



PUMPED STORAGE HYDRO POWER PLANTS IN SLOVAK REPUBLIC

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ABSTRACT

This paper deals with pumped storage hydro power plants in the Slovak Republic. The aim of the paper is describe pumped storage hydro power plants, which are important to operate power system. They're a way of storing energy so that we can release it quickly when we need it. If power stations don't generate more power immediately, there'll be power cuts around the country - traffic lights will go out, causing accidents, and all sorts of other trouble will occur.

1. INTRODUCTION

Pumped storage hydroelectricity is a type of hydroelectric power generation used by some power plants for *load balancing*. The method stores energy in the form of water, pumped from a lower elevation reservoir to a higher elevation. Low-cost off-peak electric power is used to run the pumps. During periods of high electrical demand, the stored water is released through turbines. Although the losses of the pumping process makes the plant a net consumer of energy overall, the system increases revenue by selling more electricity during periods of peak demand, when electricity prices are highest. Pumped storage is the largest-capacity form of grid energy storage now available.



Figure 1 – Pumped storage hydro power plant (PSHPP) Čierny Váh [2]

2. PUMPED STORAGE HYDRO POWER PLANT ČIERNY VÁH (735,16MW)

Pumped storage hydro power plant Čierny Váh is situated in the valley of the river Čierny Váh, approximately 10 km above its confluence with the Biely Váh river near Kráľova Lehota municipality, which is part of the Low Tatras National Park. It was built in years 1976-1983. Aggregate TG6 was put into trial operation as the first one in March 1981, last one was aggregate TG7 in October 1982. The whole project of PSHPP Čierny Váh was finished in September 1983. In the time of construction the main purposes of the PSHPP Čierny Váh were peak operation with daily water accumulation, participation in frequency regulation and transmission of power to the grid.

This hydro power plant consists of four parts: upper and lower reservoirs, penstocks, power station. The lower reservoir was established by blocking of the Čierny Váh river valley by 375m long dam. Its capacity is 5.1 mil.m³ and the available capacity for pumping operation is 3.7 mil.m³. The level fluctuates by 7.45m between elevations (726,00 - 737,45) m.

The upper reservoir of irregular shape is situated between Biely and Čierny Váh valleys. Available capacity of the reservoir is 3.7 mil.m³ of water. The level fluctuates by 25m between elevation points (1160 – 1135) m above sea level.

Hydraulic connection of the upper and lower reservoir is via three pressure penstocks \square 3.8 m, passing in the valley part into pipes \square 3.6 m. Maximum head between upper and lower reservoir is 434 m.

The lower reservoir dam comprises also the power station including the control room. There are installed six pumping turbo aggregates comprising – motor generator, Francis turbine, accumulation pump. The accumulation pump and the turbine are connected via a gear clutch. The turbo aggregates are arranged in three double-units. Total installed capacity of pumping turbo aggregates is 734.6 MW. The third double-unit is connected to a machinery set consisting of run-of-river Kaplan turbine and generator with capacity 0.8MW.

General overhauls of machinery and pumping turbo aggregates were executed in years 1997 - 2005. In substation 400 kV pressure breakers and measuring transformers were replaced by new ones with insulating medium SF6 and insulation loops in whole substation 400 kV were replaced in 2008.



Figure 2 – Upper reservoir [2]

3. PUMPED STORAGE HYDRO POWER PLANT LIPTOVSKÁ MARA (198MW)

Pumped storage hydro power plant Liptovská Mara was built as a part of waterworks Liptovská Mara – Bešeňová. It is situated on the Váh river, on its 338.40km in Liptovská kotlina.

Original design planned to use two Kaplan turbines with total capacity of 103 MW. During the construction works the design was changed and two Kaplan turbines with capacity of 198 MW and two reversible turbines were suggested.

Table 1 – Technical data

	turbine Kaplan	pump turbine
Output [MW] - number of units	50/0 - 2	49/53 - 2
Average annual production [MWh]	112 687	
Head [m]	47,3 - 17,5	47,3 - 30
Generator - output [MVA] - voltage [kV]	58,8 - 10,5	57,6 - 10,5
Transformator - output [MVA] - voltage [kV]	63 - 10,5/121	
Operation regimes	turbine, frequence start	turbine, pumping



Figure 3 – Pumped storage hydro power plant Liptovská Mara [4]

4. PUMPED STORAGE HYDRO POWER PLANT RUŽÍN (60 MW)

The power plant was put into operation 1972. It was the first power plant in the country with reversible Francise turbines produced in former Czechoslovakia. The construction was divided into two periods: firstly, an accumulation reservoir was built; secondly, a power plant and a compensation reservoir were completed. The accumulation reservoir has earth embankment strengthened with clay sealing.

Pumped storage hydro power plant Ružín is peak plant using two reversible Francise turbines. Both turbines have one common penstock. Technological equipment of the power plant is able to work in two operation modes:

- turbine
- pumping

Table 2 – Technical data

Output [MW] - number of units	60 - 2
Average annual production [MWh]	56 900
Head [m]	52,7
Generator - output [MVA] - voltage [kV]	30 - 10,5
Transformer - output [MVA] - voltage [kV]	40 - 10,5/110
Operation regimes	turbine, pumping

5. PUMPED STORAGE HYDRO POWER PLANT DOBŠINÁ (24MW)

The waterworks comprises: an accumulation reservoir Palcmanská Maša, a penstock and collection reservoir in Vlčia dolina (Wolf valley) in Dobšiná. The construction started in 1948 and the works were completed in 1954. The power plant was put into operation in 1953 – in that time it was the first pumped storage hydro power plant in Slovakia.

Originally, there were three aggregates in the power plant-except for two high pressure Francis turbines also Kaplan turbine. The last unit was dismantled in 1994 and replaced by the small hydro power plant Dobšiná II. The horizontal pumping aggregate consists of a turbine, a motor – generator and a clutch with an accumulation pump. The aggregates are attached to unit transformers with power of 13 MVA. Connection to the grid is provided by four 110 kV lines.

Table 3 – Technical data

Output [MW] - number of units	12 - 2
Average annual production [MWh]	28 700
Head [m]	285,5
Generator - output [MVA] - voltage [kV]	12 - 10,5
Transformer - output [MVA] - voltage [kV]	16 - 10,5/110
Operation regimes	turbine, pumping

6. CONCLUSIONS

A new concept in pumped storage is to utilise wind turbines or solar power to drive water pumps directly, in effect an 'Energy Storing Wind or Solar Dam'. This could provide a more efficient process and usefully smooth out the variabilities of energy captured from the wind or sun.

Pumped storage hydro power plants have important role in power system from point of view peak load, frequency regulation and reliable supply electricity to consumers and also to cover the daily load diagram.

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ACKNOWLEDGEMENT

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