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ENERGETYKA WODNA

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TRMEW

From The Editorial Office

Starting the current issue of "Energetyka Wodna", I would like to welcome both the regular readers of "Energetyka Wodna" as well as the participants of the Study Tour organised within the HYPOSO project, for whom we have prepared a special edition of our quarterly in English. In consideration of the ongoing growth in the demand for electricity around the world, while at the same time the need to reduce CO_2 emissions, initiatives promoting sustainable development and clean energy sources, including hydropower, are extremely important today. I am glad that our quarterly will become a part of such a unique event, and, at the same time, I hope that, thanks to the selection of articles on a wide range of topics, prepared by an international group of authors, there will be something for everyone!

Readers interested in the HYPOSO project are invited to visit page twelve, where Ewa Malicka, President of the Polish Association for Small Hydropower Development (TRMEW), reports on the workshops on the framework conditions for the development of small hydropower projects organised within the HYPOSO initiative in Colombia and Uganda in February and March this year.

As the issue theme, we have chosen an article by Dr Klaus Krueger, Senior Expert for Power Plant Safety & Energy Storage in Voith Hydro, presenting the current challenges and the past and present needs for flexibility in the electricity market using PSP. The article reviews flexibility-enhancing technologies and compares configurations of reversible and three-machine power turbine sets. The author also described the flexibility improvements achieved when retrofitting existing PSP, using examples from Portugal, Austria, the USA, Wales, Germany and Luxembourg.

In the Law section, Dirk Hendricks, Secretary General of EREF, summarises the current political processes in the EU regarding decarbonisation and greater energy independence for Europe, which are important for small hydropower sector and particularly relevant from the perspective of operators and investors. However, while small hydropower, with its economic and energy benefits, opportunities, and development potential, could help achieve these goals, the European small hydropower sector remains on the political defensive, as evidenced by the, paradoxically, unfavourableproposals for legislative developments for the sector.

Another cover topic is the modernisation of the Żarki SHP, being an example of the current trend of replacing outdated, low-efficiency generation systems with new ones equipped with customised, automated hydro units. This case study with an interesting story is presented by Wioleta Smolarczyk and Łukasz Kalina, representing the IOZE hydro brand.

This issue also includes advice for designers on optimising the size of water intakes in hydropower plants. Considering long-term operation of hydropower plants and costs and revenues resulting from such operation, sizing a water intake by reducing the dimensions can allow significant savings of many millions of dollars. This issue is presented by Satyajeet Sinha, a project engineer from Larsen & Toubro Construction.

It is impossible to present all the articles of the issue in detail, but let me at least mention the other topics, which include: a summary of research and development work carried out by WTW Poland, the modernisation of the small hydropower plant Rechtenstein in Germany on the Danube, the commissioning of a small hydropower plant feeding the University of Notre Dame in Indiana, USA, using StreamDiver hydropower units to generate electricity, water retention in urban areas and a summary of this year's World Water Day.

I wish you a pleasant reading!

Michał Kubecki
Editor-in-Chief

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NEWS

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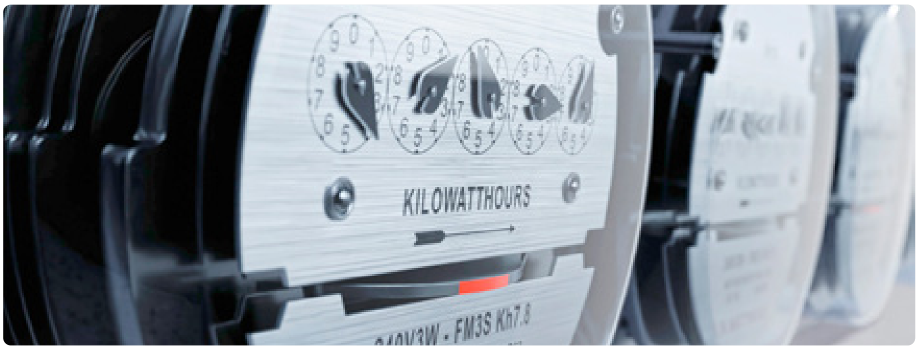
State-owned companies exempted from cap on revenues from RES energy sales

The government is opening the door to exempting certain state-owned companies from compulsory write-offs to the Difference Payment Fund when the law on investments in pumped-storage hydropower (PSH) plants is being processed. In the opinion of the Polish Photovoltaics Association (Polskie Stowarzyszenie Fotowoltaiki – PSF), this is yet another assault on the equality of doing business in the energy sector.



Źródło: Pixabay, Pixelharvester

A special law on investments in pumped storage power plants (PSP) is being worked on in the parliament. Its primary objective is to facilitate and accelerate the construction of such facilities, which are of key importance for stabilising the national electricity system.

The authors of the law, which originated in the Ministry of Climate and Environment, decided to push through regulations exempting certain state-owned companies from the restrictions imposed on renewable energy producers a few months ago, while the new regulations for the PSP were being processed.

Articles 40 and 42 of the draft law on the PSH plants are controversial. They allow an exemption from the obligation to pay a deduction to the Difference Payment Fund for entities generating electricity in RES installations that are 'owned, managed or operated by a state legal entity'. In addition, these provisions are to apply retroactively from 1 December 2022.

PSF reminds that, according to the legislation adopted at the end of 2022, electricity producers have to allocate part of their revenues to the Price Difference Payment Fund, from which the end-user support mechanisms implemented in recent months in a situation of record prices on the wholesale energy market are to be financed. Such a solution was made possible by the decision of the EU Council authorising such measures.

PSF emphasises that while, in principle, the costs of the measures indicated should be borne solidarily by all energy producers, the adoption of the proposed provisions contained in the PSH plants Act will clearly disrupt this solidarity.

In the opinion of Ewa Magiera, president of the PSF, the proposed regulations are inconsistent with the constitutional principle of equality and violate European Union law.

– The exclusion of electricity generators producing electricity in RES installations owned, managed or operated by a state-owned legal entity from the obligation to contribute to the fund is in our opinion, a breach of the Council Regulation (EU), which clearly states that emergency measures introduced by Member States should be, among others, proportional and non-discriminatory. And the proposed provisions are not such," comments Magiera.

PhD Magdalena Porzeżyńska of the law firm Brysiewicz, Bokina, Sakławski and Partners points out that the government's draft act on the preparation and implementation of investments in pumped storage power plants contains solutions that raise doubts as to the compliance with EU state aid law.

– The issue is the draft amendments to the so-called Energy Pricing Law, which exempt (retroactively) electricity generators in RES installations owned, managed or operated by a state legal entity from the obligation to pay a deduction to the Price Difference Payment Fund, notes PhD Magdalena Porzeżyńska.

PSF experts explain that the proposed regulations give preferential treatment to state-owned legal entities, i.e. the broad group of entities indicated in Article 3 (1) of the Law on Principles of State Property Management. And preferential treatment of certain generators by exempting them from the said obligation may qualify as state aid. This, as a rule, is prohibited by EU law under Article 107 (1) TFEU.

Such aid can only be deemed permissible by the European Commission after it has been notified by the member state. Aid granted in violation of the notification obligation is subject to repayment, unless it succeeds in subsequently justifying its compliance with EU regulations allowing the support to be deemed permissible.

The association stresses that similar doubts were raised by the Polish Parliament Legislative Bureau at the session of the parliamentary committee during which the draft law on PSH was discussed.

According to Dariusz Mańko of the PSF, the draft is another unfavorable solution for the RES industry in recent months introduced without adhering to the basic standards of the legislative process. It undermines business confidence in the state.

– No consultations were held, depriving not only entrepreneurs, but also public administration bodies and parliamentarians of the opportunity to analyze and evaluate the draft. Provisions raising numerous doubts after a cursory glance, of fundamental importance for the entire renewable energy industry, were "at the last minute" added to the project, whose primary goal is completely different – to simplify the PSH investment process, comments Mańka.

GRAMWZIELONE.PL

Editorial office
gramwzielone.pl

Modernisation of the Dębe Hydropower Plant at the halfway stage

The comprehensive modernisation of the Dębe Hydropower Plant, owned by PGE Energia Odnawialna of the PGE Group, has passed the halfway stage. Two of the four hydro-complexes have already been replaced, along with the electrical installation, ventilation and fire protection system. According to the schedule, the investment works, at the facility celebrating its 60th anniversary this year, will be completed by the end of 2024.

The modernisation of the Dębe Hydropower Plant will contribute to its failure-free operation, for the next at least 40 years, ensuring full automation of the hydro-assemblies, highest availability and reliability, and improved ergonomics of operation. When the work is completed in 2024, the power plant's electricity production will increase by 17 per cent to approximately 120 GWh per year. The capacity of the modernised hydropower plant will allow it to meet the energy needs of more than 50,000 households, i.e. a city the size of Bytom, says Marcin Karlikowski, CEO of PGE Energia Odnawialna.

The modernisation of the Dębe Hydropower Plant is a major engineering and logistical challenge. Among other things, two-tonne moving blades of the steering apparatus, a thirty-tonne turbine or an even heavier rotor of the generator are being removed with the help of cranes. In addition, much of the modernisation work is carried out underwater. With the cooperation of a highly specialised diving team, cavities in the concrete are being filled with injection repairs. In accordance with the project, the deepest hydrosets 4 and 3 in the machinery hall have already been replaced. In 2023 and 2024, similar work will be carried out on hydrosets 2 and 1 respectively.

By carrying out the modernisation, the Dębe Hydropower Plant will achieve numerous benefits. The operation of electrical and mechanical equipment will be centralised and automated, and the energy efficiency of the power station will be improved, as well as the use of environmentally friendly, biodegradable greases. Owned by PGE Energia Odnawialna, the Dębe Hydropower Plant has been in operation since 1963. It was built next to a water stage, comprising a 230-metre weir on the Narew River. The power station building is part of the water dam structure. Its underground part consists of two reinforced concrete blocks, each with two Kaplan turbine hydro-complexes with a rotor diameter of 4.8 m, coupled to generators of 6.25 MVA each. The above-ground part includes: a machinery hall with process rooms, control room, low-voltage switchgear.

Source: PGE EO

Photo. Dismantling of the old hydropower unit

The power station is connected to the National Electricity System by five 110 kV lines through two block transformers with a capacity of 16 MVA each, and its installed capacity is 20 MW achieved with a drop of 5.7 m and an installed turbine throughput of 428 m³/s.

Press office
PGE EO

Market consultation for the supply of large-scale energy storage Żarnowiec

PGE Polska Grupa Energetyczna is preparing to start a tender procedure for the supply of a large-scale energy storage facility called BMEE Żarnowiec with a capacity in the range of 205–269 MW in Kartoszyno. Located in the neighborhood of the country's largest pumped storage power plant Żarnowiec, the project will also be the largest battery-based energy storage facility in Europe. Its capacity will be approximately one thousand megawatt hours (1,000 MWh).

The PGE Group is preparing to launch a procurement procedure for the supply of an energy storage facility in Kartoszyno, together with power output, under the competitive dialogue procedure. This mode will enable PGE Group to formulate its needs in a way that is achievable by bidders. The planned purchasing procedure is due to the fact that at the end of 2022, the purchasing procedure conducted as an open tender was cancelled due to a lack of offers. In addition, prior to the launch of the competitive dialogue, PGE invites interested contractors to preliminary market consultations aimed at preparing optimal conditions for the launch of the competitive dialogue. The implementation of the large-scale energy storage facility BMEE Żarnowiec will allow for the provision of regulatory system services to the Transmission System Operator, as well as for the balancing of local onshore wind farms and future PGE wind farms in the Baltic Sea, planned for power output in the neighboring Choczewo 400 kV grid node. Potential revenues for the planned installation will also be generated from the power market and price arbitrage.

Press office
PGE Group

Modernisation of Gubin Hydropower Plant begins

PGE Energia Odnawialna has signed an agreement for the modernisation of the Gubin Hydropower Plant. Among other things, two hydropower units will be replaced at the facility by the end of March 2024 and a third will undergo a major overhaul.

Thanks to this investment, the Gubin Hydropower Plant will be able to operate faultlessly for the next 40 years, increasing its production capacity by 10 per cent from the current 3634 MWh to around 4,000 MWh. This will enable it to meet the electricity needs of around 2,000 households. The modernisation of the hydropower plant will be carried out in several stages. Firstly, the Hz 3 and Hz 2 hydrosets will be replaced along with the entire technological facilities. Next, the Hz 1 hydro set will be modernised, including: wicket gate mechanism, runner, support and main bearing, control system and generator. HP Gubin is one of the oldest hydrotechnical facilities in Poland. It was built together with a water barrage in 1905 in the riverbed of the Nysa Łużycka River. It has three hydropower units with a Kaplan turbines with a total capacity of approximately 1.1 MW.

"Modernisation of the technological equipment of HP Gubin" benefits from a grant worth PLN 6 million received from Iceland, Liechtenstein and Norway under the EEA funds. The aim of the "Environment, Energy and Climate Change" programme is to mitigate climate change and reduce vulnerability to climate change.

Press office
PGE EO

"Energy for rural areas" programme launched

The first edition of the "Energy for rural areas" programme, under which farmers and energy cooperatives will be able to apply for funding for RES installations, has been launched on 25 January 2023. The programme has been prepared in cooperation between the Ministry of Agriculture and Rural Development and the Ministry of Climate and Environment. Its details were presented on 18 January 2023 by Deputy Prime Minister, Minister of Agriculture and Rural Development Henryk Kowalczyk, Minister of Climate and Environment Anna Moskwa and Deputy President of NFOŚiGW Artur Michalski during a press conference.

Source: IOZE hydro

Photo. SHP Brudnice

The programme is an opportunity for a significant energy transition in rural areas. We want this to happen in a sustainable way – without restricting the development of agricultural production and food production. We want RES investments in rural areas to have a local dimension, to use locally available resources and to respond to local needs.

The implementation of the programme will increase the availability of RES investments for farmers and all those interested in cooperating within the framework of energy cooperatives. This form will be conducive to benefits for the Polish countryside, the same as those enjoyed by, among others, energy enterprises which implement RES investments. This means additional income for farmers and, at the same time, a reduction in the costs of obtaining energy by rural residents," stressed Deputy Prime Minister Henryk Kowalczyk. As the head of the Ministry for Climate and Environment, Anna Moskwa, highlighted, recent months have shown how important energy independence is for Poland and Poles.

– We are dealing with an unprecedented situation relating to Russia's aggression against Ukraine. It also has significant economic consequences for each of us, regardless of where we live or what we do. Therefore, in order to support the rural population, the Ministry of Climate and Environment, together with the Ministry of Agriculture and Rural Development, has prepared the programme "Energy for the rural areas" – she said.

– The total budget of the Energy for Villages programme is PLN 1 billion. The first call for proposals started on 25 January and will last until 15 December. The budget for this call is PLN 100 million, added Minister Anna Moskwa.

Support under "Energy for rural areas" can be disbursed in the form of a grant or a loan. Grant applicants can apply for a maximum subsidy of PLN 20 million, while those seeking a loan can apply for a maximum amount of PLN 25 million. The subsidy will come from the Modernisation Fund.

Beneficiaries of the programme are not only farmers. Energy cooperatives – those just being established as well as existing ones – and their members will also be able to apply for support. In the case of subsidised photovoltaic or wind turbine installations, it is possible to apply for a loan of up to 100% of the eligible costs, and in the case of biogas plants and hydropower plants, it is also possible to apply for a grant of up to 65% of the eligible costs. The capacity of an investment including the construction of an SHP should be between 10 kW and 1 MW.

Press office
Ministry of Agriculture and Rural Development

Ostrowiec Świętokrzyski protected against flooding

Polish Waters has increased the safety of the residents of Ostrowiec Świętokrzyski and Bodzechów. A comprehensive flood protection system, of which four polders are the main element, has significantly enhanced the protection of more than 2,000 people in an area of nearly 200 hectares against the effects of flooding caused by torrential rains.

Source: Marshal's Office of the Świętokrzyskie Voivodeship

The creation of a flood protection system is an important investment in the Świętokrzyskie Voivodeship, eagerly awaited by the local community. Thanks to the work carried out, it will be possible to retreat surge waters (including flood waters) caused by torrential rains. The investment will also improve flood safety in the catchment area of the Modła River and the tributary from Mychów. The following works were carried out as part of the task:

- construction of 4 dry retention reservoirs, with damming baffles equipped with bottom drains. The purpose of the reservoirs is to fully absorb and retention outflows caused by heavy rainfall. Reservoirs 1 and 2 are located in Mychów-Kolonia, reservoir number 3 is located in Mychów, and reservoir number 4 in Szwarszowice,
- regulation of the Modła riverbed at km 8+666 – 8+871 for the length of 205 m, including desludging, deepening and insurance of embankments, in Mychów-Kolonia,
- regulation of the inflow from Mychów at km 0+000–0+084, 84 m long, including desludging, dredging and insurance of embankments in Mychów-Kolonia,
- reconstruction of two culverts on the Modła River at km 7+918 and at km 8+837 in Mychów-Kolonia,
- raising the left embankment of the Modła River at km 0+012–0+328 over a length of 289 m with a 0.5 m high retaining wall on the side of the embankment, in the Ostrowiec Świętokrzyski.

The task also has a pro-environmental dimension. By reducing the erosion of the riverbed and the amount of pollutants discharged into the river, the level of water quality will increase. Damage to the natural environment will be reduced, resulting in fewer negative changes to the landscape, agricultural infrastructure and hydrographic network.

The investment amounted to more than PLN 14 million. 85% of this amount was covered by the European Union as part of the Regional Operational Programme of the Świętokrzyskie Voivodeship under: Action 4.1, "Counteracting the effects of natural disasters and removing their consequences" Axis 4, "Natural and cultural heritage" of the Regional Operational Programme of the Świętokrzyskie Voivodeship 2014–2020.

Press office
State Water Holding Polish Waters

Replacement of turbines at SHP Mylof

State Water Holding Polish Waters is preparing for the modernisation of the power station located at the Mylof water barrage (Pomorskie Voivodeship). An agreement has already been signed with the company that will act as a contract engineer.

The task of the contract engineer is to prepare the tender documentation, participate in the procedure for the construction work ("design and build") and supervise its proper execution.

The Mylof water barrage was built in the 1840s. It is a heritage site and is located on the Brda, about 8 km below the outflow of this river from Dybrzyk Lake. Its main components are a dam, main overflow and weir and a 0.8 MW hydropower plant. The water barrage provides flood protection for almost 5,500 hectares of land used for business and agriculture. Located at the Mylof water barrage, the small hydropower plant will be equipped with new turbines with high energy efficiency, which will allow the optimal use of water flows. This and the elimination of problems associated with the failure rate of the ageing equipment will lead to an increase in the production of clean electricity.

According to Polish Waters, the investment will increase the use of the historic site's hydropower potential, while increasing the share of renewable energy sources and reducing air pollution is an important element in the implementation of the EU's 2030 climate and energy policy framework.

Łukasz Madej
inzynieria.com

Polish Waters will modernise the power station on the Oder River

Polish Waters is preparing for the modernisation of the Rogów Opolski small hydropower plant. A contract with a contract engineer has already been signed.

SHP Rogów Opolski is located on the Oder's Rogów water barrage (Opolskie Voivodeship). The plan is primarily to modernise the hydro turbine unit. The contract engineer's tasks will include the preparation of tender documentation, participation in the procedure for the general contractor ('design and build') and supervision of the correct execution of construction works.

Utilising the potential of the SHP Rogów Opolski is expected to result in, among other things, a reduction in air emissions, which is part of EU climate and energy policy. In addition, problems resulting from the deteriorated technical condition of equipment and its high failure rate should come to an end. The project will also increase security of energy supply. The total cost of the project is more than PLN 8.5 million. Everything is expected to be ready in April 2024.

Łukasz Madej
inzynieria.com

New fish ladders in Nowy Sącz

The first stage of renaturalization of the Kamienica Nawojowska River in Nowy Sącz has been completed. Thanks to the reconstruction of the existing water barrages, the free fish migration was made possible, improving the condition of the river ecosystem.

State Water Holding Polish Waters in Kraków has completed the investment task entitled "Restoring the permeability and protection of the Kamienica Nawojowska River in Nowy Sącz with key measures to eliminate barriers for fish", which consisted in the reconstruction of three water barrages – the second, third and fifth – counting from the mouth of the Kamienica to the Dunajec River. As part of the restoration work, fish ladders were constructed:

- for water barrages two and three, a stone ramp with a bypass and central fish migration channel,
- for water barrage five, a vertical slot fish ladder.

Source: Maciej G.Szling, www.szling.com

Photo. Fish ladder for water barrage no. two under construction

The task carried out by Polish Waters is aimed at improving the ecological condition of the flowing waters of the Kamienica Nawojowska and restoring the coherence of the Natura 2000 network by unblocking facilities that are an obstacle to the migration of fish and other aquatic organisms. Upon completion of the works, fish migration monitoring will be carried out by Polish Waters together with the District of the Polish Angling Association (Polski Związek Wędkarski) in Nowy Sącz. The value of the works amounted to over PLN 20 million. Funding in the amount of PLN 10 million came from the Operational Programme Fishery and the Sea, of which the share of European Union funds is about PLN 7.5 million. Another PLN 11 million was secured from the own resources of Polish Waters.

Press office
State Water Holding Polish Waters

TRMEW news

35 years ago, a group of crazy and incredibly courageous people decided that they would do everything in order to create good opportunities for the development of small hydropower in Poland. This is the moment when the beautiful history of the Polish Association for Small Hydropower Development (TRMEW) started. It's hard to believe, but YES! In this year our Association celebrates its 35th birthday!

Over these 35 years we have together built a vibrant organisation. Thanks to our persistence, reliability and consistency, many beneficial regulations, which have developed small hydropower in Poland, have been implemented. What is more, we are very lucky that TRMEW members are extremely hard-working, well-organised and highly loyal! Many people in our group have been with the Association from the beginning. Some people have created truly beautiful friendships here. Dear all colleagues, you are wonderful! It is thanks to your contribution that it all works so well. However, the last 35 years are just the beginning! We are growing and no one can stop us anymore. We have broken down a lot of walls and trodden a lot of paths that today lead us to improved functioning of small hydropower plants. We still have a lot to do, but we know what our needs and problems are, and we know how to fight for them. Together.

I will say it again- a magnificent 35 years are over, and this is the perfect opportunity to celebrate. The nearest possibility for this is the General Assembly of TRMEW members, which will be held on 15 June this year in Kielce. This this year's General Meeting is an election convention, during which TRMEW members will elect new members of the Association bodies for the next three-year term. Detailed information will be sent in the TRMEW's newsletter and published on our social media.

I would like to write only happy and positive news, but this is not always possible.

It is with great sadness and regret I announce that Mr Jan Wieczorek, President of the TRMEW from 2001 to 2005, has passed away on 8 April this year. This is an irreparable loss to us all. To his family and friends we offer our sincere condolences and deepest sympathy.

Monika Grzybek
TRMEW office manager

Calendar

16–18.05.2023 Poznań, Poland	**GreenPOWER 2023** Organizer – MTP Group	www.greenpower.mtp.pl/en
5–6.06.2023 Gdańsk, Poland	**11th Edition of National Energy Summit OSE GDAŃSK 2023** Organizer – European Business Center	www.osegdansk.pl/en
5–7.06.2023 Shanghai, China	**Aquatech China 2023** Organizer – RAI Amsterdam	www.aquatechtrade.com/china/
21–22.06.2023 Astana, Kazakhstan	**7th Annual International Congress and Exhibition: Hydropower Central Asia and Caspian** Organizer – VOSTOCK Capital	www.hydropowercongress.com/
5–7.09.2023 Mexico City, Mexico	**Aquatech Mexico** Organizer – RAI Amsterdam	www.aquatechtrade.com/mexico/
11–12.09.2023 Rzeszów, Poland	**VIII Scientific Conference Energy Security Pillars and Development Perspective** Organizer – Ignacy Lukasiewicz Institute for Energy Policy	www.instytutpe.pl/
12–15.09.2023 Chorzów, Poland	**XX Technical Dam Control International Conference** Organizer – Warsaw University of Technology	www.tkz.is.pw.edu.pl/
27–29.09.2023 Rytro, Poland	**XXXI Technical and Science Conference Design & Exploitation of Electrical Machines & Drive** Organizer – Łukasiewicz – Górnośląski Instytut Technologiczny	www.komel.katowice.pl/tekst/pemine.html
16–18.10.2023 Edinburgh, Scotland	**HYDRO 2023** Organizer – Aqua~Media International	www.hydropower-dams.com/hydro-2023/

MAVEL

Mavel, a.s. is a global manufacturing and engineering company that specializes in the supply of hydro turbines and related technologies for hydropower plants from 30 kW to 30+ MW. Mavel has its own research and development department and is able to meet the demands of customers from all over the world.

Mavel offers following types of hydro turbines:

- Kaplan
- Francis
- Pelton
- Micro

The company Mavel was founded in 1990 and since then has already installed more than 500 turbines for 340 hydropower plants in 44 countries worldwide on five continents. Mavel is ISO 9001:2015, ISO 14001:2015, ISO 3834-2:2021 and ISO 45001:2018 certified company. All turbines are designed and manufactured in own production facilities in the Czech Republic.

Mavel offers complete services:

- Engineering, Manufacturing
- Refurbishments and Repairs
- Assembly
- Quality Control
- Electrical Equipment
- Installation and Commissioning
- Performance Tests
- Warranty and After Warranty Service
- Maintenance and Repairs
- Spare Parts Delivery
- Diagnostics of Equipment Condition and Defects
- Measurement

Mavel is among the world leaders in the supply of low-head Kaplan turbines, which are realized in all variants. The largest low-head horizontal turbines produced at Mavel so far have a runner diameter of 4500 mm. Most low-head turbines are installed in Poland and the Czech Republic. Mavel is also an important exporter mainly to the USA, Canada and Japan, but also to European and Asian countries

www.mavel.com

From Around the World

09.01.2023 Baihetan project fully operational in China

The 16 GW Baihetan hydropower project in China is fully operational, with the no 9 generating unit – the last of the facility's 16 x 1 GW generating units – having been placed into operation on 21 December 2022. The operation is seen as a milestone for China's clean energy drive. The project can generate 62.4 billion kWh of electricity a year, enough to meet the annual electricity needs of approximately 75 million people while saving approximately 19.68 million tonnes of standard coal and reducing CO_2 emissions by approximately 51.6 million tonnes. The Baihetan hydropower project, located downstream from the Jinsha River on the border of Yunnan and Sichuan provinces in southwestern parts of China, transmits electricity from the resource-rich west to energy-consuming regions in east China, contributing to the utilization of clean energy targets of the country.

10.01.2023 RWE completes megabattery that will link to hydropower sites in Germany

RWE has completed installation of Germany's first megabattery, with 420 blocks of lithium-ion batteries with a total installed capacity of 117 MW installed at RWE power plant sites in Lingen (Lower Saxony, 49 MWh) and Werne (North Rhine-Westphalia, 79 MWh) at a cost of around €50 million. What makes the new battery storage system special is its virtual connection with RWE's run-of-river power plants along the Moselle River. By selectively regulating the flow rate at these plants, RWE is able to provide additional power as balancing energy. As a result, the total capacity of power available for grid stabilisation in this system increases by up to 15%.

13.01.2023 Large dams face around 26% loss of storage by 2050 says new research

Large dams worldwide have lost an estimated 13% to 19% of their combined original storage capacity as a result of trapped sediment, with that number set to rise to 23% to 28% by 2050, new UN research warns. The report – Present and Future Losses of Storage in Large Reservoirs Due to Sedimentation – says that global loss from original dam capacity foreseen by mid-century – from ~6,300 billion to ~4,650 billion m³ in 2050 – roughly equals the annual water use of India, China, Indonesia, France and Canada combined. For the research, the United Nations University's Canadian-based Institute for Water, Environment and Health applied previously – determined storage loss rates in various areas worldwide to large dams in 150 countries to forecast cumulative reservoir storage losses by country, region, and globally. The UK, Panama, Ireland, Japan and Seychelles will experience the highest water storage losses by 2050 – between 35% and 50% of their original capacities – the study shows. By contrast, Bhutan, Cambodia, Ethiopia, Guinea, and Niger will be the five least affected countries, losing less than 15% by mid-century.

17.01.2023 Komatagawa New hydro plant begins commercial operation in Japan

Mitsubishi Materials Corporation has commenced commercial operation of the 10.326 MW Komatagawa New power plant, the first new hydroelectric power plant in Japan's Akita Prefecture for 69 years. Komatagawa New Power Plant was planned and constructed in order to increase the power supply through efficient operation of the Komatagawa no. 1, no. 2 and no. 4 Power Plants on the Komata river water system centered on Moriyoshi Dam. By efficiently taking in water previously released as unused energy, the power generation capacity of the Komata river water system is increased by 2,860 kW, enabling an increase in annually generated power of approximately 13,400 MWh. With the completion of Komatagawa New Power Plant, use of the Komatagawa no. 1 and no. 2 were discontinued in October 2022. The Komatagawa New Power Plant takes water directly from the outlet of the Komatagawa no. 4 Power Plant directly under Moriyoshi Dam and transfers it through the 8.5 km headrace tunnel to secure an effective head of about 90 m and generate 10,326 kW of power. All generated electricity will be supplied using the feed-in tariff (FIT) scheme for renewable energy.

28.02.2023 Opportunities identified for hydropower production at Anson's Paradox Lithium project

The installation of small-scale hydroelectric units could reduce carbon emissions, improve ESG credentials and reduce operating costs at Anson Resources Limited's Paradox Lithium Project, a study has found. The study was designed to identify opportunities to utilise the hydraulic power of brine flowing from the wells and utilise the energy generated by brine being transported to the production location, from the top to the bottom of a canyon – 330 m – to the processing plant. The results of the study indicated that small scale hydro power units could be installed to capture useable energy from both. Previous engineering studies indicated that the pressure of the brine at a depth of approximately 2000 m was measured and recorded as approximately 4,500 psi, and was sufficient to lift the brine to surface without mechanical pumping. It also indicated that the energy was not exhausted at the top of the well, as the pressure was measured at 1,700 psi at this point. The Worley hydro power energy study identified that each of the recovery wells could be connected to a small Pelton Pit Turbine to create hydropower. Based on the study and available information, up to 4 MW of power may be generated using small Pelton Pit Turbines. In addition, the Worley study identified that power may also be generated as the brine enters the lithium extraction and processing plant. A small powerhouse would need to be constructed to house the turbine and generator to produce up to 3 MW of power.

03.03.2023 New fish pass for Flumenthal hydropower plant, Switzerland

Alpiq has announced it is investing 10.5 million Swiss francs in a completely new fish pass at the Flumenthal hydropower plant, to fulfil the current standards for fish migration in the River Aare. The original fish pass at Flumenthal was built in 1970. In the original design, fish were able to overcome the difference in elevation between the headwater and tailwater of approximately 8 m, but this pass no longer meets modern requirements. Alpiq will now build a 480 m bypass watercourse which will ensure the upward migration of fish according to state-of-the-art science and technology. Construction work began in autumn 2022 and is scheduled for completion in late 2023. From the end of 2023, fish and other aquatic life will be able to overcome the weir at the Flumenthal in a largely near-natural watercourse. The watercourse consists of three different stretches: a natural watercourse with rapids, a longer ramp with boulders, horizontal slabs and individual basins in the form of a riffle channel, and a basin-like concrete vertical slot pass at the mouth.

06.03.2023 $3.7 million for hydropower R&D project that will strength trust with river stakeholders

The US Department of Energy (DOE) is investing $3.7 million for a project that aims to deepen relationships and trust between hydropower and river stakeholders to better incorporate community priorities in hydropower R&D activities. The investment, which is funded from the from the Bipartisan Infrastructure Law, seeks to expand collaboration on the dual goals of maintaining hydropower as a key source of renewable energy and preserving healthy rivers to support communities and the environment. Hydropower currently accounts for 31.5% of total US renewable electricity generation and about 6.3% of total U.S. electricity generation.

06.03.2023 EBRD funds hydro modernisation in the Kyrgyz Republic

A project to modernise the 7.6 MW Lebedinovskaya hydropower plant – the largest of its kind in the Kyrgyz Republic – is to receive €13.8 million in funding from the European Bank for Reconstruction and Development (EBRD). The funding package comprising an EBRD sovereign loan of €8.8 million and an investment grant of €5 million will go to Chakan GES, the state-owned hydropower operator of nine small hydro power plants, to help finance the rehabilitation and modernisation of Lebedinovskaya. Commissioned in 1943–48, the hydropower project's equipment is old, inefficient and urgently in need of replacement. The proposed improvements in productivity will help increase its annual electricity output by 56%, bringing it to 50,300 MWh. New efficiency and safety measures will also help the project improve its resilience to climate change and adapt to changing water flow levels.

21.03.2023 £100 million investment boost for Coire Glas pumped storage scheme in Scotland

The planned 1,500 MW Coire Glas scheme in Scotland is to receive a £100 million investment boost from developer SSE. Located on the shores of Loch Lochy, between Fort William and Inverness, the Coire Glas project is expected to require a capital investment of over £1.5 billion to construct and, if approved for final delivery, would be the first pumped hydro storage scheme to be built in the UK in 40 years. The project, which received planning consent from the Scottish Government in 2020, would also more than double Britain's total current electricity storage capacity – providing vital back up to an increasingly renewables-led system and bolstering energy security. SSE hopes to make a final investment decision on Coire Glas in 2024, subject to positive development progress and the prevailing policy environment, and to fully construct and commission the pumped storage scheme by 2031.

22.03.2023 Baime hydropower project was commissioned in Papua New Guinea

The 11.6 GW Baime hydropower project in Morobe Province in Papua New Guinea was commissioned in March. The project, which is able to produce 81 GWh of hydroelectric energy annually, is a part of PNG Power Limited's Fifteen Year Power Development Plan (2016–2031) which aims to replace energy production from diesel and fossil fuels with renewable hydroelectricity. The facility will power households and businesses, expanding access to electricity in the Morobe, Madang and Highlands provinces. The project has already created job opportunities and technical capacity building for many PNG nationals during design and project implementation stages. The project comprises a concrete weir connected to a 33 m high surge tank by 5 km long low-pressure headrace GRP pipeline. From the surge tank a 3 km long steel penstock connects with the surface power station. The power station houses two Pelton turbines with 5.8 MW installed capacity each.

HYPOSO – debating about framework conditions for the small hydro development in Colombia and in Uganda

HYPOSO is a research project, which has been featured several times in "Energetyka Wodna". It is funded by the EU HORIZON 2020 programme. 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 on framework conditions for the development of small hydropower projects in Colombia and Uganda held in February and March this year.

Photo 1. HYPOSO workshops in Medellín

One of the tools to achieve the project's objectives is to hold workshops on the framework conditions for hydropower (WFCs) in the target countries. Five workshops has been organised within HYPOSO one in each project target country. The intention of the organisers of these workshops was to present and discuss the framework conditions for the development of small hydropower plants (SHP) in the target countries and formulate ideas of 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. Following the WFCs organised in Cameroon, Bolivia and Ecuador in 2022, two further such events were organised in Colombia and Uganda, in 2023.

Workshop in Colombia

The WFC in Colombia was held on 28 February 2023 in Medellín. It was organised by the project partners TRMEW (Poland) and CELAPEH (Colombia) in cooperation with Antioqueña Society of Engineers and Architects (SAI). The workshop, taking place in Medellín's well-known meeting venue – Club Unión Medellín, brought together 45 participants. In the first part of the workshop HYPOSO project partners presented information on HYPOSO and its main tools, like HYPOSO Map and HYPOSO Platform. Carlos Velasquez (CELAPEH) presented the outcomes of the analysis of the framework conditions for hydropower in Colombia made within the project (the outcomes of the analysis were described in "EnergetykaWodna" issue 3/2022) and Beatrice Baratti Frosio Next gave an overview on the three selected pilot sites (Aurra, Colibrì and Palace HPPs), for which prefeasibility studies were elaborated.

The introduction was followed by the discussion panels on the actual situation and needs for SHP in Colombia as well as on the ideas how these needs can be met and how the development of SHP projects can be facilitated. Four discussion panels were organised, each one dedicated to issues related to one of the following specific stakeholders' groups:

- institutional (government, regulatory and environmental authorities),
- project owners and developers,
- electric utilities with SHP portfolio,
- European manufacturers and suppliers.

After the panel debates a plenary session, focused on barriers to SHP development and recommendations to eliminate them was organised. As a result, main barriers affecting SHP potential development were identified, most recurrent of which were:

- environmental license procedure is long and demanding (environmental authorities participants acknowledged and mentioned that reforms are under preparation),
- regulatory norms were developed for large hydro and are difficult to fulfil by small hydro. Once again, regulatory norms are under revision,
- as a result of the above, pre-feasibility studies for SHP are relatively higher than for large hydro and many project developers are reluctant to make required pre-investments,
- social concerns and community's opposition are growing rapidly, because of environmental and social impacts of large hydro plants, and communities hardly understand differences between large and small hydropower plants,
- SHP owners' budget for O&M capacity building is in many cases reduced or neglected, and frequent shutdowns and damages are the result of poor O&M personnel qualification,
- manufacturing and repair facilities for spare parts are scarce, and quite often spare parts must be imported, leading to shut down periods even longer,
- as consequence of the above shutdowns and damages, electricity generation and revenues decrease, in many cases to such a point where capital debt cannot be repaid, and power stations are abandoned,
- government authorities do not recognize the importance of SHP as a reliable and regular source of clean energy and give preference to other sources, mainly solar, wind a biomass. Therefore, fiscal incentives and financial resources are mainly allocated to such energy sources,
- solar, wind, and biomass (also large hydropower) enjoy strong support from powerful lobbies and industries to influence government policies according to their interests. This is not the case of SHP, which is regarded as the ugly duck of renewable energies family, without a lobby or organization able to bring SHP concerns to the government.

One of the activities intended to eliminate the above mentioned barriers suggested by the participants was creating a guild to represent the SHP sector as it has been done for other renewable technologies' sectors. With that in mind, CELAPEH launched the idea of a Colombo-European Association for SHP, aimed to strengthening cooperation among European and Colombian SHP stakeholders (as a follow up of HYPOSO main objective) and join efforts to become a strong voice on behalf of SHP. A survey conducted among workshop participants showed that a large majority liked the idea, and CELAPEH is committed to take the lead on the efforts to shape and create the association.

Workshop in Uganda

The WFC in Uganda was held on 15 March 2023 in Kampala, the capital of Uganda. It was organised by the project partners TRMEW (Poland) and HPAU (Uganda). The workshop, taking place in – Africana Hotel & Convention Centre, brought together 49 participants ranging from developers, government agencies, private sector actors, participants in the capacity building courses, consumers and the media.

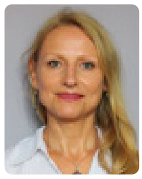
A Chief Guest, Elizabeth Kaijuka Okwenje from the Ministry of Energy and Mineral Development (MEMD) gave a brief update on the hydro power status in the country. She expressed the will of the Government of Uganda to encourage private developers, as enshrined in the Energy Policy, National Development Plan III and Vision 2040, to increase access to clean energy. She then appreciated the HYPOSO project for all the support rendered so far to the local developers, especially the three pilot sites identified. In conclusion, she expressed the need to have a successor project when the HYPOSO project ends, so that the identified pilot sites could be nurtured through the construction up to commissioning phase. The opening remarks were followed by the presentation on the general information about the HYPOSO project. Next, D. Marlone presented about the main outcomes of the analysis of the framework conditions for hydropower in Uganda (described in "Energetyka Wodna" issue no 3/2020). Next, B. Baratti gave an overview on the three selected pilot sites (Cheptui, Kibaale and Mihunga HPPs), for which prefeasibility studies had been elaborated within HYPOSO tasks.

Then, further outcomes of the HYPOSO project were presented: the HYPOSO Map and the HYPOSO Platform. Next, two presenters shared their views about the state of SHP in Uganda and its role in transition to clean energy from the perspective of state policy and a consumer advocacy group. This was followed by the last two presentations on barriers and experiences in SHPs development from the point of view of the private sector and the public sector.

This part was followed by the discussion on the actual situation and needs for hydropower in Uganda. The main points of the discussion were then summarized by E. Malicka. She highlighted:

- the financing issue, in particular the problem of the financial capacity of the Ugandan site owners/developers to meet the financial requirements;
- need of local expertise on HPP designing;
- lack of infrastructure to deliver electricity generated in planned SHPPs to the power grid leading to risk of non-bankability of projects;
- need of outcomes from feasibility studies to be shown to HYPOSO pilot projects developers;
- scarcity of in-depth information to develop sites identified in the HYPOSO Map and the need of continuation of HYPOSO;
- prohibition by the electricity regulator to proceed with a few projects at the same time and necessity to complete one project before applying for another;
- the problem of time-consuming procedures to obtain permits while other permits expire and need for regulatory bodies to communicate to each other or need for a one-stop shop for HP development;
- need to engage government to provide solutions to overcome the barrier mentioned above and need for representation of HP developers on government consultative forums as well as the need for representation of government at hydropower sector's events.
- lack of knowledge and/or information by applicants to develop hydropower projects and mistakes made by them in applications;
- impacts of climate change and need to regularly update the HYPOSO Map;
- need for insurance cover for HP projects.

Photo 2. HYPOSO workshops in Kampala



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

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

Kopice small hydropower plant (Poland)

Photo. 1. Power plant equipped with 6 horizontal tubular turbines with a rotor diameter of 1080 mm

Research and development works carried out at WTW Poland Sp. z o.o. between 2019 and 2021

The research and development project carried out by WTW Poland has resulted in development of a range of high-efficiency Kaplan turbines. The obtained results demonstrate that the hundred-year-old concept still has development potential which can benefit the owners of small hydropower plants undergoing modernisation as well as investors who are planning the construction of new power plants and are looking for modern and highly efficient solutions.

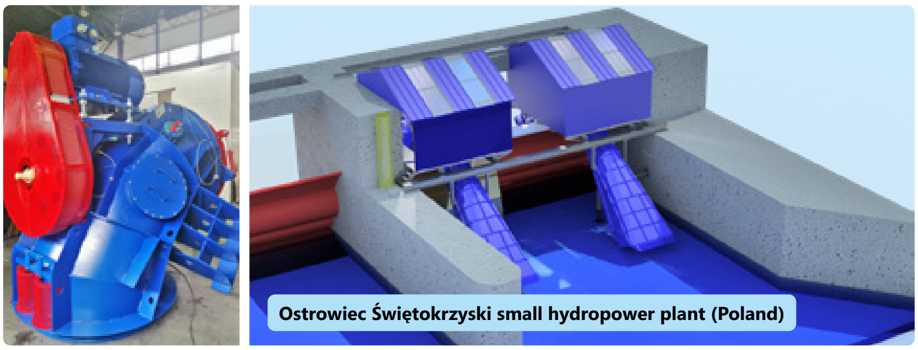
Our company has been supplying reliable solutions for the hydropower sector for many years. We specialise in Kaplan turbines, which we manufacture in multiple configurations. To meet customer expectations and improve the hydraulic efficiency of the offered devices, we have conducted research and development works, which have led to several new solutions being introduced into production. The completed project, titled "Development at WTW Poland Sp. z o.o. of high-efficiency Kaplan water turbines intended for low, medium and high heads", has greatly increased our company's potential. The project was co-financed by the European Union, under the Smart Growth Operational Programme 2014–2020, from the European Regional Development Fund; financing was awarded in the "Fast Path"

Morozzo I and Morozzo II small hydropower plants (Italy)

Photo. 2. Power plants equipped with S-type Kaplan turbines with rotor diameters of 730 and 780 mm

Pogliola small hydropower plant (Italy)

Photo. 3. Power plant equipped with a tubular turbine with a 3-blade rotor with a diameter of 950 mm



Ostrowiec Świętokrzyski small hydropower plant (Poland)

Photo. 4. Two Siphon turbines (Kaplan) with a four-blade rotors with a diameter of 1015 mm

Photo. 5. Four Z-type turbines with rotor diameters of 560 and 600 mm

Photo. 6. Four Z-type turbines with rotor diameters of 560 and 600 mm

competition organised by the National Centre for Research and Development.

Range features

Our goal was to develop a range of Kaplan turbines for heads of up to 24 m, with efficiency of at least 90% at maximum flow rate:

a) turbines with axial guide vanes and three-blade rotors for heads of up to 5 m,
b) turbines with axial guide vanes and four-blade rotors for heads of between 3 and 7 m,
c) turbines with axial guide vanes and four-blade rotors for heads of between 6 and 12 m,
d) turbines with radial guide vanes and four-blade rotors for open and/or spiral concrete chambers for heads of up to 12 m,
e) turbines with radial guide vanes and five-blade rotors for heads of between 12 and 24 m,
f) siphon tubular turbines with axial guide vanes and four-blade rotors for heads of up to 5 m.

Photo. 7. Turbine with a five-blade rotor with a diameter of 685 mm in a spiral

Despite the fact that the company's potential makes it possible to quickly design a turbine with any rotor diameter in any configuration, it was decided to develop ranges. They were developed and designed in such a way that the same models can be used for different types and different configurations of turbines.

Introduction into production

The completion of research and development works in the area of industrial works as well as development works made it possible to quickly introduce the new solutions into production. Many of our customers already have at their disposal turbines characterised by above-average efficiency parameters, which translates directly into increased production of green energy. Below is a presentation of the most interesting facilities which make use of the new flow systems. The presented turbines have already been put into operation. Implementing the results of the completed R&D works has enabled us to offer our customers turbines which ensure the maximum economic effect during their lifetime. The team of engineers at WTW Poland Sp. z o.o. is not resting on its laurels. We are preparing to develop Z and S turbines with five-blade rotors for heads of up to 24 m and turbines in a steel spiral with six-blade rotors for heads exceeding 30 m.

Eng. Grzegorz Wiszniewski
President of the Management Board
WTW Poland Sp. z o.o.

European Funds Smart Growth
Republic of Poland
NCBR National Centre for Research and Development
European Union European Regional Development Fund

Photo. SHP Buchsbaum, Austria
Source: Kleinwasserkraft Österreich

Current EU political processes with relevance for small hydropower

As the EU seeks to meet its renewable energy targets, small hydropower is increasingly gaining attention. However, navigating the EU political processes can be challenging for those in the industry. This article will explore the EU political landscape and its relevance for small hydro, providing insights into how the industry can engage with policymakers and shape future policies.

In response to high energy prices and energy security problems caused by Russia's invasion of Ukraine, the European Commission presented the REPowerEU plan last May. Among other things, it contains proposals for a faster increase in the share of renewable energies in order to quickly replace fossil fuel imports and reduce energy prices.

EREF's position is that in order to achieve the REPowerEU goals of decarbonisation and greater energy independence for Europe, all available forms of renewable energy must be used, both from the point of view of increased renewable energy production and better integration of the energy system. Although small hydropower, with its economic and energy benefits, opportunities and potential for expansion, could help to achieve these goals, the European small hydropower sector remains on the political defensive. With reference to the latest WWF Living Planet Report 2022, environmental organisations are denouncing small hydropower in broad-based political campaigns as environmentally harmful and irrelevant to the energy transition and are calling for a halt to expansion and the dismantling of plants.

Small Hydro should be included in RED

In the ongoing trilogue negotiations on the adaptation of the current Renewable Energy Directive (RED III and IV), these two positions are being intensively discussed. The EREF Small Hydropower Chapter successfully lobbied for (small) hydropower to remain eligible for so-called "go-to areas". These "go-to areas" – which should actually be called "acceleration areas" – are areas designated by governments in which a significantly accelerated and, above all, simplified approval procedure applies to renewables. Furthermore, in discussions with the trilogue negotiating team, EREF is opposed to the demand for further restrictions and tightening of the EU legislation that already comprehensively covers hydropower, especially the Water Framework Directive. The Renewable Energy Directive, which has as its objective the development and promotion of these types of energy, must not be used to hinder the continued existence and expansion of (small-scale) hydropower. EREF therefore strictly rejects the European Council's proposal to exclude hydropower from the provisions of the RED.

Faster permitting for Small Hydro

Already last year, EREF worked successfully to ensure that the negotiating positions of the European Commission and the European Parliament consider the expansion of (small-scale) hydropower to be in the overriding public interest and therefore also suitable for "go-to areas". In parallel, EREF, in cooperation with the Vienna University of Technology, showed in a study that significantly more ambitious 2030 targets for renewables and energy efficiency in the EU are feasible and, above all, economically beneficial. Then EREF introduced a final amendment to the ongoing negotiations. This amendment provides for the Commission to be mandated by the new Renewable Energy Directive to adapt European environmental legislation accordingly and to give priority to renewable energy. On 30 March 2023, EU legislators reached a provisional agreement on the Renewable Energy Directive (RED III) after a long 14-hour negotiation process.

The provisional agreement includes accelerated permitting procedures for renewable energy projects. The purpose is to fast-track the deployment of renewable energies in the context of the EU's REPowerEU plan to become independent from Russian fossil fuels, after Russia's invasion of Ukraine.

Member states will design renewables acceleration areas where renewable energy projects would undergo simplified and fast permit-granting process. Renewable energy deployment will also be presumed to be of 'overriding public interest', which would limit the grounds of legal objections to new installations. The next steps in this regard will be the drafting of a final text on the Renewable Energy Directive after the technical trilogue ended already before Easter, but a final text is not available yet.

Small Hydro to be included in NECPs

At the national level, small hydropower stakeholders should use the coming months to lobby ministries of environment, energy and economy for a strong inclusion and expansion of small hydropower in the second National Energy and Climate Plans (NECPs). These plans include national expansion targets and measures for achieving the EU-wide 2030 renewable energy targets. National governments submitted their first NECPs three years ago. According to EU regulations, they must be updated every two years until 2030. For the second version, many adjustments have to be made to the now new EU legislation, from which the small hydropower sector in particular can benefit.

As with the first NECPs, EREF and its members will analyse the governments' first drafts in summer 2022 and submit concrete proposals for improvement to the European Commission and national governments. The governments should then ideally incorporate these into the final version, which is scheduled for summer 2024.

Nature Restoration Law

Another important policy dossier is the new EU Nature Restoration Law, proposed by the European Commission in June 2022, which aims to protect and restore Europe's natural ecosystems. The proposal was announced as part of the EU Biodiversity Strategy and is the first significant addition to European environmental law in more than 20 years. Previously, the Habitats Directive, the Water Framework Directive and the EU Birds Directive as well as the designation of Natura 2000 protected areas were the main instruments of environmental protection. The aim is to strengthen existing EU nature conservation law and to include additional binding measures to restore habitats that have already been destroyed.

The Commission has presented the EU renaturation law in the form of a regulation. This means that it will enter into force in the Member States immediately after the conclusion of the negotiations in the European Parliament and the Council. Currently, the European Parliament is still negotiating its position. After that, the Commission, the Parliament and the Council will negotiate the final law in so-called trilogue negotiations.

Future challenges for EU Small Hydro

The final version of the law could have several impacts on the hydropower sector in Europe. First, it could restrict the development of new hydropower projects in certain areas, especially those considered to be of high ecological value. This could make it more difficult to obtain permits for existing plants and new hydropower projects. Second, the law is likely to require more stringent environmental impact assessments for hydropower projects, including consideration of impacts on ecosystems and biodiversity. This could lead to longer and more complex – and thus more expensive – authorisation procedures for new projects. Thirdly, the EU Restoration Act could require the decommissioning of existing small hydropower plants that are said to have significant negative impacts on ecosystems and biodiversity.

Overall, the impact of the EU Restoration Act on the hydropower sector will depend on the final version of the law and its implementation. EREF's role and objective is to organise meetings with decision-makers and rapporteurs to achieve the best possible outcome for the sector. While there may be some negative impacts, there may well be opportunities for the hydropower sector to invest in more sustainable and environmentally friendly projects.

Thanks to the support of its members, EREF is in contact with decision-makers in the European Parliament and the European Commission to make the voices of the hydropower sector heard on this important file.

Dirk Hendricks
Secretary General
European Renewable Energies Federation (EREF)

Photo 1. SHP Żarki currently
Source: Karolina Stefaniak

SHP Żarki, where history meets modernity

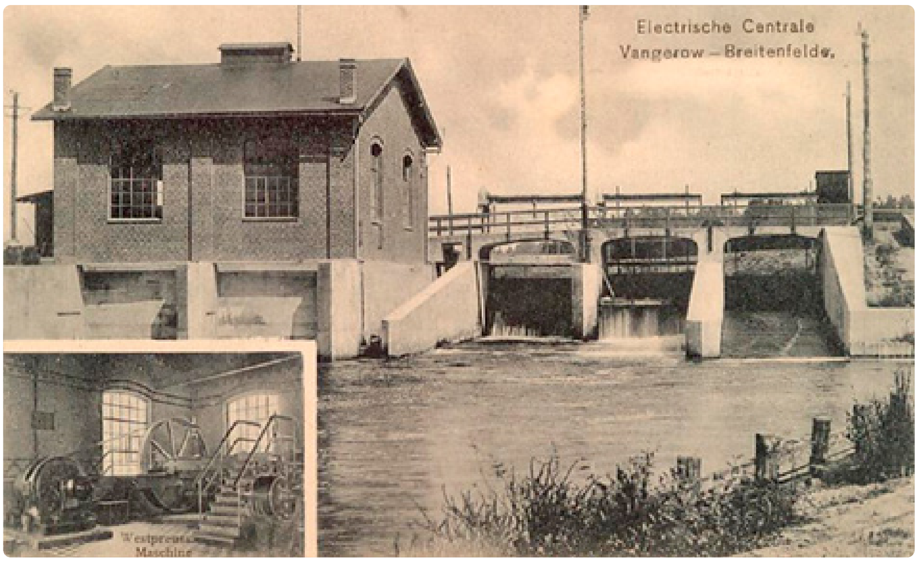
Replacing outdated, low-efficiency generation systems with new ones, equipped with tailor-made, automated hydropower units, is currently a strongly pronounced trend in the market of small-scale hydropower. The direct causes of this phenomenon are the favourable conditions for obtaining subsidies for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

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

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

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

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



Source: SHP Żarki archive

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

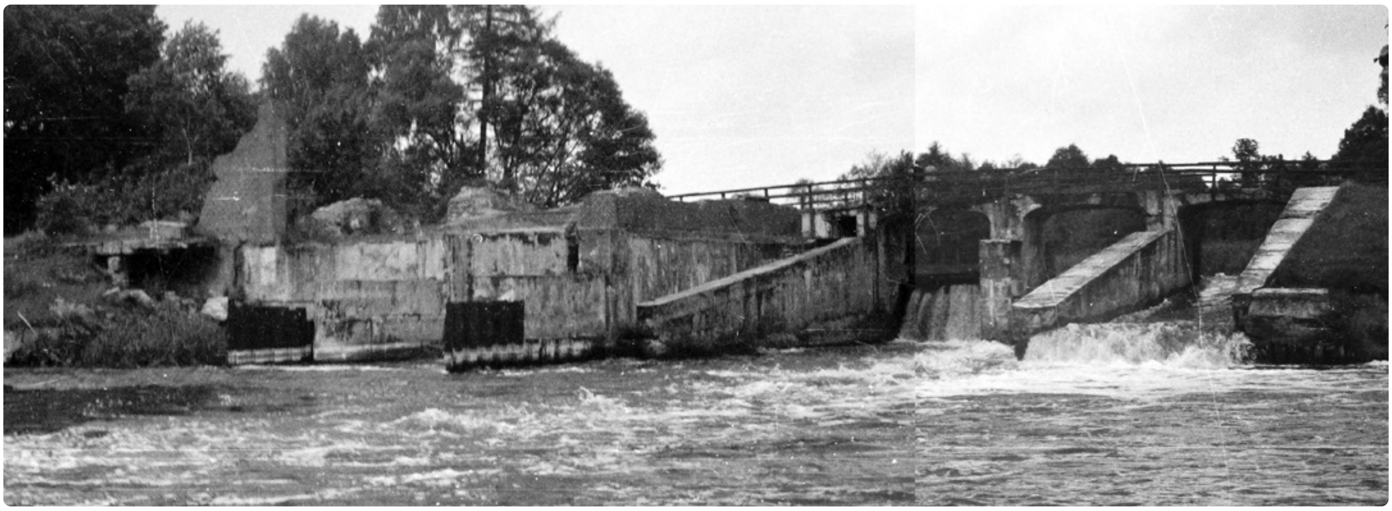


Photo 3. View of the weir and ruins of the SHP building (1980s)

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

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

Łukasz Linowski, construction manager:

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

Scope of the new investment

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

Source: IOZE hydro

Photo 4. Assembly of new turbines in the production hall

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

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

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

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

Advanced technology provides operational comfort

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

Sebastian Wites, chief automation officer at IOZE hydro:

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

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

Source: IOZE hydro

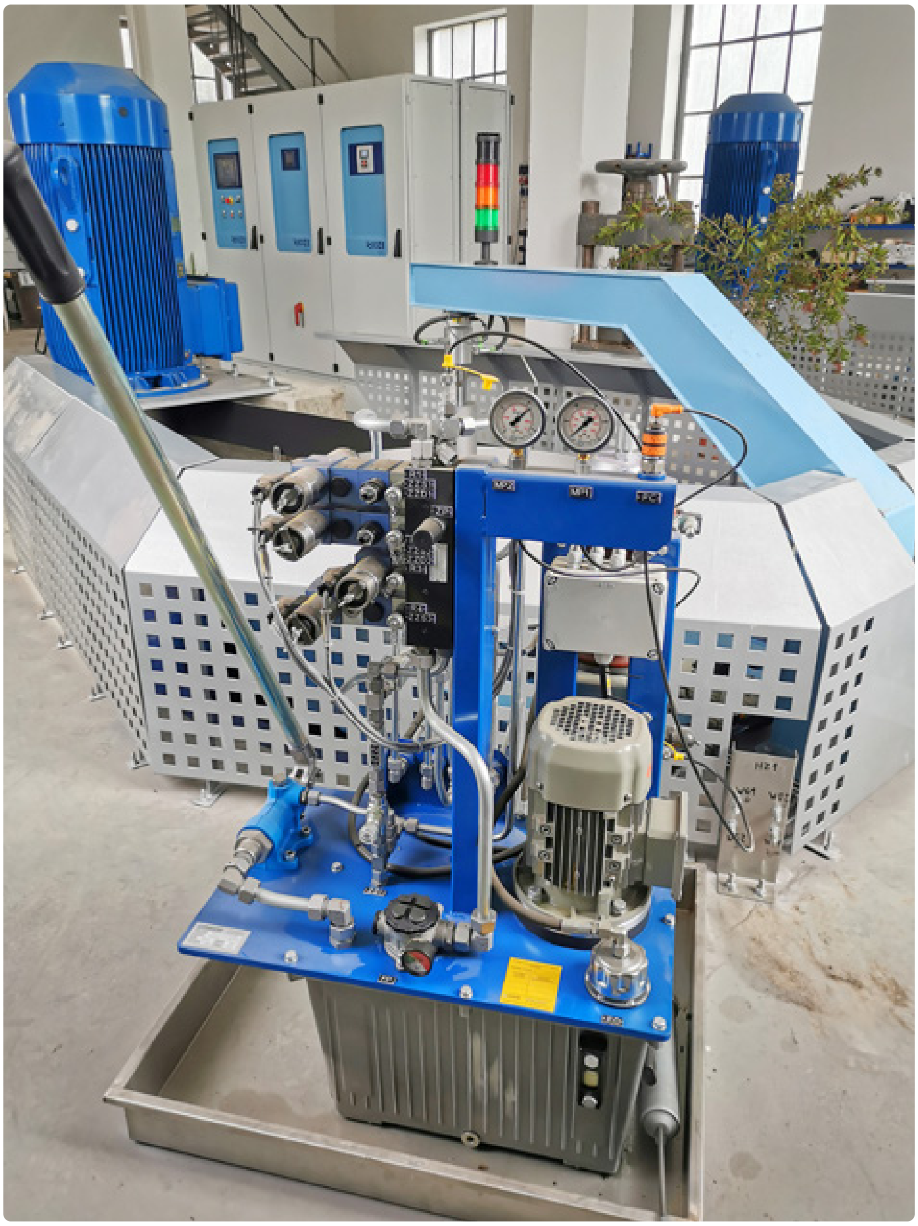


Photo 5. Interior of the machine hall after modernization

Source: IOZE hydro

Photo 6. New rotor with optimized parameters and old rotor

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

Olena Augustowska, co-owner of the facility:

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

Modernised facility in the new market reality

In the formal context and in the context of compliance with regulations on RES, carrying out the modernisation of the small-scale hydropower plant should not itself be treated as equivalent to obtaining a certificate from the Head of the Energy Regulatory Office confirming the possibility of participation in the new support system. A range of issues related to both the technical scope of the investment and the formal and legal requirements posed by the Act on RES and the Energy Regulatory Office impact whether the shape of a given investment will allow it to receive support. Also in this respect, the investor relied on the knowledge and experience of IOZE hydro experts, thanks to which the plant was included in the new support system with prices guaranteed for a period of 15 years (subject to indexation for inflation). This ensures the stability of the operation of the small-scale hydropower plant and allows for a return on capital expenditures incurred for the modernisation within the expected time. Additionally, the scope of work performed by the administrative and legal team of IOZE hydro covered obtaining the source of funding for the investment, which allowed for turning the plans into reality.

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

However, the reality facing the owners of existing small-scale hydropower plants is not fully constituted, which is linked to the numerous changes on the market. The increasing volatility of electricity prices caused by the mismatch between the supply and demand profiles of electricity, changes in the balancing market in the context of the temporary price collapse, including the emergence of negative prices in the near future, and the planned amendments to the RES act (i.a. clarification of the definition of modernisation of RES installations) will bring many complications in the planning and implementation of investments in small-scale hydropower plants. In order to make the right business decision it is necessary to provide up-to-date information of the right quality, covering many formal, technical, and market areas, so that a business model can be proposed that will deliver the highest possible value to investors, within the shortest possible period of return on investment. Therefore, services provided in the fully comprehensive model offered by IOZE hydro are gaining importance.

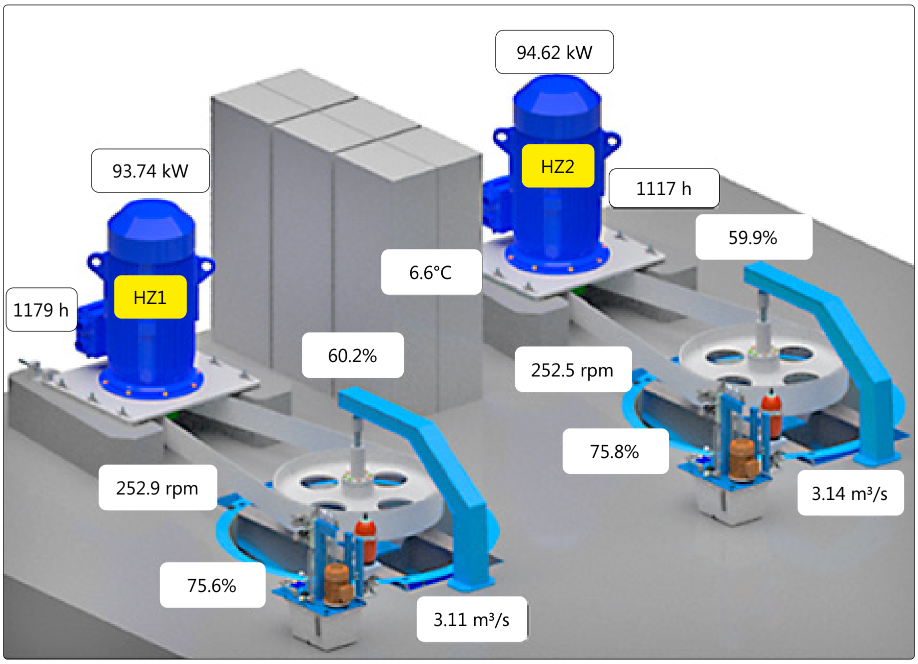


Fig. 1. View of the SCADA visualization system

Source: IOZE hydro

Wioleta Smolarczyk
Łukasz Kalina
IOZE hydro

The modernisation of SHP Rechtenstein on Danube River

The run-of-river hydroelectric powerplant Rechtenstein is located in south-east of the State of Baden-Württemberg Germany. Originally existed as a watermill during the Middle Ages, it had been many times repaired and re-modernised and becomes nowadays as one of the best examples small hydro powerplant to generate carbon free electricity while maintaining the migrating corridors for fish and ecological creatures on Danube River.

The weir "Rechtenstein" on Danube River was initially existed to run water-mill for grain-milling activities in a small rural area located in southern Germany. The first modernisation was carried out in early 1900s when the old historical water-wheels was replaced with sets of water-turbine machinery to generate mechanical and transformed into electrical energy. The generated electrical energy was then self-consumed for the operational of pulp and paper factory erected above the power plant.

From watermill to hydroelectric power

In year 1994 the paper factory was found inefficient and made redundant. The owner then converted the facility into a mechanical production workshop and the power plant started to feed all produced electricity into national grid. At the time being, the small hydroelectric power plant “Rechtenstein” operated three Francis turbines with synchronous generators generating approximately 1.8 MWh annually. To run these turbines at its full installed capacity of 130 kW each, the power plant required 27 m³/s and was utilising of approximately 1.5 to 2.3 m available head that is elevated by a 60 m long barrier across the river. The weir was built initially more than 120 years ago as a gravity structure, made from mixtures of stones, boulders and concretes that always repaired and replaster overtime to keep it partially intact to deal with the abrasive and sedimented Danube’s discharges. To elevate and to impound the waters, a row of wooden planks was built on the crest of the solid weir. Due to its condition the weir should be operated manually. During flood events its function was stretched far beyond its capacity. The upper wood planks should be removed manually in order to allow floods to over-

Salient Feature

Weir:

- 42 m width of concrete weir including 12 m long stilling basin
- Bypass / flushing channel 2.4 m (width) x 3.5 m
- Hydraulic Steel-Structure
- Fishbelly shaped radial gates 2 x 20 m (width) x 3.5 m
- Radial gate 2.4 m (width) x 3.5 m

Hydroelectric generation:

- Design discharges 36 m³/s, Head 1.5–2.3 m
- Three existing Francis turbines with synchronous generators
- 170 kW double-regulated Kaplan turbine with 200 kV asynchronous generator
- Electricity production 2.3 MWh/a.

Ecological passages:

- 16 basins (2.85 m x 1.90 m) Vertical-Slots
- Horizontal screen 24 m (width) x 2.4 m

Photo 1. Old weir during flooding (left), construction phase 2 (right)

top and to avoid water elevating on the upstream side of this barrier. This of course is crossing the health and safety acceptance while operating hydroelectric and hydraulic structure system.

Planning phases and project initiation

In year 2012 Dr. Hutarew & Partner was appointed to provide consultancy services to apply the license to rehabilitating this hydropower complex, to improving the performance of the existing hydro-electric power plant and to refurbishing all hydraulic structures that includes the weir itself. As it is as required by European Water Frameworks Directives, to apply such license to build and operate a hydropower plant, the ecological status of this HEP had to be elevated. Our first assessment also suggested the possibility to increasing electricity production by more than 25% by adding one set of turbine machinery while sustaining the existing three turbines' normal operation. For this purpose, an additional full Kaplan turbine with a design discharge of 9 m³/s was to be installed. This turbine will later run as the first starter among other existing three sets of Francis machinery. The ancient weir had also to be refurbished in order to improve the hydraulic performance to pass forward of about 500 m³/s maximum flood discharge. For this purpose, two movable fish-belly formed radial gates will be installed on the new concrete weir. These gates shall also regulate a constant water level as it is obligatory to do so, that also helps powerplant to maintain constant speeds for the mechanical and electrical generating systems. This measurement shall include the construction of hydraulic structures for weir, its bottom outlet and its stilling basins as well as the new construction works for the intake and outlet of new turbine's power channel. A construction of fish ladders with vertical-slots basins type will provide the required environment for the fishes to migrating from downstream to upstream stretches of the river. The arrangement of trash rakes and horizontal turbine screens had also to be optimised to avoid the fishes harming itself when drifting and migrating to other directions, from upstream to downstream. After approximately 3 years planning period that includes environmental and social assessment EIA studies, our client had been awarded the construction permits for the refurbishment the weir structures and the extension of the SHP. After the realisation of the project, its new concession to operate the SHP shall come into power.

Avoiding higher water levels during construction

The construction began as early in year 2015 in order to utilise the low water regimes in Danube River so the first half of the weir can be flooded before the coming wet season. During this first construction phase, water was diverted to the middle of the river bed using the coffer-dam made of sheet-piles, to allow the concreting works for the weir took place. Ancillaries such as middle pillar and stilling basin as well as its foundation with rows of 900 mm diameter bored-piles those also act as cut-off wall against seepage in the underground were carried out. After the completion of the concrete works, the first radial gate was mounted and fitted to the sill of the weir. The first flood timely arrived and passed through both on the right, already completed weir section and on natural river bed in the centre of river section. This provided the whole capacity of river section ready to pass forward the flood discharges. The second phase started in early Winter the same year. The waters then diverted to pass the right river section, so construction activities on the left river section that consisted of second weir section, fish ladders, new power channels for the 4th turbine as well as the installation of turbine screens were carried out simultaneously. After the civil works had been completed,

Services provided

- Turnkey Engineering from Feasibility Study to Detailed Engineering Design
- Baseline investigations, option and optimisation studies
- River System and Hydraulic Analysis
- Structural and Geotechnical Analysis
- Environmental and Social Impact Assessment
- Bid and Tendering Preparation for civil and hydromechanical works, electrical and mechanical equipment
- Project Coordination include communication for public and governmental hearing
- Project Management and Site Supervision
- Project's start-up, site testing, taking-over and commissioning of all project components (civil, mechanical and electrical works and equipment)
- Supervision during Defect Liability Period
- Legal frameworks to fulfil all requirement in accordance of EU Water Framework Directives, EEG (German Renewable Energy Law and Regulation) and WHG (German Water Management Act)

Photo 2. Installation of new Kaplan wheels (left); dry-test radial gates (right)

the installation of hydro-mechanical equipment took places. The new Kaplan turbine (runner's diameter = 1,900 mm) was installed in the power canal that is located nearby but separated from the main powerhouse. The construction of powerhouse building for the new turbines then progressed while the second radial gate (20 m width x 3.5 m height) was simultaneously installed, followed with the installation of the hydraulic-drives on both sides of the gates. Other hydromechanical items such as hydraulic vertical gates (2.4 m x 3.5 m) and horizontal turbine fine screening unit (24 m width x 2.4 m height inclined 65° to the ground concrete slab) were mounted, the turbines regulating and SCADA system was also upgraded, synchronised with the mechanical actuator control systems for all hydro-mechanical structures in the powerhouse and weir complex. The vertical-slots structure that strategically located in between the new powerhouse and gated weir was also completed and this provides the ideal passage for fishes migrating from downstream to upstream side of Danube River. In June 2017, weir refurbishment and power plant extension of SHP Rechtenstein were completed and an official inauguration took place in the following month.

After project commissioning and today situation

Today the SHP Rechtenstein is recognised as an example of good practise in operating a small hydropower plant. While it is operated fully automatic, it generates of approximately 2.3 million kWh/a carbon free electricity under the ecological and fish-friendly circumstance. The modern weir has improved its capability to regulate waters both in normal and high-water levels and reduces the risks of flooding significantly.

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Photos come from the archive of **Dr. Hutarew & Partner.**

A renown US-University chooses Voith Hydro's StreamDiver Units

In October 2022 the University of Notre Dame held a dedication ceremony for their new hydroelectric facility in South Bend, Indiana. Situated on the east side of the St. Joseph river beneath Seitz Park, the 2.5-megawatt facility harnesses the power of the river and is expected to produce about 7 percent of the electricity for campus and offset about 9,700 tons of CO_2 emissions annually.

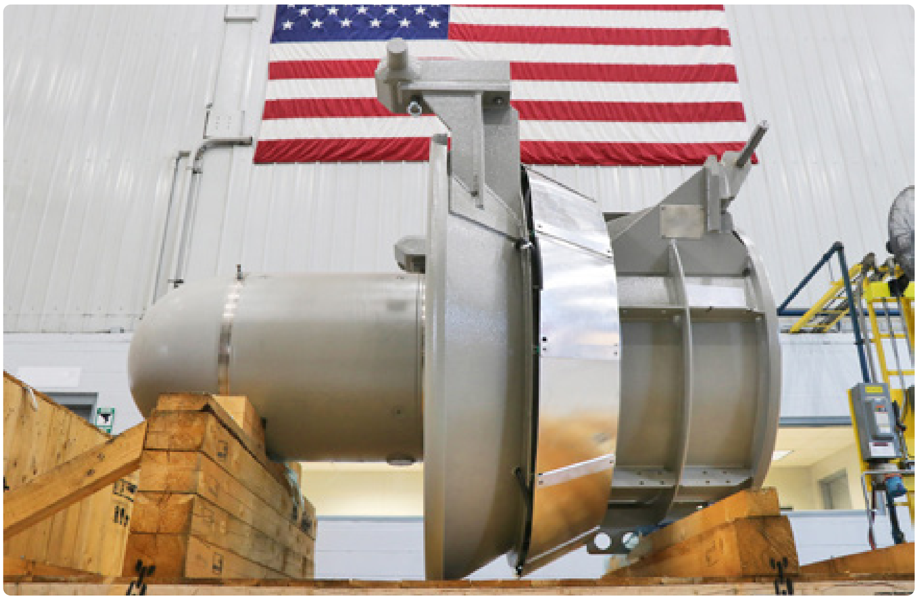


Photo. StreamDiver Unit

The initial idea to use the dam to generate hydroelectric power goes back to the 1980s. However, up until recently, reviving it was not financially feasible, and too complex. The University of Notre Dame and Voith Hydro needed to work with the Federal Energy Regulatory Commission, Indiana's Department of Environmental Management, Indiana's Department of Natural Resources, U.S. Fish and Wildlife, the U.S. Army Corps of Engineers, the city and neighbors to make this project happen. The StreamDiver turbines began delivering electricity to the University of Notre Dame in May of 2022.

Story of St. Joseph River

The 206-mile waterway was an important canoe route during pre-industrial times as well as an important source of food and raw materials. Its floodwaters helped to enrich the surrounding soil and contribute to bountiful crops. Later, with the construction of a concrete and timber crib dam and two raceways, it helped to power early industry, including glass and textile manufacturing. This continued into the 20th century, when the river was used to produce hydroelectricity for manufacturing and later cooling water for a coal-powered energy plant housed in the present-day Commerce Center. But as industry moved away from the river in search of cheaper and more abundant land, concern for the waterway as an economic asset – not to mention an environmental resource – faded, with devastating consequences. At the lowest point, it functioned as little more than an open sewer, channeling human and industrial waste downstream toward Lake Michigan. Over time, the east and west raceways were redeveloped, the former as a whitewater rafting course and the latter as a water feature for the city's new convention center. The dam became the focal point of a rejuvenated riverfront with parks, pathways and public art including River Lights, an interactive light sculpture.

Factory visit in Austria

On the beginning of the project, Paul Kempf, Notre Dame Assistant Vice President for Utilities and Maintenance and his colleagues came to Voith Hydro in Austria.

Photo. StreamDiver Units in the making

Technical details

Turbine type: **10 StreamDiver Units**
Manufacturer: **Voith Hydro**
Head: **3.17 m**
Flow rate: **9.90 m³/s**
Capacity: **0,255 MW per unit**

Using detailed assessments and based on the characteristics of the site, StreamDiver turbines were determined to be best suited for this project. Beside other characteristics of this turbine, Voith Hydro's comprehensive turbine development know-how and its references from all over the world were also decisive factors.

Automatic operation

Tucked neatly beneath Seitz Park, the facility consists of 10 turbines, each with a 250-kilowatt generator and a propeller type runner, stacked two-high across five shafts. Water from the intake tunnels turns the runner, activating the generator and pushing clean, renewable energy up the east bank of the river to campus. The water then flows back to the river at a point just below the dam.

From an operational standpoint, the facility is very much hands off. As water flows into the intake tunnels, it is filtered through a screen, or trash rack, to remove branches and other large debris. Farther along, a second rack removes fine debris, such as

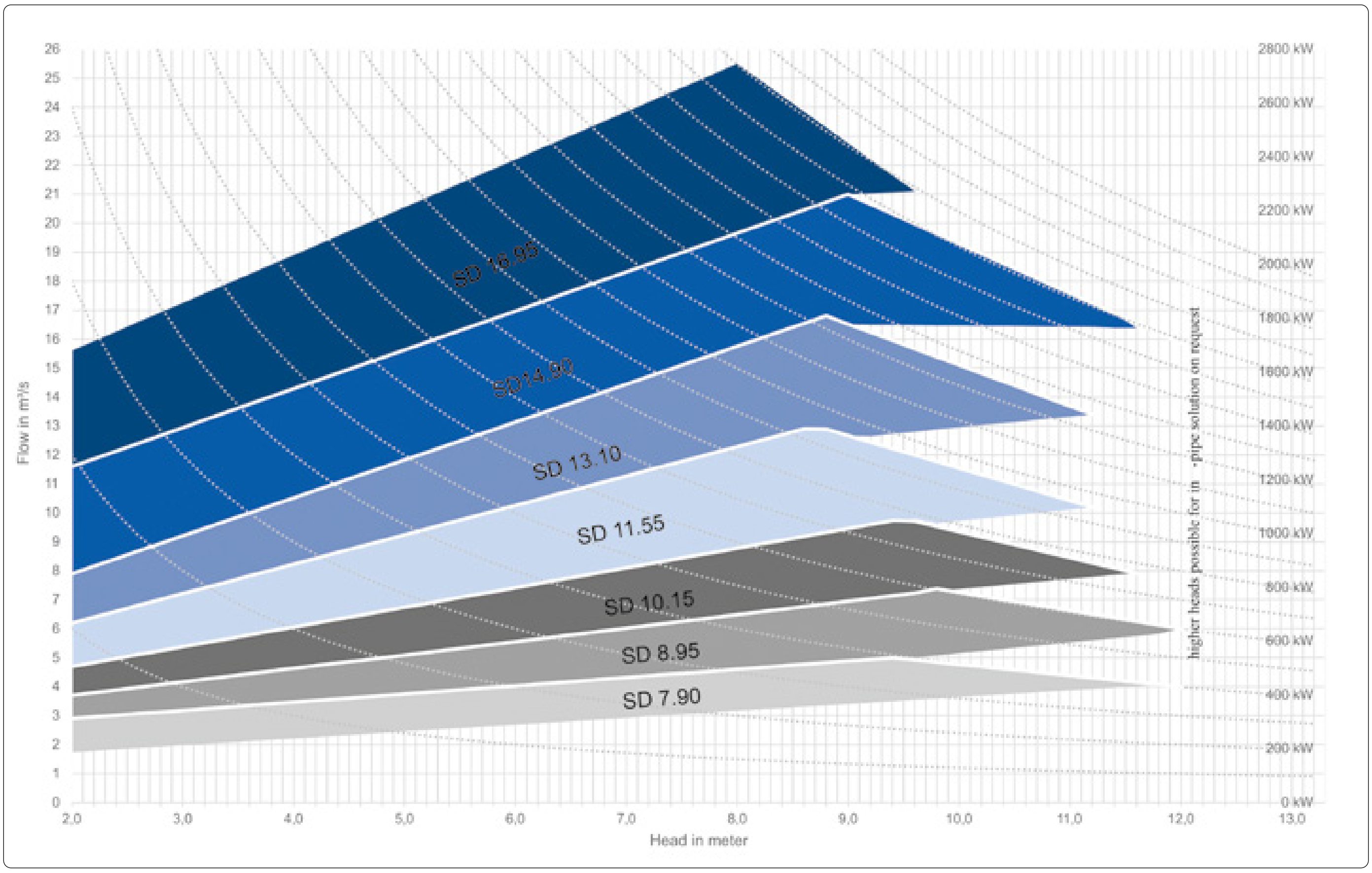


Fig. StreamDiver Application Range

leaves. A large arm sweeps the screen to keep it clean. From there, an automated system controls the flow of water to the power house and activates or deactivates the turbines based on water level, which ebbs and floods throughout the year. The turbines use water for cooling and lubrication, avoiding the usage of oil or grease. A bypass tunnel allows wayward fish to travel safely up- or downstream through the facility while avoiding the turbines.

Should maintenance become an issue, the turbines can be removed and repaired or replaced via a rail system, with no need to dewater the plant.

Procurement Partner Sustainability Award

For its exemplary innovations, products, and services it contributed to the Notre Dame Hydro project, Voith Hydro has been awarded the University of Notre Dame Procurement Partner Sustainability Award. The project is the largest carbon reduction measure implemented to date as part of the University's goal to become a carbon neutral campus by 2050.

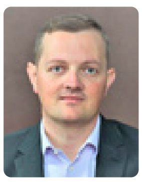
"The turbines and technology supplied by Voith Hydro played an important role in meeting our project's sustainability goal. These StreamDiver turbines are also the first such installation in North America and will supply a green energy source that we expect to contribute approximately 7 % of the campus' electricity" says Shannon Cullinan, Executive Vice President at Notre Dame.

StreamDiver references worldwide

By reducing complex technology, it was possible to achieve a compact size and an extremely maintenance – friendly and robust machine unit at the same time, which has gradually established itself on the global hydropower market with worldwide references in recent years. Today, StreamDiver units from Austria to Indonesia, from Macedonia to Brazil prove the efficiency of this approach.

StreamDiver Benefits:

- Shortened project time compared with conventional solutions
- Reduction of construction costs up to 40 %
- Easy integration into existing weirs or dams
- Minimal operating and maintenance costs
- Ecologically advantages due to water-lubricated bearings and thus oil and grease-free operation
- Water-flooded generators, no leakage risk
- Submerged installation, low visual and acoustic disturbance
- Can be assembled and disassembled very quickly due to underwater plug and suspension



Radu Carja
Head of Division Small Hydro VHGE
Voith Hydro

Photos come from the archive of **Voith Hydro.**

Current technology trends and challenges for pumped storage hydropower plants

Pumped storage hydro (PSH) has remained the most proven large-scale power storage solution for over 100 years. The technology is very durable with 80 to 100 years of lifetime and more than 20,000 storage cycles. It is further characterized by round trip efficiencies between 78% and 82% for modern plants and very low energy storage costs for bulk energy in the GWh-class.

These are the reasons why pumped storage predominates the electricity bulk storage market [1]. The total installed power of pumped storage worldwide was by the end of 2020 around 161 GW with a total storage capacity of 8.5 TWh [2]. This paper will focus first on current challenges as well as past and current flexibility needs in the electricity market using PSH. In a second section a flexibility overview and a comparison of reversible and ternary power unit configurations will be given. The third section of the paper is dedicated to examples of different flexibility improvements achieved during the modernization of existing PSH worldwide. The last section illustrates possible PSH contribution to decarbonize an electricity sector with high shares of Renewable Energy Sources (RES).

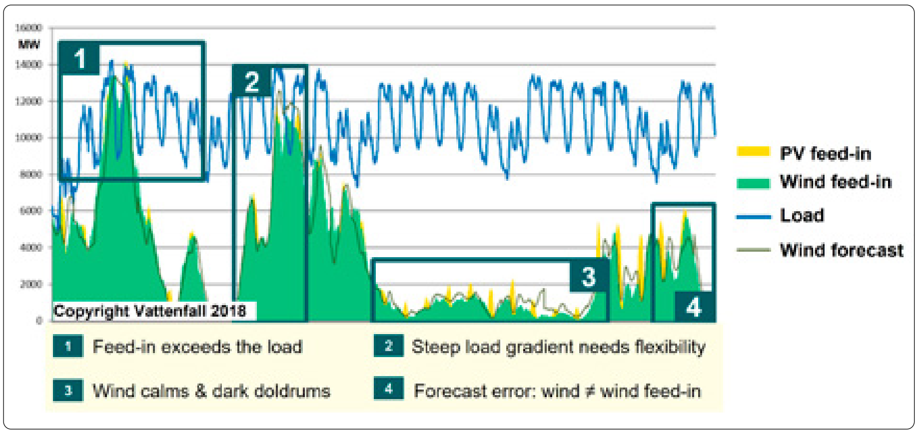


Fig. 1. Main challenges due to the volatility of RES illustrated in the month of January 2017 (TSO 50Herz zone in Germany) [3]

Source: Vattenfall 2018

Main challenges caused by introducing high shares of RES

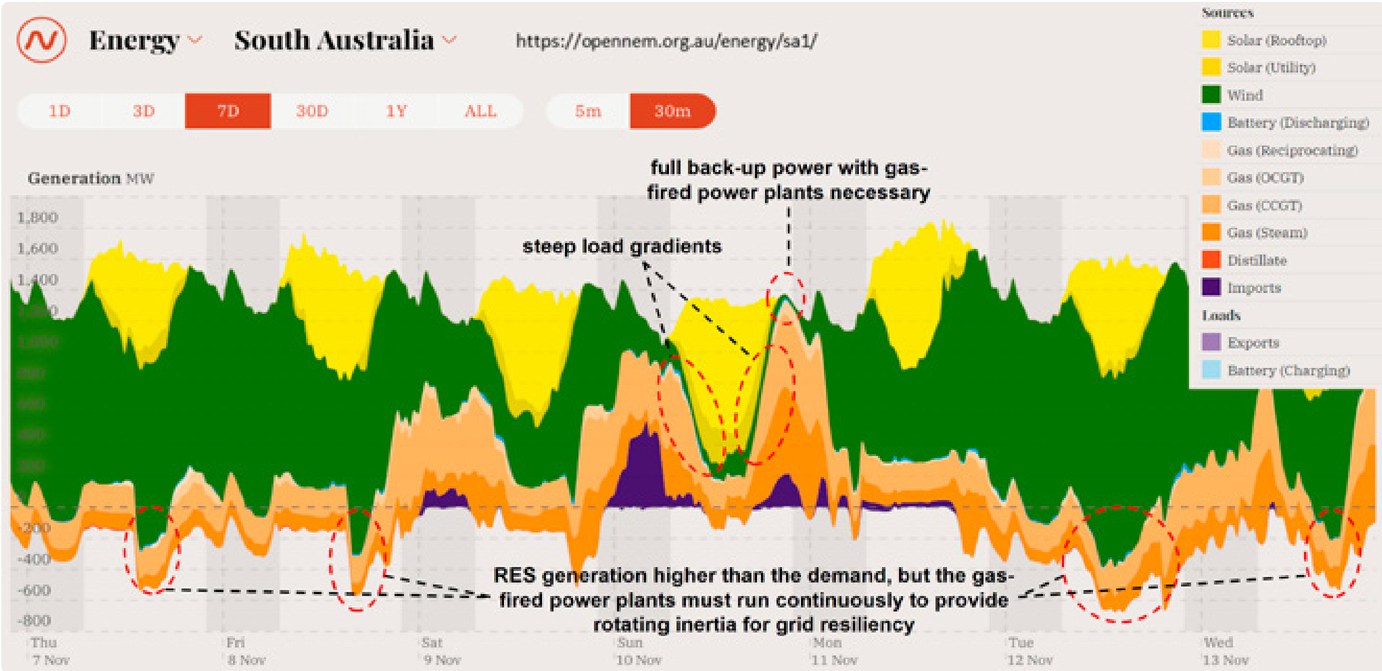
Figure 1 illustrates main challenges caused by introducing high shares of (RES) in the generation portfolio of a German TSO (Transmission System Operator). RES are characterized by volatility, i.e. the power generation is detached from the demand and the absolute forecast errors increase although the relative forecast prediction errors get lower [3]. Electricity systems with large share of RES are facing new situations and need additional flexibility [4] and temporal bulk energy shifting capabilities [5]:

- RES feed-in exceeds the load demand for hundreds of hours per year,
- very steep positive and negative load gradients,
- low infeed of wind and PV for days and weeks (e.g. wind calms and dark doldrums),
- forecast errors for wind and PV caused by unexpected special weather conditions like high fog.

In a deregulated electricity market like Germany, transmission and distribution systems operators (TSO, DSO) consider energy storage as one of several flexibility options to control the volatility of RES. In practice, the following measures were applied to manage above challenges:

- the first and cheapest option was to utilize the existing flexible thermal power generation fleet and to reduce their minimum load. In the next step, must-run and base load operated power plants were converted to more flexible generation (e.g. black coal and lignite power plants but also nuclear power plants). Allow even daily start-ups and shut-downs of thermal power plants and increase where possible the load gradients.
- Another option is the curtailment of RES and re-dispatch of thermal power plants. Re-dispatch refers to necessary grid stabilization measures to compensate forecast wind and PV errors due to unexpected weather conditions or caused by hard transmission limitations due to congestion of high-voltage lines. Re-dispatch measures could be the start or stop of fast reserves, e.g. conventional generation like gas turbines or storage facilities like pumped hydro but also coal-fired plants from the strategic reserve. The TSO expenses for re-dispatch in Germany were 2017 more than €1.4 bio with an energy volume of 20.4 TWh and 5.5 TWh curtailment of renewables [6].
- Increase the flexibility of existing combined heat and power plants (CHP) by building new heat storage facilities (hot water tanks including electrical heaters). These CHPs with heat storages, including electrical heaters, are perceived from the electrical grid operator (TSO) as an electricity storage system, like PSH or chemical batteries.
- Improve and increase the grid transfer capacity within the federal states but also with neighbouring countries. Connect the high-voltage grid of Germany with exiting bulk energy hydro storage in Norway and Sweden using new HVDC sea cables. An executed project example is Nordlink between Germany and Norway with a total length of 625 km and 1.4 GW of transmission capacity.

In other electricity markets the flexibility options are very limited and can be very expensive. Such an example is the electricity market of the federal state of South Australia (SA). Australia reached a share of 27.7% of RES and the federal state South Australia reached almost 60% in 2020. South Australia underwent a significant renewables transition from 2002 until now. In 2002, SA generated its electricity locally from brown coal (lignite) and gas and imported around 30 percent of its annual needs from Victoria where brown coal production dominated [7]. Figure 2 illustrates the generation mix in South Australia for a representative week in November 2020 with significant infeed of wind and solar PV. The different orange colours are gas fired power plants, which must



Source: https://opennem.org.au/energy/sa1/?range=7d&interval=30m

Fig. 2. RES intermittency is controlled in South Australia mainly by gas-fuelled power plants and imports & exports

run continuously and in parallel with the volatile renewables, even in the case the wind and solar PV could cover the entire load demand. In these cases, the grid dispatcher must export energy to the other federal states sometimes for very low or even negative electricity prices. The main driver is to maintain a minimum critical mechanical inertia in case of grid or generation failures in South Australia. These gas-fired plants must compensate the volatility of wind and PV continuously 24 h/day. Figure 2 illustrates very steep load gradients, along with situations where there is little wind and no solar PV when the entire demand is covered by fossil generation or imports. The small blue areas in figure 2 are indicating the contribution of chemical batteries.

Past and current PSH operational flexibility needs

The operations of PSH were characterized in the past (e.g. without highs shares of RES) as follows [4]:

- mainly fixed time slots for operation in pump and turbine mode,
- classic day / night operation: peak shaving in turbine mode during the day and pumping during night only,
- arbitrage business (peak/off-peak) was the dominating revenue stream.

This had following impacts on the current operations of PSH operated in central Europe [4]:

- dissolution of the former classic day / night operation (e.g. today during daytime PV/wind peak shaving in pumping mode is common practice);
- higher utilization of their flexibility: more frequent starts/stops and mode changes, higher load gradients;
- higher amount of fast balancing power is necessary for grid stabilization and compensation of PV/wind weather forecast errors;
- no full utilization of the existing storage capacities on a regular basis anymore and shorter slots of load operations for grid stabilization purposes. But there is still the need on rare occasions to release large amounts of stored energy over an extended time period.

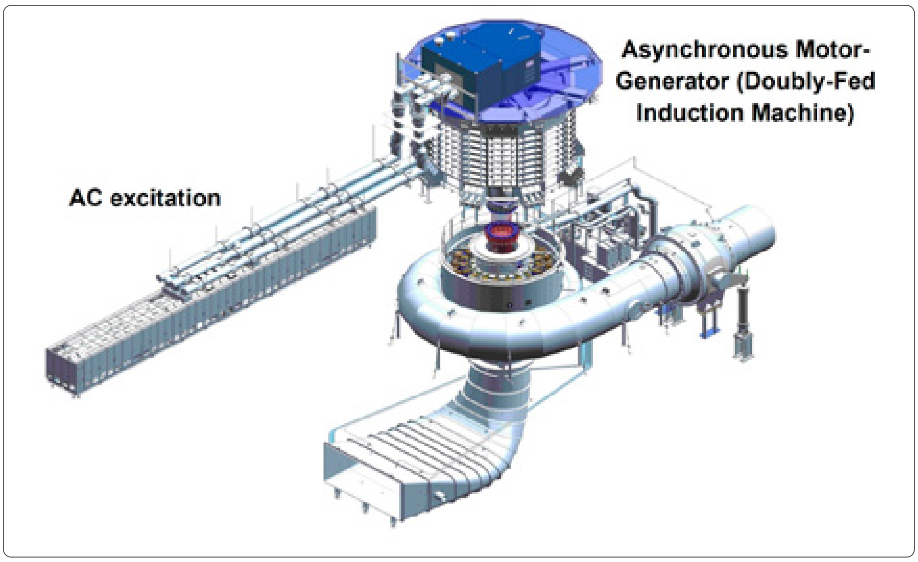
These new boundary conditions and operational requirements had an impact on the existing PSH but also on currently built PSH.

How to achieve operational flexibility and high over-all storage efficiency?

In some markets one main revenue stream of pumped storage plants was and still is the arbitrage business: high revenues from the supply of electricity in turbine mode and relatively low-cost during pump operation. For this business model the cycle efficiency has a big influence. The water way design, the choice of a suitable power unit configuration and the electrical power train design have a strong influence on the cycle efficiency. Regarding the power unit configurations, there are different technical options available to achieve high flexibility and efficiency:

a) reversible power units operated with variable-speed or

b) ternary power units: three machine solution with one common shaft and one direction of rotation.



Source: Voith Hydro

Fig. 3. 3D-Model of one power unit of Frades II, Portugal in operation since 2017

Source: Voith Hydro

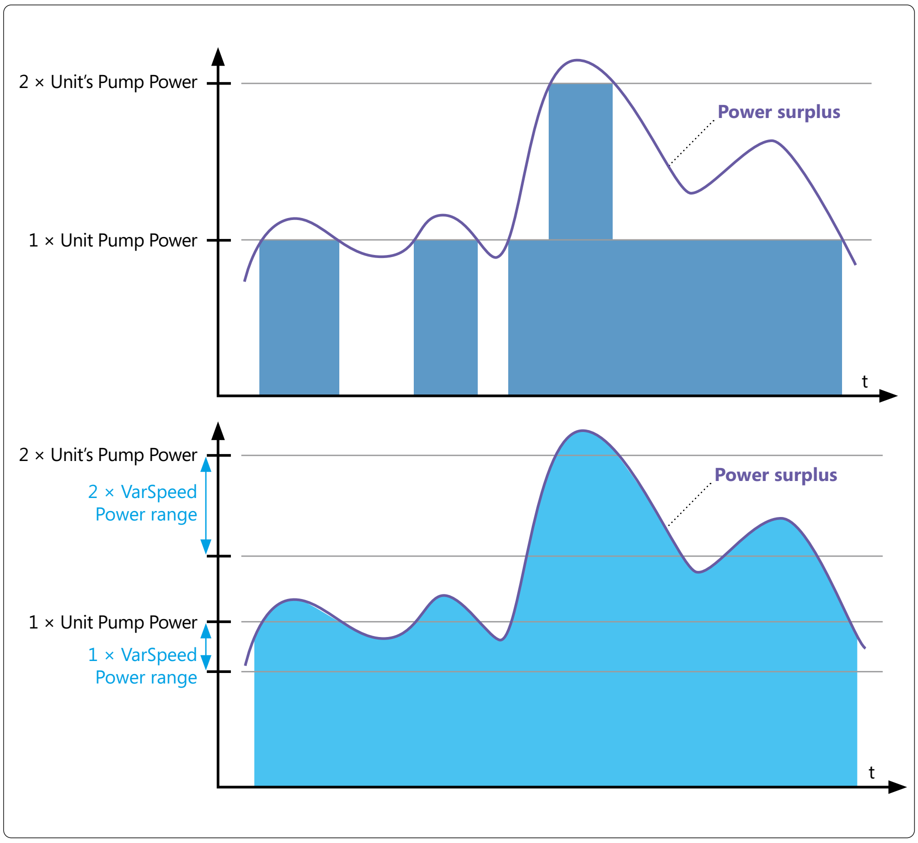


Fig. 4. Illustrative comparison of flexibility for integrating surplus power from the grid. Top: two units with fixed speed; Bottom: two units with variable speed

Flexibility of reversible power units

One example of a variable-speed PSH is Frades II in Portugal with two units (2 x 433 MVA, see fig. 3). Both electrical machines are asynchronous motor-generators (doubly feed induction machine, short DFIM) having an AC excitation connected to the three-phase rotor winding (for details please refer to [8]).

This solution is not only driving the total efficiency above 80% but also leads to following advantages:

- possibility to control the consumed motor power in pump mode (e.g. in order to compensate the wind volatility and to offer higher flexibility to the TSO). This increases also the total number of pump utilization hours in a year (see fig. 4).
- Larger head range variations are possible, i.e. better utilization of the reservoir volumes.
- Larger control band in turbine mode due to lower part load (down to 25%) and with higher efficiency can be achieved.
- Faster load ramping in pump and in turbine mode utilizing the AC excitation system for active and reactive power control. This applies also for offering important ancillary services to the grid such as primary and secondary frequency control reserves additionally in both modes.
- Potential to improve the grid stability in case of grid faults (e.g. short circuits and low voltage ride through (LVRT)) by injecting fast active and reactive power in both modes (pump and turbine mode).

Flexibility of ternary units

Unlike reversible power units, ternary units rotate in the same direction for both pump and turbine modes, i.e. a change of rotation direction is not necessary to switch between pumping and generating. This leads to significantly faster change over times and the motor-generator is a standard generator solution. Since ternary units have two separate hydraulic machines they can be designed with high individual efficiency. In the aforementioned case of a reversible pump-turbine, the hydraulic machine is always a design compromise between pump and turbine behavior including efficiency. Ternary units even operated with fixed speed can reach high total efficiency around 80% (e.g. see fig. 5). Having two hydraulic machines, which can be coupled and de-coupled from the common shaft lead to other advantages, which meets new operation requirement driven by changes in the electricity markets like the aforementioned flexibility needs.

„An important difference between ternary units and reversible units is the time required to switch between operation modes. The transition times shown in Fig. 6 are examples from executed projects, where only 6 transitions are listed. The first three columns are project examples from reversible units with fixed speed (A and B) and variable speed using a DFIM (C). The longest transition times for reversible units occur during the start

Source: illwerke vkw

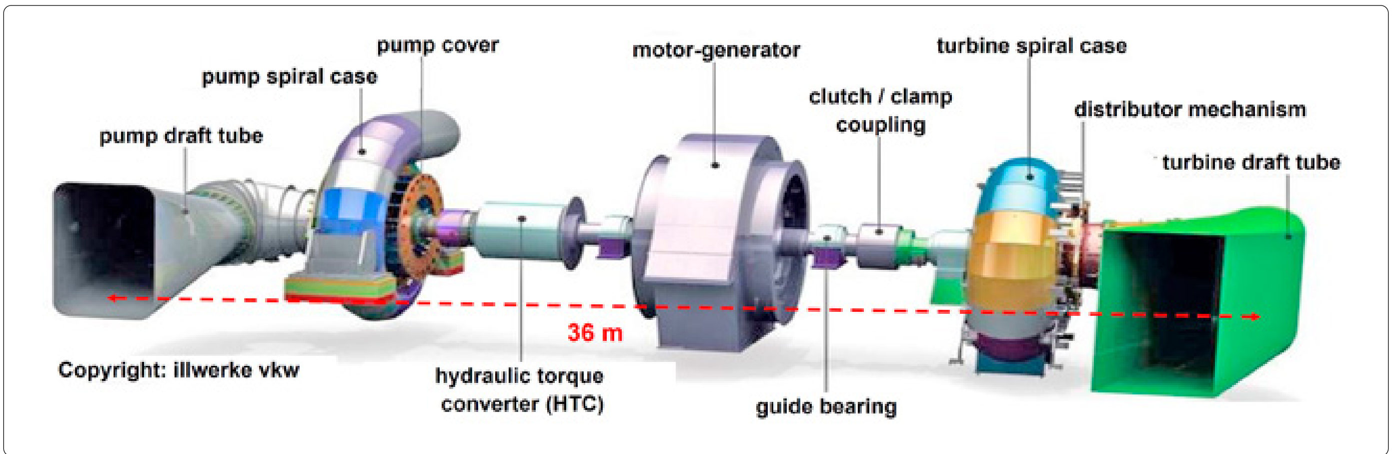


Fig. 5. Horizontal ternary unit configuration of Obervermuntwerk II, Austria, 2 x 180 MW in pump and turbine mode commissioned 2019

Source: Voith Hydro

Pump-turbine				Time (seconds)				
T	Mode change			A	B	C	D	E
1	Standstill	→	Turbining	90	75	90	90	65
2	Standstill	→	Pumping	340	160	230	85	80
3	SC-Mode	→	Turbining	70	20	60	40	20
4	SC-Mode	→	Pumping	70	50	70	30	25
5	Turbining	→	Pumping	420	300	470	45	25
6	Pumping	→	Turbining	190	90	280	60	25

Tab. 1. Examples of mode change times of reversible power units (columns A to C) and ternary units (columns D and E) [1]

Source: Voith Hydro

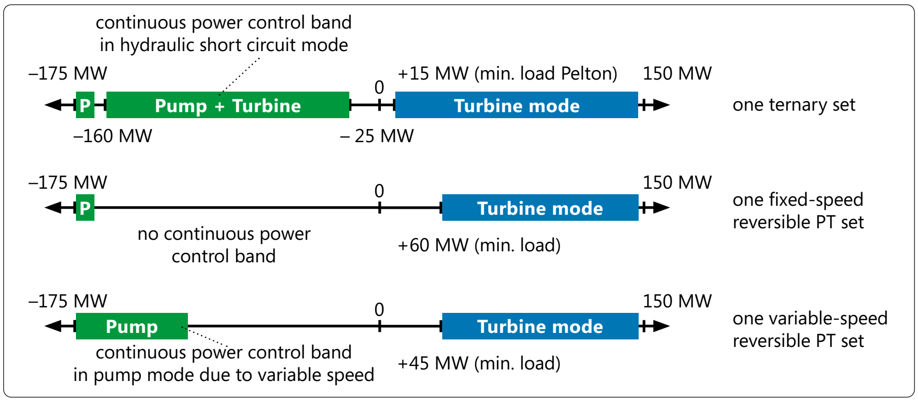


Fig. 6. Comparison of the load control band in turbine and pump mode for a ternary unit (top), fixed speed unit (middle) and variable speed unit using a DFIM as an electrical machine (bottom) [1]

Source: Voith Hydro

Type of machine	P – MG – T	MG / PT
Investments	☹	☺
Space requirements	☹	☺
Efficiency	☺	☹
Submergence	☺	☹
Transition times (e.g. T -> P / P -> T)	☺	☹
Hydraulic short circuit	☺	☹
High heads	☺	☹
Operation costs	☹	☺
Technical risks	☹	☺
Maintenance efforts	☹	☺

Tab. 2. Advantages and disadvantages of ternary units in comparison with reversible pump-turbines [1]

in pump mode, or reversing from turbine to pump mode, and vice versa. The start of the pump is mainly determined by the time for blow down until the runner can start to rotate in air and by the time to speed-up the unit (using a static frequency converter (SFC)). The long transition times T5 and T6 are result of the necessary change of rotation direction. This requires the mechanical stop of the unit and also the electrical disconnection of the MG from the grid in order to transpose two phases via the phase reversal switch. Power plant B features significantly reduced transition times in comparison with the classical reversible unit in column A. They are achieved by a large, implemented package of measures, resulting in e.g. faster opening and closing of spherical valves, faster blow down operation, or faster acceleration of the pump by an over-sized SFC. Columns D and E indicate transition times for two projects with ternary units. PSH D is a horizontal and E is a vertical unit arrangement. In general transition times of the ternary units are smaller compared with reversible units, especially the transition times T4 to T6 are remarkably shorter. It must be mentioned that table 1 is intended for general comparison purposes. Transition times for individual projects will differ, since not only the power unit concepts determine transition mode times, but also the inertia of the water ways and the design of the auxiliary systems" [1].

"Unlike reversible power units, ternary units have a fifth mode of operation, which is called hydraulic short circuit. In this mode both hydraulic machines are operated in parallel, which allows to control the overall consumed load of this power unit by regulating the turbine power generation on the same shaft. The resulting continuous load control range is illustrated in the upper part of fig. 6. The hydraulic short circuit is the only solution to vary the pump power with units operated at fixed speed. In case of reversible pump-turbines, a hydraulic short circuit is not possible within one unit. The operator has to utilize two units in parallel: one in turbine mode in one in pump mode" [1].

Comparison of reversible with ternary units

Table 2 gives an overview of advantages and disadvantages of ternary units in comparison with reversible pump-turbines. The advantages of the ternary units are disadvantages of the reversible pump-turbine and vice versa.

Flexibility increase in recent PSH modernization projects

In the following section different modernization projects executed by Voith Hydro are briefly described. Modernization examples for reversible pump-turbines are the PSH Bad Creek and PSH Raccoon Mountain in the USA. In Bad Creek the project objectives for the new pump-turbine runners (see fig. 7) were to:

- increase generating/pumping capacity from 364 MW up to a maximum of 420 MW per unit,
- provide a cycle efficiency that is equal to or better than the existing cycle efficiency,
- provide an operating range (i.e., from minimum load to full load) of at least 100 MW per unit with all four units generating throughout the normal gross head range of 347 m to 370 m.

In PSH Raccoon Mountain not only the runners but also new distributor components will be replaced – including head cover, bottom and discharge rings, sta-

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Source: Voith Hydro

Fig. 7. 3D model of the Bad Creek runner with an inlet diameter of 5.3 m

tionary seals, etc. Since the entire water ways including surge tanks were not changed at all, additional transient studies have been performed in order to ensure penstock and draft tube pressures remain within allowable limits not only during load ramping but also in case of unexpected load rejections. After the modernization and uprate works both PSH can increase revenues due to wider control and balancing power ranges.

The third example is the E&M refurbishment of two 90 MW ternary units at PSH Ffestiniog in Wales, UK (see fig. 8). The main objective of this modernization project was the improvement of the power unit flexibility in order to ensure further profitability and the safe long-term operation. Examples of measures are:

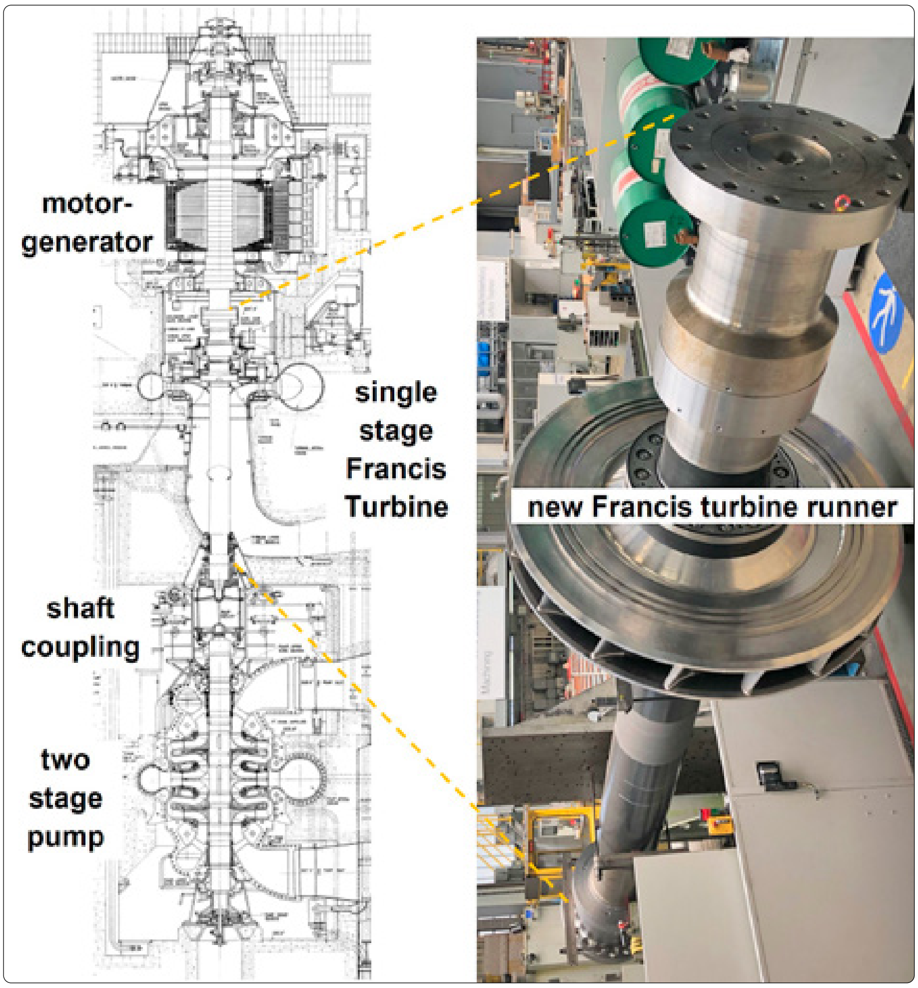
- improving total efficiency of the PSH,
- widening turbine operating ranges by new runners and generators,
- reducing the change-over times by new or enhanced E&M components (e.g. new spherical valves, new controls) and other sub-systems.

Other recent PSH modernization projects were induced by the German regulator offering grid fee exemptions for existing PSH for 10 years in pumping mode if:

a) the total output power is increased by ≥ 7.5% or alternatively
b) the usable reservoir capacity is increased by ≥ 5%.

The PSH Reisach in Germany replaced the 3 old turbine runners in the ternary configuration with new ones, which were optimized for a higher discharge and for a higher efficiency in order to increase the total generation power by more than 8% (see photo 1).

All the following PSH are located in Germany and they have increased their storage capacity by 5% in most cases by heightening the crest of the upper artificial reservoir: Häusern, Witznau, Waldshut, Waldeck 2, Goldisthal, Herdecke, Glems, Erzhausen, Rönkhausen etc. [9]. PSH Vianden located in Luxembourg with a total power of 1,096 MW increased the storage capacity from 4,625 GWh to 5 GWh by heightening both upper (see photo 2) and lower dam crests.

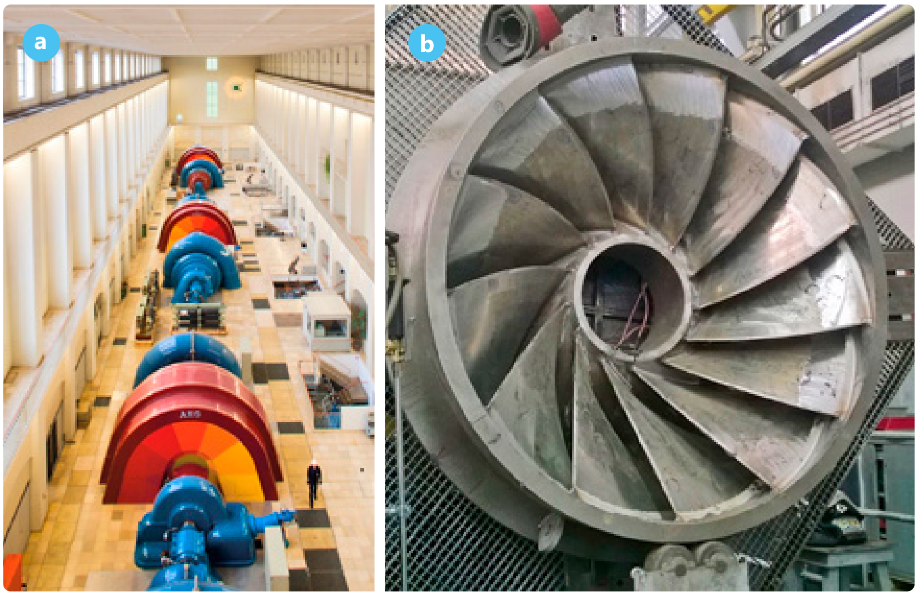


Source: Engie, Voith Hydro

Fig. 8. New Francis turbine runners for Ffestiniog PSH

Contribution of PSH to decarbonize the electricity sector

One of the reasons Australia decided to invest in seasonal pumped storage schemes like Snowy 2.0 is highlighted in fig. 13. This PSH is now under construction, and it will add 2 GW of power flexibility (y-axis) and 350 GWh of storage capacity (surface of the large rectangle) to the electrical grid. In pump mode a second large rectangular surface has



Source: Engie, Voith Hydro

Photo 1. a) Powerhouse of PSH Reisach with 3 ternary units (35 MW each); b) Prototype of the new turbine runner

Source: Matt Stocks, Australian National University, World Hydropower Congress

Fig. 9. Comparison of Snowy 2.0 PSH and Hornsdale battery in terms of contribution to compensation of RES volatility (yellow and green colour) and substitution of gas-fired generation (orange colours)

Source: Société Electrique de l'Our

Photo 2. Civil works at the upper reservoir of Vianden during heightening of the crest

to be added to the negative y-axis, since the total power flexibility is from +2 to – 2 GW! With this flexibility and together with the rotating inertia of the 6 power units it is possible to firm existing and new RES and to shut down fossil fuelled power plants in a region like South Australia in order to achieve decarbonization. The small rectangular surface in the middle of figure 8 is the contribution of the Hornsdale big Tesla battery with 100 MW and 129 MWh. The storage capacity of Snowy 2.0 is 2,500 higher than this battery and therefore it can compensate up to one week of no sunshine and no wind! The CAPEX of PSH Snowy 2.0 per kWh is a very attractive low 2-digit USD value [10].

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The article is prepared on basis of a presentation from **ASIA 2023 (14–16 march)**

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Power intake size optimization for economical hydropower

For long term costs and benefits of energy sales, the optimal size power intake suggested in this study can be adopted for million dollars saving.

In this article Satyajeet Sinha practitioner design engineer having more than 13 years of experience in hydropower design, development and innovation improve the power intake components in hydropower projects, deduced from the detail study carried out on the subject. The result paper has been published in 'Results in Engineering' Volume 15, September 2022, 100572 and available on ScienceDirect. Results in Engineering (RINENG) is a Gold Open Access Journal, published by Elsevier BV. The summary of the research outcome is discussed in this article.

Introduction

Intakes for power generation serve to provide hydraulically efficient water inlets from the reservoir to the water passages leading to the powerhouse. Usually, bellmouth entrance profile is provided at entrance. At the entrance of the intake, there is a trash rack structure responsible for keeping floating debris out of the plant. In addition, there are stoplogs and a quick action stop valve. The stoplogs allow the hydroelectric plant to be drained during maintenance work. And in the event of an accident, the quick action stop valve stops the inflow. These gates are rectangular in shape, and there is transition after the gates to the intake tunnel. The length of this zone is based on the requirement of conservation of the constant acceleration of the flow.

The purpose of this study is to optimize the overall cost of power intake structure by reducing the size of these components without impacting on the performance. The summary of state of art practice for designing these components and the suggestions discussed in this study is shown in the scope of this study in fig. 1. The state of art practice used in designing these components are discussed in this paper along with the outcome of the detail study, author's work experience, practical examples and relevant analytical results using

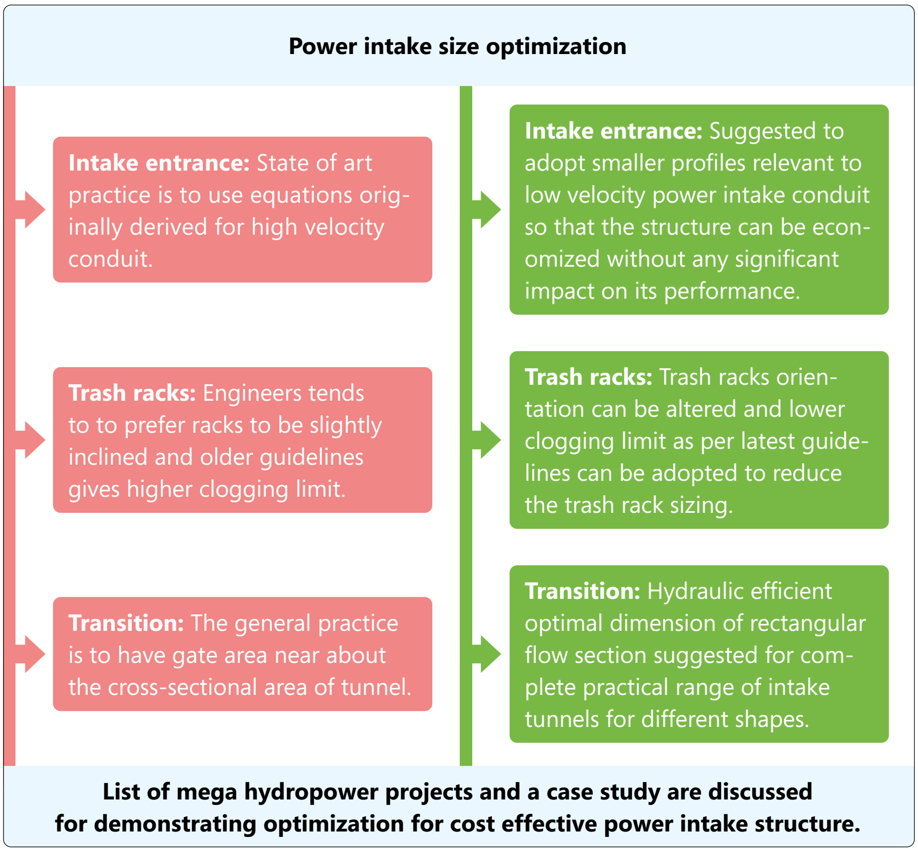


Figure 1. Scope of this study

Source: Own study

which the significant power intake quantities can be saved and cost of hydropower can be minimized.

Intake entrance

Generally, the state of art bellmouth equations is adopted for power intake design in hydropower projects. The state of art bellmouth equations that are commonly used in power intake design are shown in fig. 2. Intake shape is typically determined using design criteria for high velocity conduit entrances. It is possible that intake shapes may be reduced in size or simplified without a significant loss in efficiency. Velocities are generally low in power intakes and the resulting energy losses are also low. The size of the intake could possibly be reduced without introducing excessive additional hydraulic losses, since flow separation and resulting energy losses are less of a problem at low velocities.

Power intake entrance modification suggestions

It is observed that instead of larger bellmouth entrances obtained using equations (1) – (5) valid for high velocity intakes susceptible to cavitation; simple rounding of corners or alternate smaller bellmouth profiles can be adopted for cost-effective power intakes. it is suggested that power intake entrance profile can be economized by working between profile in the range of 0.3 d–0.6 d long. The alternate options considering bellmouth equation with x = 2 y and x = 3 y. The summary of bellmouth is shown in table 1 for understanding.

Trash racks

The design considerations related to the maximum velocity through the trash rack at MDDL level, inclination of the trash rack structure, maximum clogging limit and type of trash rack cleaning arrangement are discussed along with a list of mega hydropower projects. It is observed that the trash rack sizing can be reduced by adopting low clogging limit and increasing frequency of cleaning. The list of mega hydropower projects discussed also highlighted that most of the trash racks structures designed with some inclination, the codal provision also specifies minimum inclination for mechanical cleaning. It is suggested that wherever possible vertical

Source: Own study

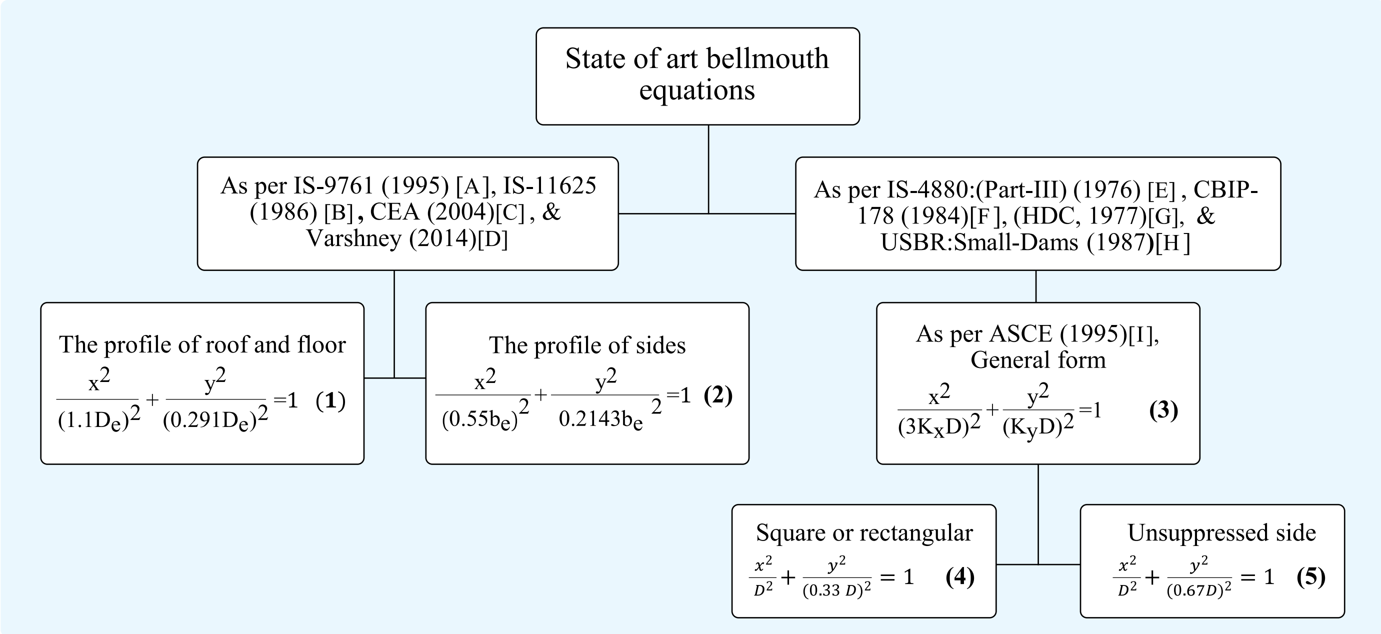


Fig. 2. State of art bellmouth equations

Source: Own study

S.No.	All sides flared equation	Bottom suppressed – top profile
1	$\frac{x^2}{(0.30\ d)^2}+\frac{y^2}{(0.15d)^2}=1$	$\frac{x^2}{(0.30\ d)^2}+\frac{y^2}{(0.30d)^2}=1$
2	$\frac{x^2}{(0.40\ d)^2}+\frac{y^2}{(0.20d)^2}=1$	$\frac{x^2}{(0.40\ d)^2}+\frac{y^2}{(0.40d)^2}=1$
3	$\frac{x^2}{(0.50\ d)^2}+\frac{y^2}{(0.25d)^2}=1$	$\frac{x^2}{(0.50\ d)^2}+\frac{y^2}{(0.50d)^2}=1$
4	$\frac{x^2}{(0.60\ d)^2}+\frac{y^2}{(0.30d)^2}=1$	$\frac{x^2}{(0.60\ d)^2}+\frac{y^2}{(0.60d)^2}=1$
5	$\frac{x^2}{(0.30\ d)^2}+\frac{y^2}{(0.10d)^2}=1$	$\frac{x^2}{(0.30\ d)^2}+\frac{y^2}{(0.20d)^2}=1$
6	$\frac{x^2}{(0.40\ d)^2}+\frac{y^2}{(0.13\ d)^2}=1$	$\frac{x^2}{(0.40\ d)^2}+\frac{y^2}{(0.26d)^2}=1$
7	$\frac{x^2}{(0.50\ d)^2}+\frac{y^2}{(0.17d)^2}=1$	$\frac{x^2}{(0.50\ d)^2}+\frac{y^2}{(0.33d)^2}=1$
8	$\frac{x^2}{(0\ 60\ d)^2}+\frac{y^2}{(0\ 20d)^2}=1$	$\frac{x^2}{(0.60\ d)^2}+\frac{y^2}{(0.40d)^2}=1$

Table 1. Summary of proposed entrance profile

Source: Own study

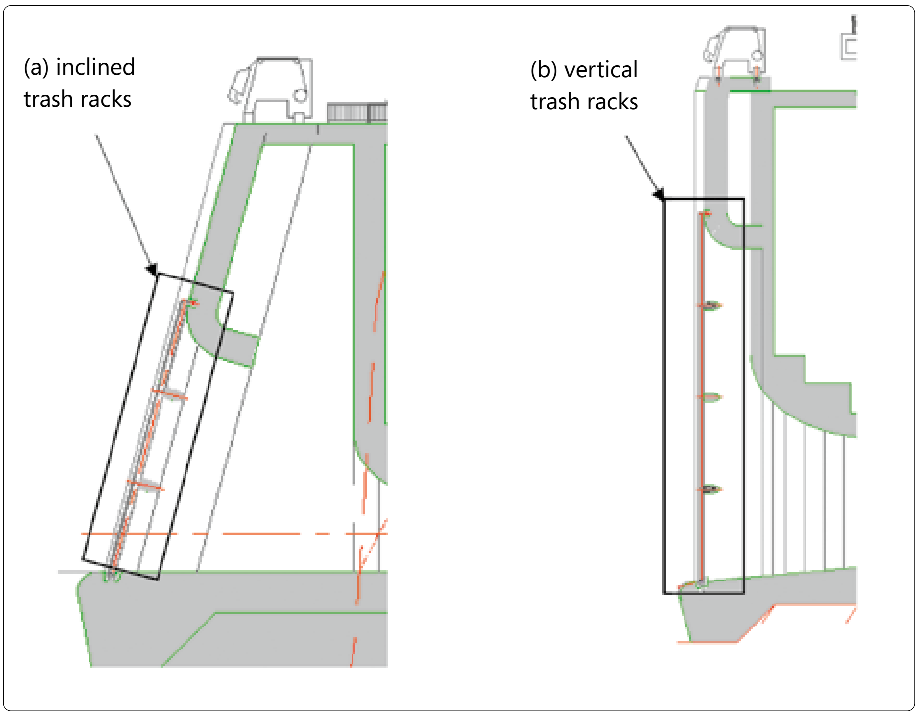


Fig. 3. Trash racks structure: (a) inclined; (b) vertical.

trashrack can be preferred to reduce cost of structure along with minimal clogging limit for optimal sizing. To understand the quantum of saving, the typical trash rack structure considering inclined and vertical arrangement is shown in fig. 3. The trash rack structure can be designed economically by adopting vertical orientation with 33% clogging limit.

Transition

It is observed that for transition from rectangular concrete section to horseshoe concrete section, the ratio of gate area to intake tunnel area is mostly in the range of 0.9–1.0 while for transition from rectangular concrete section to circular steel section is slightly higher range of 1.0–1.4. To further find out the optimal rectangular cross section, analytical study carried out for the practical range of depth of intake tunnel up to 20 m.

The optimal rectangular cross section is computed considering these parameters for corresponding circular, horseshoe and D-shaped intake tunnels having same lining material throughout. The output for circular section is shown in fig. 4 for visualization and the remaining output for horseshoe and D-shaped intake tunnels was presented in discussed research paper.

Case study

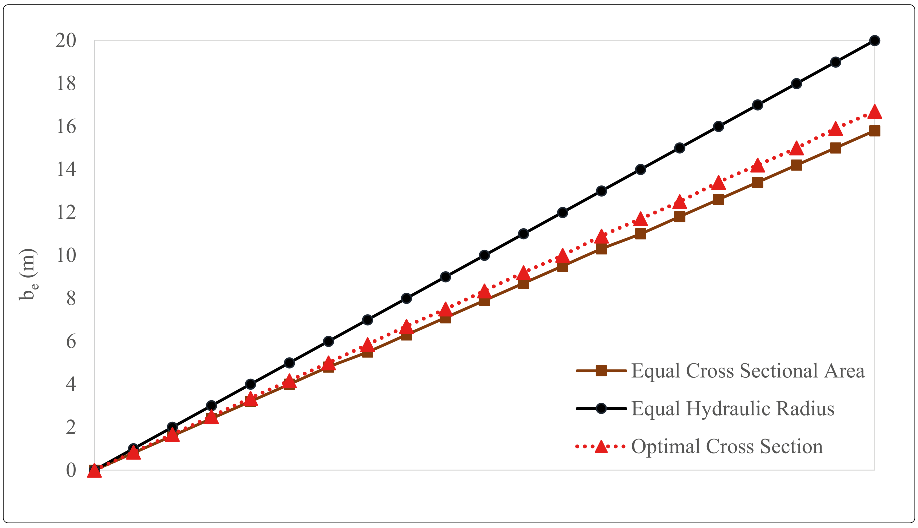
To demonstrate the applicability of this study and to quantitatively illustrate the economic values of the optimization discussed, practical example by considering the power intake of Ratle HEP (850 MW) for elaborating the implementation of the recommendations given in this study. The power intake of the said project is shown in fig. 5. showing both implemented and optimization proposed as per the outcome of the study.

As depicted in fig. 5, the power intake implemented based on equation (5) and the trash racks structure is inclined at 15˚ considering codal provision of 10˚–15˚ inclination. The alternate entrance profile can be used instead of equation (5) which is valid for high velocity intake and susceptible to cavitation. Any of the alternate equations shown in table 1 can be used for initial design and the final profile can be fixed based on numerical and physical optimal results. For the study purpose tentative conservative equation is shown under alternative layout. The trash rack structure can also be aligned vertical using hydraulic jib trash rack cleaner and the same is proposed for optimal layout. As the transition is between concrete rectangular section to steel intake tunnel so the optimal cross section shown in fig. 4 is not applicable as it is developed for same lining material throughout, accordingly it is not used.

It is observed that on the ballpark figure around 35% concrete quantities are saved. In addition to that there will be significant excavation and support quantities saved using optimal size power intake.

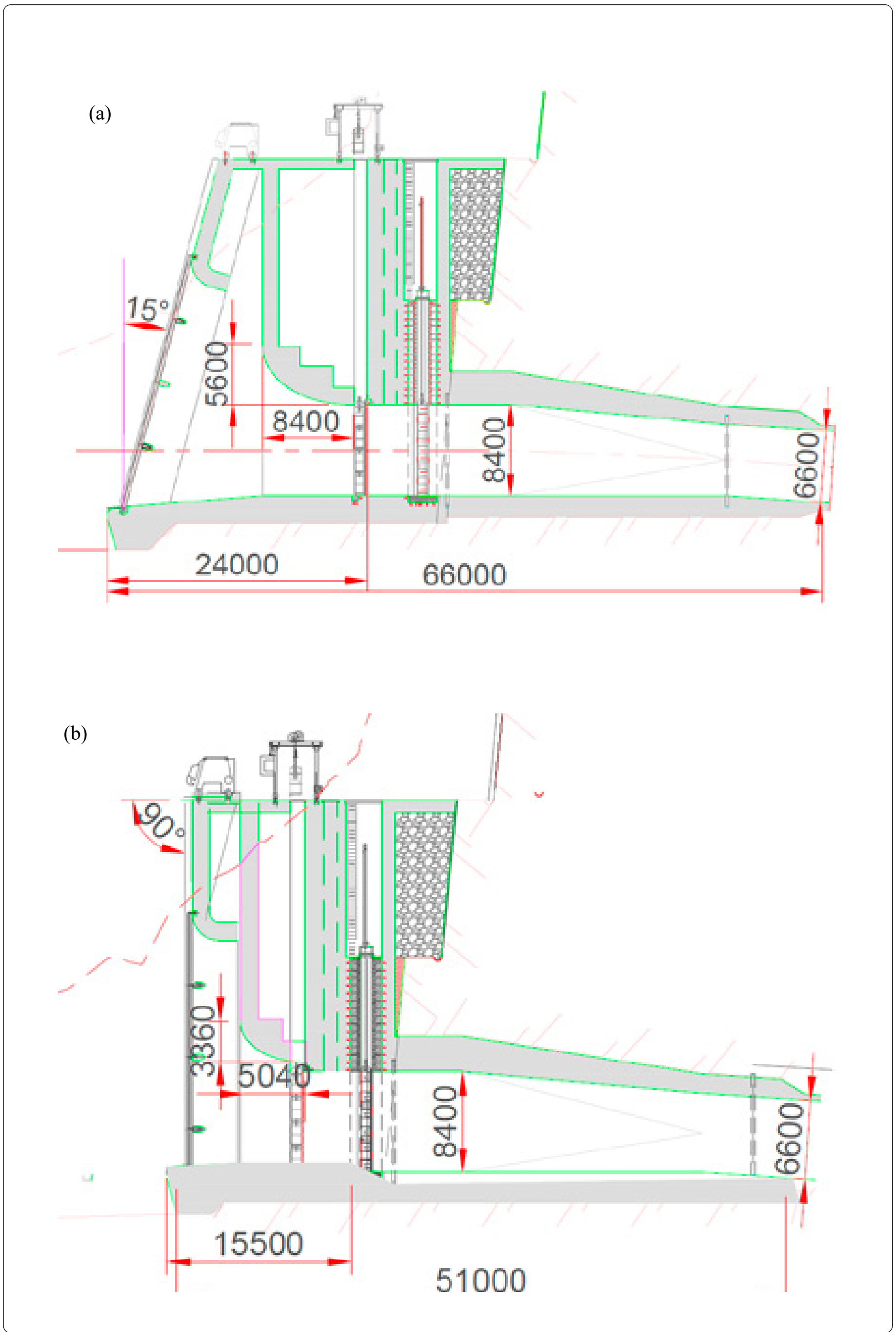
Conclusion

Based on the detailed study carried out to find out the opportunities available to optimize the power intake structure in hydropower (fig. 6) as per the author's experience of mega hydropower projects, detail literature review, and relevant analytical study carried out, it is observed that the power intake can be optimized significantly if the recommendations given in this study can be adopted. The state of art bellmouth equations discussed in codes, guidelines, manuals, and reputed literatures relevant to power intake design for hydropower projects are originally derived for high velocity. Velocities are generally low in power intakes and the resulting energy losses are also low. The size of the intake could possibly be reduced without introducing excessive additional hydraulic losses, since flow separation and resulting energy losses are less of a prob-



Source: Own study

Fig. 4. Circular section to rectangular cross section: be vs D/De



Source: Own study

Fig. 5. Case study of 850 MW Ratle HEP power intake: (a) implemented; (b) optimization proposed *(Note – Dimension in mm).*

Source: Own study

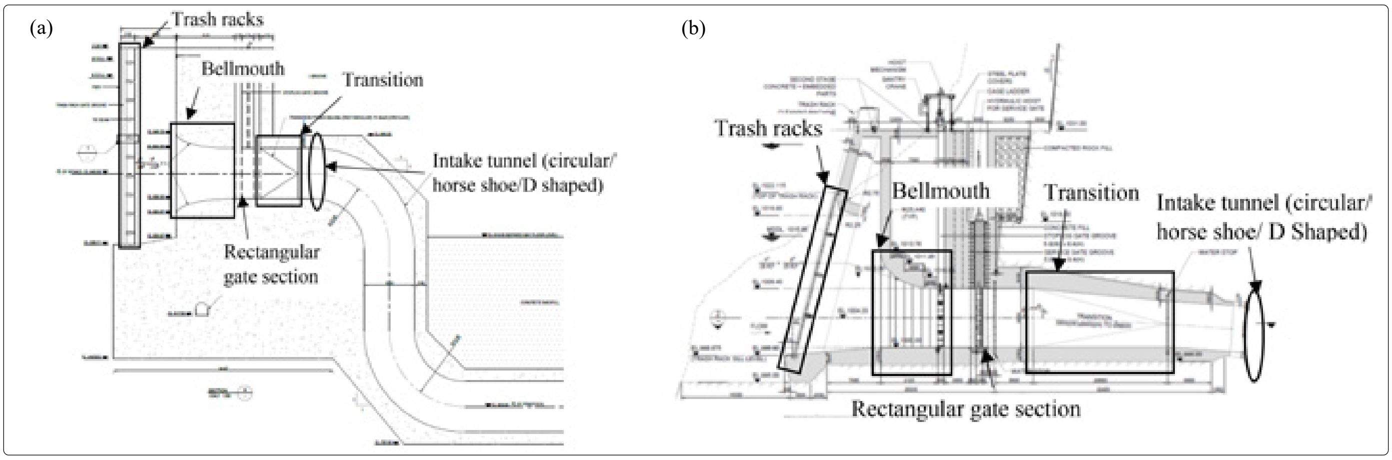


Fig. 6. Typical section of power intake (a) consist of conduits embedded in dams; (b) excavated as tunnels

lem at low velocities. It is observed that the power intake structure can be optimized by adopting different entrance profile for different gross head of hydropower projects. The degree of intake shaping can be evaluated for head and energy losses and construction cost.

It is observed that the trash rack sizing can be reduced by adopting vertical trash racks arrangement and high cleaning frequency can be adopted. Accordingly, it is suggested to adopt vertical trash racks arrangement wherever possible and higher cleaning frequency as per latest guidelines. The output obtain in this study can be utilized for considering optimal dimension of rectangular section in power intake structure. For long-term costs and benefits of energy sales, the hydropower cost can be minimized if the optimization procedures related to power intake structure suggested in this study can be adopted. These potential cost reductions in equipment and civil structures are a factor in expanding hydropower and keeping it competitively priced in the energy market.

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The article was prepared based on a paper published in Results in Engineering Volume 15; September 2022 published by Elsevier BV.

Photo. 1. Retention reservoir on the Oruński stream in the Orunia Górna district in Gdańsk
Source: Gdańskie Wody Sp. z o. o.

Water retention in the city, can we use retention to produce clean energy?

Retention is an important element of the water balance, affecting the mitigation of extremes, i.e., floods and water shortages. Additionally, retention creates better conditions for the development of living organisms, thus contributing to the improvement of the biological potential of water. Correctly applied solutions aimed at increasing the retention of the catchment area can also significantly improve the quality of water, and thus reduce chemical pollution.

The positive impact of retention on the broadly understood water management is more and more noticeable, which can be seen in the change in attitude to the idea of water retention in the natural environment and in areas transformed by man (agricultural or urbanized areas). This is reflected in the most important planning documents developed by the State Water Holding Polish Waters. In these documents, water retention is mentioned as one of the main measures to prevent floods and droughts [1] and contributing to the improvement of the condition and potential of water. Despite the widely recognized positive aspects of water retention, the process of changing attitudes to how rainwater is treated is slow. We still observe measures in the country that reduce retention, especially in urban areas. On the other hand, as a result of promotional and educational campaigns (e.g. the government program Stopsuszy.pl), social awareness and the sense of responsibility for the state of the environment increase.

Rainwater retention

Retention is the ability to hold a volume of water over time [2]. Based on this definition, we can say that the amount of retention will be described by how much water we are able to hold, and for how long it takes. Most often, retention is related to the catchment area, i.e., the area that collects water and discharges it to one reservoir. The natural catchment covers rivers, streams, lakes and reservoirs, and its boundaries are determined by the layout of the land. It can also be a catchment area of rain collectors. Then, in order to determine its boundaries, we must analyze the layout and slopes of the rainwater drainage system.

Similar catchments, i.e., those with a similar size, shape, or arrangement of the river network, may react differently to rainfall depending on their retention capacity. A catchment with natural retention will retain most of the rainfall in its initial phase, either draining rainwater to the ground or generally trapping it in the environment. On the other hand, a catchment without retention will drain most of the rainwater at a rapid pace. As a result, the outflow from such a catchment is greater (no water retention), and the peak of the flood occurs earlier. This often leads to the so-called flash floods, repeatedly observed in urban areas.

Returning to the aspect of natural catchment retention, we can mention a few involved factors:

a) the presence of vegetation, in particular forests;
b) the infiltration capacity of the soil;
c) the lack of regulation of rivers and the existence of floodplains.

All these aspects can be treated as a feature of the river basin, which contributes to a better water circulation, but most often lacks the possibility of controlling the outflow of water, hence it is called uncontrolled retention. Our intervention is limited to the adaptation of the catchment area at the planning stage, thanks to which we provide conditions for water retention. Important positive aspects related to natural retention are the facilitation of the direct use of rainfall by vegetation, the reduction of erosive water activity and the creation of appropriate environmental conditions for various animal organisms.

Natural retention is complemented by retention based on the implementation of hydrotechnical investments, in particular reservoirs. Retention of water in reservoirs is achieved by building a dam on the watercourse along with devices enabling flow regulation (spillway with gates). In this way, the water flow is regulated to retain excess flow in the reservoir during floods. The water retained in the reservoir can be later used during its deficit to meet the demand during periods of drought. In this way, retention reservoirs can mitigate extreme events, both floods and droughts, helping both users and consumers of water, as well as water and water-dependent ecosystems. Of course, the flow equalization capacity in the river is limited by the volume of the reservoir and usually does not allow for full mitigation of unfavorable hydrological phenomena. It should also be emphasized that the influence of the reservoir operation is visible in the section of the river at the adjacent vicinity. Despite these obvious limitations, water management must be based on the presence of retention reservoirs, the operation of which will be supplemented with solutions close to nature, discussed in the paragraphs above. These types of hybrid solutions are highly recommended and presented both in the catalogs of actions of the Drought Counteraction Plan and in the update of the Flood Risk Management Plan.

Retention in small water reservoirs

The observed climate changes lead to an increase in the intensity of extreme phenomena, which in our climate zone refers to the more and more frequent floods and droughts. According to the data compiled in the study of the Institute of Meteorology and Water Management, the phenomenon of drought in the last decade appears twice as often as in previous years [3]. In order to effectively shape water resources and use them rationally, Polish Waters developed the Drought Effects Counteracting Plan (DECP). As part of the DECP, a catalog of 26 measures to counteract the effects of drought has been created, which focus on increasing the resilience of sensitive sectors of the economy, society and the environment to losses caused by drought.

Among the activities listed in the catalog, it is worth paying attention to action no 3: entitled "Retention and management of rainwater and snowmelt in urbanized areas". This measure should be understood as the integrated management of rainwater (rainwater and meltwater) based on rainfall management techniques at the place of its occurrence. This means the use of broadly understood uncontrolled retention in an urban area, in order to reduce the susceptibility of urban areas to the phenomenon of drought. Such activities, in addition to mitigating the effects of drought, will also contribute to better adaptation of urban space to climate change and to counteracting urban flooding.

Of course, this shows the main course of the action but looking further into the catalog, we can see another related action: entitled: "Implementation of investment activities in the field of shaping water resources by increasing artificial retention." The legislator emphasized that the measure should apply only to areas where it is not possible to apply measures that are more favorable from the point of view of environmental protection, which in most cases will help to implement measures in urbanized areas.

Small retention reservoirs in an urban area are a frequently used flood protection measure. Most often we are dealing with reservoirs keeping water for conservation, but also having a significant volume of flood. The term flood volume is understood as a part of the reservoir canopy intended for catching the flood surge. This volume remains unfilled beyond the flood transition period. In the face of repeated flood situations, local government units often start using dry reservoirs, i.e., those that do not accumulate water at all, and all their capacity is intended to take over the flood surge. In other periods, the reservoir's canopy may be used for other purposes (recreational facilities, green areas, flower meadows), but we must not forget about the basic flood protection function.

Energy use of small water reservoirs

Retention reservoirs are located in historical places used for damming water for water power plants (examples in Gdańsk described below). Water energy was one of the basic sources of powering sawmills, mills and forges, therefore the watercourses flowing in the vicinity or through the areas of historic city centers were carefully used by man. In the era of the industrial revolution, along with the development of internal combustion

Source: Gdańskie Wody Sp. z o. o.

Photo. 2. Retention reservoir on the Oliwski Stream in the Żabianka district of Gdańsk

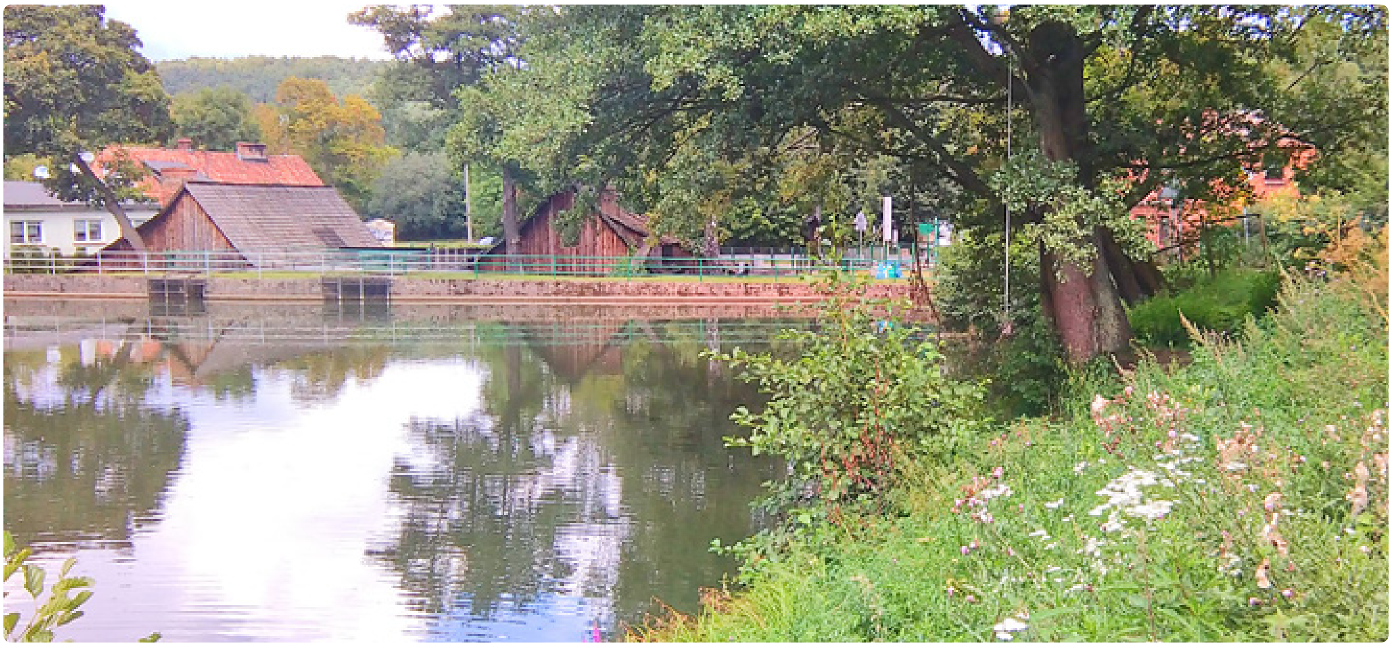

Photo. 3. Buildings of the 15th century water forge on the Oliwski Stream in Gdańsk

engines, production began to be made independent of access to flowing water, which contributed to a decline in interest in this method of using water energy. Additionally, after the Second World War, there was a massive liquidation or devastation of small hydrotechnical facilities.

One of the examples of the economic use of rivers is Gdańsk. Within the present administrative borders of the city, there are streams such as the Strzyża stream and the Oliwski stream (also known as Jelitkowski Stream). Both of these watercourses have been harnessed to work for centuries and formed the basis for the operation of numerous mills and forges. Currently, we can see traces of these functions in the geographical names: Dolne Młyny, Górne Młyny, Kuźniczki and relics of hydrotechnical construction – a water forge from 15th century. The sites of the former damming of water for water power plants have been transformed into dams over time, creating numerous retention reservoirs. Their former energy function has ceased to and the main purpose remains the retention of rainwater. Thus, they are part of the city's flood protection system.

It seems that in the current drive towards a zero-emission economy and to increase energy production from renewable sources, the idea of returning to the use of water energy is becoming more and more tempting. The most obvious solution is to convert the mechanical energy of water into electricity. Due to the low flows and relatively low damming, the profitability of the investment may raise justified doubts. Looking at the example of the Strzyża stream: the average flow in the middle section does not exceed 100 l/s, and the real head of a single object is about 2 m, i.e., the installed power of the power plant will not exceed 2 kW. The question is whether it is worth dealing with this type of investment. Taking into account the above-mentioned aspects of caring for the natural environment, the use of water energy in order to reduce the consumption of other raw materials fits perfectly into the policy of sustainable development. It is worth noting that rising energy prices may also be an argument in favor of introducing such solutions. An additional advantage in favor of the installation of hydroelectric power plants on venting structures is the use of the already existing infrastructure, which refers to the historical technical infrastructure, and mostly probable to develop a positive public perception. In addition, there is a whole range of positive effects accompanying the creation of small water reservoirs. It is worth mentioning at this point that the reservoirs will create conditions for the development of water ecosystems and water-dependent ecosystems, will contribute to the improvement of water conditions in adjacent areas as well as reduce the region's susceptibility to drought.

Summary

Water retention is a key factor in counteracting the effects of floods and droughts. The use of technical measures, including, in particular, water reservoirs is often viewed as a controversial solution due to the significant pressure they exert on water areas. On the other hand, reduction of the surface runoff and collecting water in retention reservoirs can significantly neutralize the problems associated with the increasingly frequent extreme weather phenomena. Adaptation of urbanized areas to climate change will be based on the reconstruction of natural retention supplemented by controlled retention. Introducing natural base solutions in urban areas is right, but due to the high cost of these measures in relation to the results achieved, we still have to base retention on technical measures. The optimal solution seems to be a well-thought-out construction of urban retention based on systems of small water reservoirs supplemented with a solution close to nature.

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World Water Day 2023

World Water Day is celebrated on March 22 and was established by the UN General Assembly with a resolution on December 22, 1992, during the Earth Summit Conference in Rio de Janeiro. All UN member countries, recognizing the importance of water to society, have adapted proposals to celebrate Water Day.

The main purpose of creating World Water Day was to draw the attention of societies and politicians to the problem of water availability for population, economy, industry and agriculture. As is known, without water, life on our planet is impossible. The annual celebration of the feast is associated with a specific issue concerning the world's water resources and under a specific theme. The first celebration of the feast took place in 1993 – it was held without a heading, and the next in 1994 under the heading: "Caring for water is everyone's responsibility." This heading is still relevant despite the passage of 30 years since its establishment.

World Water Day 2023 is closely linked to the sixth Sustainable Development Goal to bring safe water and adequate sanitation to all people by 2030. Today, more than 2 billion people (1/4 of the globe's population) lack access to safe water, and more than 4 billion lack access to adequate sanitation facilities. It is known that clean water and adequate sanitation facilities are essential factors for poverty reduction, economic growth and development of sustainable environment.

Main heading of WWD 2023
Accelerating change,

should be understood as the need to accelerate changes in our environment through partnership and cooperation. This is to achieve a sustainable environment and society.

WWD back over the years

Each year WWD was celebrated under a chosen theme. These were mainly related to surface water (rivers, lakes, artificial reservoirs, canals). There were headings related to water supply, floods and drought, energy, but also climate, landscape and even culture. Only once in 1998 did the WWD theme referred to groundwater – Groundwater – the invisible resource [1]. The headings presented have always represented very important problems from an environmental, economic or social point of view, but it was obvious that these problems could not be solved in a short period of time and, moreover, solving them would require huge financial expenditures that individual countries could not afford. This does not mean, however, that these headings can be forgotten, but should be revisited, as they present the problems necessary for further development. This is a special appeal to politicians and policymakers.

It seems that in an era when the effects of climate change are becoming increasingly apparent on the occasion of the WWD 2023, we should pay more attention to this problem. This problem is directly related, not only, to the broad area of water, but also energy. It is clear that the world without water or with limited access to it cannot continue to function. It is also difficult today to imagine the world without energy, especially electricity. It is therefore worthwhile to study these two areas more extensively.

World water resources and their management

In our considerations on water, we have focused on fresh water, which accounts for about 2.5% of all water and which is in constant motion (the hydrological cycle). This movement of fresh water is largely dependent on the sun's energy and the earth's gravity, causing water to evaporate, condense in the atmosphere, precipitate and flow down on the earth's surface. It is also worth recalling that about 70 percent of freshwater is frozen in glaciers, and almost 30 percent is in groundwater. Only a fraction of a percent of freshwater is is included in rivers, lakes, reservoirs, floodplains or biological water. Taking into account the world's estimated river outflow to the sea of 47,000 km³ per year (hydrological cycle) [2] and the current population of the globe (8 billion), we obtain a water availability index of about 5,900 m³ per capita/year. This is an average value for the whole world, which is fully sufficient for the normal functioning of the economy and society. However, the distribution of water resources on the globe is very uneven, and there are countries where this index is very high and countries where it falls well below 1,500 m³ (Poland about 1,600 m³), which means a critical state of water supply. If we additionally take into account surface water pollution and restrictions on abstraction for ecological reasons, we already have a water crisis in many countries.

17 Sustainable Development Goals

The United Nations General Assembly in September 2015 adapted the 2030 Agenda for Sustainable Development, covering all areas of our lives. It contains 17 Sustainable Development Goals, consisting of 169 related tasks. They are

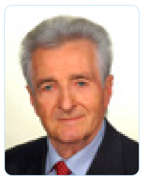
Source: UN-Water

designed to ensure a balance between the three areas of sustainable development: economic, social and environmental. Among these 17 Global Development Goals is Goal 6 – Clean Water and Sanitation, which aims to ensure that all people have access to safe (clean) water and adequate sanitary conditions through sustainable water resource management by 2030. This goal includes 8 different tasks. It is worth recalling that about 6,000 children die every day from diseases related to contaminated water and lack of sanitation. In developing countries, almost 90% of wastewater is discharged directly into rivers (without treatment), causing problems with its use. Water consumption has grown faster than population in recent decades. This is related, among other things, to the increase in prosperity. Most importantly, water unfortunately has no substitute. Many countries are already experiencing a water crisis.

Predictions for the future

Futurologists predict the possibility of even a global water crisis in the near future, given that the outflow of surface water by rivers to the seas is steady, while the population is growing. This simple analysis indicates that continuing to base the world's development only on surface water, which accounts for only 0.42% of all fresh water, is a road to nowhere and does not solve the problem of water shortages. At the same time, it is known that groundwater (water in the lithosphere) accounts for 29.4% of all fresh water, which has so far been used in limited amounts, because it was thought that groundwater of high quality should be used only as a component of municipal water. In smaller amounts should be used for agricultural irrigation or industrial processes. In many places, unfortunately, groundwater abstraction for irrigation was illegal.

Turning the economy to groundwater is a simple solution, as the volume of this water is almost 70 times that of surface water, and tapping into this water is the only salvation for the growing demand for water [3]. As a rule, groundwater is of very good quality, which makes it possible to use it for various purposes without the need for treatment, as is the case with surface water. The presentation of groundwater as a heading of WWD 2022 can be an introduction to its wider use. At first glance, this may seem like a simple solution. However, this is not the case, given the uneven spatial distribution of groundwater, the special characteristics of this water, the complicated conditions of its flow and the limitations on abstraction.



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