

Avče Pumped Storage Power Plant, Slovenia



Since 1993 AF-Colenco Ltd (formerly Colenco Power Engineering Ltd) has been providing engineering services in Slovenia to the regional power utility Soške Elektrarne Nova Gorica (SENG). In 2003, after a review of the basic design, AF-Colenco, together with a local partner, was appointed by SENG to prepare the tender design of the Avče Pumped Storage Power Plant. This second phase of the project comprised the Licensing Project followed by the Tender Design and Specifications. Additionally, the majority of the tender documentation had to be prepared in both Slovenian and English.

With the construction of the Avče Pumped Storage Power Plant, SENG, a subsidiary of the Slovenia's main power producer Holding Slovenske Elektrarne (HSE), will massively increase the production of peak load energy and, with the primary and secondary power frequency control, will provide a safe power supply to the country. Due to the lack of storage reservoirs in the country, the provision of peak energy is of major importance to the national power market. The pumped storage plant is located on the Soča River in western Slovenia close to the Italian border and will be the country's first power plant of its kind.

The project makes use of the gradient between the hill-top of the Kanalski Vrh at elevation 625 m a.s.l. and the River Soča at 104 m a.s.l. and comprises the following structures:

- Artificial upper reservoir with a storage capacity of $2.2 \times 10^6 \text{ m}^3$, conveniently located in a natural depression on top of the hill
- Headrace conveyance system consisting of a 700 m long tunnel, surge tank with an upper and lower chamber, and a 1.3 km long, partly buried penstock
- A 70 m deep shaft powerhouse with an 18 m internal diameter, housing one reversible Francis pump-turbine unit with an asynchronous motor-generator for variable-speed operation, operating under a gross head of approximately 520 m.
- The turbine capacity is 185 MW in generating mode and 180 MW in pumping mode. The plant is expected to produce 426 GWh/year, while requiring up to 553 GWh in the pumping mode.

The power grid limitation, imposed by the grid operator on the maximal power output and maximum power consumption of the plant, governs the layout of the scheme. This is not only reflected by the size of the pump-turbine and the discharges of $40 \text{ m}^3/\text{s}$ in the turbine mode and about $34 \text{ m}^3/\text{s}$ in the pumping mode, but also by the design of other components such as the capacity of the upper reservoir. It is foreseen to operate the upper reservoir within a weekly cycle starting with maximum water level on Monday morning and reaching the lowest level on Friday evening.



Construction of the powerhouse shaft, in the background soil excavation for the penstock



By installing an asynchronous machine for variable speed operations, the owner has opted for a state of the art technology. The rated speed of the machine is specified to 600 rpm, with a speed variation in the range of -4% to +6%. Compared with a conventional synchronous machine, the adjustable speed machine leads to higher turbine efficiency at varying heads and discharges in the generating mode. This also extends the operating range for this type of machine. It also allows active power control in the pump mode.

The licensing project was submitted to government authorities on August 1, 2004. On September 22, the ground breaking ceremony was held on the hilltop of the upper reservoir. The elaboration of the tender design proceeded simultaneously with the licensing project, given that the most important tender documents were due before the end of 2004. The tender documents were prepared for seven separate construction and supply contracts, and most of them in Slovenian and English.

Project Data

Upper reservoir	2.2 million m ³ storage volume, asphalt-concrete lining
Headrace conduit	700 m long concrete lined headrace tunnel of Ø 4.5 m
Surge shaft	45 m high with upper and lower chamber
Valve chamber	Safety roller gate
Penstock	L = 1300 m, Ø 3.30 – 2.90 m, open air with 11 fix points
Design flow	40 m ³ /s in turbine mode, 34 m ³ /s in pump mode
Powerhouse shaft	20 m external diameter, 70 m deep
Pump-Turbine	Vertical reversible Francis Pump-Turbine, Rated turbine power 185 MW, expected annual output 426 GWh
Motor-Generator	Variable speed unit with 576 – 636 rpm, 195 MVA rated generator output
High power excitation	3-Level voltage source inverter
Tailrace conduit	Inclined and vertical tailrace shaft, Ø 4.6 m
Lower reservoir	Reservoir of existing Plave HEPP on the Soča River
Construction period	2005-2008

In December 2004, before concluding the Design Phase 2, AF-Colenco, jointly with his local partner, was awarded the contract for the Construction Phase 3 of the project. The engineering services comprise the preparation of the construction design for the civil works, the penstock & hydro-mechanical equipment, elaboration of as-built drawings and O&M manuals, as well as support to the client during implementation and commissioning of the works.

Preliminary civil works, awarded in an earlier contract, started in January 2005. The tendering and tender evaluation of the three main lots for the civil work construction and the supply and erection of the electromechanical as well as hydro-mechanical equipment was carried out between January and June 2005. All main contracts were awarded before the end of July 2005, allowing for the start of the civil works in August 2005. With a foreseen construction time of three and half years, commissioning of the power plant is scheduled for December 2008.



View along the alignment of the penstock



Location of the powerhouse shaft on the terrace of the Soča River