Photo 1. View of the lower structure of the hydropower turbine chamber from the tailwater side

The hidden potential of the Dunajec River

As the economy develops, the demand for electricity is growing at a high rate. If we add to this the ever-declining reserves of natural resources, the spectre of an inevitable energy crisis begins to appear on the horizon. For this reason, we should, as the entire society, focus not only on increasing the share of RES in the energy mix, but also on using the available renewable natural resources as efficiently as possible. The Hydropowerplant Complex Niedzica sets out an example worth following – it has, at its facility in Sromowce Wyżne, taken an advantage of the hitherto wasted potential of the Dunajec River.

Lake Sromowieckie, the lower reservoir of the Niedzica Pumped Storage Hydropower Plant, is located in an exceptionally beautiful area. Surrounded by the peaks of the Pieniny, together with the upper reservoir of Niedzica Pumped Storage Plant - Lake Czorsztyńskie, it is a holiday destination for many people longing for relaxation among nature. It is also an example of exceptional utilisation of the hydrological potential of the Dunajec River, whose waters are used to produce electricity in two independent hydroelectric power plants:

1. Niedzica Pumped Storage Plant, which takes advantage of the difference in height between the Lake Czorsztyńskie and Sromowieckie;
2. Sromowce Wyżne Hydropower Plant, which utilises the height gradient between Lake Sromowieckie and the Dunajec River, which flows further downstream.

Niedzica hydropower plant

Plans to establish the Niedzica Pumped Storage Plant date back to the early 20th century. It was one of the elements of the construction of water reservoirs on the flood-prone Carpathian tributaries of the Vistula River. Czorsztyńskie Lake, created as a result of its construction, was intended to reduce flood accumulations and increase minimum flows in the Dunajec River. It holds 232 million m³ of water, over an area of nearly 1,226 hectares and its depth reaches up to 50 meters in some places. The power plant was finally commissioned in 1997, and two Deriaz-type reversible turbines, with a capacity of 46.375 MW each (44.5 MW of power in pumping mode), are responsible for energy production and accumulation, with water supplied by two 7-meter-diameter adits hollowed in the rock. The facility currently operates mainly in turbine mode due to economic issues, which are conditioned by current legislation and regulations.

Sromowce Wyżne run-of-river power plant

Below the Niedzica Pumped Storage Plant lies Sromowce Lake with an area of 88 hectares and a capacity of 7.5 million m³. It serves as an equalization reservoir for Niedzica Pumped Storage Plant and as a water reservoir for the Sromowce Wyżne run-of-river power plant, using the equalized water outflow from the lake into the Dunajec River. The power plant is located on the left bank of the Dunajec River below the dam and weir of the reservoir. The water supply to the power plant is via four reinforced concrete channels fed by an intake located at the left abutment of the weir. Four Flygt hydrosets with an installed capacity of 0.52 MW each are responsible for energy production. Two of the turbines have adjustable blade geometry, allowing them to handle flows in the range of 2.5 m³/s to 8 m³/s, while the other two have an unregulated flow rate, which allows them to operate at flows in the range of 5.2-6.7 m³/s. After taking into account the guidelines of the water management manual, we get a total operating flow range for the Sromowce Wyżne Power Plant of 5.4-29.4 m³/s.

Energy utilisation of all the water

Nature, although beautiful, does not always give us what we require - and we require a power plant to work 24 hours a day, 365 days a year. For this however, we need a sufficient amount of water with a very steady flow. But since we cannot force mother nature to provide us with that, we should carefully consider the utilisation of what we already have, and there is a huge unexploited potential available, in the form of a constant environmental flow of 4 m³/s. So why should we not take advantage of such an opportunity?

Specialists in the service of climate protection

Representatives of Hydropowerplant Complex Niedzica, in cooperation with the engineers of Enerko Energy Sp. z o.o., which specializes in the implementation of comprehensive solutions for the hydropower industry, decided to take advantage of this untapped flow. Due to professional cooperation, it was possible to build a new section of the power plant, named Sromowce V, in which a 0.325 MW Kaplan turbine manufactured by Voith Hydro was installed. Enerko Energy as a general contractor for the investment, carried it out in a "design and build" formula. The specialists faced a number of challenges, which

Photo 2. Left: preparation for installation of the water turbine; Right: view of the SHP facility put into operation

they had to resolve to ensure that the facility operated properly – and in harmony with the nature.

Comprehensive approach to the investment

The construction of the Sromowce V Small Hydropower Plant at the existing Sromowce Wyżne dam was not only an engineering challenge, but also a formal one. In order for the investment to come to fruition, the engineers of Enerko Energy had to develop a complete, multi-discipline general, as well as detailed design documentation, concurrently with obtaining all the administrative permits required by law, allowing for the construction and commissioning of the powerplant itself, or the adjustment of the water intake and the refurbishment of the plant's inlet channel. The fact that the Dunajec River is a border river did not make things any easier, and international agreements, at the level of relevant ministries and commissions, had to be undertaken as a part of the necessary arrangements. Once all the formalities were completed, the construction and installation work began, which included, in particular:

- adjustment of the water intake and renovation of the inlet channel of the Sromowce V Small Hydropower Plant,
- reconstruction of the existing overflow chamber,
- construction of a reinforced concrete turbine chamber and an outlet chamber,
- delivery and installation of the turbine and generator together with appropriate mechanical and electrical equipment,
- construction of the facility's high and low current electrical systems,
- construction of the main electrical distribution system,
- construction of generator power output installation,
- construction of the building's own consumption installation,
- construction of power connection to the existing infrastructure,
- reconstruction of the telecommunications installation,
- construction of a drainage system for the hydroset chamber,
- construction of ventilation system inside the hydroset chamber,
- construction of the heating system,
- training of the investor's personnel,
- carrying out commissioning of the equipment,
- carrying out final tests,
- servicing of the installation and its constituent equipment during the period for defect notification, and then during the warranty period, as well as after warranty's conclusion as part of post-warranty service.

In order to reduce the cost of the investment, and thus accelerate the return on the investment, an unused reinforced concrete water supply channel to the planned, but never realized, fish stocking centre was used to supply the turbine with water. To this end, it was reprofiled and upgraded, and all the necessary equipment was installed – namely main and emergency gates and inlet trash rack. In addition, the channel has been coated with epoxy resins for protection, also to the effect of reducing the roughness of its walls, allowing for a significant decrease in the hydraulic linear energy loss of flowing water.

The interior is important

At the heart of the powerplant, there is a Kaplan turbine and a three-phase synchronous generator hydroset. The hydroset is installed in a horizontal arrangement, connected to a suction pipe that exits into the outlet chamber. To maximize the efficiency of the system, the generator's speed was matched to that of the turbine, thus eliminating the need for a gearbox, and the generator itself was connected directly to the turbine shaft. Both the hub and the adjustable rotor blades are made of stainless steel, and the blade adjustment is carried out using a hydraulic actuator passing through the hollow shaft of the turbine and the generator. The position of the blades is determined by an inductive position transducer. The rotor blade chamber of the turbine is also made of stainless steel and in its part it is shaped spherically to achieve a constant gap at every possible blade position. The remainder of the cone-shaped housing is made as a welded structure with mounting flanges for connection to the suction pipe elbow. To ensure easy maintenance and inspection operations, the rotor chamber is made in two-piece form. The turbine actuation system is equipped with 16 directional vanes, which are connected by actuation levers to the adjustment ring. Every second lever is flexible to protect the system in case a large component gets stuck during vane closing procedure. The position of the directional vanes position is monitored by the facility's

Technical parameters of Sromowce V SHP

- Turbine type: Horizontal S type Kaplan turbine
- Gross head: 5–10 m
- Rated flow rate: 4 m³/s (min. 0.8 m³/s)
- Rated turbine efficiency: 91%
- Generator type: synchronous
- Nominal power: 325 kW
- Generator efficiency: 96%
- Number of operating hours per year: 8640 h (24 h x 360 days)
- Operating voltage: 0.4 kV

Photo 3. Key elements of the SHP equipment: water turbine, hydraulic power pack, electrical cabinets/turbine automation, synchronous generator

automation. To ensure the certainty of the vane closure, the procedure is triggered by a counterweight, while a hydraulic actuator is used to open and adjust it. The turbine's main bearing assembly is a set of oil-lubricated roller bearings that transmit radial and axial shaft forces, and each bearing is equipped with a PT100 temperature sensor, a vibration sensor and an oil level control system that monitors oil levels in the bearings and informs the operator when it is below the level necessary for safe operation. The bearing assemblies are equipped with a cooling system (water/oil heat exchanger) located inside the oil sump.

The power plant will operate in automatic mode, transmitting information to a SCADA master visualization system, and its operation will be limited only to periodic inspection and maintenance. The Sromowce V SHP is designed to sustain continuous operation, 24 hours a day, 360 days a year.

On-grid or off-grid operation

To manage and control the operation of the facility, advanced supervision, control and automation systems have been used, which, in addition to optimizing the operation of the hydropower plant, are able to ensure the proper parameters of the grid when they are islanded – and even restart the powerplant after a blackout. This is a very important function from the point of view of the entire power transmission system, because in the event of failure of large power units, a facility such as Sromowce V SHP, in cooperation with Niedzica Pumped Storage Plant, will be able to assist in their restart and reconnection to the power transmission system. Attempts to restart the power system have already been made several times, utilising Skawina and Jaworzno power plants. The first of these attempts has been made in 1996. The trials were successful and showed that the power plants' generating units are capable of transitioning to island operation under the various conditions of power imbalance encountered prior to separation. The plants were also capable of maintaining themselves in operation during such an event, even when there were load changes occurring on the island, on condition that frequency and voltage are kept within the limits of acceptable deviations.

Was it worth it?

The Sromowce V Hydropower Plant, implemented within an existing power plant and damming, can serve as a good example of responsible asset management and maximum use of the available hydropower potential in the vicinity of those powerplants that are already in operation. The facility in Sromowce Wyżne is not an exception in this case. There is often untapped potential available in other facilities of this kind, which, after a careful analysis, can be developed for electricity generation. Enerko Energy Sp. z o.o. specializes in providing comprehensive services for hydropower projects and offers support at every stage of cooperation. Each hydropower project is unique and requires an individual approach from the contractors. At every stage of our involvement – i.e. in design, construction, engineering or even during consultation procedures, we use modern tools and solutions. Our priority is to ensure maximum profitability of the investment for our clients throughout the entire life of the installation, from the analysis and consultation phase to the long-term operation of the facility. Therefore, we build individual teams, employ professional subcontractors, and our experience, knowledge and reliability allows us to implement even the most complex of the projects.

Piotr Włodarski
Development Department
Enerko Energy Sp. z o. o.

Photos come from the archive of **Enerko Energy Sp. z o.o.**

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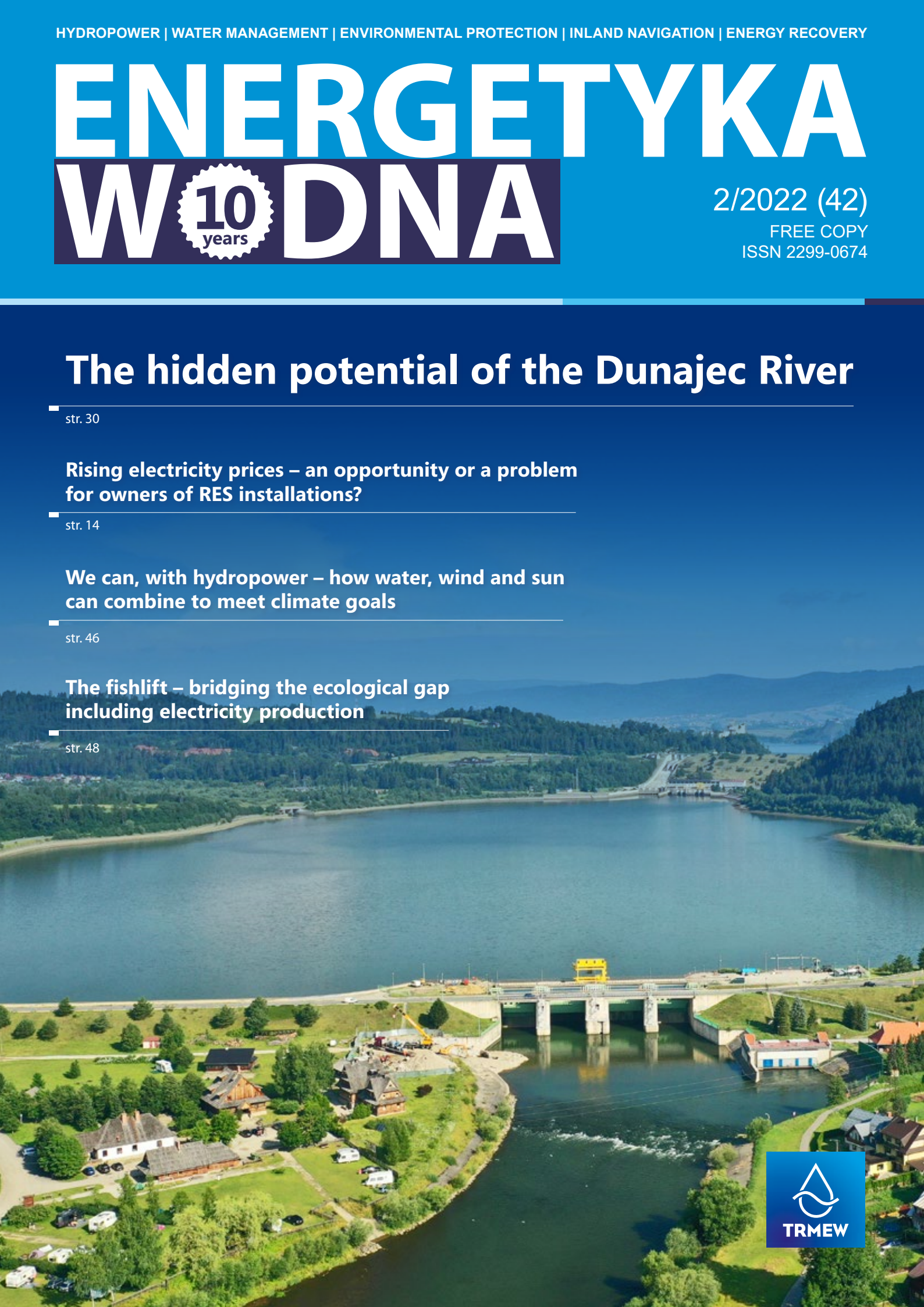

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