additional role can pumped storage play in the future of a nation facing rapidly growing needs for storage capacity and green power, and that is relying on an economic recovery spurred on by investment in renewable energy

technology and associated jobs? With the American Recovery and Reinvestment Act of 2009 and evolving state and federal renewable portfolio standards as catalysts, and given the accompanying legislative and regulatory policy support for investment in this technology, the opportunities for pumped storage to play a key role are significant.

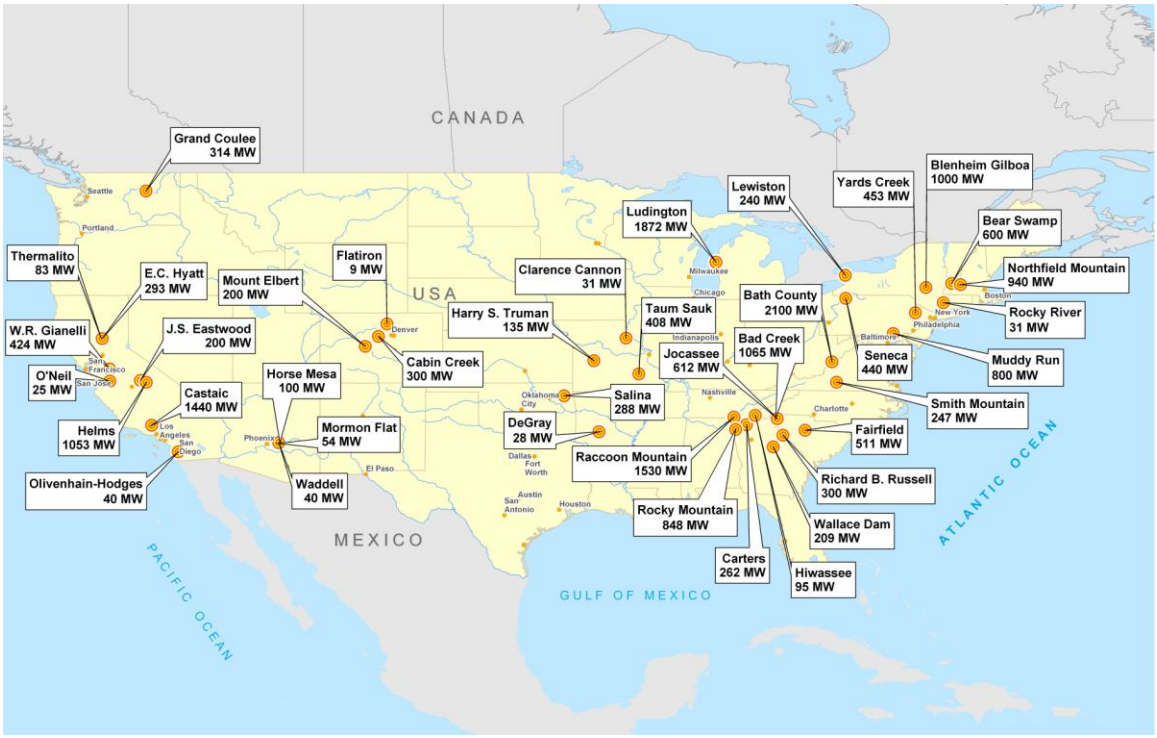

Figure 1 Existing Pumped Storage Projects in the United States

<u>What is Pumped Storage Hydro?</u>

Pumped storage is a type of hydroelectric power generation that stores energy in the form of water in an upper reservoir, pumped from a second reservoir at a lower elevation (Figure 2). During periods of high electricity demand, the stored water is released through turbines in the same manner as a conventional hydro station. Excess energy, usually at lower cost during the night and on weekends, is used to recharge the reservoir by pumping the water back to the upper reservoir. Reversible pump/turbine and motor/generator assemblies act as both a pump and a turbine. Pumped storage stations are unlike traditional hydro stations as they are a net consumer of electricity. In reality, pumped storage plants are transmission facilities and they can be very economical, from an overall system operation perspective, due to peak/off-peak price differentials and, more importantly, the provision of ancillary grid services.

Pumped storage historically has been used to balance load on a system and allow large, thermal generating sources to operate at optimum conditions. Pumped storage is the largest-capacity and most cost-effective form of grid energy storage currently available. Pumped storage systems also provide ancillary electrical grid services such as network frequency control and reserve generation. This is due to the ability of pumped storage plants, like other hydroelectric plants, to respond to load changes within seconds.

Pumped storage is now being applied to firm the variablity of renewable power sources, such as wind and solar generation. Pumped storage can absorb excess generation (or negative load) at times of high output and low demand, and release that stored energy during peak demand periods, proving to be an enabling technology for the growing wind power penetration into the United States energy supply system.

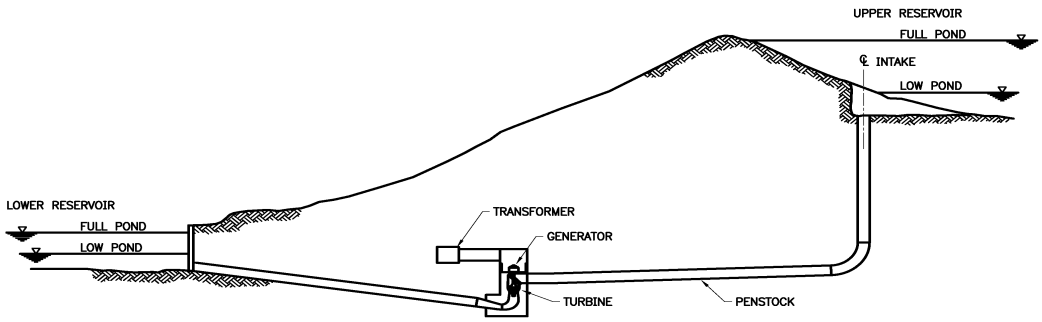

Figure 2: Typical Pumped Storage Plant

The Critical Need for Energy Storage

As mentioned previously, pumped storage hydro has, since its inception, provided significant benefits including storage, load balancing, frequency control and reserve generation. Compressed Air Energy Storage also provides bulk storage, but currently there is only one installation in the United States, with others under development or consideration. In contrast to these bulk storage technologies, batteries, flywheels, super capacitors – which are all receiving considerable development attention and growth today -- function best when applied closest to the end-user at load centers, substations and even behind the meter at the consumer.

Increasing bulk energy storage capacity has not been a priority of utility planners or energy legislation in recent decades. Since many utilities deregulated in the 1990s the industry has had no mechanism or incentive for the coordinated integration of new generation, storage and transmission. Yet these are three components of a reliable energy generation and transmission system that require coordinated long term planning. This disconnect has resulted in new renewable energy projects being unable to move forward due to lack of transmission capacity. Relatedly, the addition of large amounts of variable generation in certain market regions that are not equipped to provide the load balancing required to accommodate these sources is creating havoc with the

transmission system and to the grid operators. These very experienced grid operators have significant history managing the variability of changing load, and, up until recently, they have had the capacity and flexible energy options available to meet that changing demand.

Despite these technical hurdles, the need and demand for additional renewable generation continues to grow. Over the past decade 29 states have enacted Renewable Portfolio Standards requiring that renewable sources represent a certain percentage of new generation being brought on line. Climate policy initiatives are also driving investment in renewable sources. This has created a framework for rapid growth in variable generation such as wind and solar, but there has been no corresponding capacity or transmission planning. The result is that in areas such as Texas, California and the Pacific northwest there is excess energy from wind with not enough corresponding demand at the times when the electricity is available (typically occurring at night). Alternatively, there is not enough peaking power supply to provide on-demand capacity when the wind and solar plants can not generate.

Many advocates of increased renewable generation point to Denmark as the example for integrating large amounts of variable generation and how it can be adopted by the U.S. The key point that is overlooked is that the Denmark transmission system does not provide its own system balancing services – the two systems (East and West) depend on the interconnections with Germany and Norway for those grid stabilizing services, countries that are rich in pumped storage and conventional hydro respectively (Mason 2005; Sharman 2005; White 2004; VTT 2007).

Several studies have documented how bulk-storage capacity can support the increasing development of wind integration. These analyses shows that not only does bulk storage add capacity and offer load balancing, but it also reduces the cost of wind integration. For example, a Wind Integration Study conducted for the Public Service Company of Colorado (PSCo) in 2006 reported that doubling the pumped storage capacity within the PSCo system could reduce the cost of integration by as much as $1.30/MWh in a 20% wind penetration case analysis (EnerNex 2006).

Similarly, the Northwest Wind Integration Action Plan (Northwest Power and Conservation Council 2007) acknowledges that the increased development of wind energy in the northwest requires a corresponding increase in flexible generation, including pumped storage. The plan notes that the cost of wind integration is dependent upon several factors including the availability of flexible sources within the region's system, and calls for The Northwest Wind Integration Forum to "characterize options for augmenting system flexibility" including options for storage technologies (Northwest Power and Conservation Council 2007).

With the emergence of new renewable technologies and the ever increasing investment in variable generation sources including wind and soar, the need for storage has never been greater.

The Opportunities for Pumped Storage Today

Existing pumped storage hydro projects are critical transmission system tools providing crucial storage, generation and ancillary services throughout the United States today. In

response to the growing need for storage, and the exceptional synergy between pumped storage and variable renewable energy sources such as wind and solar, the hydro industry is proposing to more than double the pumped storage capacity in the near future. The Federal Energy Regulatory Commission (FERC) has recently issued 23 preliminary permits for new pumped storage hydro projects, representing approximately 15 GW of new pumped storage capacity. Another 15 applications for preliminary permits pending before FERC could provide an additional 16 GW of capacity (FERC 2009a, 2009b)

As shown in Figure 3, these new developments are situated in key areas of the western United States, where new development of variable generation sources, including wind and solar, is occurring at a rate that is challenging the capabilities of the existing transmission system to manage the variability of these sources.

Figure 3: Pumped Storage Active Preliminary Permits and Applications in Process at FERC (January 2009).

How significant is the 15-31 GW of proposed pumped storage capacity? The United States Department of Energy (DOE) recently projected that in order to meet a national goal of obtaining 20% of our electricity from wind generation by 2030, utilities must integrate some 300 GW of wind generation onto the grid. To accommodate the variability of this new wind generation, an estimated 50 GW of new peaking generation, probably from natural gas, would be needed (DOE 2008). However, new generation is not the only way to address this need. In its December 2008 report to the DOE the Electricity Advisory Committee advocates using storage to provide some of this capacity rather than new generation sources (Electricity Advisory Committee 2008).

With its current proposals the pumped storage sector of the hydropower industry is poised to fulfill an estimated 30-60% of the storage capacity needed to meet the national

20% wind initiative. This would reduce the need for additional fossil fuel derived peaking generation and avoid the greenhouse-gas emissions associated with those resources. Importantly, by directing our investments in new energy infrastructure to storage facilities that would be used at or near capacity -- while also providing many ancillary benefits -- we would avoid investing in large fossil fuel generation sources that operate only a fraction of the time.

Achieving the Potential of Pumped Storage

Pumped storage is the only viable, large-scale resource we have that is being broadly utilized today for storing energy, and it offers the best option available for harnessing off-peak generation from renewable sources. With the ever increasing investment in variable generation sources, energy storage will be a critical tool for using our clean energy resources effectively. While the 31 GW of new pumped-storage project proposals now before FERC demonstrates the hydropower industry's commitment to building new pumped-storage capacity to support other renewable sources, developers still face significant obstacles, including an uncertain investment climate and long development timelines. These issues must be addressed in order to ensure an investment climate that facilitates the permitting and construction of these new pumped storage plants.

Federal policies that encourage investment and stabilize the development process are needed. Although Energy Secretary Steven Chu recently stated that pumped storage technology must play an integral role in our national plan to expand our clean-energy resources and integrate variable renewable-energy resources into the transmission grid (Pennwell Publications 2009), the federal government currently has no program to spur development of pumped-storage resources. Incentives are needed that attract investors and encourage rapid development of new pumped storage projects.

Providing investment tax credits and other mechanisms that reward investment in pumped storage and create a more stable investment environment will be critical. Policies that promote intergovernmental cooperation and streamline the permitting and licensing process will also add more certainty to pumped storage development and encourage growth.

The American Recovery and Reinvestment Act of 2009 has set the stage for new investment in renewable energy through investment tax credits, production tax credits, clean renewable energy bonds, grants and DOE research funding for renewable energy projects. Although these incentives do not work well for pumped storage, they will encourage rapid investment in other sources, including wind and solar, that require the capacity and load balancing that pumped storage offers.

The U.S. hydropower industry can show a direct link between tax incentives and the jobs and investment it continues to create. Since incremental hydropower projects first qualified for production tax credits under the Energy Policy Act of 2005, members of the National Hydropower Association report that their development work has increased from between 25 and 50 percent. That increase has translated to high-quality, long-term green jobs in all regions of the United States. If the incentives that spurred this growth in conventional incremental hydropower were applied to pumped storage, the economics would justify the investments needed to move these projects ahead, and the additional growth in green jobs would be equally significant.

Enhancing and updating America's energy transmission infrastructure offers many benefits that address some of the country's most pressing priorities. Transmission development can provide jobs, create new businesses, and improve the security of this critical national resource. An enhanced transmission system will also accommodate new technologies, ensure electric reliability, and offer efficiencies that maximize energy use and minimize environmental impact. With pumped storage hydropower's ability to serve and support the transmission system -- and its role as an enabler of greater penetration of variable renewable generation -- the U.S. hydropower industry, and our nation, needs sound policies that provide for growth in energy storage. The electric power system is a real-time system that must balance supply and demand continuously. Pumped storage projects are a proven technology to store excess energy at night and utilize that excess energy during the peak hours of the day when it is most needed. This ability to time shift variable generation sources and also relieve transmission congestion by providing critical load balancing services is an essential component of an enhanced transmission grid.

The Energy Storage Council identified a number of steps that are needed to encourage the development of new energy storage technologies and construction of energy storage (Energy Storage Council 2003). These include treating energy storage facilities and services on a comparable basis to traditional transmission facilities expansion for purposes of qualifying for transmission pricing incentives and participation in transmission planning processes. The ESC also advocated for the establishment of a "safe harbor" for transmission owner pass through of costs associated with contracting for energy storage services that enhance transmission system capacity, reliability and security, and for investing in energy storage services that enhance constrained transmission systems or substitute for investment in upgrading them. Although the Energy Policy Act of 2005 did recognize pumped storage as a transmission enhancement, FERC should also consider allowing pumped storage to qualify as transmission facilities for purposes of determining eligibility for future incentives.

Expanding the current investment and production tax credits, the possible creation of an energy storage credit, coupled with policies that recognize pumped storage as a part of the transmission system for purposes of qualifying for transmission rate incentives currently afforded to transmission system upgrades and expansions, would create the investment environment needed to encourage growth in pumped storage. This growth would displace the need for additional fossil-fuel based peaking generation, and provide the load management capacity necessary to meet our national renewable energy goals.

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CO-AUTHOR

Mr. Richard R. Miller is a civil engineer with extensive and diversified experience in water resources, hydroelectric and pumped storage plant operations and engineering, developed throughout his 30-year career in the electric power industry. Formerly the

CEO of Devine Tarbell & Associates, Mr. Miller is currently a Senior Vice President within HDR|DTA Hydropower Services and is responsible for the firm's hydropower services practice. Mr. Miller's expertise includes civil engineering, large scale project management, conventional hydropower and pumped storage operations and resource planning. In addition, he had total responsibility for Duke Power's HydroVision rehabilitation program to modernize 25 hydroelectric facilities.

Previously, as Director of Operations for Duke Energy International–Brasil (DEI Brasil), he was responsible for all Operations and Maintenance (O&M) activities for DEI Brasil's 2307 MW Paranapanema Hydro System. He was also responsible for engineering, system optimization and dispatching, environmental programs, and the training and management of more than 285 engineers, scientists, and maintenance staff.

Mr. Miller is also involved in industry activities. He served as President of the National Hydropower Association (NHA) from 2008-2009, and formerly co-chaired NHA's International Committee. He remains active with NHA as a board member and as a member of several standing committees and working groups.

CO-AUTHOR

Ms. Maureen Winters, currently a Corporate Consultant with HDR|DTA, has over 24 years of experience in environmental consulting and regulatory affairs. Ms. Winters is a project manager with extensive experience in the planning and execution of multi-disciplined projects including FERC licensings, strategic planning, and asset acquisitions. Previously, she served as Northeast Regional Manager for DTA, and as Vice President and Manager of Environmental Affairs for the Maine Pulp and Paper Industry association. Ms. Winters has served as the Chair of the NHA Public Affairs Committee since 2008.
