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ENERGETYKA W DNA

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TRMEW

#TAURON'sGreenTurnaround

The Rożnów dam and hydroelectric power plant was built in the narrowest point of the Dunajec sub-mountain gorge between the headland of Łazy Mountain (323 m above sea level) and Ostra Góra (459 m above sea level). It is one of 34 hydroelectric power plants belonging to the TAURON Ekoenergia Sp. z o.o. portfolio.

TAURON Ekoenergia Sp. z o.o., with its headquarters in Jelenia Góra, is a dynamically developing provider of green energy from water, wind and sun. The company operates hydropower plants with a total installed capacity of 132.944 MW, 9 wind farms with a total capacity of 380.750 MW and 2 photovoltaic farms with a capacity of 14 MW. TAURON Ekoenergia builds on many years of experience, combining the best traditions with modernity. The company actively participates in the implementation of TAURON's Green Turnaround by scaling up its RES capacity.

The TAURON Group was the first power sector corporation in Poland to initiate the Green Turnaround – the process of changing the generation mix towards RES – in 2019. The next step is a plan to generate energy primarily in onshore and offshore wind farms, photovoltaic installations, hydroelectric and gas-fired power plants. By 2025, the TAURON Group wants to increase the total capacity in RES by 300% – up to 1.6 GW – and by 2030 it plans a 520% increase up to 3.7 GW. TAURON will become climate-neutral in 2050.

www.tauron.pl
www.tauron-ekoenergia.pl

From The Editorial Office

Many people, both, related to the electric industry at large and fans of large-scale construction engineering endeavours, are familiar with the date of September the ninth this year. On that day, Nant de Drance pumped storage powerplant in Switzerland, which some are calling "the investment of the century," was officially commissioned. People referring to this plant as "the largest investment" have solid grounds for naming it as such, as the powerplant is impressive in virtually its every respect. Suffice to say the power plant's nearly 200-meter-long machine chamber has been placed in the heart of an Alpine mountain range, accessed by a 5.6-kilometer-long tunnel, and the total length of all the adits and tunnels created for the project is roughly 17 kilometres. The power plant, with an installed capacity of 900 MW, acts as a huge energy storage facility with a capacity of 20 GWh and has an efficiency of over 80%, which is one of the highest in the world. I have presented just a few facts about this fascinating project, and there are definitely more! If you are interested to learn about the object, I can humbly invite you to read this issue's leading article, in which engineers from BG Consulting Engineers company, will "give you a tour" of this impressive powerplant.

In addition, this issue includes an overview of current and future initiatives aiming at taking care of the welfare and development of the European hydropower industry. It would seem that as mature branch of renewable energy as hydropower is, would be so well established, there shall not be a need to solicit its interests in any way. Paradoxically however, practice shows that the world's largest generator of green energy is in need of constant support, particularly in Europe, where a thriving movement of environmental organisations is threatening the industry's very operation. The overview was compiled by Dirk Hendricks, Secretary General of EREF.

This year marks the 80th anniversary of the commissioning of the Rożnów dam and hydropower plant, which was a huge economic and technical achievement of the interwar period in Poland – even by European standards. Therefore, the investment itself, as well as its designers and builders, deserve special words of commemoration. The history of this facility, and the figure of its designer, as well as manager of construction process, Professor Wacław Balcerski, has been presented by Professor Wojciech Majewski.

The issue also contains a number of publications related to the practical and technical aspects of hydropower, including a summary of the training carried out under the HYPOSO project, an experience from the implementation of the research on ultra-low-power Kaplan turbine, a presentation of methods for machine repair using polymer-based technology, the concept of a modular hydropower plant, and an overview of the most popular energy storage technologies in light of issues related to grid-balancing.

Finally, in the "Ecology" section of the issue, we take a closer look at the position of the French Association for the National Coordination of Waters and Rivers for Humanity (Coordination Nationale Eaux & Rivières Humaines - CNERH), which refers to the proposal for a directive on nature restoration, submitted by the European Commission's Directorate-General for the Environment, which, in the name of the idea of "free movement of water", may pose a threat to European hydraulic engineering structures. Charles-François Champetier and Elodie Denizart presented the issue in the context of the French experience in river restoration.

Michał Kubecki
Editor-in-Chief

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State Water Holding Polish Waters has received the Fish Passage 2022 international award

State Water Holding Polish Waters has received an award at the International Fish Passage 2022 Conference. World experts recognized the work of the State Water Holding Polish Waters towards a modern approach to clearing migration barriers on the Biała Tarnowska and Wisłoka rivers and their tributaries, making these rivers regain ecological continuity over 350 kilometres of their length.

Source: Zakład Badań Ekologicznych

Photo. Fish pass on the Wisłoka river, in the vicinity of the SHP Pilzno

The award was given at the Fish Passage 2022 Conference, held in June in Richland, USA. State Water Holding Polish Waters received the award for its activities in two projects:

- elimination of migration barriers for aquatic organisms on the Wisłoka river and its tributaries – the Ropa and Jasiołka rivers,
- restoration of ecological continuity and implementation of measures to improve the functioning of the free migration corridor on the Biała Tarnowska river.

Restoring the possibility of unrestricted migration of fish and other aquatic organisms up and down the rivers is one of the goals of the projects undertaken by the branch of the State Water Holding Polish Waters for the Cracow region. This branch is responsible for water management in the Upper Vistula river basin. Restoring access to spawning sites and creating conditions for reproduction is the most effective method of improving ecological status of rivers. This is also the first attempt in the region to develop different types of crossings for migrating fish, with a special emphasis on solutions using natural materials, which is very different from standard technical fish pass approach. The design and construction process in both projects resulted from the joint work of engineers and biologists:

- on the Biała Tarnowska river and its tributaries, 15 fish migration barriers were cleared for passage, which made possible to restore the migration corridor on the river for a total length of 101.8 km, i.e. from the source to the river's estuary,
- on the Wisłoka river and its tributaries - Jasiołka and Ropa, the elimination of 7 migration barriers resulted in the clearing of the free biological flow at a length of 254 km.

All the measures taken on the rivers were in accordance with close-to-nature solutions, imitating the conditions that prevail in a natural river. Thus, they ensure the full ecological continuity of the rivers, that is, the uninterrupted flow of water, the incessant possibility of transporting bottom sediments, and guarantee bi-directional (upstream and downstream), migration of aquatic organisms.

As part of the monitoring of the effectiveness of the built crossings, using a variety of research techniques, information was obtained on the crossings of the passes by fish, as well as on the species composition and quantity of migrating individuals. The main goal of such research was to determine whether fish migration occurs through the fish pass solutions implemented as part of the two projects. Analysis of the collected data made it possible to determine the migration of fish of different swimming abilities and sizes. The research confirmed the migration of fish of different species and different sizes through the fish passes on both rivers, recording these passages in scanner and video records. Continuous cycle observation will be carried out in subsequent years, making it possible to compare changes in migrating fish populations over the long term.

Currently, branch of State Water Holding Polish Waters in Cracow is implementing a third project aimed at improving the ecological status of the waters of the Vistula river and the lower sections of the Soła and Skawa rivers. The coherence of the Natura 2000 network of areas will be restored, and historic ecological corridors linking the Vistula with the Soła and Skawa will be reconstructed. As a result, there will be protection and stable perspectives for the preservation of natural habitats and species included in the ecosystem of the Soła and Skawa river valleys. Activities carried out during the project are supposed to result in construction or modernisation of 7 fish pass devices. The total cost of implementing these three projects is over PLN 112 million. The projects are co-financed from the European Union funds.

Press office
State Water Holding Polish Waters

Storm gates on the Tuga river nearing completion

Construction of storm gates on the Tuga river is nearing completion. The completion of the works is 95 percent. The State Water Holding Polish Waters is responsible for the implementation of the EU project related to the construction of the gates.

Source: State Water Holding Polish Waters

Żuławy Wiślane is a picturesque and unique area, which is threatened by floods due to its location. Currently, the project "Comprehensive Flood Protection of Żuławy - Stage II" is being implemented in the area of Żuławy Wiślane, which is the next stage of the program "Comprehensive Flood Protection of Żuławy - until 2030 (including the 2015 stage)", called "Żuławy Programme - 2030". It includes five tasks, and one of them is the construction of storm gates on the Tuga river - a right tributary of the Szkarpawa river. The Tuga flows through Nowy Dwór Gdański, where storm surges coming from the Vistula Lagoon have repeatedly contributed to flooding of the city. The gates will protect an area of about 100 square kilometres, inhabited by more than 15,000 people. They are located in the estuary section of the Tuga river at its intersection with the Szkarpawa river, in the municipality of Stegna, in the Nowodworsk district. In addition to the construction of the floodgates, the project includes, among other things, the execution of fortification works in the vicinity of a flood barrier, which are already 90% complete. The construction of a side overflow structure to the Pryżnik canal has also been completed, while the reconstruction of the Pryżnik canal itself along a section of about 2.5 km is too nearing completion. Works on the right bank of the Tuga river and road works remain to be done.

The floodgate is a three-span reinforced concrete structure with two spans of 6.5 meters each and one span of 3 meters. Between the spans there are bulkheads to be closed (automatically or manually) when a flood wave arrives. In case the gates are closed, excess water flowing in the Tuga river will be diverted through the overflow structure into the Pryżnik and Linawa canals, and further on to the Szkarpawa river, being finally released into the Vistula Lagoon. Work is still underway on the floodgate control system, which will close automatically when the water level in the Szkarpawa river reaches 0.6 meters above sea level. With the gates closed, if the water level in the Tuga rises and reaches the ordinate of 0.65 m above sea level, the side overflow structure diverting water into the Pryżnik canal will gradually open. Water will then flow through the overflow structure and further through the Linawa river channel to the Chłodniewo pumping station. When the water level in the Tuga river decreases and is equalized on both sides of the gates, the storm gates will be opened again.

The project "Comprehensive Flood Protection of the Żuławy region" is 85% subsidized by the European Union. The supervising institution is the National Fund for Environmental Protection and Water Management of Poland, and the remaining 15% of the funds for these investment projects come from the state budget. The value of the project is PLN 130 million. The expected completion date is October 31, 2022.

Zuzanna Biernacka
Aplan Media

POLCOLD – NEWS

Polish Committee on Large Dams, a member of International Commission On Large Dams (ICOLD), is involved in international conferences and cooperates with polish representatives of hydroengineering.

As an additional information to that from the previous issue of „Energetyka Wodna" about the participation of POLCOLD representatives in ICOLD congress in Marsewille it should be stressed that EngD Krzysztof Radzicki (Cracow University of Technology) and Prof. Janusz Zaleski (Meteorology and Water Management, Wroclaw University of Science and Technology) represented POLCOLD in working group of ICOLD Levees Technical Committee. Especially the final editorial and publication aspects of two ICOLD Bulletins were discussed, which have been being prepared for several years by the members i.e. „Comparison of dams and levees – Similarities, differences and recommendations" and „Levees around the world – Characteristics, Risks and Governance".

More, both of them participate in „Levees and flood defences working group of the European club of ICOLD", which was the seed of ICOLD Levees Technical Committee created recently. As a part of this activities, dr Radzicki was invited to present the topic of mobile antiflood barriers during the international online conference „Temporary, mobile, demountable barriers (or defense structures)", which was realized on November 6th.

On the 29th of June the second meeting of POLCOLD members took place. The participation on ICOLD Congress was summerised, running problems were discussed, particularly the procedure of POLCOLD's representatives to ICOLD's technical committees appointment. The importance of colaboration with energetic companies was underlined. PGE, Tauron and ENEA declared their will already, waiting for response from ENERGA.

The EU ETIP (European Technology and Innovation Platform) HYDROPOWER project officially launched on the 1st of September. The project has a budget of about EUR 1 million and will run for the next 3 years. POLCOLD can appoint its representatives to work in this project. We are waiting for applications from interested persons, also to other ICOLD technical committees and European teams.

Piotr Śliwiński
President
Polish Committee on Large Dams POLCOLD

The Vistula Spit Crossing opened

The Vistula Spit Crossing was put into operation on 17th of September this year. The 1.3-kilometer-long and 5-meter-deep shipping channel is the main element in the construction of the waterway connecting Vistula Lagoon with the Gulf of Gdańsk. The construction of the crossing through the Vistula Spit will guarantee Poland free and unrestricted access from the Vistula Lagoon to the Baltic Sea, bypassing the Russian-controlled Piława Strait.

Source: ND/Besix

The elements of the navigation channel through the Vistula Spit, are a sluice and a closure structure, along with waiting stations on both sides of the crossing. The passage over the crossing is possible via two moveable steel bridges with a vertical axis of rotation. The length of these bridges is 62 m, and the width is 17 m. Ships arriving at the crossing from the direction of the Gulf of Gdańsk will enter a sheltering port before using the crossing. The port consists of a 1,000-meter-long eastern breakwater and a 500-meter-long western one. The port has an area of approximately 260,000 m². The construction of the breakwaters utilised 400 thousand tons of stone riprap, and nearly 10 thousand of so-called x-blocks, which are prefabricated concrete elements designed to combat wave action during severe weather.

The sluice is nearly 270 meters long and 25 meters wide (its depth reaches 6.5 meters below the water surface, and the height of the walls including the caps is more than 9 meters). All of its four gates are made up of six segments, each containing 730 elements. Each gate weighs about 160 tons, and the heaviest of its elements weighs about 33 tons. To make a 1,300-meter-long, 5-meter-deep and 120-meter-wide (at its widest point) trench, 800,000 cubic meters of excavation material was extracted. The material has been used to build an artificial island in the Vistula Lagoon. The Ester Island with dimensions of 1906 by 1166 m, a circumference of 4.9 km and an area of 180 ha has since become a habitat for wild species. Steel cofferdams were used to give it its shape, from which sheet pile walls of almost 112,500 m² were made to protect the island from the elements.

Łukasz Madej
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Łapino hydropower plant dam after modernization

Energa Wytwarzanie has completed the modernization of 552 meters of the surface of the earthen dam at the Łapino hydropower plant. This will protect the embankment from erosion, and thus from flooding of the surrounding area in the event of a sudden raise of the Radunia river water levels.

The investment, worth more than PLN 1 million, included hardening the area of the earthen dam and protecting its bank by strengthening it with Ehlers plates. This will make the dam more resistant to adverse weather and hydrological conditions. Rapid runoff of snowmelt water down the Radunia river or heavy rains might have become the cause of dam's damage. To ensure proper operation of the power plant, several other modernization works have also been carried out in recent years. First of all, the body of the dam was reinforced and the concrete stairs leading to the dam's crown were replaced. In the near future, there are also plans to tighten the dam against leakage in the area between the reservoir and the oxbow lake - which will reduce the intensity of the phenomenon of suffosion, i.e. the washing out of soil particles and minerals by flowing water.

Built in 1927, the Łapino hydropower plant is a reservoir dam-based powerplant. Its reservoir was created by closing the outlet of the Radunia river valley with an earthen dam. The length of the dam's crown is 552 meters, and its height is 13.8 meters. As a result of the pre-war construction of the dam and damming up of the river, an old paper mill, a sawmill, a forest, a road and several farm buildings were have found themselves at the bottom of newly-created reservoir.

There is a storm gate on the left side of the powerplant, which is an original and unique object of engineering in Poland. The solution for raising its bulkhead is particularly noteworthy. The gate serves to maintain a constant water level in the Radunia river. The powerplant has three Francis turbine equipped hydrosets. The total power of the power plant is 2.907 MW.

Press office
Energa Group

XXX PEMINE Conference – Jubilee Event

On 21-23/09/2022 the participants of Scientific-Technical Conference „Operational Issues of Electrical Machines and Drives" met in Rytro for the thirtieth time. The Conference is organised by Research Network Łukasiewicz – Institute of Electrical Drives and Machines.

Photo 1. Inaugural speech by director Lukasiewicz-KOMEL, Prof. Jakub Bernatt

Photo 2. Presentation of the latest developments Lukasiewicz-KOMEL

More than 160 persons representing 70 companies and institutions took part in the conference, in particular there were representatives from 8 institutes constituting Research Network Łukasiewicz. The opening speech was given by General Manager of Łukasiewicz-KOMEL, Prof. Jakub Bernatt, he presented the program and goals of the conference (photo 1). He described 30 years of the conference, beginning with the very idea of the event until the present. The Manager informed the participants that Łukasiewicz-KOMEL is currently being reorganized, three different institutes are to be joined into one entity. From next year, KOMEL will function within the framework of Łukasiewicz – Upper Silesia Technological Institute. Next, Dr. Stanisław Gawron talked about the most important current achievements of the Institute, the ongoing projects and R&D work. He also outlined plans for the future. During the conference, 4 plenary sessions and one dialogue session were held. Electromobility issues were traditionally included within a separate session. There, the stress was laid on problems related to design and operation of vehicles and other electric drive transport means.

The papers presented during the conference have been published in the journals "Maszyny Elektryczne – Zeszyty Problemowe" and "Przegląd Elektrotechniczny". Eight industrial companies involved with electrical drives and machines presented new technologies, products and services; advertising presentations were employed as well as company booths. Łukasiewicz-KOMEL stand was equipped with numerous novel and innovative designs of electrical drives, including electrical boat drive, scooter motor, electric motor dedicated to wheel hub installation, bus motor and generator with permanent magnets (photo 2).

Mariusz Czechowicz
Conference Secretary

70 years of Dychów pumped storage power plant

Dychów pumped storage power plant, owned by PGE Energia Odnawialna, is celebrating its 70th anniversary this year.

The Dychów power plant is the oldest pumped storage power plant in Poland. It plays a key role in the Polish National Power Transmission System, performing very important grid management and emergency tasks. It is a kind of energy storehouse used in emergency situations - says Wojciech Dąbrowski, CEO of PGE company. Moreover, with the planned increase in the share of renewable sources in the national energy mix, pumped storage plants such as the one in Dychów are essential for the uninterrupted functioning of the Polish power grid system, he adds.

The project was launched in November 1933, when Dychów was outside Poland's borders. The project included a weir on the Krzywaniec river, a storage reservoir and eight road bridges, one railroad bridge and seven siphon culverts. The power plant operated reliably and trouble-free almost until the end of the war. This changed in February 1945, when Red Army soldiers entered Dychów. They dismantled all the most important equipment, transporting it to the east. When the power plant was taken over by the Polish administrative authorities, a decision was made to rebuild it. After several years, it was possible to bring back the accumulation pumps, and turbines were made to resemble those looted earlier. The power plant resumed operation in September 1952, and for years – until 1968 – was the largest of its kind in the country, until Solina power plant became operational.

Today, after upgrades, Dychów pumped storage plant is a very modern facility, performing important power balancing tasks in the power system, says Marcin Karlikowski, CEO of PGE Energia Odnawialna company. Last year, the power plant underwent a major overhaul. The scope of work was very extensive. As a part of the overhaul, the rotor and stator of the generator, the entire hydraulic system of the turbine, the guide apparatus, the hydroset control unit, turbine's rotor, water and oil circulation system, as well as the electrical installations were renovated in each of the powerplant's hydrosets. In addition, two accumulation pumps were renovated, allowing the power plant to fill the upper reservoir even at low river flow rates – he adds.

The Dychów power plant is a medium-sized power plant. It has approximately 88 MW of installed capacity and is equipped with three vertical Kaplan turbine units. In addition, it has four pumping units with a capacity of 18 m³/s each, equipped with synchronous electrical motors of 2 x 5.9 MW and 2 x 5.74 MW respectively. In the event of a catastrophic failure of the grid, Dychów plant - acting as a starter - can provide a supply of power for at least 5 hours at an average load of about 17 MW. The emergency role of the Dychów power plant could be seen last year when Rogowiec switchyard failed. During this event, PGE-owned pumped storage power plants played a key role in balancing the Polish National Power Transmission System. Combined, they supplied more than 1.5 GW of power to the grid at the time of peak power demand.

Press office
PGE EO

More HPs with power market agreements

PGE Energia Odnawialna has received confirmation from the Polskie Sieci Elektroenergetyczne (PSE) operator company that the Raduszec Stary and Dębe hydropower plants can execute the seven-year long contracts regarding the plants' functioning on the Polish power market. This guarantees additional revenues for the company for keeping the two hydropower plants on standby, ready to generate energy, and supply it to the grid when the reserve in the transmission system is low.

Under Poland's power market mechanism, contracts are concluded for one, five and fifteen years. In addition, if the generating units meet emission standards, the multi-year contracts can be extended for an additional two years (so-called green bonus).

Fifteen-year contracts are reserved for newly-built power plants, while five-year contracts can be entered into by modernized facilities. The latter mechanism has been utilized by the aforementioned PGE's hydropower plants. The main advantage of this type of contract is that it secures long-term revenue stream, thereby improving the profitability and predictability of the upgrade investment process. Dębe HP was awarded the contract during the 2019 auction. It will remain in force for seven years (five year base duration and two additional years per green bonus scheme), from 2024 to 2031. Two years later – in 2021, the company concluded a similar contract for Raduszec Stary HP for the period of 2026-2032.

Winning the auction did not guarantee that the contracts would be implemented. For this to happen, the generating units had to meet two so-called Milestones. The first of these, the Financial Milestone, involves confirming to the operator that agreements with contractors have been concluded, and certain expenses to modernise the facility have been incurred – says Marcin Karlikowski, CEO of PGE EO company. The next step is the implementation of the so-called Operational Milestone. In case of PGE's hydropower plants, Operational Milestones were achieved well in advance. Dębe HP achieved them more than a year and a half earlier, and Raduszec Stary HP astounding three years ahead of schedule. In case of Dębe HP, the upgrade included performing the necessary design work, followed by the delivery of upgraded plant's equipment and the installation of a hydroset.

Regarding Raduszec Stary HP however, the work completed as part of the overhaul of the HZ-2 hydroset included: renovation of a turbine regulator, as well as fitting of new guide vanes, runner blades and a fresh mechanical transmission.

Press office
PGE EO

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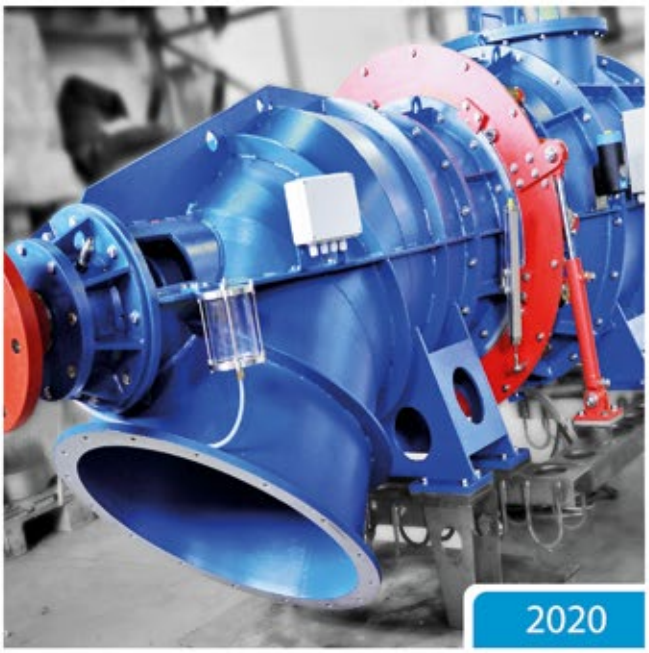
SHP Glebocko, Poland

6x136 kW (d=1090mm, H=3.1m)

SHP San Secondo, Italy

1x92 kW (d=720mm, H=5.4m)



SHP Naviglio, Italy

1x84 kW (d=560mm, H=7.6m)

SHP Chancza, Poland

1x177 kW (d=590mm, H=11.9m)

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From the World

05.07.2022 More hydro needed in Africa, says report

An additional 40 GW of hydropower is needed in Africa by 2030, a new report from the International Energy Agency (IEA) has suggested, which would require doubling investment, with a significant chunk needed from the private sector.

The Africa Energy Outlook 2022, which includes the Sustainable Africa Scenario (SAS), explores how to transform Africa's energy sector to achieve development goals, and to shift to more affordable and cleaner sources of energy.

The report says that hydropower remains a cornerstone in the provision of affordable and dispatchable electricity, with the use of natural gas and coal gradually expected to be replaced by hydropower, wind and solar PV in the years ahead. "To unlock private investment governments and policy makers need to reward the vital low carbon flexibility provided by hydropower. Projects can and must be developed sustainability, with the Hydropower Sustainability Standard providing a benchmark by which to assess projects."

Modernising the ageing African Hydropower fleet could also help to meet the IEA's SAS scenario. Sixty per cent of the hydropower installed capacity in the region is over 20 years old. To address this, the African Development Bank (AfDB) is undertaking an Africa Hydropower Modernization Program, supported by IHA. This will enable existing plants to increase generation capacity at a low-cost, and with relatively short lead times and minimal environmental impact.

15.07.2022 EDP inaugurates floating solar plant at Alqueva Dam

EDP inaugurated the new floating solar photovoltaic power plant at the Alqueva dam reservoir in Portugal – the largest floating solar plant in Europe on a reservoir.

The project features approximately 12 thousand photovoltaic panels and will have an annual production capacity of 7.5 GWh. It is expected to supply electricity to around 1500 families in the Portel and Moura region. EDP said Alqueva will become a kind of 'living laboratory', by allowing the complementarity between dispatchable (hydroelectric) and non-dispatchable (photovoltaic) renewable energy production technologies to be tested, as well as long-term energy storage technologies (pumping) and short-lived (battery). With the power of 1 MW and storage capacity of around 2 MWh, the battery will use lithium-ion technology, which is already widely used in the electrical sector globally. The pumping system allows the use wind and solar energies, in periods of lower consumption, to pump water from the reservoir and, in this way, reuse it to produce a new hydroelectric power, increasing the flexibility of renewable energy.

11.08.2022 Eesti Energia planning Estonia's first pumped storage plant

Eesti Energia is carrying out preliminary design and environmental impact assessment for what would be the first pumped storage hydroelectric plant in Estonia.

The planned 225 MW plant is planned for the industrial area of the Estonia mine in Ida-Virumaa. It's upper reservoir will be built on a tailings structure, and a closed mine will be used as the lower reservoir. The project is expected to start operating in 2026, "Ensuring Estonia's energy security and energy independence with our own assets is more important than ever before", said Margus Vals, a member of the board of Eesti Energia. "In light of the connection to the continental European electricity system, which is planned for 2026 at the latest, it is extremely important that the necessary energy markets and production or storage assets are created in the Baltic States, with which security of supply can be ensured in the greenest and most affordable way possible".

17.08.2022 US hydro industry welcomes signing of Inflation Reduction Act of 2022

The National Hydropower Association in the US has welcomed the news that President Joe Biden signed the Inflation Reduction Act of 2022 into law, with CEO Malcolm Woolf stating that the legislation will help to accelerate the development of new pumped storage hydropower projects and hydropower generation on existing dams.

In a statement, Woolf described the legislation as the 'nation's most significant climate legislation to date', adding that the industry has been advocating for long-term extension of renewable tax credits at a rate that puts it on par with wind and solar. "This law rightfully provides hydropower with tax parity, and, by moving to a technology-neutral approach, ensures that it is never left behind again," Woolf said. "Flexible, carbon-free generation like reservoir hydropower and long-duration energy storage are essential to firm up our increased reliance on variable resources like wind and solar. Hopefully, the new 30% investment tax credit for energy storage will jumpstart development of new pumped storage for the first time in a generation."

Woolf said that while the bill recognizes that new hydropower generation is essential to a reliable, clean energy grid, the NHA is disappointed that the existing hydropower fleet, which currently serves an estimated 30 million Americans, may have been overlooked.

From the World

"The provisions to encourage environmental improvements at the existing hydropower fleet, championed by Sen. Cantwell and Murkowski in S.2306, were not included in the bill that reached the President's desk," he said. "We look forward to working with Congress to preserve our nation's fleet as we cannot address climate and ensure a reliable grid without the nation's second largest renewable electricity resource."

01.09.2022 Voltalia to build small hydropower plant in French Guiana

Voltalia has announced that it is developing a 2.9 MW run-of-river hydroelectric power station in the commune of Maripa-Soula in French Guiana.

The renewable energy firm has signed a 30-year contract with EDF SEI for the sale of electricity from the project – with the contract due to start with the commissioning of the project, scheduled for 2026. The deal has been authorised by the French Energy Regulation Commission (CRE). Located on the Inini river at Saut-Sonnelle, the Maripa-Soula project is expected to produce 12.7 GWh per year, and will replace the current diesel generators used, reducing emissions by more than 18,000 tonnes of CO_2 each year.

The impacts of this run-of-river hydroelectric plant will be offset by the implementation of ambitious environmental measures, with more than €1.1 million to be invested in a programme to preserve the surrounding forest, the creation of a fish spawning area, and ecological monitoring (fauna, flora, sediments and water quality) upstream and downstream of the facility.

Serge Anelli, mayor of Maripa-Soula, added: "The implementation of this hydroelectric power station fully meets the objectives of ecological transition of the municipality: it will significantly reduce the carbon footprint of the municipality by offering the inhabitants of Maripa-Soula electricity produced from a local and renewable resource. Moreover, it will improve the quality of electricity supply to the population and create local jobs. This is a project that the town has been waiting for and that I have been advocating for several years. I am very happy to see it come to fruition."

27.09.2022 Hydro provides reliable electricity even during historic droughts says new study

A new study funded by the US Department of Energy's Water Power Technologies Office (WPTO) has found that hydropower has continued to provide reliable electricity even during times of historic droughts.

The Pacific Northwest National Laboratory (PNNL), with funding from WPTO, conducted a multi-regional study of drought's impact on 21st century hydropower generation in the western US – with the report the described as the most comprehensive look into the effects of drought on hydropower generation in the US this century. The analysis reveals that though drought does raise concerns for hydroelectric generation, the overall hydropower fleet sustained 80% of its average generation for the years 2001–2021. Also during this time period, hydropower could still be relied upon to supply flexible power during periods of high energy demand, even during the most severe droughts of the past two decades.

The western United States has always been a region of extreme climate variability, with large fluctuations in rain and snowfall precipitation from year to year. Climate change, and especially extreme weather events such as droughts and floods, is only increasing those fluctuations. This has enormous implications for the energy grid, sanitation, drinking water, food and agriculture, and more.

That data indicated 2021 to be the second worst year for drought this century, with overall hydropower generation 16% lower than the average since 2001. The 2021 drought most severely impacted hydropower generation in California (48% below average) and Oregon (16% below average). However, the large sizes of western states, and wide range of weather across the West means drought rarely impairs hydroelectric power across all climate sub-regions simultaneously. Consequently, the overall hydropower fleet remains reliable even if certain plants or sub-regions produce less power. Washington and Idaho, for example, only experienced an average drop in hydropower generation of about 12% in 2021, and the entire western hydropower fleet was still able to maintain 84% of its average expected generation.

28.09.2022 Queensland in Australia could be home to the world's largest pumped storage scheme under plans unveiled by Premier Annastacia Palaszczuk

The plans for a bold clean energy future for Queensland unveiled by the premier include a 5 GW pumped storage scheme in the Pioneer Valley near Mackay which will supply half of Queensland's entire energy needs.

The $62 billion Queensland Energy and Jobs Plan envisages that 70% of Queensland's energy supply will come from renewables by 2032, with 80% by 2035. It includes two new pumped hydro schemes at Pioneer/Burdekin and Borumba Dam by 2035, and a new Queensland SuperGrid connecting solar, wind, battery and hydrogen generators across the State, unlocking 22 GW of new renewable capacity.

The plan also includes converting publicly owned coal fired-power stations to clean energy hubs to transition to, for example, hydrogen power, with jobs guarantees for workers. The plan is for Queensland's publicly-owned coal-fired power stations to stop reliance on burning coal by 2035.

Hydropower initiatives in Europe

It might seem that such a mature branch of renewable energy as hydropower is so well-established that there is no need to solicit its interests in any way. Practice, however, shows that paradoxically the largest global generator of clean energy needs regular support, particularly in Europe, where a buoyant movement threatening the industry's operation has formed through environmental associations. This article presents current and emerging initiatives that are aimed at taking care of the welfare and development of European hydropower industry.

The role for hydropower for a decarbonised European energy system goes far beyond the production of renewable electricity. Its increasingly important purpose lies in providing energy system services, most importantly generation flexibility to facilitate the integration of large amounts of variable renewable energy sources into electricity grids and provide reliability of electricity supply. Despite its importance for the energy transition as well the economy and decarbonisation of Europe, the European hydropower sector - including its plant operators, equipment producers, research institutes, project developers and investors as well as national (small) hydropower associations - never had a European umbrella association representing the interests of the hydropower sector at the European institutions and decision-makers.

European hydropower supporters

Yet, there are many hydropower representatives in Brussels who promote the benefits and opportunities of hydropower for the new European energy system and work against the political efforts of environmental NGOs to marginalise large hydropower and to de facto abolish the small hydropower sector. Main players in the Brussels arena include the Working Group Hydropower of Eurelectric, the Small Hydropower Chapter of the European Renewable Energies Federation (EREF) and representatives of utilities and equipment producers.

Their activities are complemented by other players. VGB, the International Technical Association for Generation and Storage of Power and Heat is mainly an operator association, which focuses on equipment. VGB PowerTech Hydro provides a platform of operators, equipment manufacturers and consulting companies to share experience and knowledge.

The International Hydropower Association (IHA) is an international organization which builds and shares knowledge in the hydropower sector, with a focus on international good practice and sustainable development. The European Energy Research Alliance (EERA) is a European energy research community in Europe. It brings together 250 universities and public research centres in 30 countries. EERA's joint research programmes cover the whole range of low-carbon technologies as well as systemic and cross-cutting topics which are aligned with the priorities of the SET-Plan.

The EERA Joint Programme Hydropower aims to facilitate a new role for hydropower as enabler for the renewable energy system by aligning and targeting research efforts in Europe. The "Strategic Research Agenda" of the EERA Joint Programme Hydropower identifies key challenges and opportunities for hydropower development and provides guidance to policymakers about future research needs. The Strategic Research Agenda represents a holistic cross-disciplinary approach and addresses technological, economic, environmental and societal challenges.

New projects

The new EU project ETIP Hydropower (September 2022 – August 2025) will closely link the EERA Joint Programme Hydropower to the new European Technology and Innovation Platform (ETIP) for hydropower. It succeeds the HYDROPOWER EUROPE project (2018-2022) which created a forum for more than 600 stakeholders representing all sectors (including

Photo. SHP Øvre Forsland, Norway – the technologically and architecturally groundbreaking hydropower plant is intended to raise public awareness of the possible harmonious interplay between nature and technology as well as learn about the role of hydropower.
Source: Helgeland Kraft Vannkraft AS

design, construction, production, sectoral associations, environmental and social issues). These stakeholders participated through a program of review and consultation addressing needs of the whole hydropower sector targeting an energy system with high flexibility and renewable energy share. Based on this extensive consultation, the HYDROPOWER EUROPE Forum developed a Research and Innovation Agenda (RIA) as well as a Strategic Industry Roadmap (SIR), towards implementation of the vision "Hydropower as a catalyst for the successful energy transition in Europe" within the framework of the European Green Deal.

ETIP HYDROPOWER will further align and coordinate these industry RIA and SIR strategies to provide consensus-based strategic advice to the SET Plan covering analysis of market opportunities and research and development funding needs, biodiversity protection and ecological continuity. Another goal is deepening the understanding of innovation barriers and the exploitation of research results. EREF is responsible for the coordination of and input for working groups, to ensure consistency between ETIP outputs and emerging policy priorities and to disseminate project results to its hydropower network.
The PEN@Hydropower project, which also started in September 2022, is an additional networking initiative to bring academic and industrial institutions together to discuss the situation of hydropower, research fields and solutions. The project sets up a network of 51 partners from 33 countries who have a wide variety of expertise needed for establishing sustainable hydraulic power solutions. It organises workshops to coordinate research activities and provides capacity-building through summer training schools.

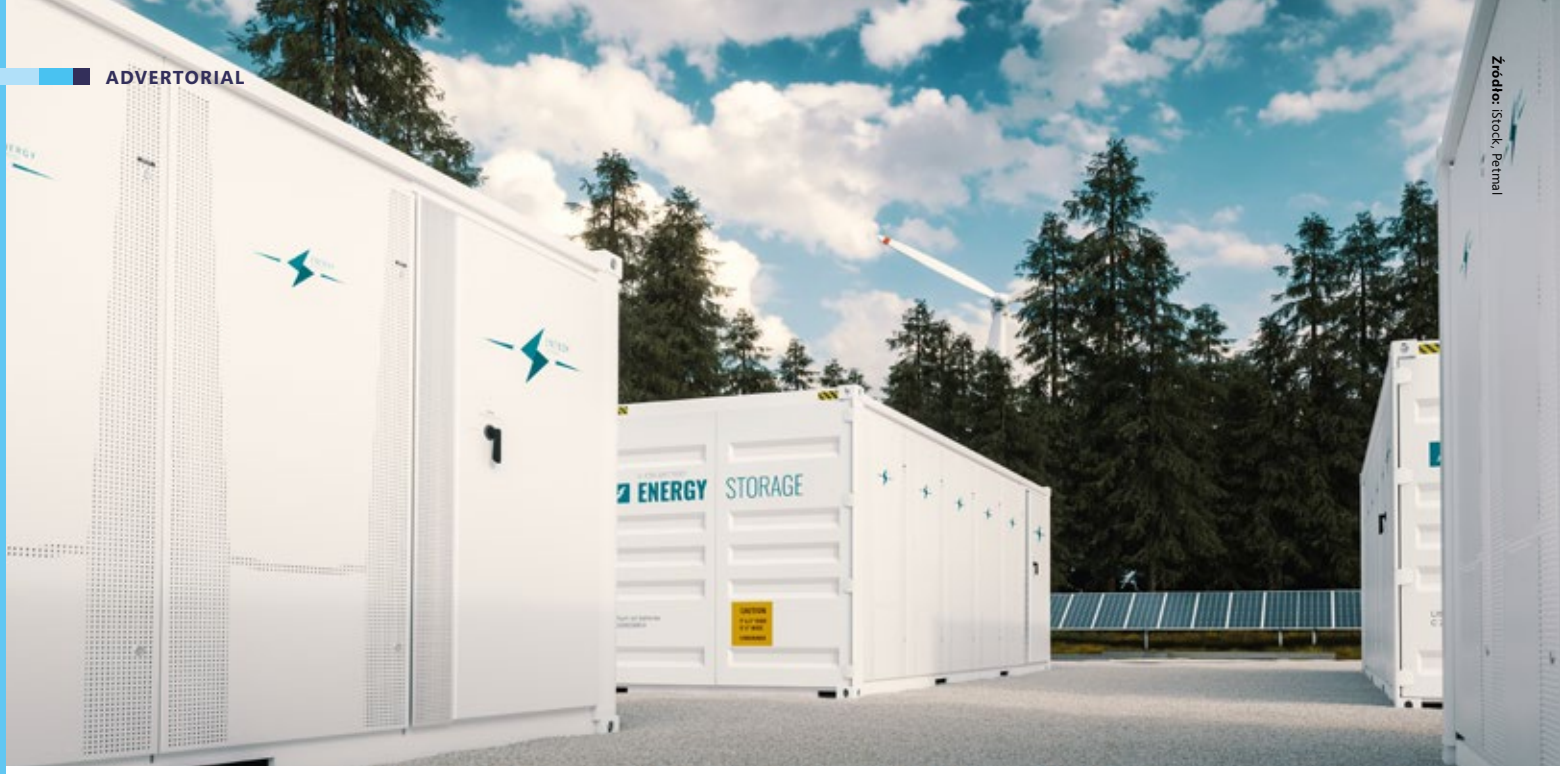
European hydropower beyond the continent

The EU project HYPOSO promotes the European small hydropower industry (equipment producers, project developers and investors) in Africa and Latin America. The HYPOSO Platform is an online Marketing Platform for the small hydropower industry to facilitate business contacts with the stakeholders in Africa and Latin America. Registration is free of charge and registered companies are individually marketed to other members. When registered on the platform, HYPOSO platform users have exclusive access to the GIS online map with all Hydro Power relevant information and resources (i.e. > 2000 potential sites) initially for Bolivia, Cameroon, Colombia, Ecuador and Uganda. It also includes early and exclusive information about business opportunities for deployment in the target countries exclusively provided to registered users. EREF and partners of the EU project HYPOSO developed a new handbook on small hydropower. In addition to information on the history and on the application areas of small hydropower, this handbook shows and describes various technical solutions for the small hydropower sector. Valuable information on planning and financing models complete this book.

EREF contribution

EREF is involved in the above-mentioned projects and cooperates with the mentioned organisations to collect data on and to promote the European small hydropower industry at European and national levels as well as outside the EU. Over the last two years, EREF staff and members have provided input on the European small hydropower sector to the teams of the International Centre on Small Hydro Power (ICSHP) and UNIDO for the new edition of the World Small Hydropower Development Report and three stand-alone thematic publications on youth and small hydropower, gender and small hydropower, climate change and small hydropower. They will be officially launched in November 2022. Have a good read!

Dirk Hendricks
General Secretary
European Renewable Energies Federation (EREF)



Źródło: iStock, Petrmal

Energy storage as a key factor in development of renewable energy sources

The European energy market is facing a challenge it has never faced before. The unstable geopolitical situation, the increase in raw material prices and the highly dynamical environment have resulted in a shaky energy security and an unfavourable, from the consumer's point of view, electricity prices. However, in this difficult situation one can also see opportunities for business and energy sector development related to energy generation, energy storage and proper management of available resources.

The situation in the fossil fuel market and European policies aimed at achieving climate neutrality have resulted in an even stronger turn towards renewables, intended to ensure the reliability of electricity supply and secure energy development. According to "Poland's Energy Policy until 2040," a strategic document approved by the Council of Ministers, the share of renewable energy sources (further on referred to as "RES") in the energy mix of Poland is to reach no less than 32% by 2030[1].

Renewable energy is an inevitable direction in the current energy transition. RES, as an important part of the energy mix, requires solutions to store energy and manage its distribution. The answer to these needs are energy storage systems, which bring many benefits, both from the point of view of the power grid, as well as in the eyes of entrepreneurs, for whom these energy sources represent a real business value.

Current situation of the energy sector in Poland

The energy crisis, initiated by the Russian invasion of Ukraine, has forced a new outlook on the future of the energy sector in Europe. Rising demand for electricity, along with disrupted hydrocarbon supply chains, have led to energy deficits in many of the European countries. The current situation clearly demonstrates the consequences of building energy security and stability of energy supply based on the dominant role of imported fossil fuels. The discussion of a blackout, which is currently being considered as a potential scenario, is increasingly being raised in public. In the last days of September this year, the Polish Power Grid was forced to launch a Demand Side Response (DSR) service, which is an intervention and countermeasure in a situation of imbalance between energy demand and available supply.

A way to become independent of external suppliers of energy resources is to develop renewable energy. However, the growth of renewable energy sources is a considerable challenge for systems used to generate, transmit and distribute electricity. RES are mostly characterized by high variability in volume of generated energy, resulting from atmospheric conditions that may vary any given time. Their production is difficult to predict, and the daily generation profile does not coincide with the demand profile of consumers. To ensure grid security and a properly balanced mix, there is a need for flexible generation sources with short response times and the ability to store the generated energy.

Importance of hydropower for energy security

Hydropower is considered the most stable renewable energy source. It is characterized by a relatively predictable volume of energy generated and a constant nature of daily production. Hydropower plays a key role in balancing other less stable renewable sources, so it is not possible to achieve an energy mix based 100% on RES without an adequate share of energy generated from hydropower. Investments in run-of-river hydropower plants and pumped storage powerplants are definitely a step towards increasing energy security of a country.

Due to the rapid development of RES and the resulting need for energy storage, pumped storage powerplants have become particularly important in recent years. These facilities are the oldest, and at the same time the most capacious types of storage facilities that have been invented

so far. Their value is very important from the point of view of RES balancing and situations requiring emergency intervention, such as failures of major power generation facilities. This is because they have the ability to start up relatively quickly, and therefore realistically improve energy security.

Poland has 6 pumped storage power plants, which were built in the 20th century. In recent years, there has been an intensification of work on the development of pumped storage plants - another 6 facilities are at the planning stage. Work is currently underway on the once-stalled 750 MW Młoty pump-storage hydropower plant. Instytut OZE company is involved in the development of a feasibility study for this project in terms of the basic design, the possibility of its connection to the grid, as well as an economic and financial analysis of the entire project.

Energy storage – an important direction of development for energy supply systems

The intensive development of energy storage technology has led to the popularization of new competitive solutions. Electrochemical energy storage is gaining popularity in the market. Its strong competitive advantages over pumped hydro storage are shorter project implementation time, lower capital expenditure and speed of operation.

Large-scale electricity storage facilities offer a wide range of services to national grids. Thanks to their ability to accumulate surplus energy, they make it possible to match the energy supply profile with that of energy demand. Thus, they allow the implementation of a energy arbitrage strategy, which consists of achieving financial benefits as a result of deferring sales of energy in such way, so as to maximize them during the hours when electricity prices are the highest. In addition to financial benefits, such actions have a positive effect from the perspective of supply stability.

Energy storage facilities make up for power deficits at the time of peak energy demand, thus contributing to grid stabilization and reducing the risk of frequency collapses. They also take part in reactive power compensation, which has a positive effect on the quality and longevity of the power infrastructure. The ability to garther significant electricity reserves is also raising the security of the entire system in case of failures or overloads. High storage availability plays a key role in resetting the power system after a blackout.

Effective and efficient energy storage means ensuring the best possible use of the energy produced, as well as creating conditions for the emergence of further RES generation capacity. Europe's largest electrochemical storage facility is to be built in Poland. It is to be located in Żarnowiec in the near vicinity of a pumped storage plant. The battery energy storage system will be connected to the Żarnowiec main power supply station – to be realised at voltage of 400 kV, which is also a planned connection point for large-scale photovoltaic and wind installations intended to be created both offshore and onshore. Polish generation company PGE has already obtained a license promise for this project from the Polish Energy Regulation Authority. Instytut OZE is involved in the development of the Feasibility Study and the Functional and Utility Program for the investment. The battery-based electricity storage facility is designed for a total capacity of just under 1 GWh.

A wide range of applications for smaller-scale storage facilities

Electrochemical energy storage technology proposes solutions that open up space for a wider range of customers. Due to their versatility, modularity and scalability, they can be applied in solutions with capacities of a few kW to several hundred MW. Storage systems with smaller output power and lower capacities show great potential and find application in various sectors of the economy. The greatest economic rationale is to implement them nearby photovoltaic installations, which are characterized by high daily variability of production, so that accumulating surplus energy and then releasing it at the right moment brings tangible results. Storage systems are used for commercial generation installations, installations working with a specific enterprise or even a household. On the one hand, they allow the use of energy arbitrage and increase the profitability of the business conducted, and on the other hand, they play an important role in the efficient management of the facilities' electricity demand, and are minimizing the amount of energy drawn from the grid. In addition, companies may use energy stored in storage facilities during periods of peak demand – which influences the flattening of the energy consumption profile (so-called peak shaving), and this has a globally beneficial effect on the power grid.

Electrochemical storage facilities are also being applied to other generation sources such as wind farms and, where viable, hydropower plants, providing a similar range of services as in the case of pairing them with solar farms. Another recipient of this technology are vehicle charging stations, which require adequate power for optimal operation. The storage system can also be successfully used as a local balancing element, located at main power supply stations.

Summary

Nowadays, consumers are facing a drastic increase in the cost of purchasing electricity. Most Polish enterprises have the potential to build their own RES generation schemes. In order to obtain the maximum economic benefit, it is necessary to conduct an analysis and appropriate selection of generation sources, often to be paired with energy storage, and implement a intelligent system for electricity production and consumption management.

Instytut OZE is a company that specializes in implementation of investments in renewable energy sector. We provide advice, comprehensive support and care for the entire project cycle. We perform audits and propose effective solutions for individual small-scale projects, as well as projects for the professional large-scale power industry solutions. Knowledge and experience accumulated over the course of our operation allows us to provide the best solutions to meet the needs of all the investors.

Magdalena Sitek
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Instytut OZE

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HYPOSO – the connecting link for the small hydro sector in Europe and Latin America

HYPOSO is a research project, which has been featured several times in "Energetyka Wodna". It is funded by the EU HORIZON 2020 programme and TRMEW is one of the partners in the project. The aim of HYPOSO is to support the European small hydropower industry and, at the same time, to stimulate the sustainable development of this sector in selected African and Latin American countries. This article reports on workshops held in Bolivia and Ecuador in July this year and a seminar on hydropower plants organised in Colombia in early August.

Photo 1. The Escuela Politecnica Nacional (EPN) Hemicycle in Quito (Ecuador's capital)

The HYPOSO project has been implemented since 2019 by a consortium comprising 13 partners, including eight European organisations and companies and five from the African and Latin American countries. Two Polish entities - the Szewalski Institute of Fluid-Flow Machinery of the Polish Academy of Sciences and TRMEW sp. z o.o. – are involved in the implementation of the HYPOSO project tasks. Activities in HORIZON 2020 projects are implemented in so-called work packages, for which designated partners are responsible. TRMEW is a leader of one of such packages. It is dedicated to cooperation between representatives of the European hydropower industry and local stakeholders and aims to accelerate the market uptake of EU hydropower technologies in the target countries.

Purpose of the workshop

One of the tools to achieve the project's objectives is to hold workshops on the framework conditions for hydropower in the target countries. Five workshops has been planned during the HYPOSO project, one in each project country. The intention of the organisers of these workshops is to present and discuss the framework conditions for the development of small hydropower plants in the target countries. This is done based on the analysis carried out by HYPOSO experts as well as on the examples of pilot SHP projects selected for the HYPOSO project.

The debate during the workshop should result in the formulation of initial recommendations for decision-makers in each project country on how to facilitate the development of small hydropower plants and create better framework conditions for the investments in hydropower.

Workshop in Bolivia

Following the first workshop on the conditions for the development of the small hydro sector organised in Cameroon earlier this year, two further such events were organised in the HYPOSO Latin American target countries, namely in Bolivia and Ecuador, in July 2022. The first HYPOSO workshop in Latin America was organised by TRMEW in collaboration with Bolivian HYPOSO project partners from the Universidad Mayor de San Simón (UMSS). The event took place on 22 July 2022 at the university's headquarters in Cochabamba. Some of the participants were present on site, while the rest participated remotely, as the event was also webcast. A total of 55 participants attended the workshop.

Representing UMSS, Andres Gonzales, together with the author of this text, Ewa Malicka (TRMEW), opened the meeting and welcomed the guests, after which Ewa Malicka presented background information on the HYPOSO project and the objectives of the workshop. After the introduction, Mauricio Villazón (UMSS) presented the results of an analysis of the framework conditions for hydropower in Bolivia, carried out by Lithuanian partner VDU as part of the project. Nino Frosio from the Italian company Froso Next then presented the three SHP projects selected as pilots for Bolivia and outlined the potential barriers to their implementation. The programme was followed by a discussion, moderated by Bernhard Pelikan (Frosio Next), on recommendations for Bolivia to create an investment-friendly climate for small hydropower based on the case studies presented and the results of the framework analysis.

After summarising the discussion and formulating recommendations, Janusz Steller (Szewalski Institute of Fluid-Flow Machinery of the Polish Academy of Sciences) presented the HYPOSO Map, which helps to identify potential sites for SHPs in Bolivia, as well as containing other information that may be useful for professionals in the hydropower industry. Finally, Ewa Malicka invited the participants to use the HYPOSO Platform to establish business contacts with the European SHP industry.

The main conclusions and recommendations for Bolivia are as follows:

- Bolivia has some loopholes in the law regarding small hydropower plants and the participation of private institutions in the sector.

- The HYPOSO platform is a useful tool for Bolivian stakeholders; ENDE Corani and ENDE Corporacion (ENDE stands for Empresa Nacional de Electricidad, or National Electricity Company) are interested in this application to contact companies about the supply of equipment. Representatives of private companies have also shown interest in the platform.
- The pilot projects selected in Bolivia are of interest to ENDE. Participants asked about the timing of the feasibility studies to be prepared by HYPOSO experts and about funding opportunities for these projects.
- Some local scientists at UMSS are also interested in the HYPOSO map, especially the possibility of downloading different layers from the HYPOSO map.

Workshop in Ecuador

The third (of five) HYPOSO workshop on the framework conditions for small hydropower development was held on 26 July 2022 at the Escuela Politecnica Nacional (EPN) Hemicycle in Quito (Ecuador's capital). They were organised by project partners TRMEW (Poland) and EPN (Ecuador). There were 47 participants present. Patricia Lorena Haro, Professor of EPN, opened the event and welcomed the guests, followed by Ewa Malicka, who gave a few words of introduction, after which she presented information about the HYPOSO project, as well as the objectives of the workshop. After the introduction, Luis Rios from the EPN presented the results of the analysis of the framework conditions for hydropower in Ecuador. Nino Frosio then presented three selected pilot projects, the sites of which were to be visited by project experts in the coming days. He pointed out the potential barriers that could jeopardise the implementation of these projects.

Next, Fernanda Jara, Director of Energy Development and Transmission at the Ministry of Energy and Non-Renewable Natural Resources, presented the small hydropower sector in Ecuador from a state policy perspective. The next two speakers, Alexandre Barahona, director general at CBS Ingeniería, and Antoni Villagómez, hydropower manager at EPMAPS - Quito, gave presentations on the barriers and experiences of SHP projects from the private and public sector perspectives respectively.

This was followed by the most important part of the workshop, a discussion, moderated by Prof. Bernhard Pelikan, on the current situation and needs of hydropower in Ecuador, as well as ideas on how these needs can be met and how the development of small hydro projects can be facilitated. Views and ideas were discussed together with representatives from two ministries (Energy and Non-Renewable Natural Resources (MEM) and the Ministry of Environment (MAAE), public and private companies, scholars and other stakeholders, representing entities such as CBS Ingeneria and CBS Energy, EPMAPS, MAATEARCERNNR, IIGE, Hidroequinoccio EP, Constructora Nacional, EEQ, CIE, Fundacion Cice, EPN, University of Vienna and the HYPOSO project. Participants pointed to the need for a serious improvement in the legislation on small hydropower, including a simpler approach to these type of projects and a clear distinction between small and large hydropower. Another issue identified by the participants was the need to improve the feasibility of small hydropower projects, which seems to be closely related to better access to information on administrative procedures related to SHP projects. In this regard, a recommendation was made to create a small hydropower association in Ecuador. Other issues raised in the presentations and later in the discussion included the need for tariff stability, at least for the payback period, and the need to improve the allocation of existing 'green credits'. Finally, the importance of energy recovery through the installation of hydropower plants in water supply and sewerage systems was highlighted.

The main points of the discussion were then summarised by Prof. Pelikan, and participants expressed the need and desire to formulate recommendations to be forwarded to the relevant decision-makers and authorities.

At the end of the workshop, the results of the HYPOSO project - the HYPOSO Map

Photo 2. Workshop at the university's headquarters in Cochabamba

Photo 3. Project coordinator Ingo Ball at a booth at the VI Seminar on Hydropower Plants, organised in Colombia

and the HYPOSO Platform - were presented to participants as tools to increase investment in sustainable projects in target countries, facilitate communication between stakeholders in Europe and Latin America, as well as stimulating the market uptake of EU technology.

Seminar on hydropower plant in Colombia

The most recent event related to the HYPOSO project and taking place in Latin America this summer, which the author of this text attended, took place in Colombia and was of a slightly different nature to the workshops described above (these are planned for Colombia next January). On 3-5 August 2022, the renowned Colombian association SAI (Sociedad Antioqueña de Ingenieros y Arquitectos - Association of Engineers and Architects of Antioquia, based in Medellín, the capital of the Department of Antioquia) organised the VI Seminario de Centrales Hidroeléctricas (VI Seminar on Hydropower Plants). The aim of the event was to present different points of view so that decisions concerning the energy sector are made in the right way and allow the necessary energy security and independence that Colombia needs for its future to be built. The event attracted more than 400 participants (on-site and virtually) and was accompanied by a small exhibition where participants met during breaks to network and continue discussions from the sessions. The presentation and promotion of the HYPOSO project was made possible thanks to the Colombian partner of the project, the CELAPEH association. On 4 August 2022, four presentations were made in the morning session, informing participants about the project.

After welcome words from Carlos Velasquez (CELAPEH), HYPOSO coordinator Ingo Ball (WIP Renewable Energies) provided background information on the project and the current status of its implementation.

Ewa Malicka then spoke about what activities in the project allow to connect Colombian and European stakeholders of small hydropower. She therefore presented the tools provided by the HYPOSO project, i.e. the HYPOSO Platform, the workshops on the framework conditions for small hydropower and the study trip to European companies planned at the end of the HYPOSO project for African and Latin American stakeholders to establish business cooperation. The speaker was supported by Laura Velasquez (CELAPEH), who translated the lecture into Spanish.

Beatrice Baratti (Frosio Next) then presented how the 15 potential HYPOSO pilot projects were selected, and the next steps for selecting 3 of them. The selection takes into account the environmental and socio-economic conditions of the projects under study. She also mentioned that the economic viability and various financing options of these projects will be assessed based on the results of pre-feasibility studies. Carlos Velasquez (CELAPEH) gave a presentation on how CELAPEH is contributing to the HYPOSO project in Colombia, explaining the different tasks it is working on. He concluded his presentation by informing participants about CELAPEH's mission, concluding with a call for the creation of a dedicated Colombian association of owners and investors in small hydropower plants.

Following the presentations, the HYPOSO project experts provided additional information to the participants in a short Q&A session.

Acknowledgements

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Ewa Malicka
President of the Polish Association for Small Hydropower Development (TRMEW)

Photos come from the archives of **HYPOSO project**

TB Hydro – solutions for hydropower in Poland and worldwide

TB Hydro is a manufacturer of specialized large-size, high-pressure butterfly shutoff valves (type BTV) and ball valves (types BLV and SPV), as well as other water system fittings used in hydropower facilities.

Fig. 1. TB Hydro's realizations around the world (marked in blue)

During the more than 20 years of our presence in the market, we have manufactured and sold more than 2,500 different valves that have been installed at power stations in Poland, Austria, Norway, Switzerland, Italy, France, Spain, UK, Canada, USA, Brazil, Colombia, Chile, Guatemala, Kenya, India, and many other countries around the world (figure 1). In Poland, our butterfly shutoff valves are installed, among other locations, in the Porąbka and Świnna Poręba hydropower plant, and our other SLV-type valves - at the Żarnowiec and Porąbka-Żar pumped-storage plant.

Porąbka hydropower plant

Owned by PGE Energia Odnawialna, the Porąbka hydropower plant is a reservoir power plant located at the dam on the Soła river that forms the Międzybrodzkie Lake. For its operation, the dam uses the natural flow of the Żywiec Lake. The Porąbka hydropower plant was commissioned in 1953 and is equipped with two Kaplan hydropower units and one Francis unit, giving it the total capacity of 12.5 MW. Water is supplied to the turbines via pipelines: two with the diameter of 3,250 mm and one with the diameter of 1,000 mm. There are butterfly shutoff valves upstream of the turbine inlet on each pipeline.

A comprehensive upgrade of the entire power plant was carried out between January 2017 and November 2018. The works on the project were commissioned by PGE Energia Odnawialna. The upgrade project was carried out by the company Ekologiczne Projekty Energetyczne MADEX from Zielona Góra and the supplier of the butterfly shutoff valves was TB Hydro Sp. z o.o. Poznań (manufacturing plant in Wągrowiec).

TB Hydro designed, manufactured, and supplied two DN3250 butterfly shutoff valves and one DN1000 butterfly shutoff valve. These valves are opened by integrated hydraulic cylinders that are controlled by pressurised oil supplied from the hydraulic units, and they are closed by gravity with a counterweight installed on a lever. Butterfly shutoff valves are suitable for emergency closing at full flow. In normal conditions, the valves are opened at a maximum differential pressure of 2.2 bar.

Świnna Poręba hydropower plant

Another place of installation of a butterfly shutoff valve designed and manufactured by TB Hydro is the Świnna Poręba hydropower plant owned by the State Water Holding Polish Waters. It is located on a dam on the Skawa river in the Mucharz Municipality near Wadowice. The power plant was commissioned in 2019 and is equipped with two 2.25 MW Kaplan turbines and a 0.11 MW Francis turbine, giving it a total capacity of 4.61 MW. For this facility, TB Hydro supplied a butterfly shutoff valve with the nominal diameter of 2,400 mm. The valve does not require constant operation and is controlled from a control room. The valve is opened and closed with a hydraulic actuator controlled by pressurised oil supplied from a hydraulic unit. This is a shutoff valve suitable for emergency closure in full flow conditions.

TB Hydro – 20 years

TB Hydro is celebrating the 20th anniversary of the company's founding in 2022. From the very beginning, the company has been working on its own know-how. It has specialized engineering and production staff. Specialized software for 2-D and 3-D drawing, as well as strength and flow calculations are used to design valves. These valve designs are then made at the manufacturing plant in Wągrowiec, from material procurement through welding, machining, shot blasting, painting and assembly. Each valve, before it leaves for the customer, is checked in accordance with the relevant standards for dimensional, movement, tightness, as well as coatings corrosion protection.

Photo 1. Butterfly shutoff valves DN3250, Porąbka hydropower plant

Photo 2. Butterfly shutoff valves DN1000, Porąbka hydropower plant

Photo 3. Butterfly shutoff valves DN2400, Świnna Poręba hydropower plant

TB Hydro has the necessary certifications for manufacturing of valves including ISO 9001-2015.

TB Hydro is a recognizable brand, identified with the highest quality of manufactured fittings for hydropower plant.

Wiesław Grzesiak
TB Hydro

Graphics and photos come from the archive of **TB Hydro Sp. z o.o.**

Modern solutions for SHPs

One of the most important aspects in selecting an energy conversion system for hydropower plants is their efficiency. Small hydropower plants (SHPs), which are mostly run-of-river plants, are characterized by the need to operate under varying hydrological conditions. For this reason, energy conversion components should provide high efficiency over a wide range of water flows. This article presents modern solutions proposed for use in SHPs, which may lead to a significant reduction in investment costs, while maintaining favorable operating properties. The proposed solutions involve simplified integration of the turbine with the generator through installation in dedicated prefabricated concrete modules.

In traditional SHP solutions, water turbines operate at constant speeds when the generation system is based on a synchronous generator, or at speeds that are almost constant and vary over a very small range when squirrel-cage induction generators are used. Turbine operation at maximum efficiency values, while maintaining constant speed for changing hydrological conditions of the river, is possible thanks to special control systems used for turbine's blade and vane actuation (Kaplan turbine). Such a dual control system is a mechanical system, which is relatively complex and expensive both in construction and operation. Simplifications of the mechanical control system of turbines by using only a single control in the form of guide vane actuation system (Francis and propeller turbines) or blade pitch control system (propeller turbines), lead to a significant reduction in the cost of construction and operation of turbines, but do not ensure the achievement of optimal efficiency values when fluctuations in flow and head are encountered. A certain solution to this problem is a departure from the principle, commonly adopted in SHPs, of maintaining a constant speed of the generator. The generation of electricity at variable generator speeds (as is the case in wind power plants) requires the use of an appropriate power electronic system that adjusts the parameters of the generated energy to meet the requirements of the power grid.

Over the past few years, ideas of integrating turbines with an electric generator have emerged as a low-cost solution proposed for SHPs. The authors of the article and AQUA-Tech company have been working on aletrnative solutions for low-head SHPs for almost 15 years. These solutions involve the use of independent hydroset components (a turbine and a permanent magnet generator without a mechanical gearing, operating at variable speed), and the integration of these components is based on their placement in a single prefabricated concrete block, providing insulation from water while effectively dissipating heat. The primary assumption of such solution is, apart from simplicity and durability of the offered solution, also a relatively low price compared to regular solutions.

Modular prefabrication of SHP construction technologies

In recent years, it has become very popular to equip weir installations with movable composite closures, called inflatable gates. Their operation does not cause water congestion during high flows and floods. These solutions perform well during low flows, allowing for riverbed retention. Inflatable weir gates are most often filled with water drawn from the river, thus providing a solution which boasts high environmental safety. Inflatable gates have many operational advantages, especially in winter, as floe and current ice do not stick to the elastomeric weir gate, so they have become a popular solution for damming heights of up to 5 meters. Further technological development of inflatable rubber gate weirs are composite actuated flap weirs with a gate actuator of pneumatic or hydraulic (i.e. filled with water) type. This solution is particularly recommended for damming heights between 0.5 and 1.5 m. The working medium of such a weir is a gate actuator of the pneumatic type. Flap gates are made of carbon or high-density polyethylene composites. The elimination of steel elements in these solutions significantly improves operational safety in winter conditions. Moreover, elements made of composites do not react with water and do not require maintenance and lubrication, thus they are environmentally clean. The aforementioned devices are attached to the reinforced concrete bottom structure, pillars and bank abutments. The main role of the proposed technology is to shorten the time of construction that needs to be carried out in the riverbed area and to improve the quality of block elements made of precast concrete with composite reinforcement.

In order to eliminate quality problems and shorten the construction time of small power generation facilities, we propose to unify the series of precast reinforced concrete elements. These shall include the elements of the inflatable gate weir, the hydropower plant itself, as well as the elements of a fish pass (figure 1).

By betting on prefabricated elements, we are not only able to erect permanent object much faster and more conveniently than with traditional solutions, but arso more cheaply. The cost of constructing a building using the method of prefabricated composite elements is 20–30% less than for the same buildings made using traditional construction technology.

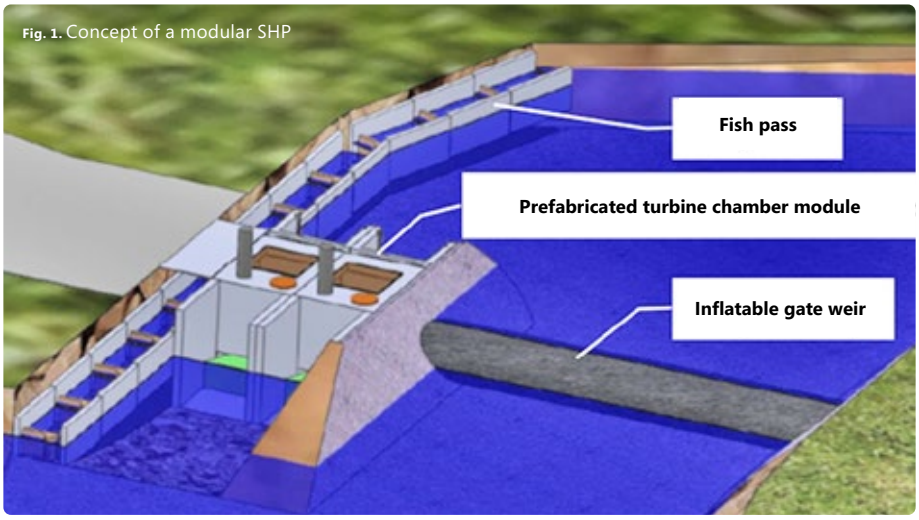

Fig. 1. Concept of a modular SHP

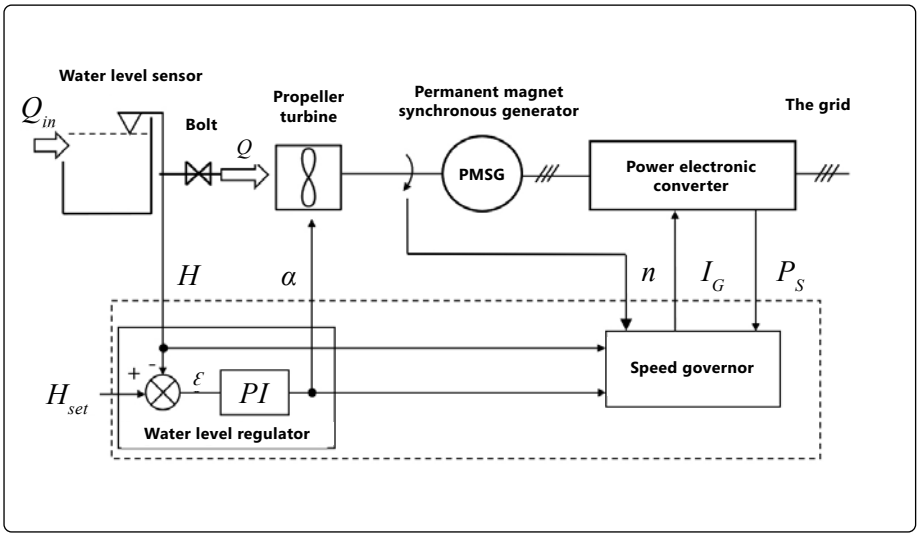

Fig. 2. The main elements of the energy conversion system of a SHP operating at variable speed, equipped with a permanent magnet synchronous generator (PMSG) driven by a propeller turbine

Turbine module with power generation system

The assumption regarding variable speed turbines and the use of a permanent magnet induced synchronous generator (PMSG) stems from the need to simplify the turbine design and eliminate the mechanical gearing. For hydropower, such solutions are still a novelty, although they are already in use. The operation of the turbine at variable speed provides opportunities to simplify the design by eliminating blade pitch actuation systems or allowing to use only a single adjustment mechanism (which implies either stationary guide vanes or stationary turbine rotor blades). The above requirements are met by turbines of propeller design. The solutions of the flow system with these turbines installed can satisfy the need to obtain a favorable combination of a relatively high level of efficiency and high speed, which is associated with relatively small dimensions of the turbines, significantly reducing the cost of manufacturing the hydroset. When it comes to the flow rate, these solutions allow for an efficient way of utilizing the hydropower potential at low-head dammings.

SHPs (especially run-of-river ones) are characterized by large changes in generated power depending on hydrological conditions. In view of this, the amount of electricity generated per year will depend on the efficiency of the generator for different power values. The use of a permanent magnet synchronous generator has significant advantages, which are primarily:

- high energy conversion efficiency over a wide load range,
- absence of mechanical transmission,
- high reliability.

There are, however, some disadvantages of this solution, as a power electronic converter is required, converting the electricity from the generator to match the requirements of the power grid (e.g., 400 V, 50 Hz voltage). Such an energy conversion system, however, additionally allows accurate control of active and reactive power and gives the generator the ability to operate at virtually any speed. This is important when matching the speed of a hydroelectric turbine to the selected location of the power plant. The power electronic system also takes over the role of the classical mechanical control system, such as the pitch of turbine blades, which ensures a constant speed of the generator in classical solutions. This is a very important advantage of the proposed solution, since the reliability of power electronic systems is much higher than that of the mechanical blade pitch control system, and the operating costs are significantly lower. The ability to adjust the rotational speed to given circumstances can bring an increase in the efficiency of the entire hydroset. What's more, the speed change can be done online, while the hydroset is in operation.
The turbine is designed as an individually customised element to match the hydrological conditions of the river. The main element controlling the water flow is the head regulation system, whose task is to ensure the appropriate water level in the upper reservoir. The regulation of turbine power depends mainly on the current hydrological conditions, i.e. the current value of the flow Q. The main components of the power conversion system of the SHP, operating at variable speed, are shown in figure 2.

The main task of the control algorithm of a hydropower plant management system is the control of hydrological parameters, i.e. the upper reservoir water level or turbine flow rate. For run-of-river power plants, it is required to maintain invariant hydrological conditions, i.e. to keep the upper water level at a specified value. This is implemented by a water level regulator. As a result of such control process, a certain volume of water is fed to the water turbine. Optimal conversion of this flow into electricity requires appropriate management of the turbine speed, which is another important task performed by the algorithm. In powerplants using variable speed technology, the upper water level regulator controls the angle of the guide vanes for propeller turbines or the angle of the rotor blades for semi Kaplan turbines. A gate valve or flow valve (e.g., butterfly type) is used to completely shut off the flow to the turbine. The speed governor, on the other hand, controls the optimal operating conditions for the turbine, i.e. maximum conversion efficiency.

Summary

Concluding, it should be emphasized that variable-speed operation makes it possible to maintain high energy conversion efficiency for different values of turbine flowr rate, while simplifying the mechanical design of the hydroset.

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Graphics come from the archive of **AQUA-Tech Sp. z o.o**

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Photo. SHP Rechtenstein, Germany
Source: Arbeitsgemeinschaft Wasserkraftwerke Baden-Württemberg

Request to include small hydropower in "go-to" areas

The EREF Small Hydropower Chapter and its members, national hydropower associations from EU Member States, urge Members of the European Parliament, to refuse the tabled amendment to exclude small hydropower (SHP) from access to on "go-to" areas which are object under Article 2 (9a) of the amended Renewable Energy Directive (EU) 2018/2001.

As instrument to ensure the REPowerEU objectives to increase Europe's energy independence and to speed up its decarbonisation, all forms of renewable energy, including small hydropower, must be used both under considerations for an increased renewable energy production and for a better energy system integration.

It is for this reason that EREF thinks it is important that "go-to" areas should better be renamed as "acceleration" areas, conveying a more positive term, and not excluding other areas from the development of renewables.

The exclusion of hydropower plants below 10 MW adopted by the Environment Committee in the European Parliament contradicts the principle of technology neutrality and lacks any scientific justification. Due to latest innovative technical solutions, small hydropower and good ecological status of a river can go hand in hand harmoniously. Hydropower is not a threat to the ecological status of rivers if basic ecological requirements are met, e.g., sufficient environmental flows (minimum water flows) and fish migration aids. Ecological monitoring of watercourses very often reveals stretches of water used for power generation where there is not only a minimal difference to the unused stretches but a specific biodiversity resilient to draught. The European small hydropower industry is regarded as world leader, offering the complete range of technical solutions which comply with even the strictest environmental laws and regulations.

Over the last decades, owners of European hydropower plants have invested billions of Euros in upgrading existing plants with environmental mitigation measures, showing their commitment and support to the ecological requirements of the Water Framework Directive, and demonstrating that small hydropower and environment go hand in hand.

In the 27 EU Member states, around 25,000 small hydropower plants provide annually 13 million households with electricity and contribute already to the EU's decarbonization by saving CO2 emissions from energy production.

A recent assessment on the residual and hidden potential of small and micro hydropower in the EU estimates an additional yearly production of 79 TWh of green electricity under the strictest environmental constraints. This would be an additional substantial contribution from the small hydropower sector to the REPowerEU objectives to increase Europe's energy independence and to speed up its decarbonisation. It would also help against soaring energy prices and potential energy shortages during upcoming winters.

Prof. Dr. Dörte Fouquet
EREF Director

Ghislain Weisrock
Spokesperson of the EREF Small Hydropower Chapter

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Photo 1. View of the machine hall during installation of the generator rotor

The Nant de Drance pumped-storage plant – a brief overview

With the rapid development of on-grid renewable energy sources, and the programmed decommissioning of a number of nuclear power stations in mainland Europe, the need for large scale, adaptable electrical energy storage and generation solutions in the near future is self-evident. Modern pumped hydro storage offers a technologically proven and efficient solution to reduce volatility and match supply and demand on grid.

Located in the Valais region of Switzerland, the Nant de Drance project involved adding a 900 MW pumped-storage power plant to an existing hydropower scheme by connecting the two existing reservoirs of Emosson and Vieux-Emosson. Projected capacity was achieved by installing six vario-speed pump-turbines of 150 MW each and by heightening the upper, smaller Vieux-Emosson dam in order to double its storage volume. The power plant is expected to produce 2500 GWh per year. Its official inauguration took place on 9 September 2022.

Project background

The Nant de Drance project was constructed within an existing hydropower scheme which has been developed continuously over the past 100 years:

- the first reservoir built on this site was Barberine, developed from 1920 to 1926 by the Swiss Federal Railways (SBB) to power its electrical rail network,
- the Vieux-Emosson reservoir, located 2205 m a.s.l. above Barberine, was constructed by SBB between 1952 and 1955 to provide an additional 10 million m³ of storage capacity to the scheme. Power generation over this head difference (future Nant de Drance) was not considered economical at the time,
- from 1967 to 1975, Emosson Dam (180 m high, 560 crest length) was constructed by a Franco-Swiss joint venture (EDF and ATEL), drowning the Barberine scheme. A large network of underground adits and tunnels was constructed in parallel to increase the hydrological catchment area.

Nant de Drance overview

The Nant de Drance project consists of a 900 MW pumped-storage power plant connecting the two existing reservoirs of Emosson (1930 m a.s.l.) and Vieux-Emosson (2225 m a.s.l.) in the Alps in the south-west of Switzerland (photo 2). The project was initially designed for a total capacity of 600 MW, provided by four variable speed pump-turbines of 150 MW each. During the detailed design phase, the installed capacity was increased to 900 MW by adding two pump-turbines of 150 MW and by raising the height of the upper, 45 m high Vieux-Emosson dam by 21.5 m, thereby doubling its storage volume. In order to build and access the main powerhouse cavern (KMA), the adjacent transformer cavern (KTR), the power waterways and the valve chambers, a 14 km long system of access tunnels was excavated. The main access tunnel, which connects the main entrance (located in the Village of Châtelard at 1100 m a.s.l.) and the main powerhouse cavern (located at around 1700 m a.s.l.), has a length of 5.6 km and a slope of more than 10%. It was excavated using a 9.45 m diameter hard-rock tunnel boring machine (TBM). The tunnel was completed at the end of August 2012. The remaining access tunnels, with cross-sections of 46 or 52 m² and slopes of up to 12%, were excavated using the drill and blast method. A cross-section of the scheme is given below (fig. 1).

Photo 2. View of the Existing Scheme from Vieux-Emosson dam

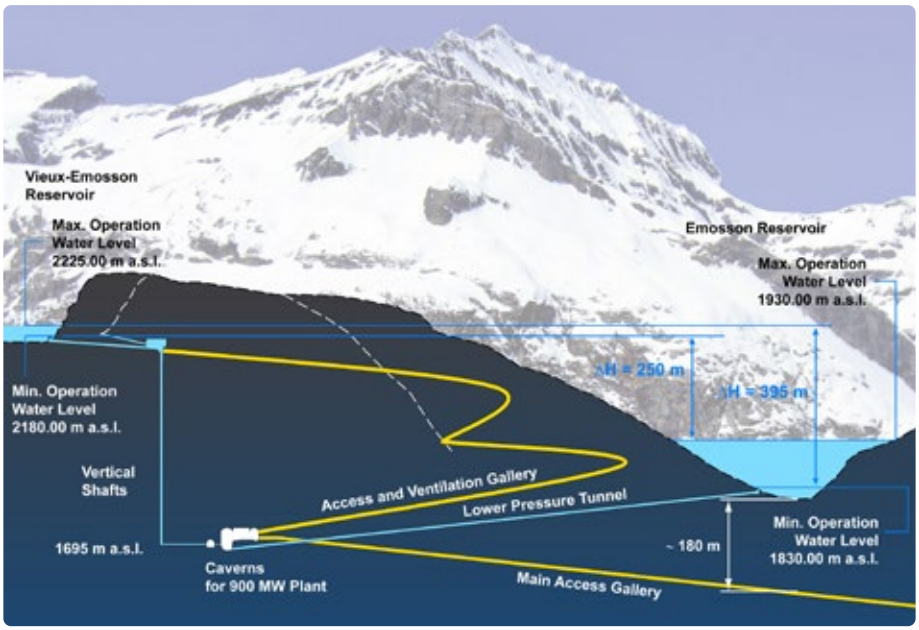


Figure 1. Cross-Section of the hydraulic system and access galleries

The underground powerhouse, located 600 m below the surface, houses reversible Francis pump-turbines with variable speed technology.

Key figures are summarised in table 1 below.

Project cost	**CHF 2.2 bn (€ 2.2 bn)**
Installed capacity	**900 MW (6 x 150 MW)**
Annual production	**250 GWh/yr**
Head	**Min 250 m, Max 395 m**
Max flow rate	**2 x 180 m³/s**
Start of works	**Autumn 2008**
Commissioning	**2022**

Table 1. Nant de Drance key figures

Key players in the project

Nant de Drance is a joint venture between a number of Swiss utilities and power firms, as well as Swiss Federal Railways (SBB). Shareholders are summarised in the table 2:

Company	Participation in Nant de Drance
Alpiq	39%
SBB (Swiss Federal Railways)	36%
IWB (Basel Utilities Company)	15%
FMV (Valais Power Company)	10%

Table 2. Nant de Drance shareholders

The principal consultants involved with the design of Nant de Drance are summarised in the table 3:

Company	Participation in Nant de Drance
AF Consult (now AFRY)	general consultant, HEM
BG Consulting Engineers	powerhouse and switchgear caverns, HSVE
Pöyry (now AFRY)	waterways, access tunnels
SRP and PRA	spoil management
Stucky (Gruner Group)	Vieux-Emosson dam heightening

Table 3. Principal designers for Nant de Drance

The principal contractors involved with the design of Nant de Drance are summarised in the table 4:

Company	Participation in Nant de Drance
GMI (Joint venture Marti Implenia)	civil works
GE Hydro	electro-mechanical works
Andritz Hydro	steel lining works
ABB	electrotechnical works
KEVT	HSVE general contractor

Table 4. Summary of main contractors

Notable features of the Nant de Drance scheme

This chapter outlines some of the particularities of the scheme, difficulties encountered and engineering solutions devised to overcome them.

Geological Conditions and Access Tunnels

The powerhouse caverns are located in metamorphic rocks of sedimentary origin belonging to the crystalline platform of the Massif des Aiguilles Rouges (Mont-Blanc area). Overburden at the axis of KMA is about 600 m. The caverns sector was investigated by 5 core-boring exploratory drills up to 660 m deep.

The lithologies encountered, all of which present excellent geomechanical properties, are slaty gneisses, micaschists, metagraywakes (shales rich in chlorite) and paragneisses (coarse grained gneiss). These rocks are in good condition, hard, laminated to interbedded. The main lamination plane dips 70 to 80°, at a strike angle almost perpendicular to the cavern axis. It has no effect on the stability of the rock, which is globally good to very good. The fracture state can be described as poorly fractured to unfractured. Fractures are generally closed, with cristallisation of quartz, epidote and calcite. Observed fractures are weakly persistent. Six types of fractures were observed.

From a hydrogeological standpoint, several fracture flows have been encountered. Individual inflow discharges encountered are very low, never exceeding 0.1 l/s.

Caverns and access tunnels were excavated using the drill-and-blast method, except for the main access tunnel, which was excavated using a 9.45 m diameter hard-rock tunnel boring machine (TBM) (photo 3).

Powerhouse caverns

The powerhouse cavern (KMA) is 32 m wide, 52 m high and 194 m long and is connected to the transformer and switchgear cavern (KTR), which is 20 m wide, 15 m high and 130 m long, located in its vicinity. They are among the largest of their kind in Europe. A view of the fully excavated KMA is given in photo 4.

Pressure shafts

The scheme comprises two power waterways, each of which consists on its upstream

Photo 3. Mounting the TBM cutter head at Châtelard Portal

Photo 6. Bifurcators with diameter reduction from 5.5 m to 3.2 m

Photo 7. Raise drill for pressure shaft excavation

Photo 4. Fully excavated powerhouse cavern, summer 2014

side of a 200 m long concrete-lined pressure tunnel (Ø = 7.70 m), followed by a 434 m deep concrete-lined vertical shaft (Ø = 7.00 m) (photo 5) and an 130 m long steel-lined pressure conduit (Ø = 5.50 m) including the bifurcators (Ø = 3.20 m) (photo 6). The pressure shafts were excavated using the raise-drill technique, which involved the following steps:

- exploration borehole drilled from top to bottom,
- attachment of drill-bit and excavation from bottom to top (photo 7),
- widening of the excavation from top to bottom (drill-and-blast method).

Downstream intakes

Nant de Drance has to be constructed while maintaining the Emosson in operation with minimal disruption. For this reason, the time window for executing the downstream intakes was too short for in situ construction in the bed of the lake.

Photo 5. Installation of a butterfly shutoff valves on the upper section of the fairway between the Vieux-Emosson reservoir and the vertical shaft

The solution which was devised was to build them at high water level (photo 8) and then float them using immersed box techniques to their final location (photo 9). The hydraulic connection between intakes and waterways was only completed once the downstream gates were fully commissioned.

Heightening Vieux-Emosson dam

Due to the scheme power increase which was decided during detailed design, it was necessary to increase the height of Vieux Emosson Dam (final height 66.5 m) in order to double the reservoir volume. By doing so, the dam was converted from a single curvature to a double curvature arch dam. This heightening was carried out in the following steps:

- demolition of upper 20 m of dam in order to correct its geometry,
- re-construction of upper 40 m to new crown level,
- grout injections and surface treatment.

The heightening operation is illustrated below (photo 10).

Spoil management

Managing the muck generated by the Nant de Drance project was an arduous task: over 4.2 million tonnes of muck were produced during construction, including a considerable volume of spoil containing high amounts of radioactivity and arsenic (both found naturally in the bedrock), which required special treatment.

With limited backfilling options and a view to minimising environmental impact, the following measures were worked into the project from the outset:

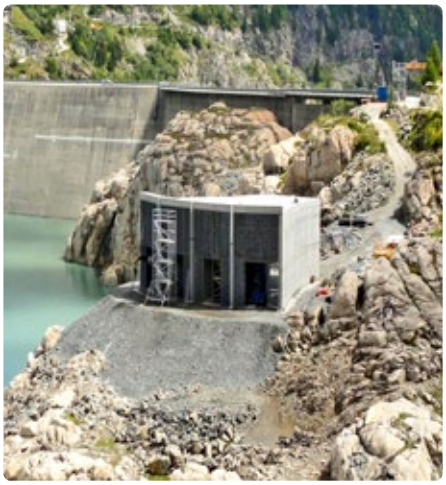


Photo 8. Construction of downstream water intake

Photo 9. Floating downstream water intake across Emosson Lake

- production of all concrete for site requirements using aggregate generated from spoil (600,000 tonnes of spoil reused), see photo 11,
- use of spoil to backfill and revitalise an existing quarry, see photo 12.

Variable-speed pump-turbines

In contrast to conventional pumped storage plants where the power of each pump can't be adjusted, Nant de Drance is equipped with variable-speed Francis pump-turbines and motor-generators, which allow operators to pump precisely the amount of energy the electrical grid wants to offload, so the region's wind and solar power aren't wasted — on the

Photo 10. Heightening of Vieux-Emosson dam, July 2013

Photo 11. Production of concrete aggregate from spoil

Photo 12. Backfilling of existing La Gueulaz Quarry with spoil (backfill capacity 350,000 m³)

contrary, they're highly valorized. In addition to making the grid more efficient, the variable-speed machines are themselves more efficient than their fixed-speed cousins, capturing more potential energy when producing power and using less electricity to pump uphill. The additional benefits of using variable-speed machines include:

- regulation of energy absorbed in pumping mode, facilitating energy storage when power levels on the network are low, helping to reduce starts and stops and regulate network frequency or voltage in pumping mode,
- operating close to the turbine's optimal efficiency point, which results in a significant increase in global plant efficiency. In case of Nant de Drance it totals above 80%, which is currently one of the highest value for a pumped storage power plant,
- elimination of operation modes prone to hydraulic instability or cavitation, resulting in improved reliability, reduced maintenance, and increased lifetime,
- operating in a wider head range, increasing the availability of the plant,
- correcting sudden voltage disruptions/ variations caused by network problems thanks to instantaneous power output adjustment.

Because Nant de Drance will be both pumping and generating power on a frequent basis, it needs to be fast. While a coal-fired power plant takes more than four hours to start up, and a combined-cycle gas turbine two to three hours, Nant de Drance's pump-turbines can start churning out 900 megawatts in just 100 seconds. When the grid suddenly has more power than it needs, Nant de Drance can react almost as quickly, taking six minutes to go from producing power to pumping water back uphill to the Vieux Emosson reservoir. The scale of this Alpine battery also makes it a powerful tool for leveling the peaks and valleys created by intermittent renewable energy. When full, the Vieux-Emosson reservoir can provide around 20 gigawatt-hours of electricity.

Photos 13, 14, 15 show successively the installation of the spiral housing, turbine and the ball valve.

Protecting the environment

One of the priorities of Nant de Drance and the licensing authorities is to reduce environmental impact as much as possible. Fifteen projects at a total cost of twenty-two million Swiss francs have been, or will soon be, completed to offset the environmental impact of the following constructions: pumped storage power plant and very high-voltage line connecting the power plant to the power grid.

The work is managed by Nant de Drance SA and monitored by an advisory group represented by WWF, Pro Natura, the public authorities concerned, the canton of Valais as well as the Swiss Federal Office of Energy. Most measures aim to recreate specific biotopes locally, especially wetlands, in order to encourage recolonisation of the area by certain rare or endangered animal and plant species in Switzerland:

- four measurements are being carried out on the site perimeter. They concern four areas – located in Châtelard, in Bierle (municipality of Trient), at the Gueulaz pass and at the foot of the Vieux-Emosson dam - used in particular to store the excavated material from the tunnels and caverns. Nant de Drance is rehabilitating these areas and creating environments that encourage biodiversity. It is also planned to create an educational trail in Châtelard,
- the Salanfe SA's overhead power line, located between the Miéville plant and Salanfe, has been installed below grade because it was dangerous for birds,
- in Salvan, pastures have been reopened following brush-clearing work. Wet biotopes will also be created. This measure is carried out in collaboration with farmers and breeders from the region and enables to support mountain agriculture,
- the wetland of the Fond du Mont in Vernayaz, which had been drained, has been refilled with water, in collaboration with the municipality. As part of this project, the Lantze Canal will undergo renaturation (photo 16) and downstream, in

Photo 13. Installation of the turbine scroll case

Photo 14. Turbine runner installation

Photo 15. Installation of a ball valve under the turbine

Photo 16. Renaturation of the Lantze canal near Vernayaz

Miéville, small lakes will be created along the Salanfe river,

- in Vernayaz, the bed of the Trient river will be widened by relocating the existing dyke between the SBB bridge and the motorway bridge in order to create an alluvial zone and give more space to the river. Additionally, specific biotopes will be developed set back from the bed of the Trient river,
- in the municipality of Dorénaz, work is being carried out as part of a project to secure the stream in Alesse and a wetland has been developed along the right bank of the Rhône.
- from the mouth of the Trient to the Dorénaz bridge, the bed of the Rhône will be widened to give it more room to expand, particularly in the event of flooding. Considered a priority, this measure is being carried out during the 3rd Rhône correction with the financial participation of Nant de Drance SA,
- going up the Rhône in the direction of Martigny, the so-called "Lac des Sables" measure will consist of reclaiming a gravel quarry lake and creating wetlands,
- in the municipality of Martigny, biotopes have been developed in the forest along the Bienvenue Canal in order to increase the amphibian population, or more specifically, yellow-bellied toads,
- in Saxon, as part of a project to secure the municipality's canals, Nant de Drance SA has completed the widening and regeneration of these canals in order to promote biodiversity,
- Nant de Drance, in collaboration with WWF, is managing an on-going project to eliminate invasive plants, such as Japanese knotweed, which have colonised the banks of the Trient.

Official Commissioning and Epilogue

After 14 years of work, Nant de Drance was officially commissioned on 9 September 2022, with the participation of Simonetta Sommaruga, member of the Swiss Federal Council and Roberto Schmidt, President of the Valais Council of State.

At the height of construction, up to 650 labourers were present on site, working deep underground in particularly challenging Alpine conditions, on a project of an exceptional scale and complexity. This was achieved without any serious accidents – remarkable given the scale of the project.

Conclusion

Given the current energy production context and future trend, the ability to store and generate electricity rapidly on-grid is going to be increasingly important. By its ability to absorb or inject up to 900 MW of power, Nant de Drance is going to be a key instrument for stabilisation and regulation on the Swiss and European grid.

Acknowledgements and references

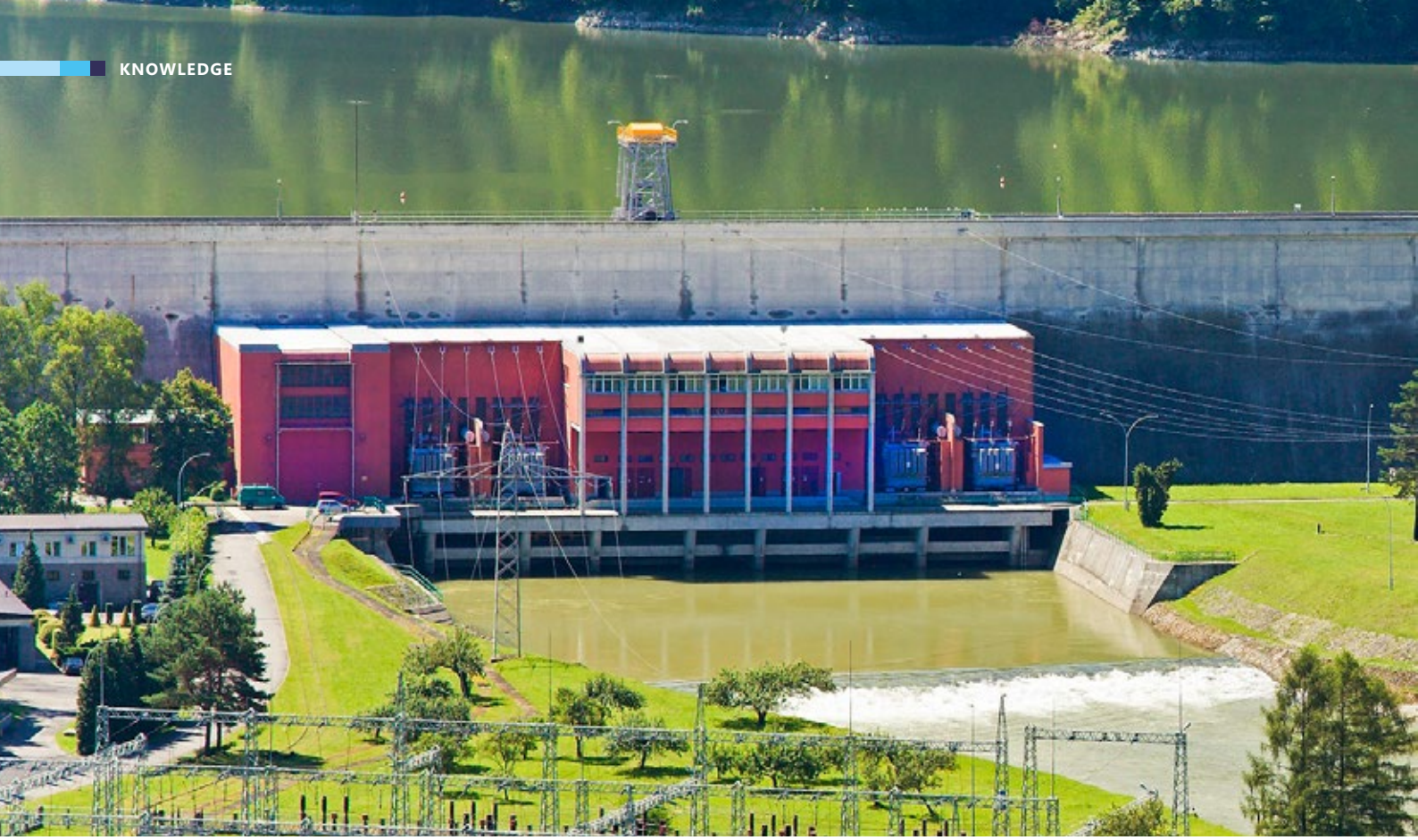
The author would like to thank Project Client Nant de Drance SA and GE Renewable Energy company for its support in writing this article, for providing information on the variable pump-turbines and environmental measures and illustrations.

For more detailed information regarding modelling of the excavation and structure, the reader is referred to the following articles:

1. Nilipour, N., Garin, E., Ihly, T., Seingre, G., "Adding a 900-MW pumped storage power plant between existing reservoirs in the Swiss Alps", Proceedings, HYDRO 2012, 29-31 October 2012, Bilbao
2. Garin, E., Nilipour, N., Fournier-Bidoz, L., Kohler, P., "Geomechanical design of a large deep underground powerplant", Proceedings, HYDRO 2012, 29-31 October 2012, Bilbao
3. BG Consulting Engineers ltd., "SCIA User Contest 2015: Nant de Drance", 16.02.2015
4. Kazerani, T., Nilipour, N., Garin, E., Seingre, G., "Application of numerical modelling for large-scale underground excavation in foliated rock mass", Proceedings, EUROCK 2015 & 64th Geomechanics Colloquium, Schubert Ed.

Patrick Heck
Nima Nilipour
Gérard Seingre
BG Consulting Engineers

Industry catalog



Dam and hydropower plant Rożnów on the Dunajec river

This year marks the 80th anniversary of the commissioning to exploitation dam and the hydropower plant Rożnów. This was, even on the European scale, important Polish economic and technical achievement of the inter-war period. Therefore, not only this investment, but also their designers and builders deserve special words of recognition.

In the beginning of the 1930s the Second Republic of Poland, after destructions and neglections caused by the partitions, started fast reconstruction of the country. One of the basic economic needs was electric power. There were plans to establish the Central Industrial District (COP) in the south of Poland. In connection with this there was the survey for the location of the dam and hydropower plant, which would fulfill this requirement.

One of the locations was Rożnów on the Dunajec river, which is the most abundant in water rivers in Poland. The Dunajec is the right bank tributary of the Vistula. It is 249 km long and has the catchment area of 6804 km². It flows through Pieniny mountains and its average discharge at the mouth to Vistula is 84.3 m³/s. Rożnów location was important due to its high hydroenergy potential, simultaneously high flood hazard, and the need to protect the region against flood. Prof. Karol Pomianowski from Warsaw University of Technology was promoter of these actions. The first technical studies for this location date back to the years 1920–1930. Investment was, however, shifted in time because of its high cost and financial shortages of the country. The construction of the dam, reservoir and hydropower plant was, however, significantly accelerated by catastrophic flood in the Dunajec catchment in 1934, which resulted in important economic losses (about 100 million of contemporary zloty), social losses, and death of many people.

The concept, design, commencement and completion of the construction

In 1935 the design of the investment was prepared by the Office of Waterways of the Ministry of Transport. The Rożnów dam is the concrete construction of gravity type. Its height is 32.5 m and it is immersed 17.0 m into the ground. The dam is 550 m long and has the widths of 9.0 m in the crest. It is equipped in 7 spillways closed by segment gates and 5 bottom outlet works. It has chamber fish pass, mainly for migratory fish during their movement upstream for spawning. Hydropower plant had peaking character and was equipped with 4 vertical axis Kaplan turbines of installed power 12.5 MW each.

The total installed discharge was 240 m³/s. The estimated production of electric energy in an average hydrologic year was 125 GWh. Rożnów reservoir created by the damming extended on 22 km of the Dunajec course and had the surface area of 11 km². The initial volume of the reservoir was 200 hm³. It is worth mentioning the fact that gigantic flood on the Dunajec catchment in 1934 caused losses estimated for 100 million of contemporary zloty, while the cost of the whole Rożnów project was estimated at 60 million zloty. The construction of the dam Rożnów was initiated by the Polish-French Society. Eng. Ziemowit Śliwiński was appointed as the head of the project, and his deputy for technical matters eng. Waclaw Balcerski, graduate from Warsaw University of Technology. It was first on a such large scale complicated construction requiring very good organization and engineering skills. The key technical staff of the construction consisted of Poles, who in the future established scientific and technical staff of Warsaw and Gdansk Universities of Technology. Majority of workers was from sur-

Source: TAURON Ekoenergia sp. z o. o.

rounding nearby villages and cities. It was a region of meager agricultural infrastructure and high unemployment. Construction started very dynamically in 1935 and run according to schedule.

The outbreak of the war and disruption of the construction

In September 1939 the outbreak of war disrupted the construction. Most parts of the project were already completed. Large part of technical and administration staff was called to military service. Eng. W. Balcerski as the reserve officer became member of the general Kleberg's staff. He was taken as military prisoner and escaped from prisoners camp. Returned to Rożnów where his family remained. Germans after occupation of Poland quickly realized that the dam and hydropower plant are on the stage of completion and to put it into operation will not present problem. Hydropower plant will supply large amounts of electric energy necessary for their armament industry. They sent to Rożnów their technical team headed by an Austrian ingenieur, who supposedly was not the the follower of Hitler. According to his suggestion Germans declared that all workers employed on the construction of Rożnów will be safe from deportation to work in Germany.

It was concluded that the design of the construction is very good and does not require any changes in realization. For the completion of the construction, however, Polish technical staff was necessary, which up till now carried out the construction and hundreds of workers. There was important controversy for engineering staff: whether to collaborate with the occupant or complete the project, which as it was assumed should be completed, because it will serve future economy in the independent Poland after victorious war. This view prevailed and the dam and hydropower plant were completed and put into operation. The filling of the reservoir started. Eng. W. Balcerski served under German supervision as manager for technical matters.

In 1944 the end of war was drawing to an end and there was a threat that retreating German army will want to destroy the dam and hydropower plant. The Home Army operating in this area, the local population and the serving staff of the power plant was prepared for such action. The Germans managed only to dismantle some of the equipment of hydropower plant and sink them in the reservoir. Decisive Polish action secured the project, thus preventing its destruction or damage. After the war a special team was formed headed by eng. W. Balcerski. After a relatively short time the project was restored to a good technical state and prepared to operation and exploitation. This task was fast completed and the operation of the hydropower plant resumed.

Development of the hydrotechnical potential of the Dunajec

During the design of the Rożnów dam it was stated that it is indispensable to have compensating reservoir downstream. In 1936 the first design of the compensating barrage Czchów was prepared. Construction of it, however, was initiated only in post war period and the project was put into operation in 1954. It consists of an earthfill dam 12.5 m high and 430 m long. The spillway section forms the 5-bay weir closed with plain vertical lift gates. Hydropower plant has 2 Kaplan turbines of the power 4 MW each. The total installed discharge of the turbines amounts to approximately 90 m³/s. The average annual production of electric energy is 35 GWh. The dam forms reservoir of the volume 8.9 hm³, surface area 346 ha and the length 9 km. At the dam there is chamber fish ladder of the 9 m head. This construction had to reduce discharge of the Dunajec from 200 to 114 m³/s. The maximum discharge through the barrage was estimated at approx. 4000 m³/s.

During the construction of the dam and hydropower plant it was stated that the amount of produced electric energy will be higher than the regional demand. A similar situation occurred at the Pomerania region after construction of Żur and Gródek hydropower plants. Therefore, a transmission energy line of 150 kV was constructed

Source: Gdańsk University of Technology

Photo. Prof. mgr eng. Wacław Balcerski (1904–1972)

connecting Rożnów via Starachowice and Tarnów with Warsaw.

The initial volume of Rożnów reservoir was 200 hm³, however, it was well known that the Dunajec is the river, which carries large amounts of sediment, especially during high discharges. The volume of the reservoir was rapidly diminishing as the result of sediment deposition and currently is 165 hm³. The first measurement of the reservoir siltation was carried out in 1957. After postwar era the project underwent several modernizations and was equipped with modern control-measurement instruments, which were located in the galleries running in the body of the dam. The dam resisted floods in 1970 and 1997. The region since the construction of the dam changed its character from agricultural to tourist and recreational thus bringing significant revenues to the local people.

The Hydraulic Energy Establishment Niedzica

The culmination of hydro-energy development of the Dunajec was the construction of the dam Czorsztyn-Niedzica with compensating reservoir Sromowce-Wyżne in the years 1971-97. The earthfill dam with clay sealing is 56 m high, 404 m long and has the crown width of 7 m. It is equipped with surface spillway and bottom outlet works. When the reservoir is filled to the elevation 534.5 m above sea level the total discharge through the barrage amounts to 2140 m³/s. Hydropower plant is located at the dam and equipped with 2 reversible Deriaz turbines of the power 92 MW, which enable pump-storage operation with the use of compensating reservoir Sromowce-Wyżne. Its maximum volume is 6.7 hm³. The minimum inviolable discharge during summer time downstream from the dam Czorsztyn-Niedzica and compensating reservoir Sromowce-Wyżne was settled at 12 m³/s. There is famous raft flow on the Dunajec downstream from the dam Czorszty-Niedzica and compensating reservoir Sromowce-Wyżne. Thanks to the inviolable discharge downstream from the reservoir the rafts flow can operate regularly. Before the construction of Czorsztyn reservoir frequently during summer period low discharges in the Dunajec occurred, which impeded the flow of tourist rafts.

Professor Wacław Balcerski

Born on 18 August 1904 in Skierniewice in a family which cultivated traditions of his grandfather Janicki, outstanding engineer of these times, builder of the Suez Canal. Wacław Balcerski after obtaining his matriculation in 1922 began studies at the Warsaw Technological University. He completed his military service in Modlin. As a volunteer took part in Warsaw Battle in 1920, for which he was awarded the Cross of Valour.

During studies he worked part time and completed number of engineering practices in the country and abroad. After completing his studies in 1935 with a very good result, he commenced work on the construction of the dam Rożnów on the Dunajec. Eng Balcerski attractedd his attention with organizational and technical sills and became technical manager of the construction. During the war he worked under German supervision on the construction of Rożnów dam and after its completion in 1942 continued his work in Rożnów and significantly contributed to the protection of the project against destruction. After the war he headed the team preparing the project for reopening.

After the war and completion of reconstruction of hydropower plant eng. Balcerski was employed in the Department of Waterways of the Ministry of Transport. In 1946 at the indication of his teacher prof. K. Pomianowski he was directed to Gdańsk University of Technology as a contract professor. Initially he worked as the head of

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the chair of Statics and Engineering Constructions in the Department of Architecture. After the death of prof. K. Pomianowski in 1947 he took over the chair of Hydraulic Engineering at the Department of Civil Engineering and remained at this position till his death in 1972.

During his work at Gdańsk University of Technology he obtained the title of professor and next title of full professor. He devoted himself to teaching with great passion. Had great authority among students. Except of lectures he carried out diploma seminars and was supervisor of diploma thesis. Sincerely encouraged students to learn foreign languages. He educated large group of hydraulic engineers, who after receiving diplomas became responsible designers and builders of many hydrotechnical objects in Poland. Was very active in the organization of Gdańsk University of Technology. During 1945-51 was the Vice-dean on the Faculty of Civil Engineering. In 1952 he became Dean on the Faculty of Hydraulic Engineering established by his initiative. In 1956 in the first democratic elections he becomes Rector of Gdańsk University of Technology. He was great friend of young people and showed interest in their problems. At his support the first authentic Student Parliament was formed in Poland. At this time when history brought more hope to Polish society and encouraged to several initiatives, prof. Balcerski became deputy to Polish Sejm (Parliament). He was very active in the work of Parliament and especially in water resources management and hydraulic engineering. He was also involved in the work of Gdańsk Scientific Society and was elected its President for the term 1963–65.

At a very versatile activity in the organization of Gdańsk University of Technology and in the social life prof. Balcerski maintained close contacts with Polish hydroengineering and water resources management. From the beginning of his work he was engaged in the elaboration of assumptions for the perspective plan of water resources management taking into account modest water resources of our country. Under his leadership complex program of Polish water resources management was developed including their comprehensive use for navigation, hydroenergy, water supply and protection against flood and drought. This program was closely associated with his name. There was no hydraulic project, in which he would not be involved in the form of design or construction. Prof. Balcerski had a significant part in the design and construction of pumped storage power plant Żydowo, for which he was awarded the First Grade State Award.

Extraordinary charisma and remarkable personality distinguishedd him at every step. He was modest and never distinguished himself. When he spoke, he spoke concisely and to the point. He willingly took part in any discussions listeninig to all adversaries. He had the ability to sum up even most controversial exchange of ideas. He also had an exceptional gift to find mistakes and deficiencies in various elaborations and frequently he participated in public defenses of doctor thesis. For his scientific, educational, engineering and social activity he was awarded with numerous national, regional and ministerial distinctions. He received Knight's and Commanders Cross of Polonia Restituta. Wide description of his activity can be found in the book Pioneers of Gdańsk University of Technology (Pionierzy Politechniki Gdańskiej, eddition 2005) and in the ececyclopedy of the city of Gdańsk. In the main hall of the Faculty of Civil and Environmental Engineering there is the relif commemrating prof. Balcerski. Died prematurly at the age of 68 in full force of creative powers. He was burried at Srebrzysko Cemetery in Gdańsk in profesor's qater. His funeral was attended by crowds of his former and current students and colleagues from the whole Poland.

As the author of this paper I had the honour of meeting prof. Balcerski on my engineering and scientific road, initially as a student and then as long-term collaborator. Prof. Balcerski was my model as lecturer and a man of great engineering knowledge, personal culture and ability for cooperation, even in conflict situations.

Prof. dr hab. eng. Wojciech Majewski
Institute of Hydroengieerng
Polish Academy of Sciences in Gdańsk

Ultralow head Kaplan's hydro turbine – the experiences gained from laboratory project execution

The growing demand for water turbines designed for low-slope facilities prompted T-G DNALOP to carry out a research project that involved the design and production process of such machines. The following article presents the methodology used, indicates the practical experience gained during the project, and presents the results obtained.

The topic of using low head (1.5 - 3 m) applications for the needs of hydropower has been present in industry discussions for many years. This problem arouses ambivalent opinions among investors and turbine manufacturers, on the one hand it is still a very large potential to be used, on the other hand, however, upfront costs remain at a relatively high level. Particular chalange is selection the proper machine for low head facilities, which is of key importance for the utilization of maximum available energy and the optimisation of investment costs. This problem is particularly relevant for small and micro hydropower plants. Such a hydro unit should ensure the appropriate quality of workmanship, reliability and confirmed high energy parameters. Therefore, it is necessary to use a series of turbines with repeatable, proven solutions that will be available to the customer from the "shelf". According to the authors, this is a solution that allows significant improves the economic aspects of investment process, and at the same time use in the optimal way the potential of the water damming structure.

Returning to the technical discussion on specific types of machines dedicated to low head applications, it should be stated that in larger power plants, where the installed capacity is 500 kW or higher the straight axis Kaplan turbines (so called "Bulb" or "Pite" types) are the most common solutions while for smaller hydro power plants there is a greater variety of proposed solutions. On the one hand, these are low specific speed water machines with very large dimensions, such as Archimedes screws or VLH (Very Low Head) turbines, on the other hand, high-speed Kaplan turbines - compact units equipped with high speed generators, very often coupled directly to the turbine shaft.

The T-G DNALOP company, in line with the latter trend of the proposed technical solutions, decided to undertake activities related to the development of high-speed Kaplan type turbine structures for low head applications dedicated to SHP (small hydropower) facilities.

The company has been implementing a research project on the design optimisation and production of ultralow (should state range of head in meters for ultra low head) head water turbines since 2020. The above actions are undertakes in the frame of project, which is co-financed by the National Center for Research and Development (project number POIR.01.01.01 00-0960/18). The idea to implement the task resulted from precise investigation of domestic and foreign markets for low head potential site. As it results from analysis of various types of reports and inventory data of existing dams, such as Renewable Energy Sources Transforming Our Regions (RESTOR), in Poland there is still a very high potential of energy for currently unused damming stages for small (suggest stating kW range) and micro (suggest stating kW range) installations. It should be also kept in mind that in many cases the operational process of the small hydropower plants requires the necessity of a deep modernization. This is due to the bad technical condition of the equipment and wear of the machine components staying in operation over a long period of time. In addition, these types of machines can also be successfully used to recover gravitational energy by discharging of water in wastewater treatment plants. For the authors of the aforementioned project, the above premises became the starting point for the entire process of designing, manufacturing and implementing a series of high speed turbines (UHE 100) intended for use in low head facilities (1.5-4 m head) for small and micro hydropower. The project is carried out with the main subcontractor – the Szewalski Institute of Fluid-Flow Machinery of the Polish Academy of Sciences (IMP PAN).

Turbine project

The figure 1 shows the concept of the discussed turbine. It is a Kaplan type turbines, with a high specific speed, are designed in a single elbow with the shaft extrud-

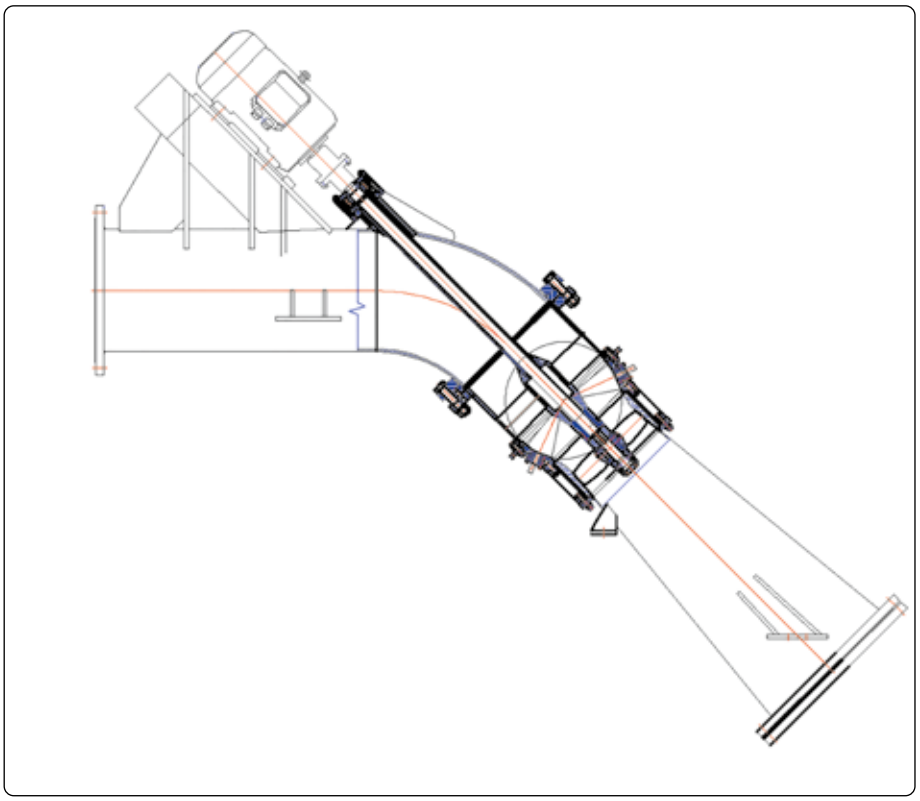

Fig. 1 Conceptual drawing of the UHE 100 high-speed water turbine

ing from the water inflow side. This type of assembly with a slight limitation of the machine speed (inlet elbow) allows for a very convenient service of the device including easy access to the generator, bearing and seal. The turbine will contain a number of modern solutions, both in terms of its structure and design. The most important advantages of the described turbine include:

- high performance passage system, numerically designed and experimentally tested thanks to the use of modern design and computing programs,
- turbine energy parameters and its cavitation properties confirmed by model tests,
- significant reduction in the use of oil lubricants and hydraulic oil thanks due to the use of water lubricated bearings, self-lubricating bearings by THORDON,
- very low friction losses in the THORDON project hydrodynamic bearing,
- high specific speed index, what results in relatively small dimensions of the assembly,
- the system is equipped with a triple regulation by changing the settings of the wicket gates operating mechanism, rotor and rotational speed (using a PMG generator),
- most of the machine's elements are made on a precise five-axis CNC machine, each processed element is subjected to individual quality control with the measuring arm.

Project description

The project is characterized by a comprehensive approach to the design and production of high-speed water turbines. The entire process has been divided into four main stages: starting from the conceptual assumptions and design of the flow system in the first stage, through the execution of the model and its testing at the laboratory stand in the second stage, optimization of the turbine component manufacturing technology process in the third stage, and ending with the erection, installation and tests of the turbine prototype in the fourth stage. The design of the turbine flow system was made using modern CFD (Computational Fluid Dynamic) flow design and numerical analysis software. In the first step, the shape of the turbine runner and control ring was designed using a two dimensional method (the so called "simple task"). Noteworthy is the innovative approach to the design of the guide vanes profile, characterized by a very large bend of the skeleton surface. In the next step, the remaining elements of the flow system were designed and a series of numerical calculations were made in order to verify the assumed parameters of the turbine operation. As a result of the performed calculations, the distributions of local flow parameters (fig. 2) as well as global values, such as shaft power, flow and hydraulic efficiency of a flow system, were obtained.

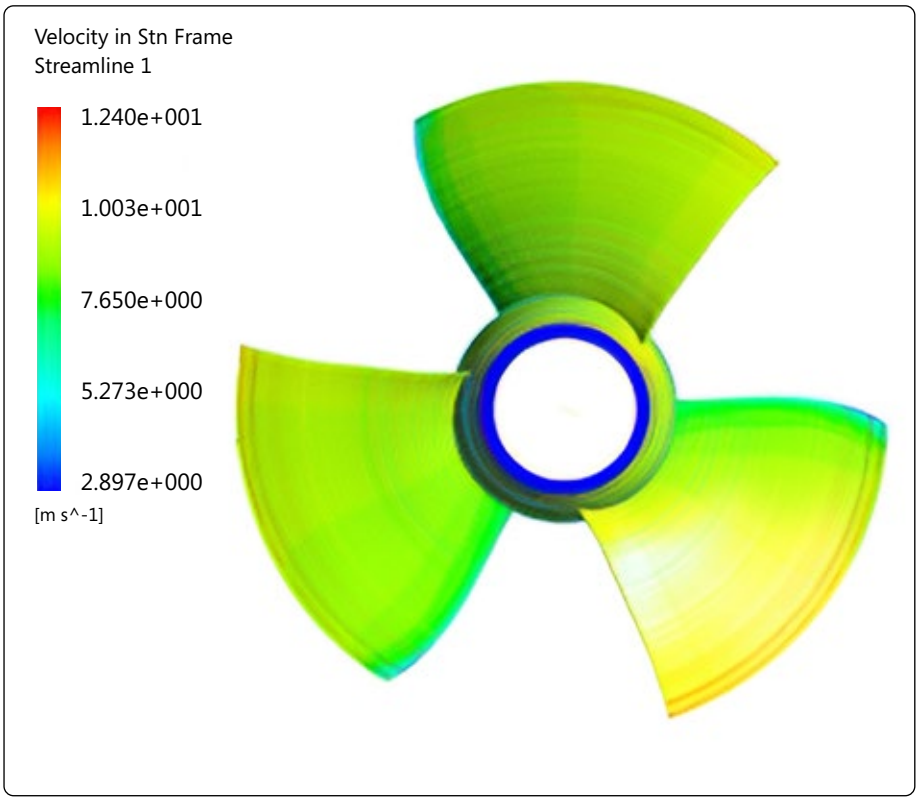

Fig. 2. Velocity distribution around the model rotor blades

The numerically determined operating characteristics showed a high level of turbine efficiency in a wide operating range. The maximum achieved efficiency of the turbine is 89% for a rotor with a diameter of 300 mm.

In the next project stage, based on the geometry of the flow system, a technical design of a model turbine was made (photo 1). The device was entirely made by the T-G DNALOP company with the use of the existing machine park. Taking into account the need to optimize the costs of the production process company's machining workshop and assembly area were adapted to the production of turbine components, used so far for the production of bearings and seals. Most of the flow system elements as well as key structural elements were machined on a five-axis CNC machine.

The last step in the implementation of stage 2 was the assembly (photo 2), commissioning and model testing of the turbine at a laboratory stand at IMP PAN. The tests were carried out on a dedicated stand for testing water turbines and pumps in a closed system, with the possibility of regulating the pressure inside the installation. The photo below shows TG -D hydro unit with a model turbine installed on a laboratory stand at IMP PAN (photo 3).

The final result of the research was to obtain the Kaplan turbine hill chart in a wide range of operation and to develop cavitation curves for selected angles of the rotor and steering wheel blades. Model tests confirmed the high efficiency of the model turbine, reaching 88.5%.

Cavitation tests carried out for selected runner and wicket gates mechanism opening angles allowed to determine the so-called cavitation curves for successive operating points. Vibroacoustic, visual and

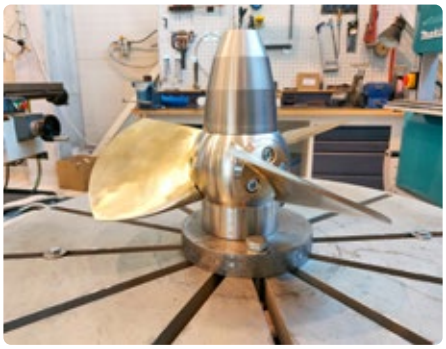

Photo 1. Model turbine rotor

Photo 2. Assembly of the model turbine wicket gate operating mechanism

Photo 3. A TG-D model turbine on a laboratory stand at the Szewalski Institute of Fluid-Flow Machinery of the Polish Academy of Sciences

Photo 4. Visualization of the steam bubbles on the rotor blades for the Thoma cavitation number Th = 0.9

energetic measurements were carried out in parallel for different Thom cavitation numbers (photo 4).

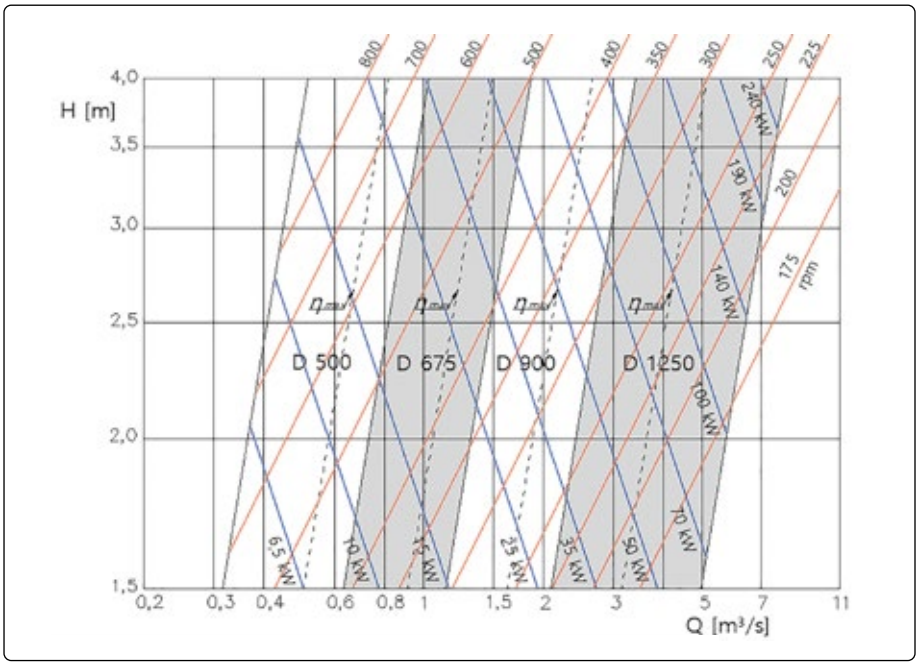

Fig. 3. Nomogram of the UHE-100 turbines

Having such extensive knowledge about the operating of the machine in various conditions will allow for the optimal selection of the hydro unit and ensuring non-cavitation operation of the machine, which is an undoubted advantage of the proposed solution. Already at the initial stage of submitting the inquiry, the client will receive detailed information about the performance of the hydro-unit, as well as the required height of the runner elevation.

Work is currently underway on the construction of a turbine prototype with a diameter of Ø500 mm, which will be installed in our MEW Strużyska demonstration facility. The flow system will be an exact copy of the solutions proven during model tests. The final result of the project will be the creation of a whole series of similar turbines with rotor diameters: Ø500 mm, Ø675 mm, Ø1250 mm, and Ø1250 mm working in the range of 1.5–4 m heads, with a max. shaft power output up to 240 KW. The figure below shows the nomogram of the turbine series described above (figure 3).

Summary

The conducted numerical simulations and laboratory tests confirmed the high efficiency of the flow system and good cavitation properties of the machine. Extensive knowledge of the machine parameters will allow for its precise selection for specific site hydrological conditions. The design of the machines will ensure reliable and fully ecological operation thanks to knowledge and experience of technologists and designers engaged in that project. According to the authors of the project, the created structures of hydro units are to be repeatable within the developed range of series of types, based on unified, proven solutions, and quick to produce.

Co-financing

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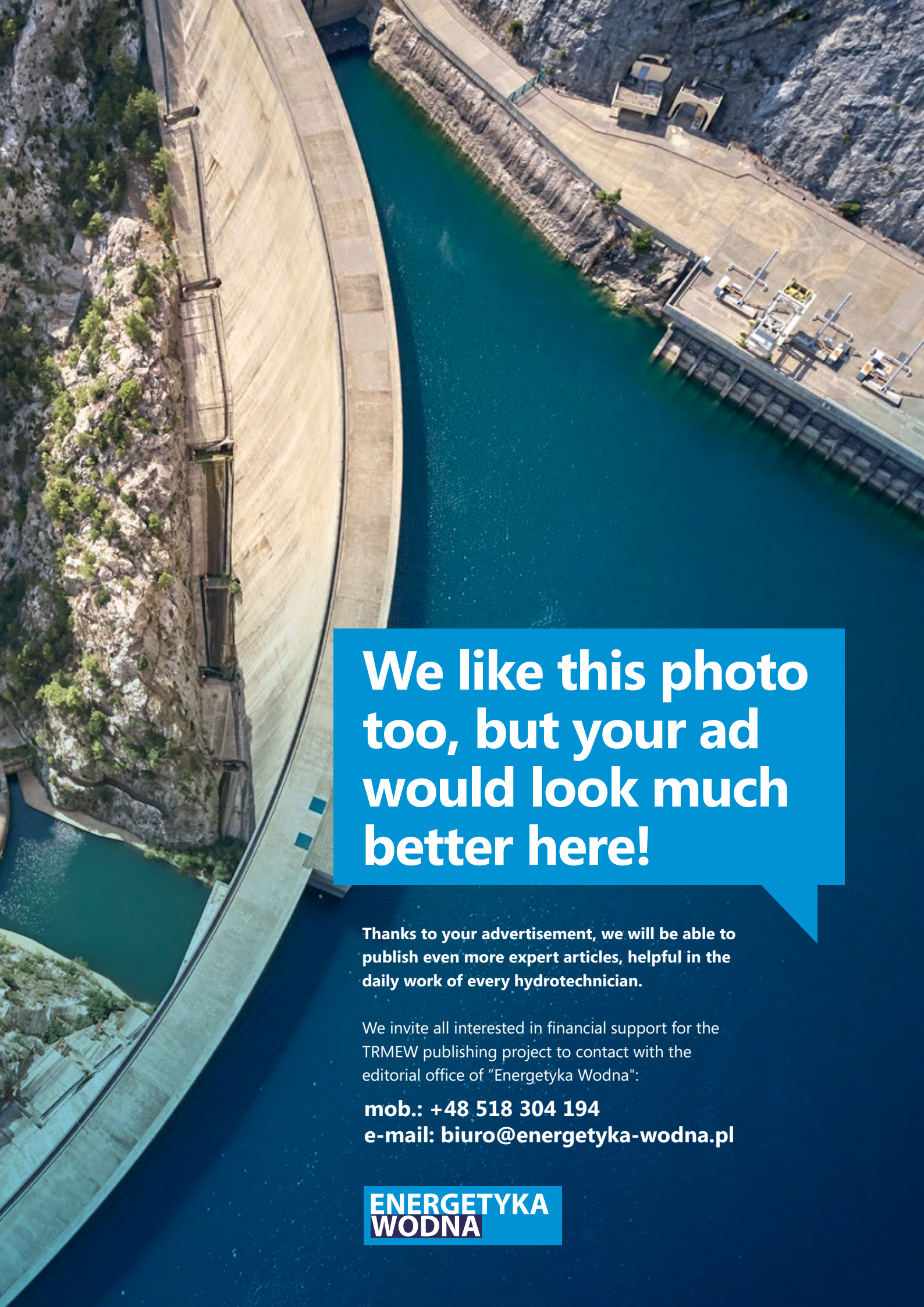

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Utilisation of BELZONA polymer composites in industry

Technological progress and competitiveness have made it necessary to improve the durability and reliability of machinery and equipment operated in different branches of the industry. The improvement in durability is related to the increase in the requirements placed on materials in terms of mechanical properties, fatigue and thermal resistance or physical and chemical properties related to the corrosive endurance. The durability of a material largely depends on the condition of its surface (more precisely, the surface layer). The physical and chemical state of this layer can be very different from the properties of the native material, making a number of machine's utilisation opportunities determined only by the state of their surface.

In order to increase the service life, as well as to enable the regeneration of machine parts and equipment, special layers with predetermined repeatably reproduced properties are placed on their surfaces. Surface modification techniques also include technologies for regenerating these surfaces with BELZONA polymer composites. Application of these composites is possible in temperature range from 5°C to 35°C, and in some cases even from -5°C to 150°C. The main advantage, compared to the application of layers by high-energy techniques (such as hardfacing, metallizing and others), is that the composites can be applied under normal conditions, at ambient temperature.

BELZONA polymer composites are designed to achieve optimum resistance to factors acting directly at the composite layer. Composites designed for use in highly corrosive environments are built from components that are resistant to the corrosive medium in question. On the other hand, when a machine component is exposed to severe erosion (abrasion), they can be coated with composites reinforced with Al2O3 particles, such as BELZONA(1811) and (1812) (photo 1).

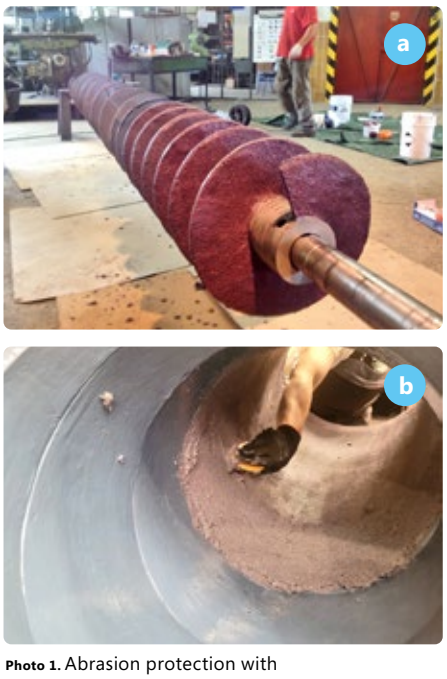

Photo 1. Abrasion protection with BELZONA(1811) and (1812) composites: a) screw feeder, b) dust duct elbow

Surface repairs of machine components

When another reinforcing material is added to the polymer matrix, it is possible to obtain completely new, much better properties of the composite compared to those of its individual components. In this way, the most popular composite used in the refurbishment and modernization of machine parts, i.e. BELZONA(1111) composite, was produced. This composite was strengthened by filling its matrix with particles of alloyed steel with added silicon. These particles surrounded by a polymer matrix form a dispersion-reinforced composite. BELZONA(1111) has mechanical properties unparalleled among other polymeric materials, i.e. it behaves under load in a way similar to steel, showing elasticity (limited creep) and excellent fatigue strength. BELZONA(1111) composite can be used for repairs and surface modifications of many machine components, such as shafts, bearing housings, or large-size bearings (photo 2).

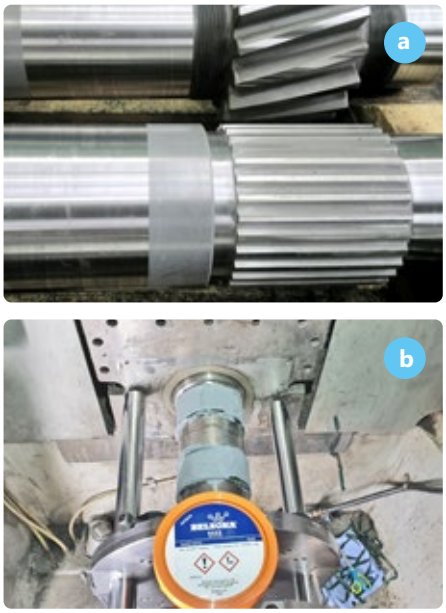

Photo 2. Refurbishment using BELZONA(1111) composite: a) shaft journal, b) roller bearing housing

Photo 3. Strengthening of the structure using the technique of "cold" bonding with BELZONA(1321) composite

The increase in the seating strength of the bushing presented in photo 3, compared to the same seating, but made with the use of a classical method with significant metal-to-metal contact area, resulted from the elimination of inconsistencies in the shape of the bushing in relation to the socket, errors in alignment, and the improvement of the contact surface of the parts to be seated. It is through the use of semi-fluid composite BELZONA(1321) or, for larger clearances, BELZONA(1111), that metal surfaces were "swapped" for composite ones, thus improving the strength of the seating. Structural strengthening technology using composite materials is also possible due to the excellent adhesion of BELZONA materials to applied surfaces.

"Cold" bonding technology

The adhesion of BELZONA composites to materials such as concrete, stone, plastics and rubber exceeds the strength of the substrate material. This property has been used for a whole range of "cold" bonding techniques for different materials. Using this technology, it is possible to join metal to metal elements (e.g. steel to aluminum), as well as metal elements to polymeric material, such as steel pipe to PVC one. A good example of such utilisation

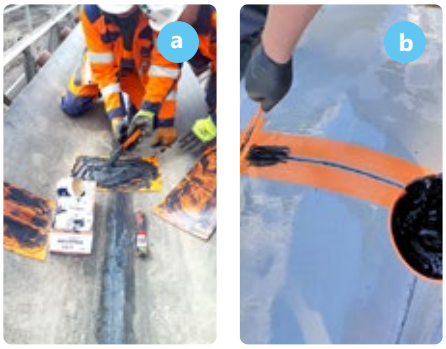

Photo 4. a) Repairs of damage to rubber and plastic elements, b) and c) sealing of expansion joints of fire prevention water tank

Photo 6. BELZONA(1341) composite coating in a rotodynamic pump

is also the technology for repairing and bonding of torn conveyor belts. By performing bonding with BELZONA(2131) composite, it is possible to achieve nearly 78% of the nominal strength of the continuous belt at the joint area. Meanwhile, using BELZONA(2211) or (2311) composite, it is possible to make a quick and effective repair of damage to many rubber or other elastic components (photo 4).

The aforementioned technologies for repairing conveyor belts improve the durability and reliability of their operation, in which one more technology, the BELZONA Grip System, fits in. The application of a layer of composite, externally reinforced with corundum, on the surface of the conveyor belt drive drum increases its coefficient of friction many times over. As a result, there will be no slippage during the start-up of the conveyor belt, regardless of weather conditions. Moreover, after the application of this technology, the belt pretension may be reduced by about 2-3 times, which will consequently relieve the load on the bearings on which the drum is seated, as well as the belt itself.

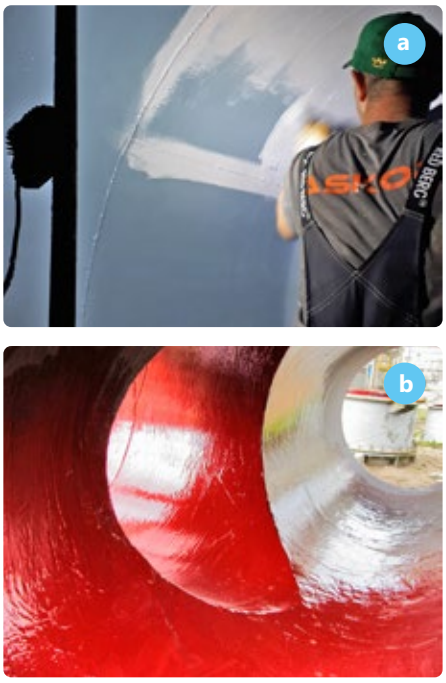

Photo 5. corrosion protection with BELZONA composite coatings: a) chemical storage tank, b) acidic fume outlet duct

Corrosion protection

Excellent adhesion and good mechanical properties are also very important factors when it comes to corrosion protection, as only those outer layers of composite will protect the surface well against corrosion – so it is important that our composites adhere well to the substrate (no subsurface corrosion) and are impermeable (high resistance to microcracking and other mechanical damage during exposure to a corrosive environment). A whole group of composites used for classical corrosion protection have such properties. There are many such examples in industry, where the application of a thin layer of composite coating effectively protects surfaces from corrosion, as well as from erosion caused by aggressive chemical liquids (photo 5).

A special type of coating that also protects against corrosion is BELZONA(1341) composite coating. Applied to the inner surfaces of pump components, it significantly reduces the flow-related hydraulic losses in the device. Smooth and hydrophobic surface structure (photo 6) allows to improve the efficiency of the pump by several percent when compared with the uncoated device of the same kind.

Improved durability due to corrosion/erosion protection and due to improved mechanical seating of parts in contact with each other, as well as reduced energy consumption, are the main advantages of using BELZONA polymer composites for refurbishing and upgrading parts of machinery, equipment and facilities operated in different branches of industry. What makes it even more incredible is the fact that the mass share of the composite layer often does not exceed a mere 1% (BELZONA layer thicknesses – 0.2 to 6 mm) of total mass of the refurbished elements, and yet it is often the one that radically changes their durability!

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Photos come from the archives of **Belse Sp. z o.o.**

Nature restoration directive a threat for European hydrotechnical structures

The European Union is considering a nature restoration directive, which includes normative aspects on the management of structures in rivers. These structures are of various kinds: river crossings, watermill weir, fishpond dyke, historical heritage facilities, agricultural canals, dams for many uses (energy, irrigation, drinking water, leisure). The project opposes to these structures to an ideal of "free flow".

Photo. Destruction of a watermill (weir, reservoir, canal) in France to impose a free flowing river

The text prepared by the Commission's Directorate-General for the Environment separates and opposes from a normative point of view nature and society. Everything that is seen as human intervention on nature is analyzed as an "impact". The "reference state" of nature is seen as a nature without humans, which becomes a normative objective. This point of view has given rise to numerous and growing criticisms in the scientific literature.

Nature and humans are not separate

European aquatic environments have long been shaped by human activities, so that their current nature is "hybrid", a natural and human co-construction [10], [29], [41]. The notion of a natural "reference state" is therefore problematic, in particular at a time when climate change is modifying what was the previous historical state, considered as the natural reference for watersheds [7]. The naturalistic ontology separating nature and human ignores the diversity of appropriations and interpretations of the environment [14], [30], [31]. More than "restoring nature", our challenge is about improving the way humans and non-humans co-exist in constantly changing environments. The question that must be asked is: "which natures do we want?" according to ecological, social, economic, aesthetic and ethical criteria.

River structures also create ecosystems

A hydraulic structure cannot be reduced to an "impact": it also creates a new environment. The structure is associated with reservoirs, canals, aquatic or wetland annexes. These environments have been called in the scientific literature new ecosystems [2], [25] or anthropogenic cultural ecosystems [19]. It has recently been suggested that small structures in rivers should be interpreted as ecotones, transitional environments with environmental gradients [17]. It was also pointed out that the environments created by these works (reservoirs, lakes, ponds, canals, wetlands), numbering 500,000 for a country like France, are currently absent from the management framework of the European water framework directive, often orphans of studies and management [40]. In some cases, a river with a structure enters a stable alternative ecological state: it has lost its ancient natural dynamics, but reorganizes the energy, sedimentary flows and biotic communities in a new configuration [37]. Environments of artificial origin have beneficial effects on certain aspects of aquatic biodiversity, whether they are canals [23], local reservoirs [20], ponds [43], watermill canal [39], small bodies of water and other human hydraulic environments [6], [11], [12], [16], [24], [27], [42], [44]. A hydraulic structure is not a pollution or disappearance of aquatic and wetland environments, it creates such environments and also hosts biodiversity, sometimes greater than that of the prior natural environment. Hydroclimatic change accentuates the role of refuge and resource that these structures can have, including for surrounding terrestrial biodiversity.

River structures provide many ecosystem and social services

By analyzing a hydraulic structure in a river as being only an impact whose elimination would be required, we ignore many scientific publications that have shown that these structures can be of economic and social interest, but also ecological ones. Research has shown that small water bodies can provide up to 39 ecosystem services [26], as examples:

- weirs and dams, even modest ones, can make a significant contribution to the carbon-free energy transition through hydroelectric equipment [35], [36],
- hydraulic structures contribute to depolluting watercourses of nitrogen and phosphorus inputs [13], [33], sometimes pesticides [21], [22],
- weirs, dams and and their annexes, such as canals and ditches, maintain a water line during drought, supply groundwater, retain winter water in soils and aquifers. Removing these structures as "barriers" has the opposite effect, incising the bed, accelerating the flow [1], [32], [34]. The dam can also be seen and managed in the future as a refuge from climate change [5],
- hydraulic structures are inserted into a cultural, societal and historical heritage which is a mode of co-existence attentive to natural environments [15], [28], [38],
- the weir and dam removal in countries where it has been strongly supported raises social controversies and sometimes produces questionable results [4], [9].

All the benefits of river hydraulic structures must be analyzed before intervention, with nearly 40 potential ecosystem services for society.

French (bad) experience about river restoration

The experience of river restoration in France is interesting because it has anticipated the EU Restore Nature regulation project. In

2006, the law on water and aquatic environments established the need for "ecological continuity" on some rivers. In 2012-2013, the French water administrations regulated more than 20,000 km of rivers to restore connectivity, by dealing with the problem of longitudinal barriers. The first intention solution of the public managers was removal, just as the Restore Nature project is now suggesting on a European scale. These measures concerned mainly the weirs of water mills, the dykes of fishponds, but also two large EDF dams on the Sélune river (Normandie) and some smaller hydroelectric plants.

The reaction of the citizens has been quite negative, because of the brutal and one-sided dimension of the removal option. Many reasons have been put forward to explain the attachment to hydraulic structures threatened with destruction [3]: historical heritage, landscape of the valleys, water regulation, hydroelectric production, public cost of this policy for elusive ecosystem services. A call for a "moratorium on the destruction of structures" obtained the support of hundreds of associations and thousands of elected officials in the middle of the 2010s. An independent administrative audit report recognized that the "credibility of the State" was weakened by delays and conflicts. Auditors of public managers choices have observed: "It seems desirable today to seek - and if possible to obtain - a better balance between the three objectives of ecological continuity, enhancement of the heritage linked to water and development of renewable energies" [8]. Some researchers observed that dam removal was a "political choice" rather than a purely ecological one, because depending on what you measure as effects of the removal on biotic communities, hydrologic functions and ecosystem services, you will find different winners and losers of the new flow regime [18].

Judicial disputes around dam and weir removal broke out on many rivers, which led the French supreme courts to rule (Conseil d'Etat for administrative law, Conseil Constitutionnel for constitutional law). The courts recalled that the water rights could not be arbitrarily abolished and that the hydraulic structures are protected as real estate property. They ruled that returning to a better ecological continuity did not imply returning to a state of naturalness, the functions of fish crossing and sedimentary circulation being possibly obtained without destroying or prohibiting a hydraulic structure. Finally, they stated that the hydraulic heritage and hydroelectric production are of general interest, legally in accordance with the Environmental Charter of the French constitution.

French deputies and senators noted the diffuse and multiple problems associated with a vision of river restoration restricted to weirs and dams destruction. They changed the law several times in the 2010s, introducing the respect for cultural heritage and the promotion of small hydropower in the public rules for "sustainable and balanced water management". Finally, a "climate and resilience" law of 2021 prohibited the destruction of the current and potential use of hydraulic structures, in particular the destruction of water mills.

This French experience suggests that the EU Restore Nature regulation must add options for the management and equipment of structures to its exclusive option for "removal" as presently proposed by the Commission. Options such as the gates management, bypass rivers, fish passes, minimum instream flow in the river are much more accepted as solution for restoring some natural functionalities of the watercourse. And they do not conflict with other legal commitments on climate, energy, water, heritage, property and safety.

Legal changes are needed

In the light of this scientific work and policy experience, which reinforces the field experience of owners, riverside residents and managers of hydraulic structures, we

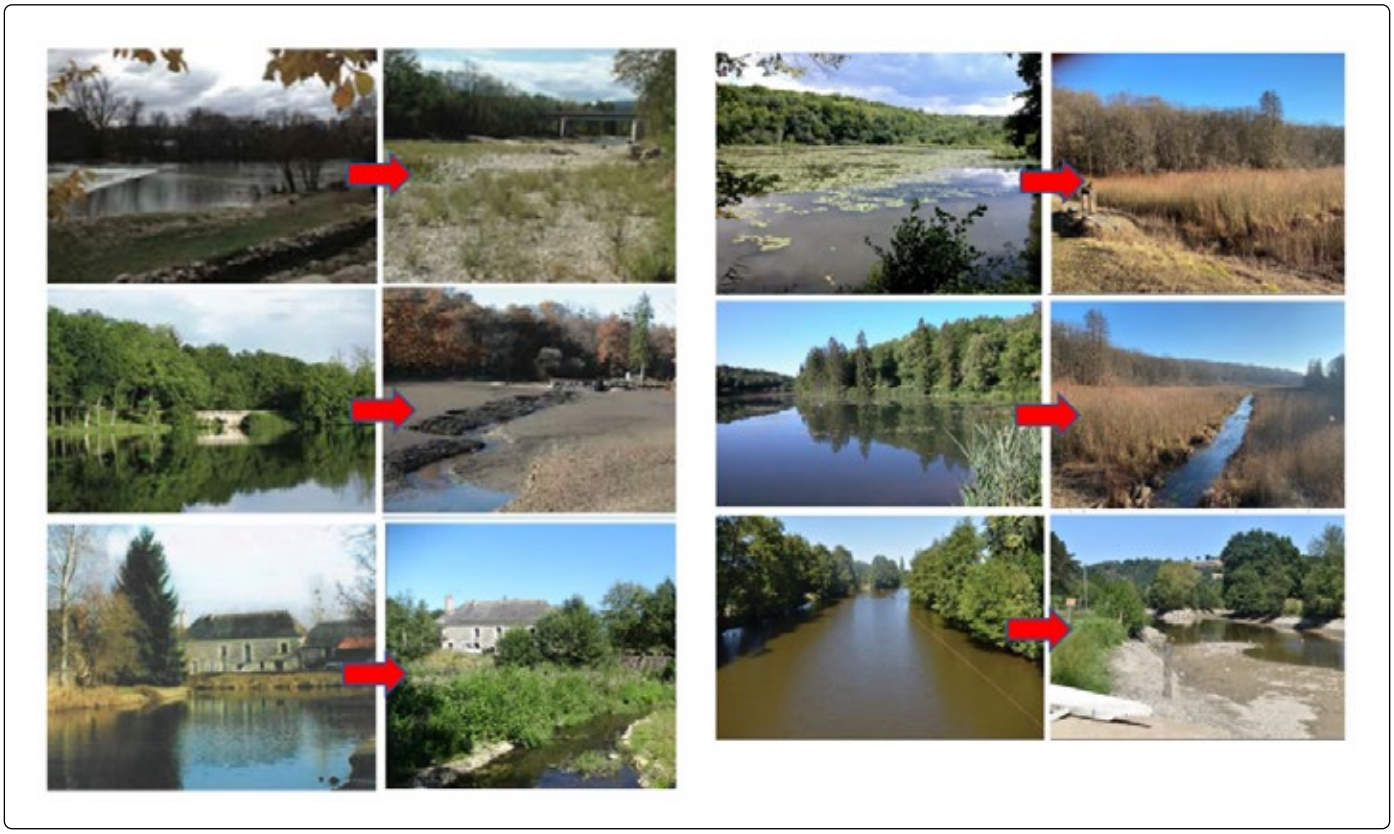

Fig. Influence of weir removal on the intensification of the drought phenomenon

request that several points be included in the nature restoration project:

- formal recognition of anthropogenic and cultural water ecosystems by European law, with the need to study and protect them as well,
- the obligation to carry out a complete and sincere analysis of ecosystem services, not limited to endemic biodiversity but including all socio-ecological dimensions,
- the need to balance biodiversity issues with energy, water and climate issues, the fight against climate change (prevention, adaptation) being of normative priority in the event of a conflict of norms,
- the urgency of adding and not opposing solutions based on nature and solutions based on culture & technology to guarantee the management of water as a resource, as we face critical episodes of drought or flood.

Restoring nature should not mean destroying the heritage and uses of rivers. The destruction of hydraulic structures (weirs, dams) to restore free-flowing rivers poses many problems: drying of water reserves, destruction of low-carbon hydroelectric potential, social and legal conflicts, destruction of anthropic ecosystems that have often been in place for centuries.

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Photos come from the archives of **National Water and Human Rivers Coordination**

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