HYDRO PUMPED STORAGE POWERPLANTS: CHALLENGES AND OPPORTUNITIES IN EUROPE

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Pumping water up to a reservoir situated at a higher altitude is transforming electricity into potential energy, which can be stored during any period of time. This potential energy can be transformed back into electricity when water passes through the turbines and returns to the altitude from which it had been initially pumped. This is the principle of Pumped Storage Powerplants (PSP), which are in most cases using two lakes or reservoirs situated at different altitudes. PSP is the most widely-used system for electricity storage, and will remain so for a very long period to come.

The first PSP may have been built in 1902 in Ruppoldingen in Switzerland. In 1926, in the French Alps, the steel company Ugine managed to use the lake of Girotte to pump water at moments when the demand for electricity from the steel industry was low, and to turbine water when the electricity demand was higher. In 1933, the hydro plant of Kembs on the Rhein river was built in order to provide the city of Mulhouse with electricity. Two lakes in the vicinity of Mulhouse, Lake Blanc and Lake Noir, with a 100 m altitude difference, were used as a PSP to store electricity from the Kembs power-plant during the off-peak hours of electricity demand [1].

As seen from these historical examples, the initial utility of PSPs was to contribute to a response to the differences in the electricity demand between peak and off-peak hours; in deregulated energy markets these differences are reflected by variations in the price of electricity on the spot market. In Europe, the present development of intermittent renewable sources of energy, such as wind and solar energies, is nowadays increasing drastically the need for energy storage. According to European and national energy policies, intermittent renewable sources of energy should provide in 2020 16% of the electricity in Europe, and 26% in the case of Germany. Wind and solar energy can only provide electricity when the resource is available, and not when the electricity demand is high, typically in the morning and the evening of weekdays, and in winter when the temperature is low (in northern

countries for heating), or in summer when it is hot (in southern countries for air cooling). In northern Europe, an anticyclonic situation in winter with low temperatures and no wind over a large area will therefore be a difficult situation. This is why there is an increasing need for energy storage in Europe. PSP is the cheapest solution for energy storage, and has a global efficiency (up to 80%) much higher than other solutions for energy storage like batteries or compressed air storage. A PSP can provide a "black start" to help a power system recover after a black-out. PSPs can also provide so-called ancilliary services to the power system, allowing real-time tuning of frequency and tension of the electricity delivered by the grid, thanks to modulation of the power of the PSP, both in pumping and turbining mode. This is made possible thanks to the development of modern variable-speed pump-turbines [2] [3] [4]. The increasing need for power systems in terms of flexibility and fast variations of the power lead to use pumps and turbines in unsteady regimes, which needs advanced special manufacturing skills and R&D programs, and appears to be an area of competitive advantage to European turbine manufacturers .

The overall installed capacity of PSP is estimated as 140000 MW worldwide, including 46000 MW in Europe. There is today a large development of PSPs in Portugal, Switzerland, and Austria. Germany has a great need for energy storage: there is in Germany today about 6700 MW of installed capacity of PSPs. Considering German national plans for energy, it is considered [5] that the storage capacity should be 100 times greater to face a winter situation with low wind period of 10 days. A major PSP project in Germany is Atdorf (1400 MW) in the Black Forest. A part of the German energy storage need could be covered by neighbouring countries like Switzerland, Austria, and possibly Norway.

In Portugal [6], there is about 5300 MW of large hydropower plants in operation, including 1200 MW of pumping capacity. In 2020, Portugal is expecting to have developed 5800 MW of wind energy, supported by a PSP capacity of about 3200 MW.

France has already a PSP capacity of 4900 MW in the pumping mode, and 4200 MW in the turbining mode, with 6 PSPs in operation. Grand Maison, commissioned in 1985, with 1160 MW in pumping mode and 1790 MW in turbining mode, is the most powerful PSP in Europe [7]. Other French PSPs are undergoing renovation programs.

Austria, Switzerland and Norway have the ambition to become the « green batteries » of Europe, thanks to their large capacities of PSP development, and regulations favourable to PSPs. Switzerland [8] has 11 PSPs in operation, with an overall capacity of 1400 MW. PSPs in construction or under upgrading process will add 2100 MW of new capacity, and other new projects of PSPs could add 1600 MW more. Two major PSPs should be commissioned in 2015 : Nant de Drance (620 MW) by Alpiq on Emosson lake, and Linthal (1000 MW) on the lakes of Limmern and Mutt. Norway has 11 PSPs in operation, with an installed capacity of 1400 MW. Taking advantage of the large natural reservoirs existing in Norway, it is considered feasible to have about 20000 MW of generating capacity from PSPs in Norway by 2030, with new galleries and new pumping/turbining stations between existing lakes, combined with the development of electrical grid interconnexion (DC lines) through the North Sea and offshore wind development in the North Sea [9].

This paper has presented a short survey of pumped-storage development in Europe, but it has to be noted, in conclusion, that other areas in the world having an important program of development of wind and solar energy, like China, have also a very important program of PSP development underway.

References

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