Fig. 1. View of the SHP Pilzno with the weir and the accompanying fish ladder for aquatic fauna

Repowering of the SHP Pilzno

The small hydropower plant (SHP) Pilzno has recently undergone repowering. The task set for the designer and the supplier of technology was all the more challenging as the facility is relatively "young" and has been characterised by a high technical standard from the beginning. So let's take a look at how its modernisation has been undertaken and what the results are.

As an introduction, it is worth outlining the historical background of the construction of the hydropower plant. The SHP, picturesquely located on the edge of the Carpathian Foothills, was built at the same time as the accompanying rubber dam, i.e. in 2000. It is located on the right bank of the Wisłoka river. A river damming with a span of approx. 100 m (the rubber dam alone measures more than 70 m in length) was constructed south-east of Pilzno in connection with the reclamation of the aggregate post-mining area. The flooding of the area between Strzegocice and Mokrzec led to the creation of a water reservoir of over 140 ha. The investment landscape is complemented by an impressive over 400-metre fish ladder for aquatic fauna, completed in 2021, in the form of a bypass channel consisting of 45 stone pools[1] .

Impulse for action

Among the modernised facilities that we have so far had the opportunity to talk about in "Energetyka Wodna" magazine, the SHP Pilzno stands out in several respects, both technically and in terms of optimising the business side of the project. The investment is an example of good practice. The decisive driver for the owner to replace the generation system with the accompanying infrastructure was the ending support for the production of green energy. A necessary condition to be met in order to participate in the new scheme was the implementation of a completely new RES installation to the extent consistent with the statutory definition and interpretation of the Energy Regulatory Office (URE).

A separate issue that was taken into account was the degree of wear and tear of the equipment currently in operation and the overall efficiency of the system, which left room for optimisation (especially as the facility was affected by flooding in 2010). In the course of the conceptual analyses, it was established that the modernisation would enable annual production to be significantly higher than that recorded to date.

The business model developed in the initial stage, together with financial analyses, formed the basis for the investor's decision to launch the project. Equally helpful was the multi-variant technical concept, which allowed different configurations to be traced and the most optimal solution to be recommended in terms of cost and technical-economic efficiency.

Technological and functional puzzle

The project involved the dismantling of the existing hydro units and the construction in their place of three highly efficient gen-

Fig. 2. Transport of the turbine runner

[1] https://wislokabezbarier.com/mokrzec-rzeka-wisloka/

Fig. 3. Installation of the Kaplan turbine case

erating systems, representing separate RES installations with individual power connections for each. This, of course, involved obtaining separate connection conditions and concluding separate connection agreements, and later distribution agreements, resulting from the planned form of electricity sales. The investment has been submitted to both the RES auction and the FIT/FIP support scheme. Finally, two of the newly completed generating systems qualified for the sale of energy at the guaranteed price obtained in the auction, and one generates energy that is sold under the FIP scheme. Both forms of support will last for the statutory period of 15 years, which significantly affects the profitability of the project.

In addition, the control system implemented for the facility makes it possible to manage the operation of individual new RES installations both independently and interdependently. In practice, this means that when available flows are too low, the facility operator may decide which generating system is currently operating in the most cost-effective manner. Ultimately, the new SCADA solution will allow this to happen automatically.

What is still worth mentioning in terms of the technical scope of the project is the construction work carried out in the facility. The installation of the new hydro units required the reconstruction of the concrete surfaces of the inflow chambers, as well as the suction pipes and the ceiling of the building. It was also necessary to install additional guides to allow the safe and precise placement of the approx. 7-tonne turbines and a similar weight of generators. The scope of the facility's structure correction was designed and constructed to suit the needs of the operation of the equipment.

New operating culture of the facility

The three new RES generating systems are equipped with classic vertical Kaplan turbines with an installed capacity of 300 kW each, working together with synchronous generators excited by permanent magnets. This is an innovative solution in terms of SHP standards, as up to now the use of generators of this type was associated with the need to support the operation of the plant with inverters. The turbine controller system implemented in the facility allows stable operation with an efficiency of up to

Sebastian Wites, Chief Automation Officer at IOZE hydro

Thanks to the use of synchronous generators with permanent magnets (produced on special order), which cooperate with the turbines without the use of a gearbox, we have not only achieved a higher efficiency of the entire system, but also a noticeable improvement in the operating culture of the equipment. It is now extremely quiet inside the machine room, even when operating at full power.

Moreover, when designing our control and automation systems, we pay particular attention to their usability. We are keen to ensure that the SCADA application is ergonomic, as simple and intuitive to use as possible, while at the same time providing maximum data on the operation of the equipment and its condition. The basic assumption in its development is to achieve the most efficient operation of the generation system. It is how hydro units operate and in what combinations that is the result of a number of factors: hydrological, technological and functional. The control system's task is to make use of the maximum of the current resources on which it operates.

It is worth emphasising that the change in technology at the SHP Pilzno to a system of three independent RES installations is a very interesting practical procedure which, in the case in question, translates into concrete, highly satisfactory electricity production performance, sold at the highest available price. This is because, among other things, it is possible to automatically maintain the set water level for the indicated RES installation whose operation is most economically advantageous at a given time. The machines can operate independently of each other, in adjustment to factors resulting from the support scheme in which the system is registered and current energy prices. The SHP is also prepared to provide system services in addition to generation only. The control system can cooperate with an energy trading company by directly and automatically adapting the facility's operation to the current energy sales conditions.

What is important from the perspective of the use of the installation — as part of our services, we provide remote supervision over the correct operation of hydro units, and in the event of incidents — if possible — we remotely remove their causes. Our service technicians are also available if any work is needed in the facility.

Fig. 4. Model of the SHP developed at the conceptual stage

Fig. 5. From top: turbine cases awaiting installation, turbine chambers

Fig. 6. View of the interior of control cabinets

97%. There is no need for reactive power compensation in this case. Additional information, among other things, in this respect is presented in the box.

Turbine production from the inside

The new quality in the SHP facility is reflected not only in the method of its control, but equally in the technology of the installed equipment. We can find a few words on this subject in the statement of the turbine design engineer.

Andrzej Kuszak,

Mechanical Design Engineer
at IOZE hydro

IOZE hydro turbines have the advantage over the so-called old generation turbines that their shape is the result of highly advanced CFD simulations. We conducted the simulations in collaboration with world-class specialists in computational fluid mechanics and flow machines. Thanks to this, the hydromechanical efficiency of our turbines is much higher than that of dismantled hydro units and allows for increased electricity production yields at the same available flow. Additionally, in the case of the investment in question, the renovation of the suction part of the system led to the elimination of flow disturbances that previously reduced the efficiency of the hydro units. Another issue is the elimination of waste of available flow thanks to the turbines designed and constructed by us, to which we pay special attention.

It is worth mentioning that the mechanical solutions used in the systems installed in the SHP Pilzno are definitely more environmentally friendly than the old installation. There are fewer components requiring lubrication, so there is minimal risk of leakage. The components used are produced in such a way that they generate the smallest possible carbon footprint (we even use a special calculator to calculate the carbon footprint). In addition, we try to optimise these structures on our own so that the consumption of *materials is as low as possible and so that as little waste as possible is generated during production. The intensive work of our technologists focuses on planning the production of turbines in accordance with the 6Rs principles (Rethink — Refuse — Reduce — Re-use — Recycle — Repair). Our products not only generate clean energy, but their production is also focused on environmental friendliness.*

Fig. 7. Interior of the facility after repowering

Summary

The investment we discussed here is an expression of a flexible approach to the challenges faced by the owners of SHPs to maintain the highest possible profitability in the operation of their facilities under evolving market conditions. The cooperation of the investor with IOZE hydro's consultancy and design team in the case of the SHP Pilzno was based on the assumption of comprehensiveness of services and resulted in the resumption of operation of the modernised facility from January 2024 and the first energy produced since then (nearly 2,000 MWh).

As shown above, in the case of the installation in question, despite the relatively good technical condition of the power plant, it was worth repowering and ensuring a profitable period of its operation. It should be stressed at this point that investments implemented by IOZE hydro are practically never limited to the mere supply of technology. This is due to the deep awareness that hydropower projects are so complex that even seemingly insignificant formal oversights, e.g. in the case of the procedure at the Energy Regulatory Office, may make it impossible to implement the assumptions that affect profitability. The cooperation of investors with an experienced team helps to avoid many pitfalls.

In addition to the supply of technology, the owner of the SHP Pilzno received full support in the administrative process, during procedures related to obtaining certificates from the Energy Regulatory Office, as well as in obtaining funding for the project through intermediation in discussions, preparation of the necessary analyses and fulfilment of formalities with the bank. The construction design was also prepared by engineers who create and optimise hydropower plants on a daily basis. As a result of the efforts of the Investor and the consultancy and design team, the guaranteed energy sales price obtained for the individual installations is almost three times higher than would have been possible for the same facility if the modernisation had not been carried out. Every successfully completed project begins with the belief that it will bring real, measurable benefits to the investor. IOZE hydro ensures that the basis for such a belief has strong professional justification.

Finally, for the sake of accuracy, it should be emphasised that in the case of the SHP Pilzno, the legislation and official interpretations of the Energy Regulatory Office in force at the time of the procedure were used. The aforementioned procedure of replacing all the equipment of an existing SHP installation with new equipment, which is herein referred to as repowering/modernisation, was treated by the Energy Regulatory Office in the same way as the construction of a new RES installation, and thus made it possible to obtain 15 years of support under the FIT/FIP scheme. The current situation is no longer so simple and unfortunately not all power plants will be able to undergo a similar process, but for some facilities the possibilities discussed above are still available. We stress that each case should be treated individually, with a precise approach to formal and legal issues and the planning of the entire process in order to guarantee the achievement of the desired business objective. This paper presents one example of good practice in the optimal use of hydropower potential as well as formal opportunities to intensify the benefits of hydropower activities — in line with the slogan "Turn water into profits".

Wioleta Smolarczyk
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