



SHP ZABRZEŻ – THE RESULT OF OPTIMISATION WORKS

Construction and mechanical works on a new Polish hydropower plant are underway – both in the production hall and on a picturesque island located in a bend of the Dunajec River. This investment project is a testament to the fact that a holistic approach is required in the construction of SHP facilities. This is reflected in satisfactory production and economic results afterwards. We encourage you to read the SHP Zabrzeż case study.

The formal history of SHP Zabrzeż began in 2011 when an application for environmental permission was submitted. After nearly 10 years, the investment project is in the final stretch and its launch is planned to take place by the middle of the next year. Nonetheless, several factors had to coincide to make it possible to reach such an advanced stage of works within this time. A facility building permit was issued as early as 2014; afterwards, the investor began looking for a general contractor. And this is where the difficulties began, as the quotations prepared by the bidders left little doubt – building the SHP in the original location for which permits were issued was too expensive and would result in a return on investment time that was unacceptable for the owner.

The uncertainty of RES regulations was yet another obstacle at the time. Therefore, after several years of the project's development, the investor was close to giving up. The documentation gathered indicated that there is little chance of implementing it. It seems that the source of the problem faced by the investor was an impractical and non-market approach to designing technical solutions.

LIGHT AT THE END OF THE TUNNEL

However, the belief that the decision to construct the SHP is right, as well as the perseverance of the company's shareholders, led to the cooperation with a design office capable of undertaking the project's technological and business optimisation based on a technical audit. The investor decided to

employ the services of a company that works in the hydropower industry and has experience in rationalising the costs of such investments. The works began with a detailed formal and legal audit of the activities undertaken so far, the conditions in the area where the SHP was to be constructed and solutions proposed in the original construction and executive projects. As a result of the

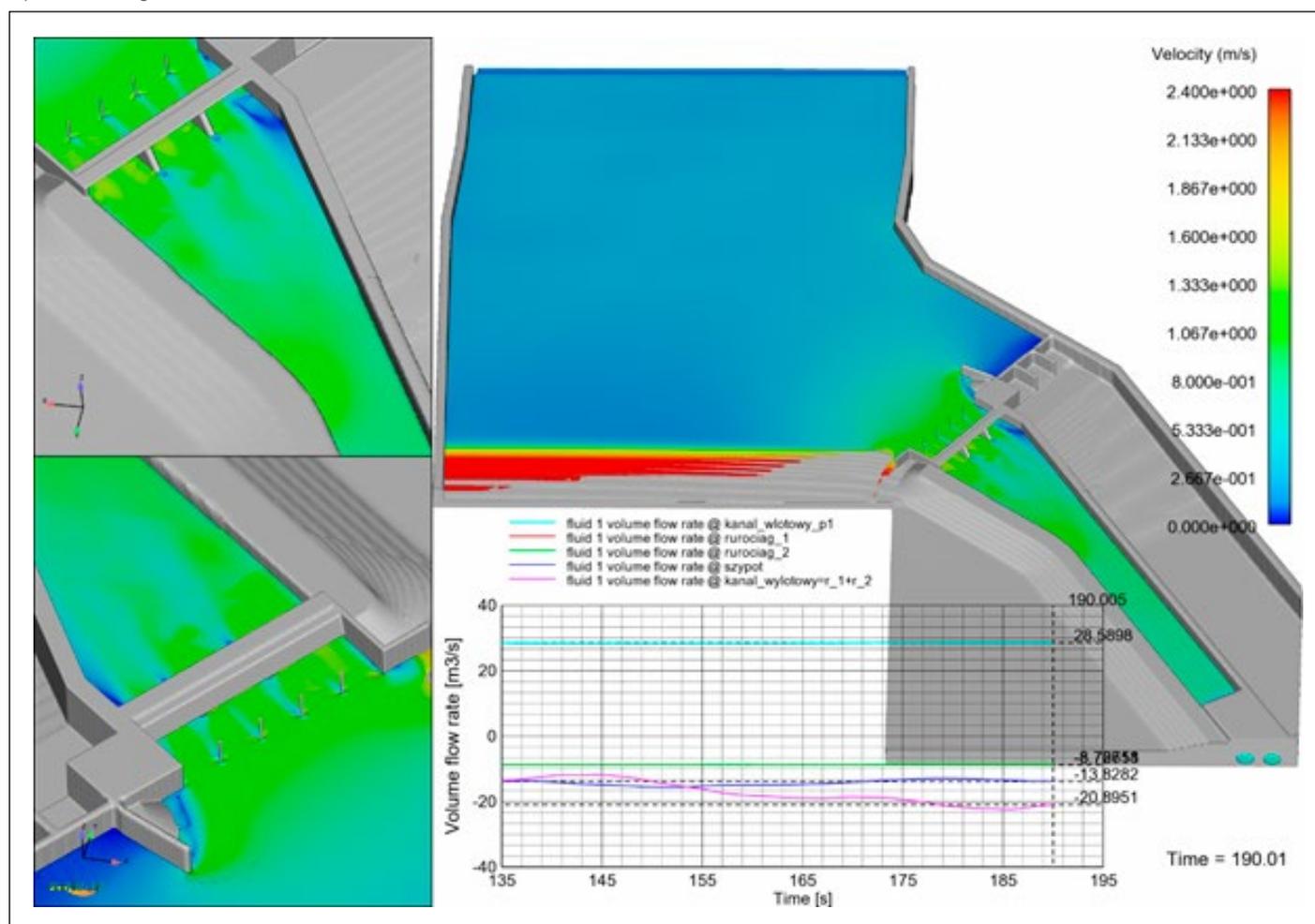
Investor's opinion

When choosing to work with IOZE, we needed someone to provide comprehensive services to support the project. Initially, we doubted that it would even be possible for a single company to provide all we need. Nonetheless, we are very pleased with our cooperation so far. The project's general contractor provided us with comprehensive services, assistance at every stage and in every situation, as well as legal, formal, financial and business consulting and the detailed technological solutions concerning all industries. We are convinced that we have entrusted the implementation of the project to the best industry professionals. – Dorota Chowaniec, President of the Management Board of the SHP Zabrzeż investment project owner.

Photo. The initial part of the power plant's inflow channel (the picture shows the exposed section made of reinforced concrete; the underground diversion channel consisting of two parallel pipelines is not visible).



Fig. A FLOW 3D simulation of water flow and water levels within the intake prepared by a CFD modelling specialist – provided by Instytut OZE Sp. z o.o., SHP Zabrzeż replacement design documentation contractor.



analysis, it was recommended that new project documentation be prepared to enable investment optimisation. The investor finally accepted the SHP Zabrzeż implementation offer based on the design-build method and could look to the future with optimism ever since – especially since the service also included obtaining project funding. For the investor, the most important thing is to get

a chance to achieve the expected rate of return on financial expenditures, as well as ensure the technical and business coherence of the project while maintaining high safety and quality standards.

OPTIMISED TECHNOLOGY

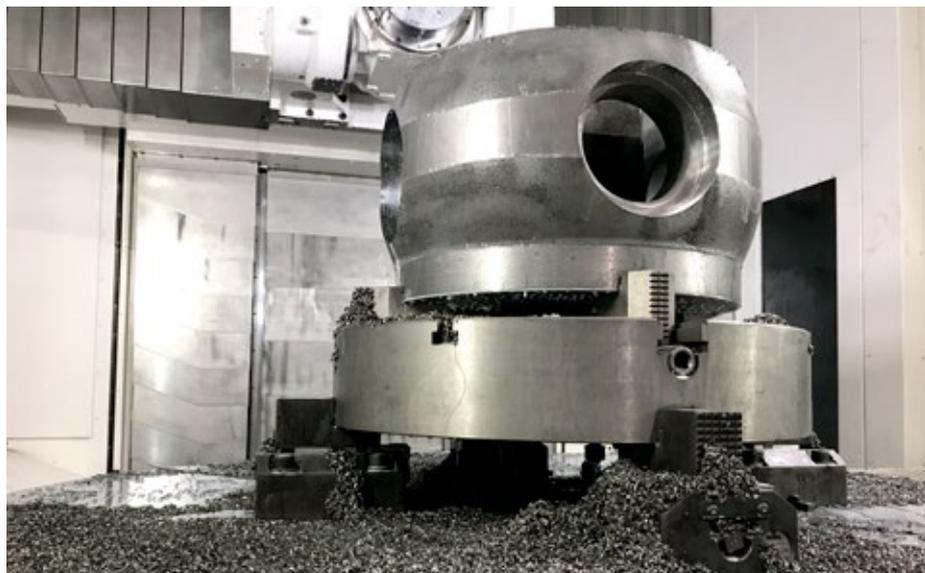
The new project reflected the designers' conviction that implementing the project

in a profitable version is possible – a fact supported by their experience and multi-criteria hydrological and hydrotechnical analyses conducted. As part of the optimisation process, the SHP's entire hydraulic system was analysed, including the water intake, the inflow channel to supply water and the inflow chamber. The solutions used for this included the FLOW 3D software used to perform numerical simulations of liquid flow and water levels. The simulation made it possible to remodel the water intake's shape to make it more efficient (smaller energy losses; better adapted to the nature of a mountain river and the changing water levels in the different seasons). Water from the Dunajec will be directed to the intake using a stone groyne and then flow through an open canal. Importantly, the diversion canal changes its cross-section in 2 planes within the first 28 metres. The sloped bottom plate and narrowing walls enable slow and uniform water flow and eliminate turbulent water movements. The remainder of the canal has a constant cross-section. The main part of the system guiding the water into the turbines consists of two pipelines with a length of 142 m, a diameter of 2.4 m

Basic advantages of the technology

A characteristic feature of a traditional vertical Kaplan turbine system – like the one designed for SHP Zabrzeż – is the low failure rate, which ensures stable, long-term operation of the facility. The turbine's design makes the number of parts that require maintenance very limited. At the same time, the turbine is easily accessible during any required maintenance works that the SHP might have to undergo. Furthermore, even while one turbine is undergoing maintenance works, the other can still operate and generate electricity. This is because each turbine has an autonomous energy generating system. All you need to do to shut down a turbine for its scheduled maintenance is to close the gates on the pipeline feeding water to it. Apart from the turbine, the RES installation includes a spiral, reinforced concrete inflow chamber (the first part of the chamber has a circular cross-section while the second a rectangular one), which, like all other elements, was modelled in specialised software to ensure the most efficient form. Another thing worth noting is the SHP's high level of flood safety. This includes the building itself, which will be capable of withstanding total submersion while preventing floodwater from getting inside thanks to special flood gates. The necessity of introducing such solutions stems directly from the nature of the river on which the project is located.

Photo. The hub of the Kaplan turbine, which will be installed at SHP Zabrzeż, during a five-axis CNC machining process



and a longitudinal slope of 0.35%. The total head possible to obtain for the SHP is up to 4 m, but this is also supplemented by a weir that supports the canoeing track. The constructional changes introduced (as a result of CFD – Computational Fluid Dynamics tests, among others) in the case of the intake's and diversion canal's designs, as well as the SHP building, the turbines and the drainage canal, were vital not only for the system's efficiency but also for the technical feasibility of the whole project. The heart of SHP Zabrzeż will be two vertical Kaplan turbines with a the runner diameter of 1670 mm, which are already being manufactured in the technology supplier's production hall. The facility's installed electrical power will be 0.5 MW and each turbine will be equipped with a four-blade adjustable pitch runner and 20 guide vanes, which make it possible to direct the water stream and control the turbine flow rate.

PICTURESQUE LOCATION AND SMART DEVELOPMENT

The new small hydropower plant is being built in a bend of the Dunajec River, surrounded by the Beskid Wysoki, on an island separating the riverbed from a canoeing track which has been operating since the mid-1990s. The two facilities are expected to operate interdependently, which was one of the primary conditions provided for in the administrative decisions concerning the SHP. The power generating system will work around the clock throughout the cold season while between April and October it will allow for operation of the canoeing track. It is worth to emphasize the eco-friendly nature of the solutions utilised, such as the stone groyne used to divert water to the

inflow canal, which is quite similar to natural structures. Obstructing the riverbed and disturbing the biological continuity of the Dunajec River – and putting the aquatic fauna at risk – is out of the question in this case. The facility, which is already partially completed, corresponds to the existing land use criteria and will exploit the previously unused hydropotential of this area. Sustainability in its pure form.

FURTHER PLANS

The investment project, which has been under construction for several months, is in line with the general upward trend in hydroelectric power engineering. This is a direct result of both the stabilisation of the RES sector support system and the national and global policy of reducing the share of traditional fossil fuels in the energy sector. By using a Kaplan turbine designed individually based on the needs of the project, the SHP will be able to generate energy steadily and reliably. The launch of the facility in the first half of next year will enable the investor to take advantage of the recently introduced fixed energy sales prices under the FIT tariff. Considering the investments in the small hydropower plant sector in a slightly broader perspective, and in the context of the current economic situation and impact of the pandemic, one can surmise that banks and investment funds should be interested in seeking such investment alternatives to trading funds. This is especially since a well-designed facility makes a simple payback period of up to several years and an Internal Rate of Return (IRR) between a dozen and several dozen per cent achievable. To sum up, it is worth emphasizing that the

broadly understood success in the case of such investments lies in using a comprehensive approach. It also involves using solutions developed based on experience gained in many projects – a successful power plant is not simply an engineering facility built according to a project, but rather a sequence of interdependent legal, formal, economic, technical and technological factors, each of which requiring that all others be taken into account.

However, it often happens that the start of an SHP investment is held up by administrative procedures, errors in the engineering documentation and unprofitable technological assumptions. In such situations, seeking the help of a professional design office is a great choice, as this can help identify optimisation opportunities and prepare an economically and technologically feasible investment project that meets all legal criteria and encourages the investors to proceed with its implementation.

Holistic approach of the Instytut OZE

At our company, we utilise a holistic approach to projects and apply technically and financially optimal solutions, which ensures that the given project has a chance to achieve the rate of return expected by the clients. Scope of services:

- hydropower potential analysis,
- selection of optimal technology,
- SHP technical solution concepts,
- calculation of investment expenditures and operating costs; evaluation of the investment project based on profitability indicators (NPV, IRR, DPP).

The design office provides comprehensive services on the domestic market and shares both its good practices and extensive experience with such foreign entities as advisors, investors, design offices, general contractors and end clients. Instytut OZE is also capable of successfully transferring its vision of how to run an RSE business to foreign markets.



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- Oferujemy **kompleksowe** doradztwo w zakresie inwestycji w elektrownie wodne włącznie z dostarczeniem **autorskich technologii** oraz wykonawstwem pod klucz.
- Tworzymy **interdyscyplinarne zespoły ekspertów i specjalistów** z zakresu hydrotechniki, mechaniki, automatyki i budownictwa, którzy proponują **rozwiązania precyzyjnie dopasowane do potrzeb** Klientów.

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ENERGETYKA WODNA

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