Photo 1. SHP Żarki currently
Source: Karolina Stefaniak

SHP Żarki, where history meets modernity

Replacing outdated, low-efficiency generation systems with new ones, equipped with tailor-made, automated hydropower units, is currently a strongly pronounced trend in the market of small-scale hydropower. The direct causes of this phenomenon are the favourable conditions for obtaining subsidies for renewable energy for installations that meet the definition of a new generation source and, paradoxically, the current turmoil in the energy market. New sources include not only new facilities but also repowered small hydropower plants, such as SHP Żarki. Let us examine the investment that may serve as a source of good practices for other small-scale hydropower plant owners.

The history of Żarki small hydropower plant (photo 1), located within the charming woodland enclave of less than 3 hectares in size, dates back to 1904, when the water mill that had operated there was converted into a commercial power plant (photo 2). It was one of the first facilities of this kind in Pomerania, which is confirmed by German-language literary sources dating from 1913.[1] The power plant survived two world wars. However, it was closed down in the 1950s, when the communist authorities of the time liquidated private hydroelectric power plants on a mass scale, thus making local residents dependent on electricity supplies from the state-run power system (before its closure, Żarki power plant supplied electricity to the nearby landed estates). Left unattended, the facility fell into utter disrepair in the following decades (photo 3).

What remained despite the complete destruction of small-scale hydropower plant was the damming on Gwda river and a residential building adjacent to the ruins of the facility. In the early 1980s, these remains attracted the interest of the current owners, who used them to fulfil their dream of a small-scale hydroelectric power plant. It is worth noting here that the investment effort was launched at a time when expressions of civic entrepreneurship were not viewed too favourably by government officials yet (despite the resolution of the Council of Ministers that permitted private individuals to take over hydropower structures and to build hydropower plants[2]), and when inertia and bureaucracy in specific institutions (including the power utility) could effectively discourage interested parties. This was a major obstacle, especially at the first, administrative stage of the investment. The investors' admirable perseverance in the pursuit of their goal (which

[1] Ludnin A. 1913, Die Wasserkrafte – ihr Ausbau und ihre wirtschaftliche Ausnutzung, verlag Julius Springer

[2] Resolution 192 of the Council of Ministers of. 7 September 1981 on the development of small-scale hydropower

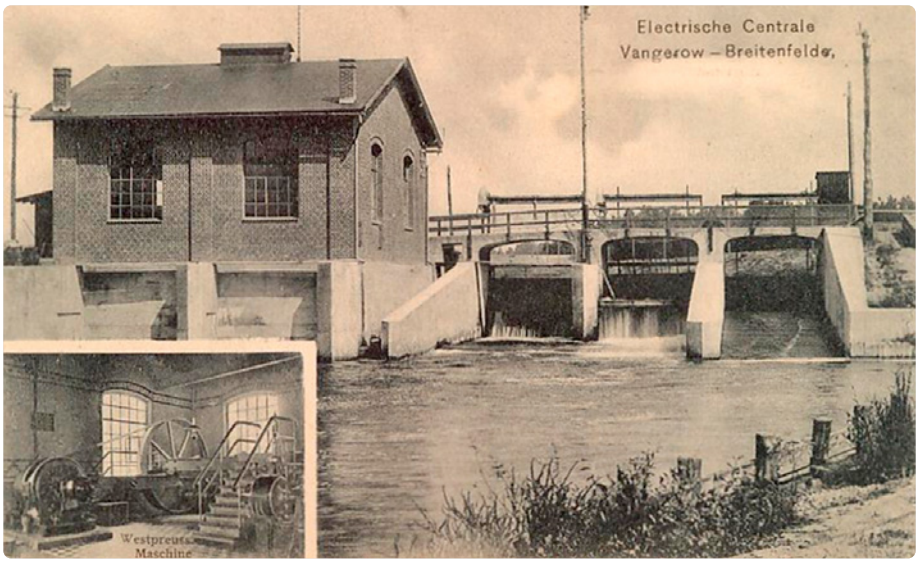
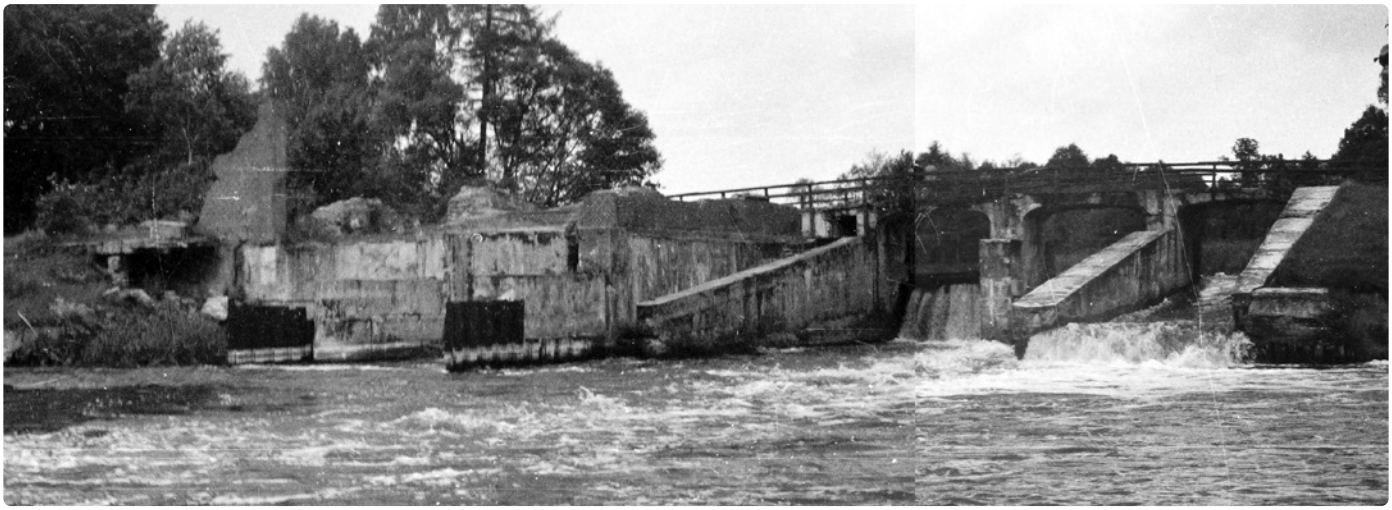


Photo 2. SHP Żarki in the first half of the 20th century
Source: SHP Żarki archive



Source: SHP Żarki archive

Photo 3. View of the weir and ruins of the SHP building (1980s)

involved an intervention at the Central Committee of the Polish United Workers' Party) paid off, as four years after they made the decision and started making their efforts, they obtained a permit under the Water Law Act for a small-scale hydropower plant (in 1985); then they secured a construction permit and ownership of the property which had previously been owned by the State Treasury. In November 1989, the facility was launched and started producing electricity.

Żarki power plant was self-built, which involved a significant effort on the part of its owners. It is interesting to note that they found the first Kaplan turbine (dated 1924) and dug it out with their own hands from the sediments deposited in the cellars of a former powerhouse that formed part of a paper mill in Lower Silesia. They renovated the turbine and installed it in the power plant. The second turbine was partly made by the owners themselves, i.e. they ordered a casting of a Kaplan turbine and processed it on their own. They also designed all the instrumentation of the power plant and made it with their own hands from parts they managed to obtain (interestingly, the bevel gearbox between the generator and the turbine was originally part of a combustion engine). Summarising the colourful story of the origin of the facility one cannot fail to mention the support provided to its owners by engineer Marian Hoffman (called the father of the post-War hydropower), with whom they cooperated in the later years in the Polish Association for Small Hydropower Development. This cooperation resulted in numerous legal and administrative initiatives and in the development of technological solutions that facilitated the ventures undertaken by successive small-scale hydropower enthusiasts.

Łukasz Linowski, construction manager:

SHP Żarki was one of the many investment projects that we approached in a comprehensive manner. The model of operation in which builders work closely with mechanics, electricians, and automation specialists, has been highly successful. However, the process was not entirely free of surprises, which sometimes occur when work is done in facilities of this type. It turned out that a reinforced concrete suction pipe had been made for one of the hydropower units, which was not shown in the source design documentation. Following an unsuccessful attempt to adapt it to the new technology (it was established that this would result in a deterioration in the efficiency of the hydropower unit's operation), a decision was made that a new suction pipe had to be installed. We dealt with this inconvenience by shoring up part of the structure and, once a steel suction pipe was installed, we adjusted its outlet to the rest of the structure on site. This was not an easy task, due to significant leaks through the structure of the then already old power plant, and the absence of sufficiently detailed archive construction documentation. In addition to that, it was necessary to "disassemble" the new suction pipe into smaller parts using cutting tools and to assemble them in the limited space of the power plant unit. Another test of our construction team's flexible approach to the facility was the renovation of a suspended roof slab of varying thickness, reaching up to 1 m at its widest point. This work was necessary to perform, due to the adjustment of the outlet of new suction pipes to the existing structure of the power plant, which translated into improved operating conditions for the entire hydropower unit. The greatest challenge during the work inside the facility was the transportation of turbines that weighed nearly 7 tonnes. It was done using crane beams that were originally found in the facility. Having analysed the available archive documentation of the ceiling and planned the installation step by step, we felt that putting the almost 5-metre long element in place in a room with headroom of less than 4 metres was like the proverbial "piece of cake". The crowning of the entire work was the renovation of the engine room, as there's more to a Contractor's life than turbines.

Scope of the new investment

SHP Żarki has operated practically uninterrupted for more than 30 years that have passed since its launch. To sell the electricity they produced, the owners first took advantage of the option to negotiate the sale price with the Ministry of Energy. Since 2004, they benefited from the system of green certificates, which provided them with relative stability until it was abolished. After years of operation, a number of objective factors led the partners in the company that managed the facility to make the decision to modernise it. These factors included the

Source: IOZE hydro

Photo 4. Assembly of new turbines in the production hall

discontinuation of the previous system of support, the need to meet new regulations governing the eligibility for RES support, difficulties in the operation of the facility, due to the absence of automation and the need for manual control, as well as the awareness that the facility was worn out.

The optimised renovation plan was approved after a series of consultations with the Contractor; it was determined that it would involve mechanical measures (two new turbines with suction pipes), electrical and automation measures (new generators, control cabinets, electrical installation, and control system, automation of one weir valve), as well as construction measures (renovation of concrete surfaces of surge chambers and the floor). It is worth noting that, as it turned out during the dismantling work, this was the last moment to act, and the decision to fully modernise the plant and replace both turbine sets was absolutely right (especially as it was no longer possible to purchase spare parts).

Sebastian Wites, chief automation officer at IOZE hydro:

Despite a similar installed capacity, the new hydrosets are significantly more efficient than the technology used to date. This is not only due to the design of the device itself (whose shape is the result of advanced CFD simulations brought to reality through multidimensional CNC machining), but also to the turbine controller, based on a freely programmable logic controller (PLC). The controller adjusts, in a stepwise manner (in the function of the water level) the opening of the guide apparatus and the position of the rotor blades, maintaining the preset headwater level. In this way, it allows energy yields to be as high as possible, with no loss of flows and the highest possible head (NWL).

The infrastructure installed at SHP Żarki meets the highest technological standards both in terms of the operation of the generating system itself and of the entire supporting infrastructure. In addition to meeting the obvious objectives in terms of power generation efficiency, IOZE hydro places a particular emphasis on process automation, operational safety, and diagnostics in its work. This translates directly to the increased comfort of operation of the facility by persons responsible for the constant supervision of the power plant. It is of high value to the owner of the facility that all elements of the technological system are supplied by the same Contractor, which allows us to obtain optimum compatibility of individual modules. This not only translates into daily operation but also reduces the downtime of the small-scale hydropower plant to the minimum in emergency situations, as, thanks to an extensive system of various types of sensors, the type of failure/cause of the alarm, is diagnosed very efficiently.

The investment project involved the dismantling of old turbines and suction pipes, which were replaced with two Kaplan-type turbines with a vertical axis (photo 6). Repairs were also made to the concrete structures of surge chambers to improve the operating conditions of the small-scale hydropower plant. Categorising the work performed as a renovation does not fully reflect its complexity, which was described by the construction manager for the purposes of this article.

The slightly playful metaphors used in the account of the construction work should not obscure the objective fact that the placement of two turbines of considerable size (photo 4) in the existing building and the installation of suction pipes required an advanced logistical preparation of the Contractor's team and its close cooperation with the technologists who designed the whole installation. The success of this cooperation is evidenced by the first production results recorded by the power plant.

Advanced technology provides operational comfort

Following the modernisation of the heart of the facility – the worn out dual generating system was replaced with a new one, equipped with two high-efficiency Kaplan turbines in a vertical arrangement, with a total installed capacity of 320 kW.

Source: IOZE hydro

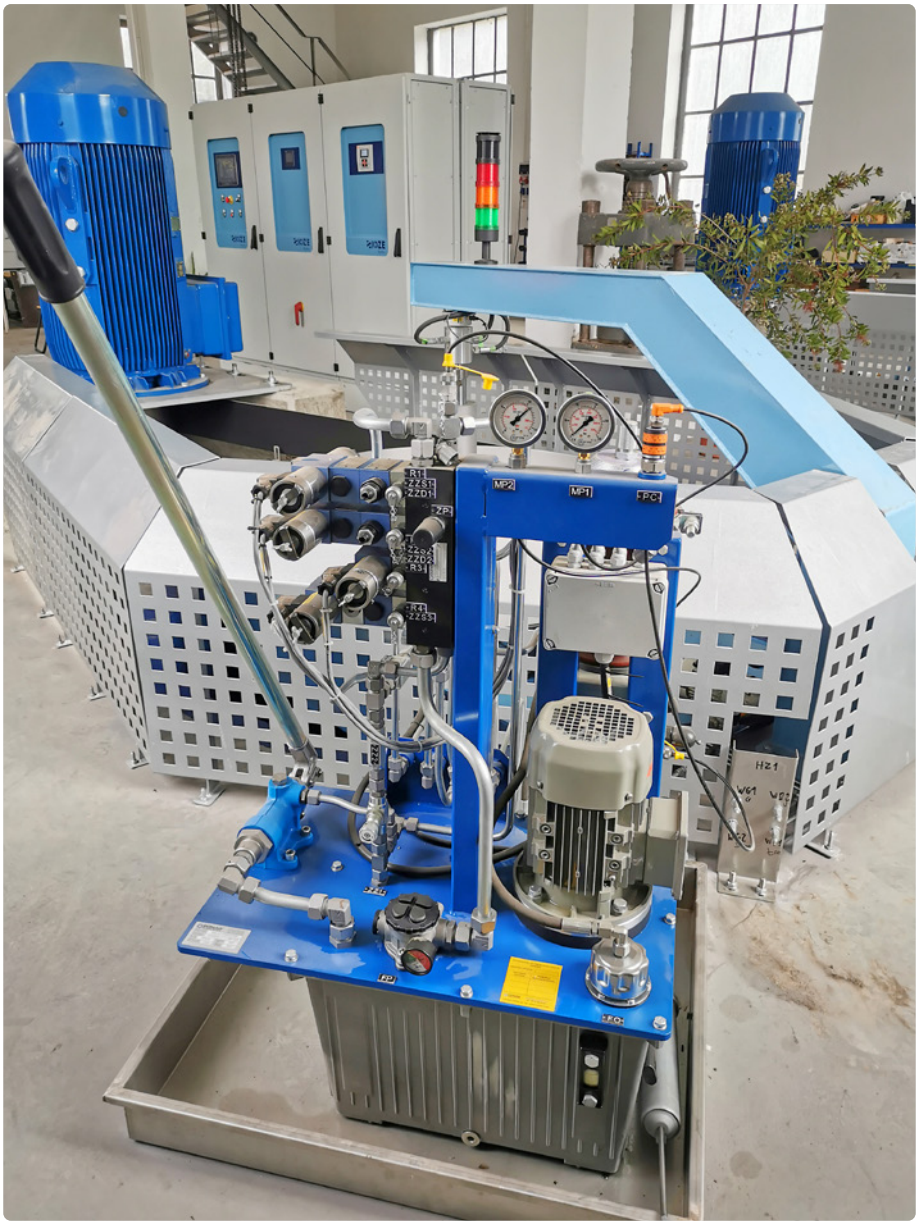


Photo 5. Interior of the machine hall after modernization

Source: IOZE hydro

Photo 6. New rotor with optimized parameters and old rotor

SHP Żarki has taken a quantum leap from fully manual, labour-intensive operation (including manual setting of turbines for the current water level, synchronisation with the grid, and temperature control) to a modern, fully-automated facility (photo 5) with access to a remote desktop that allows for its operation to be monitored and controlled from any Internet-enabled device in any place in the world (photo 6).

Olena Augustowska, co-owner of the facility:

What I appreciate a lot in the cooperation with IOZE hydro is the fact that all technical, as well as formal and legal responsibilities related to the modernisation rested with the Contractor. This means a significant burden was taken off our [partners in the company] shoulders. I could rest assured that everything would be organised and carried out in a professional and, above all, efficient manner. We had it guaranteed that the stated goal of obtaining support for the facility for the next 15 years would be achieved. I also appreciate the fast and efficient performance of the construction work. The initial start-up of the facility has already taken place; electricity from the new plant has been discharged into the grid for the first time; and huge changes, both in the machine hall and in the preliminary production results, can be seen with the naked eye. Production volumes have incerased by at least a third Owing to the automating of the use of water flow, it is possible to fully utilise the power of the installed turbines and to harness the potential of the water.

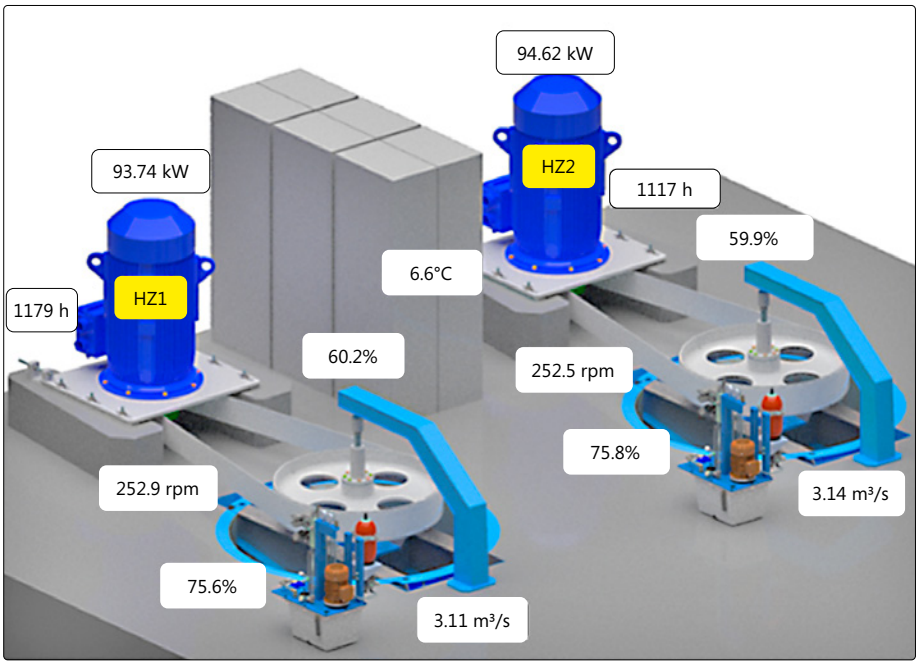
Modernised facility in the new market reality

In the formal context and in the context of compliance with regulations on RES, carrying out the modernisation of the small-scale hydropower plant should not itself be treated as equivalent to obtaining a certificate from the Head of the Energy Regulatory Office confirming the possibility of participation in the new support system. A range of issues related to both the technical scope of the investment and the formal and legal requirements posed by the Act on RES and the Energy Regulatory Office impact whether the shape of a given investment will allow it to receive support. Also in this respect, the investor relied on the knowledge and experience of IOZE hydro experts, thanks to which the plant

was included in the new support system with prices guaranteed for a period of 15 years (subject to indexation for inflation). This ensures the stability of the operation of the small-scale hydropower plant and allows for a return on capital expenditures incurred for the modernisation within the expected time. Additionally, the scope of work performed by the administrative and legal team of IOZE hydro covered obtaining the source of funding for the investment, which allowed for turning the plans into reality.

The example of the modernisation of SHP Żarki described here is used to show how we put into practice the mission of IOZE hydro "turn water into profits". Thanks to the planned and effectively implemented actions of the team comprising specialists in various areas, we were able to fully automate the work and simplify the operation of the facility. The effects of the modernisation are experienced by the investor through the reduced costs of operation, coinciding with an increased volume of electricity produced.

However, the reality facing the owners of existing small-scale hydropower plants is not fully constituted, which is linked to the numerous changes on the market. The increasing volatility of electricity prices caused by the mismatch between



Source: IOZE hydro

Fig. 1. View of the SCADA visualization system

the supply and demand profiles of electricity, changes in the balancing market in the context of the temporary price collapse, including the emergence of negative prices in the near future, and the planned amendments to the RES act (i.a. clarification of the definition of modernisation of RES installations) will bring many complications in the planning and implementation of investments in small-scale hydropower plants. In order to make the right business decision it is necessary to provide up-to-date information of the right quality, covering many formal, technical, and market areas, so that a business model can be proposed that will deliver the highest possible value to investors, within the shortest possible period of return on investment. Therefore, services provided in the fully comprehensive model offered by IOZE hydro are gaining importance.

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Łukasz Kalina
IOZE hydro

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