HYDROPOWER | WATER MANAGEMENT | ENVIRONMENTAL PROTECTION | INLAND NAVIGATION | ENERGY RECOVERY

ENERGETYKA WODNA

10 years

2/2022 (42)
FREE COPY
ISSN 2299-0674

TRMEW

From The Editorial Office

It is a strange political world we are living in, when European and national decision-makers label fossil gas and nuclear as environmental friendly and sustainable, while regard small hydropower as main problem for biodiversity.

Since February, the European and international community has been living with the conflict in Ukraine, which, among other things, results in a reduction in the supply of energy resources, thereby causing their prices to rise. Europe is anxiously turning its sights to the upcoming winter, which could be extremely difficult, due to fossil gas and fuel shortages. Meanwhile, the European Parliament has decided that the EU Taxonomy will treat natural gas as a sustainable energy source, contrary to earlier plans to turn Europe into a climate-neutral continent as soon as possible. Not only will the emission-intensive energy source be officially classified as green, but betting on an energy resource that is mainly imported from Russia, will not be conducive to achieving energy independence in the current situation.

Controversial decisions are also being made at the level of individual member countries. In Germany, with the so-called "Easter package," small hydroelectric power plants, with capacities up to 500 kW, were to be excluded from the support system, with a real risk of their liquidation (finally, thanks to the intervention of the Federation of German Hydroelectric Power Plants (BDW), support for SHPs will be retained). Meanwhile, in France, the La Roche-Qui-Boit hydropower plant has been demolished while preparations are underway to restart the extinguished Emile Huchet coal-fired power plant in Saint-Avold. Decommissioning a functioning facility with an installed capacity of more than 1.6 MW, or risking the closure of the entire domestic SHP industry at a time when every kilowatt of power on the grid counts, seems unwise, to say the least.

To take a breather from the curiosities of the current quarter, I invite you to read "Energetyka Wodna." Of course, I recommend reading it from cover to cover, however, I recommend the cover articles first. The topic of the issue is the Sromowce V Hydroelectric Power Plant, launched on the first of July, utilizing "to the last drop" the hydropower potential coming from the biological flow of the Sromowce Reservoir, which serves as an HPP Niedzica regulating reservoir. Piotr Wlodarski, Business Development Manager of Enerko Energy Sp. z o.o., presents details of the development of an unused reinforced concrete water supply channel to the planned fish stocking center.

In turn, Radosław Koropis, Vice President of RENPRO sp. z o.o. analyzes the current situation in the energy market to answer the seemingly simple question, are rising electricity prices an opportunity or a problem for owners of RES installations?

In the knowledge section, we zoom in on the details of the "We can, with hydropower" information campaign launched by the International Hydropower Association (IHA), which aims to draw public attention to the need to develop hydropower as an enabler of net-zero greenhouse gas emissions and to put the topic in the sights of decision-makers.

In the ecology section, in turn, we present the concept of a fish elevator developed by Prof. Bernhard Pelikan, which not only enables the migration of ichthyofauna, but also allows the flow necessary for the operation of the fish ladder to be almost entirely used for power generation, thus minimizing production losses in existing or planned hydropower plants.

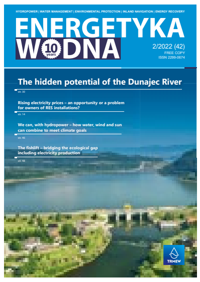
Michał Kubecki
Editor-in-Chief

ENERGETYKA WODNA

International quarterly

NO 1/2022 (41) – estimated readership: 2 500 unique recipients

www.energetyka-wodna.pl



NEWS

PRACTICE

LAW

PROJECTS

KNOWLEDGE

ECOLOGY

Editorial office:
Michał Kubecki – Editor in Chief
Michał Lis – Managing Editor
Aleksandra Wołowiec – Editor
Dominika Wójtowicz – Editor
redakcja@energetyka-wodna.pl
mobile: +48 518 304 194

Subscription and advertising:
Monika Grzybek
biuro@energetyka-wodna.pl

DTP:
Gustaw Nowak
grafika@energetyka-wodna.pl

Printing house:
Agencja Wydawnicza „ARGI"
ul. Żegiestowska 11
50–542 Wrocław

Program council:
Wojciech Majewski
Janusz Steller
Bogusław Puchowski
Ewa Malicka
Radosław Koropis
Robert Szlęzak
Andrzej Grześ
Małgorzata Stolarska
Michał Krzyszkowski

Photo on cover:
SHP Sromowce V under construction
Source: Enerko Energy Sp. z o.o.

Publisher:
Polish Association for Small Hydropower Development (TRMEW)
ul. Królowej Jadwigi 1
86-300 Grudziądz
phone: +48 (56) 46 49 644
fax +48 (56) 46 49 643
e-mail: biuro@trmew.pl
www.trmew.pl

TRMEW

Orders for institutional subscription adopts Kolporter Sp. z o.o. Sp.k. Information available at the hotline number 0 801 40 40 44 or on the website www.dp.kolporter.com.pl

It was published: 01.08.2022

HYDRO 2022 – the global community together again

Strasbourg held the honorable role of the world capital of hydropower for three days in April with the HYDRO 2022 conference and exhibition. This year's edition of the event was enthusiastically received by the participants, who for the first time after a two and a half years hiatus were able to exchange knowledge and experience in hydropower in person.

Source: Author's archive

Photo. Opening remarks by Alison Bartle, Editor-in-Chief of The International Journal on Hydropower and Dams

The theme of this year's edition was the maxim "The role of hydropower in global recovery" which was originally intended to refer to the reconstruction of the world economy, affected by the COVID19 pandemic, however it has taken on special significance as a result of the ongoing conflict in Ukraine, which was clearly emphasized by the organizers of the event. The term energy independence, forgotten in recent years, has become relevant again.

The topics of the conference also referred to the role of hydropower, including pumped storage power plants, in the energy transition to mitigate climate change. In addition, the thematic sessions addressed issues such as the use of available hydropower potential with a focus on developing countries, engineering challenges encountered during the construction of new dams and hydropower plants, lessons learned during design, construction, operation and repair, the impact of climate change on hydropower plants, the interdependence between hydropower and other RES technologies, lessons learned from investments carried out in disaster-prone areas.

This year's conference also included a thematic session devoted entirely to the HYPOSO project, which aims to develop hydropower in selected African and Latin American countries and promote European suppliers of equipment and services for hydropower plants.

Among the most important conclusions of the conference were the insights of the chairmen of the various panel sessions, which can be taken as a signpost for the industry for the coming years:

- new capacity is needed for the global economy accelerating after a pandemic and current hydropower development is too slow for existing needs,
- dynamic growth of storage capacity in newly built pumped storage plants is expected in the coming years,
- one of the important trends in European hydropower will be modernization and renovation of existing facilities,
- hydropower should be treated as a significant tool for mitigating climate changes
- consistent action and consolidation of the entire industry is needed to lobby at the EU level and educate the public, as the benefits that hydropower offers are not widely known outside our industry,
- the image of hydropower needs to be changed, as the public perceives the industry as old and undeveloped, which is contrary to the facts. An example is the progress that has been made in environmental technologies and operations, optimization of production, robotization or remote monitoring,
- the development of technology for the damming of rivers and care for the environment is the responsibility of the industry, not to create a bad image of hydropower,
- hydropower plants should be designed and built with prudence, responsibility, respect for the forces of nature, the principles of sustainable development and the interests of local communities and neighboring countries,
- when planning new investments, it is necessary to keep in mind the long time horizon in which hydropower plants will operate, rather than focusing solely on short-term profits,
- the issue of safety of hydroelectric structures is becoming a priority in the context of the advanced age of existing dams around the world,
- due to the loss of storage capacity of reservoirs, it is important to design new facilities in such a way as to minimize the problem of sedimentation.

Among the participants of the event was the Polish representation consisting of: Ewa Malicka, President of TRMEW, Piotr Włodarski, brand ambassador of IOZE hydro, and the author of this article on behalf of "Energetyka Wodna" quarterly. However, the Polish accent had a much greater dimension, thanks to the media cooperation, which continued as in previous years, between the HYDRO organizer, Aqua Media International publishing house, and the editorial board of "Energetyka Wodna", within the framework of which our quarterly in English version was distributed to all participants of the event in the already legendary HYDRO bags.

HYDRO trade fairs and conferences are an excellent source of inspiration and knowledge about current trends in the global hydropower industry. Each time the event ends, I am left with a certain dissatisfaction, as the three conference days are far too short to take full advantage of all that is on offer. Therefore, my thoughts turn with curiosity towards the next edition of HYDRO, which will be hosted next year in Edinburgh.

Michał Lis
Managing editor
„Energetyka Wodna"

News from TRMEW

We have to admit that the second quarter of this year was a bit more relaxed for the Polish Association for Small Hydropower Development (TRMEW) Board than the last 2 years, where we fought fiercely for the extension of the public support period and later helped energy producers fill out the documentation and successfully transit to immutable FIT/FIP tariffs. However, this does not mean that absolutely nothing happened. Let's begin with a report on the most important event in recent weeks, the General Convention and Hydropower Congress of 2022!

The Hydropower Congress began on 2nd June, which is the annual meeting of TRMEW members and supporters. This time the event took place at the wonderful Kliczków Castle. We are pleased that the attendance was good, especially during the part devoted to discussing current situation of hydropower plants in Poland. During the conference, the speakers were, as usual, our indispensable Board members Ewa Malicka and Radek Koropis, as well as our Supporting Partners from Renpro, Respect Energy, IOZE hydro and Aqua-Tech. In addition, our guests were representatives of the State Water Holding Polish Waters and an online presentation was delivered by the Director of the Department of Renewable Energy Sources at the Ministry of Climate and Environment. It was a very intensive day, the participants had the opportunity to learn about many current issues of hydropower and have their questions answered.

The second day was intended entirely for a tour of the surrounding hydropower plants and the Wodel production facility. We would like to thank our guests and representatives of Wodel, Merol Power Polska and MEW Kliczków for making their facilities available – all located among beautiful landscapes. On Saturday, the last day of the congress, the TRMEW General Meeting was held. Traditionally, we discussed the Association's current activities, finances and further plans.

We are planning to organise our next conference in November/December this year - please reserve your time for us now!

In the flurry of work in preparation of the Congress, we have not forgotten our legislative activities. We have recently submitted proposals for revisions to the draft act amending the Renewables Act. Our postulates were mainly focused on the issues of upgrades to hydropower plants, which will enable to obtain support proportional to the modernisation expenses incurred. The work is also underway on a continuation support scheme for SHPPs (support without additional investment, on an "as is" basis for a period of 10 years). In addition, we have submitted comments to the draft act amending the Spatial Planning Act, as well as the act amending the Provision of Information on Environment and Its Protection Act.

All the best (and much rest) during this holiday season. We will be constantly monitoring the situation and react quickly to any changes and relevant news in the coming months. Best wishes!

Monika Grzybek
Office manager
Polish Association for Small
Hydropower Development

The smallest SHP in Poland in the support system

As part of our pro bono work, we helped the owner of the Wejherowo SHP to take advantage of a support period extended to a length of 17 years, which was introduced last year thanks to the efforts of the Polish Association for Small Hydropower Development.

The thirteen-kilometer-long Cedron Stream, which is a right-bank tributary of the Reda River, feeds the smallest hydropower plant in Poland - the Wejherowo SHP. Upstream of the plant, there is a small pond closed by a weir equipped with a wooden gate, next to which the inlet channel to the turbine chamber of the power plant begins. The power plant has been built in 1993, at a site of a former water mill, which was in operation until the 1980s. Interestingly – rather than a water wheel – the old mill was equipped with a 60 cm diameter Francis turbine producing a power of about 4 kW. The current owner has made necessary upgrades to this system, equipping the turbine with a belt transmission and a 3 kW generator. The installation is connected to the grid governed by Energa Operator. "Owing to these upgrades, the water in the mill is at work again instead of being wasted", summarized the owner, Mr. Roman Prena of his investment.

The Wejherowo SHP will benefit from the feed-in tariff system for the next 24 months, selling electricity to an obligated seller. It seems interesting to ask how it will fare under market conditions, after the end of this period

Radosław Koropis
Vice President of the Management Board
Polish Association for
Small Hydropower Development

Source: Author's archive

POLCOLD – reactivation and participation in the XXVII Congress of Large Dams

On the 29th of September by the order of the Polish Ministry of Infrastructure the Polish Comittee of Large Dams (POLCOLD) was established. It means, that POLCOLD is back to life and again a member of The International Commission on Large Dams (ICOLD) after several years of absence. ICOLD is a forum for discussion and for the exchange of knowledge and experience in dam engineering for engineers and others concerned with the development of water resources in the planning, design, construction and operation of dams and associated works. It was founded in 1928, the central office is located in Paris.

Photo. From the left: Krzysztof Wrzosek, Piotr Śliwiński, Gabriela Puchalska, Michael Rogers together with his wife and Przemysław Sobiesak

Source: Author's archive

The following memebers were appointed to the committee (representatives of IMGW, PGW WP i MI): Piotr Śliwiński – the president of POLCOLD, Krzysztof Wrzosek – the v-ce president, Aneta Krawczyk – the secretary, Jerzy Gamdzyk, Paweł Wiejacz, Wojciech Skowyrski, Przemysław Sobiesak and Paweł Płoński.

For a beginning 3 technical committees were established:

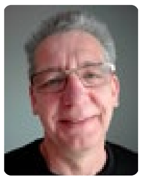
- subsoil and construction (KIP),
- safety and supervision (BIK),
- exploitation and modernization (EIM),

cooperating with their counterparts in ICOLD.

With the development of POLCOLD the committees will be expanded, modified and created the new ones depending on the interest and the needs. Soon there will be created a team of polish experts ready to act in a new EU programme ETIP HYDROPOWER (2022-2025), which is going to be led by EurCOLD.

From the 27th of May to the 3rd of June 2022 the XXVII Congres of Large Dams with the participation of polish representatives was held in Marseille, which covered an extraordinary wide range of subjects. The days were full of meetings of national and regional Committees, workshops, symposia, young engineer's forum, exhibitions and finally, technical presentations. This time the main questions discussed were: Concrete dams design innovations and performance, incidents and accidents concerning dams, surveillance, instrumentation, monitoring, data acquisition & processing and dams and climate change.
The cooperation of POLCOLD with ICOLD was renewed during the Congress. Our delegation had arranged the meetings with the General Secretary of ICOLD, the presidents - former and the new one just elected - and the president of EurCold. The aim of the talks was to allow polish represenatives to take part in technical committees activities and also discussed the possibility of translations of ICOLD materials to Polish and presentation of mentioned above on POLCOLD's and ICOLD websites. All the participants of the Congress were invited to Poland to attend polish hydroengineering confereces.

The polish delgation was kindly hosted by representatives of ICOLD, which expressed their satisfaction of POLCOLD comeback to an international cooperation dealing with a safety, design, construction and exploitation of dams. The direct contacts made allow to develop a collaboration in the nearest future. The reestablishment of POLCOLD and its presence on the Congress reopened the possibilities for such cooperation with ICOLD.



Piotr Śliwiński
President
Polish Comittee of Large Dams (POLCOLD)

Source: iStock, anderm

The LIFE 2022 call has started – €598 million is available!

On 17th May the EU Commission has officially launched a new call under the LIFE program in Poland and published invitation to submit proposals.

The EU Commission has allocated €598 million this year to support projects related to nature conservation, environmental protection, climate action and the transition to clean energy in Poland.

Under the four LIFE subprograms, the distribution of available funds is as follows:

- nature and biodiversity – €242 million (including €145 million for strategic projects);
- circular economy and quality of life - €158 million (including €52.8 million for strategic projects);
- climate change mitigation and adaptation - €99 million (including €30 million for strategic projects);
- transition to clean energy – €98 million.

Deadlines for submitting proposals for this year's LIFE call are:

- subprograms for promotion of circular economy and quality of life, nature and biodiversity improvements, climate change mitigation and adaptation – traditional projects (SAP): 4th October 2022;
- clean energy transition subprogram – LIFE Action Grants: 16th November 2022;
- strategic projects (SIP and SNAP): 8th September 202 – deadline for submission of project card; 7th March 2023 - deadline for submission of a complete proposal;
- technical assistance (TA) projects supporting of strategic projects (SIP and SNAP) – 8th of September 2022.

More details on the types of projects that can be financed with LIFE program funds and tips on how to apply are available at https://cinea.ec.europa.eu/

Press office
National Fund for Environmental Protection and Water Management of Poland

Calendar

10–12.08.2022 Guangzhou, China	**POWER CHINA 2022** Organizer – Guangdong Grandeur International Exhibition Group	www.bspexpo.com
12–13.09.2022 Rzeszów, Poland	**VII Scientific Conference "Energy Security – Pillars and Development Perspective"** Organizer – Ignacy Łukasiewicz Institute for Energy Policy	www.instytutpe.pl/konferencja2022
21–23.09.2022 Rytro, Poland	**XXX Technical and Science Conference Design & Exploitation of Electrical Machines & Drives** Organizer – Łukasiewicz Research Network, KOMEL	www.komel.lukasiewicz.gov.pl
21–23.09.2022 Warsaw, Poland	**IV National Hydrological Congress** Organizer – Association of Polish Hydrologists	https://kongreshydrologiczny.urk.edu.pl
10–11.10.2022 Lublin, Poland	**National Energy Summit OSE 2022** Organizer – European Business Center	www.osg2022.pl
19–20.10.2022 Cracow, Poland	**13th International Trade Fair for Suppliers of Maintenance Products and Services – MAINTENANCE** Organizer – Targi w Krakowie Sp. z o.o.	www.symas.krakow.pl
26–27.10.2022 Warsaw, Poland	**Polish Hydropower Conference HYDROFORUM 2022** Organizer – Polish Hydropower Association	www.hydroforum.tew.pl
26–27.10.2022 Ankara, Turkey	**5th Annual International Summit and Exhibition Turkey and Balkans Power** Organizer – Vostock Capital	www.hydropowerbalkans.com

30th Jubilee Scientific & Technical Conference PEMINE

We are glad to inform you that the annual Technical and Scientific Conference „Design & Exploitation of Electrical Machines & Drives" organised by KOMEL will take place dd. 21–23 September 2022 in the village Rytro, located in the southern part of Poland, in the picturesque valley of river Poprad.

The Conference includes the following topics:

- design, exploitation and diagnostics of electrical machines,
- electromobility, including the design, features and exploitation of vehicles with electric drives,
- new concepts of electrical motors,
- designing and calculation of motors,
- permanent magnet motors,
- exploitation, diagnostics of electrical motor,
- monitoring, testing and modern measurement equipment,
- reliability and influence of exploitation conditions on machine lifetime,
- modernisation of electrical drives,
- damages of motors and drives as well as restoration possibilities,
- frequency converters and other controlled sources of electrical energy,
- influence of power supply from frequency converters on the performance of electrical machines,
- safe exploitation of electrical machines and electromagnetic compability,
- insulation systems and materials.

Due to the great interest during the previous conference PEMINE, a separate session will be a session on electromobility, where we will present the issues related to the design, operation and transport vehicles with electric drive. The conference will showcase electric vehicles, including off-road version, and all interested participants will have the opportunity to personally test them during a test drive. Since the conference is an ideal event to show different solutions and knowledge, commercial papers and advertisements are welcome as well. There will be also a possibility to delivere commercial speech and/or exhibition during the conference.

The conference language will be Polish, but a Polish-English interpreter will translate presentations and discussion.

The registration fee for participants amounts to €550 – includes accommodation and board (with banquet), participation of the conference and a copy of the Procceedings. For a single room an extra fee €160 will be charged.

Information is provided by:
The secretary of the conference,
Msc Mariusz Czechowicz
phone +48 (32) 258-20-41 ext. 25,
mob. +48 606-308-827
fax +48 (32) 259-99-48
e-mail: info@komel.lukasiewicz.gov.pl
www.komel.katowice.pl/tekst/pemine.html

100 years of the hydropower plant in Rosnowo

The Rosnowo hydropower plant, owned by Energa OZE, an ORLEN Group company, is celebrating its 100th anniversary this year. It is one of Energa's 44 small hydropower plants. Their installed capacity is about 40.35 MW. In 2021, they produced a total of about 100 GWh of electricity.

Source: Beata Zbonikowska

The origins of today's Rosnowo hydropower plant date back to 1922. It is placed deep in a large forest complex located within the Białogard Plain, on the Radew River. A derivation canal with a length of about 2662 meters was built for the purpose of supplying a small hydropower plant there. An old watermill once operated on the oxbow lake of the Radew River. The power plant uses the retention at Rosnowskie Lake, cooperates with the Niedalino hydropower plant, built in 1912 to protect the nearby area from flooding.

During World War II, in March 1940, there was a construction accident. The thaw after a very cold winter caused a large outflow of the Radew River and broke the dam on the Rosnowo Canal. The flood wave, pushing massive ice blocks reached far beyond the limits of Koszalin, going all the way to the Parsęta River. There was considerable damage of buildings and bridges, while communication along flooded roads was also disrupted for a period of time. It was not until 1944 that the damage was repaired and the power plant was able to resume its operation. Today, a number of safeguards and procedures are in place at all of Energa's hydropower plants to prevent events similar to the one at Rosnow in 1940.

Energa OZE modernized the power plant in 2009 and 2011, installing modern speed governors. In 2011, a new shaft has been delivered to replace the one in the generating unit number 2. In 2015, comprehensive (both surface and in-depth) concrete repairs were carried out on: the intake walls, intake's abutments and dividing pillar, the thrash rack and hoisting service platform, as well as external walls, stairs, channel embankment protection and anti-corrosion coatings of the regulating weir equipment. In order to improve the working conditions of the plant's staff, a trash rack cleaner has been installed. Thus, manual labour required for the operation of the power plant has effectively been halved.

Due to its nature and location, the Rosnowo hydropower plant is a peaking power plant. As flows increase due to rainfall, snowfall or thaw, it's operating time increases. The hydropower plant is equipped with three Francis twin-rotor turbines, each with an installed capacity of 1.1 MW and a rotational speed of n=375 rpm and three 1,690 kVA generators, mounted on a common shaft with all the turbines. The total installed capacity of the power plant is 3.297 MW.

Press office
Energa Group

The new investment will increase the capacity of Dębe hydropower plant

PGE Dystrybucja is building a new control room at the Dębe hydropower plant, owned by PGE Energia Odnawialna. The investment, worth nearly PLN 6 million, will increase efficiency and improve the reliability of the power plant's operation.

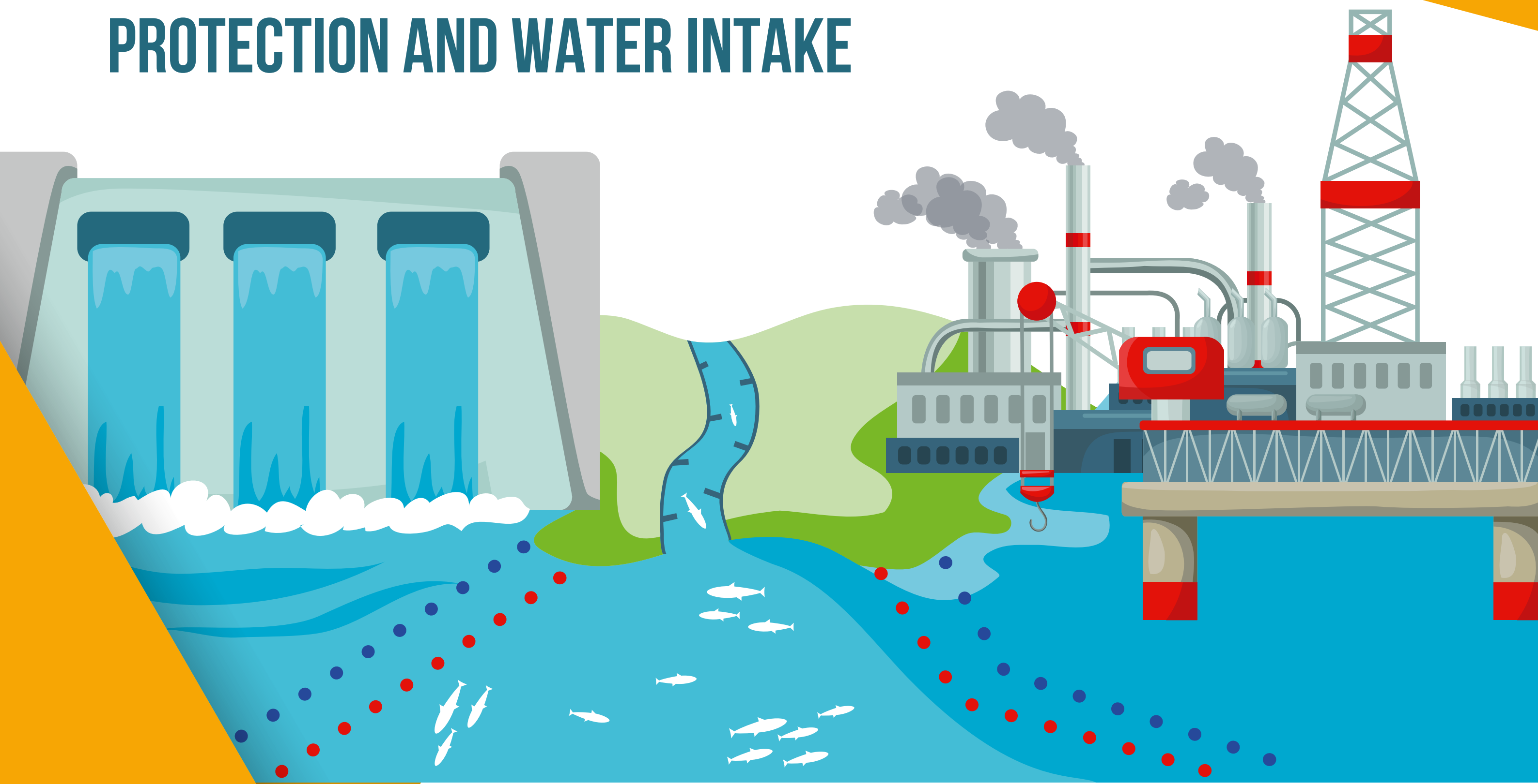
The next stage of construction of the new control room for the high-voltage switching station (HV) at the Dębe hydropower plant is being carried out by the Warsaw Branch of PGE Dystrybucja. This investment is combined with the modernization of the power plant, which is being carried out by PGE Energia Odnawialna, involving the replacement of four hydrosets. This will contribute to a 17 percent increase in green energy production.
– The work carried out by PGE Dystrybucja is synchronized with the modernization of the power plant's hydrosets. The relocation of the control room is the first step in the planned investment process, the next step will be the modernization of the existing switching station," explains Sylwester Szczensnowicz, general director of the Warsaw Branch.
– The investment, costing nearly PLN 6 million, will be completed later this year, Director Szczensnowicz adds. The construction of the new control room will allow the replacement of already depleted equipment with modern and reliable ones.
The investment will strengthen transmission capacity for more electricity generated by the Dębe hydropower plant. The modernization will also improve periodic maintenance.

Press office
PGE Dystrybucja

neptun

EFFICIENCY IN THE NATURAL ENVIRONMENT
100%

INNOVATIVE TECHNOLOGY FOR FISH PROTECTION AND WATER INTAKE



Technology based on the method of producing increasing non-linear electric field intensity in the water environment

NEPTUN –
effective solution to deter fish from surface water intakes.
The system keeps fish away from exploring water engineering objects.
Its properties help protect fish and reduce maintenance costs of technological installations.

ADVANTAGES OF THE NEPTUN SYSTEM:

- High, nearly 100% efficiency in the environment proven by tests of independent units in the country and abroad
- A wide range of applications regardless of hydro-technological conditions
- Easy assembly in existing and brand new facilities
- High resistance to mechanical damage
- Low energy consumption

LAUREATE PROJECT

EKO ODPOWIEDZIALNI W BIZNESIE

GREENEVO AKCELERATOR ZIELONYCH TECHNOLOGII

PROCOM SYSTEM S.A.
ul. Północna 15-19 bud. 2.2.
54-105 Wrocław

tel. +48 71 66 700
info@fishprotection.eu
www.fishprotection.eu

PROCOM SYSTEM

Wide-ranging restoration plans on World Fish Migration Day 2022

As part of the 2nd update of the River Basin Management Plans (II RBMPs) for 2022-2027, more than 13,000 corrective actions have been planned in river uniform surface water bodies, for improving the hydromorphological conditions of rivers and streams. The success of their implementation will depend on the involvement and cooperation of stakeholders and entities across the country.

River Basin Management Plans are among the most important planning documents in water management. One of the biggest challenges of the current update of the plans was development of solutions for improving the hydromorphological status of rivers and planning of the priority actions. The planning cycle for 2022-2027 started with the identification of pressures with their assignment to uniform bodies of water (UBW), water regions and river basin districts. The work resulted in the creation of a national database of hydromorphological changes – the first of its kind in Poland – containing more than half a million sites. Thanks to the information gathered, it became possible to plan comprehensive remedial measures for all uniform bodies of water, through which good water status could be achieved, improved or maintained.

There are 18,424 remedial actions planned for implementation for the surface UBWs, and more than 70% are for the elimination or reduction of significant pressures affecting the hydromorphological conditions of rivers and streams, including biological continuity, water dynamics and flow conditions and the objectives of water-dependent protected areas. Consultation of II RBMPs resonated with the public, particularly in the context of water renourishment, whereby sets of remedial measures for the elimination of hydromorphological pressures were expanded. Additional technical measures to restore the biological continuity of rivers have been identified, also in terms of renourishment and the range of non-technical measures has been expanded to result in increasingly better living conditions for aquatic organisms.

During the planning work, the experts identified in detail specific damming structures that generate pressures leading to the deterioration of, among other things, fish migration conditions and proposed measures for their restoration. These measures relate to the development and implementation of the selected option for unblocking specific river, the reconstruction of transverse structures in a way that ensures the restoration of biological continuity and the control of the operation of fish migration facilities. In terms of ensuring biological and morphological continuity of rivers and streams, a total of 1,473 measures have been identified for 1/4 of the river UBWs nationwide. For 511 UBWs, the implementation of restoration measures is planned, taking into account the preservation of watercourse functions and the implementation of a restoration programme for the priority area designated in the National Programme of Surface Waters' Restoration (NPSWR). In the II RBMPs, a total of technical measures to improve hydromorphological conditions, which are part of the measures indicated in the NPSWR, were assigned to 1,064 river UBWs.

In the 2nd update of the RBMPs, measures indicated in the Plans of Protection Task/Protection Plans for protected natural areas, including Natura 2000 areas, were also included. A total of 7,791 remedial measures were planned for 1,175 river UBWs nationwide. In addition, close to 2,000 actions have been identified for 1,023 river UBWs, which include the identification of the grounds for implementation of remedial actions in protected areas. These focus, among others, on reducing the negative impact of damming facilities on environmental objectives, maintaining the natural character of the riverbed and implementing environmental requirements for rivers boasting a high population of submerged plants.

Press office
State Water Holding Polish Waters

New reservoir will be built in the Kleszczewo municipality

At the end of 2022, the construction of the Tulce Reservoir in the Kleszczewo municipality (Greater Poland Province) will come to a conclusion. The investment had been waiting for completion for 30 years. The facility will be created by damming up the water of the Męcina River after the construction of a dam located about 70 m above the Tulce-Środa Wielkopolska road.

The Kleszczewo municipality receives annual rainfall of less than 550 mm, one of the lowest in Poland. There are no lakes or wetlands and meadows cover only a small area. The scarcity of rainwater and the poorly permeable ground, with practically no forests, cause serious problems with low specific runoff and erratic flows. The water deficit can particularly be felt by the intensive agriculture carried out in these areas. The most important task of the reservoir with a retention capacity of 242,000 m^3 will be to store almost 67,000 m^3 of water for agricultural irrigation, including irrigation of grasslands. The water balance and retention capacity of the catchment area are going to be improved and residents shall be protected from periods of intense rainfall interspersed with the occurrence of prolonged droughts. The administrative area of the reservoir will be 22.45 ha. According to the schedule, the construction work will be completed by the end of December 2022. Commissioning of the facility will then begin. The total cost of the investment is almost PLN 22.07 million, the funding from the Regional Operational Program for Wielkopolskie Province amounting to more than PLN 16.21 million.

Wojciech Kwinta
inzynieria.com

Weir renovations in Podlaskie Province will increase retention in the Narew Valley

State Water Holding Polish Waters has signed a contract for the renovation of two weirs at Narew River in Babino and Rzędziany (Podlaskie Province). The structures will be restored to an appropriate technical condition and will increase channel retention capacity in the Narew River Valley.

Both weirs were constructed in the 1980s. During their operation, technical corrections were made, mainly in order to protect the upper and lower embankments. The gates, abutments and control rooms were not renovated. The Babino weir has been opened in 1984. It is a Class IV structure of reinforced concrete, with a fixed sill, a 2x7.0 m clearance and a damming height of 1.32 m. The Rzędziany weir has been opened a year later and has a similar construction, but with a damming height of 2.25 m. The refurbishment of both weirs will include the restoration of abutment walls, pillars, race floor structure, as well as strengthening of weir gates andbridge slabs. The contractor will also renew steel footbridges, control rooms and the paved surfaces inside, as well as the entrances to the crossing slabs. Babino and Rzędziany weirs dam the water of the Narew Valley for the needs of the Narew National Park and nearby agriculture. Among other things, their function is to improve water distribution for agriculture (especially during the crop-growing season) by affecting the network of drainage ditches between Rzędziany and Babino villages. The damming of water takes place all through the year with 14-day breaks to allow fish migration and breaks necessary for harvesting grass and hay from weir adjacent areas. State Water Holding Polish Waters informs that slowing down the free flow of the Narew River, including the flow in its oxbow lakes, will improve retention capacity of the river and neighbouring network of drainage ditches. The cost of the planned works amounts to almost PLN 9 million. They will be completed in the second half of 2023. The Regional Water Management Board in Białystok has also commissioned design works for the reconstruction of four weirs on the Kuwaski Canal and two on the Jabłonka River, as well as eight damming structures on the Gać River together with another two weirs and a penstock on the Kulikówka River.

Wojciech Kwinta
inzynieria.com

Reconstruction of reservoir in Mazovia – contract is ready

PLN 14.5 million will be spent on the reconstruction of the Ruda Reservoir in Mława (Mazowieckie Province), covering an area of nearly 58 hectares. An agreement with the contractor has been signed on 22th March this year.

The Ruda Reservoir has been created by damming of Mławka River. The main purpose of constructing this structure was to increase retention and protect against floods and drought. For the current renovation, the facility will be emptied in two stages (so as to protect the aquatic fauna inhabiting the reservoir). The plan is to dismantle the damaged reinforcement of the upstream embankment made of concrete slabs and to construct new seals and reinforcements of the embankments and the dam. In addition, the contractor will repair spillway gates, tipping flaps and groynes. The reservoir will also be desludged (at an area of 38 hectares) and a fish ladder is going to be be built. The damming levels and the size of the canopy will not be changed and the expected result of the reconstruction will be reinstatement of the original parameters of the Ruda Reservoir. Flood safety of areas downstream of the dam will be increased, water retention will be improved and the likelihood of drought in adjacent areas will be reduced – according to the information provided by Marek Gróbarczyk, Deputy Minister of Infrastructure. In addition, increasing the depth of the reservoir will improve oxygen content in water, which will benefit the species diversity of aquatic animals residing in the reservoir. The reservoir will also once again become an attractive recreational destination.

Wojciech Kwinta
inzynieria.com

First QGIS plug-in of State Water Holding Polish Waters

State Water Holding Polish Waters (PGW WP) has released the first plug-in for QGIS software called "Wody Polskie - WMS Database". It gathers all WMS (Web Map Services) viewing services published by Polish Waters in one place and allows to load them into QGIS with the click of a button. For ease of use, the services are grouped into 6 thematic tabs.

The database plug-in can be downloaded from the official QGIS repository. In the current version 1.0.1, 28 WMS viewing services are available, bringing the total to over 400 thematic layers. In order to acquire the above resources in the form of lists, map compositions or vector data, please visit the website https://www.wody.gov.pl/. Available thematic tabs include:

- map of Hydrographic Division of Poland in 1:10,000 scale,
- updated River Basin Management Plans (RBMPs),
- organizational branches of State Water Holding Polish Waters (including territorial boundaries of these),
- preliminary flood risk assessment studies,
- flood hazard maps,
- flood risk maps.

Press office
State Water Holding Polish Waters

From Around the World

16.03.2022 New collab using satellite data to help optimise Swiss hydropower production

New consortium of Swiss hydropower companies and science firms are working together to help optimise hydropower production through the use of satellite data.

Supported by the Pilot and Demonstration programme of the Swiss Federal Office of Energy (SFOE), climate tech start-up Wegaw and hydrology experts as well as the WSL SLF Institute for Snow and Avalanche Research and nine hydroelectricity companies, are working on the "Defrost for Hydropower" project to improve water supply forecasting in dams across Switzerland's alpine regions. The "Defrost for Hydropower" project combines SLF's snow expertise with satellite imagery from Wegaw's geospatial technology and Hydrique Engineers advanced modelling skills, in order to more accurately predict water flow into hydro dams up to four months in advance as well as hydrological inflows on a regional scale. These improved forecast insights would support numerous key areas that are important to industry stakeholders, such as hydroelectricity asset efficiency, trading decision making, due diligence and national sustainability efforts.

18.03.2022 MIGA supports first private sector led hydro plant in Gabon

The Multilateral Investment Guarantee Agency (MIGA) has issued guarantees to Meridiam for equity investments into Asonha Energie SA, which will build and operate the 35 MW Kinguélé Aval Hydropower Plant in Gabon – the first project developed by an independent power producer (IPP) in the country.

The 20-year guarantees totaling €25.3 million (approximately US$28.7 million) provide protection from breach of contract, expropriation, transfer restriction and currency inconvertibility, as well as war and civil disturbance. MIGA guarantees for this project are considered critical given Gabon's electricity sector challenges and risks posed by the broader political and economic environment. Gabon rates among the countries having highest hydropower potential in Africa. The government of Gabon (GoG) is taking steps to transition into sustainable energy sources and create a single national integrated grid using hydropower. GoG intends to rely on IPPs to exploit its largely untapped hydropower potential.

22.03.2022 Fichtner to support new pumped storage project

Fichtner, together with its British subsidiary Fichtner Consulting Engineers Ltd, has been contracted by Quarry Battery Company Ltd. to support its 100 MW pumped storage hydro development in Wales. The Glyn Rhonwy site in Llanberis comprises two disused slate quarries which will be re-purposed as reservoirs for the new-build pumped storage system. The reservoirs will have storage volumes of up to 1.3 million m³ and a height difference of some 300 m.

Fichtner's services on the project include a value engineering phase, followed by the preparation of tender documents and support during tendering.

29.03.2022 Norwegian hydro to help power silicon metal production

Around 40% of the electricity needs at a silicon metal production site at Holla in Norway is to be met by hydropower over the next five years, as Statkraft signs an agreement with chemical company Wacker.

Under the terms of the deal, Statkraft will supply a total of 2.35 TWh of certified Norwegian hydropower to Wacker's Holla site between January 2022 and December 2027. Around 525 GWh of this will come from the Svean hydropower plant under a green power purchase agreement (PPA). "Switching to green power in our production is an important lever for achieving our sustainability goals," said Wacker CEO Christian Hartel. "The Holla site is the first step. In the short to medium term, we intend to steadily expand our green power portfolio with further purchases in Norway and Europe."

29.03.2022 Construction starts at Gratkorn hydropower plant, Austria

Construction has officially started at the 11 MW Gratkorn hydropower plant on the river Mur, north of Graz, Styria, Austria, with the formal groundbreaking ceremony held on 25 March.

The project is being jointly developed by Verbund and Energie Steiermark, who have invested around €80 million. Expected to be put into operation in 2024, the project will generate around 54 million kWh a year, covering the annual electricity requirements of around 15,000 households.

"The current developments on the international energy markets shows us in a drastic way how urgent it is to expand renewable energies," said Michael Strugl, CEO of Verbund. "The hydroelectric power plants – like here with the Gratkorn power plant – but also wind power and photovoltaics will be the supporting pillars of the renewable energy future."

06.04.2022 Nyamwamba II hydro plant operational in Uganda

Serengeti Energy has announced that its 7.8 MW Nyamwamba II hydropower plant on the Nyamwamba river, in Kasese, western Uganda, has officially begun commercial operations.

Owned 100% by Serengeti Energy, the project costed around US$22 million to build, with construction having started back in October 2019. The project is Serengeti Energy's second hydro project on the Nyamwamba river, and its third to become operational in the country. The Regional Liquidity Support Facility (RLSF) an initiative by KfW (German state-owned development bank) and African Trade Insurance Agency (ATI), to mitigate short term liquidity risks on independent power projects in Africa, is supporting the project and documentation will be executed shortly.

Nyamwamba II is part of the Ugandan government's efforts to utilise renewable energy to strengthen and diversify the country's electricity infrastructure. The new capacity will support the local government to reach its 100% renewable energy target for Kasese district.

13.05.2022 World's first 600 rpm pumped storage unit in commercial operation

The world's first reversible pumped storage unit with 600 rpm and 350 MW has been successfully placed into operation at the Changlongshan pumped storage plant in E Zhejiang Province, China, as Voith Hydro has announced. Voith has provided two complete power units (5 and 6) to the six unit project, which has an installed capacity of 2.1 GW. Unit 5 successfully passed the 15-day trial operation at the beginning of May and was officially put into commercial operation. The station has a rated head of 710 m which is among the highest in China. The new unit's rated speed of 600 rpm with a capacity of 350 MW is a world's first for such high-capacity and high-head units.

26.05.2022 Study investigates feasibility of restoring Sweden's largest pumped storage plant

A feasibility study is being carried out to investigate the possibility of restoring the Juktan pumped storage power plant in Sweden. The study has been started by Vattenfall, with AFRY investigating the technological issues, as well as the scope necessary works in the areas of the existing units, civil work, electricity, and permits. Juktan's power plant is located between the lakes Storjuktan and Storuman in the upper part of the Ume River, 20km north of Storuman municipality. The power plant was the first large pumped storage plant in Sweden and also the largest pumped storage power plant in operation from 1979 to 1996 with a storage capacity of ~ 30 GWh. An unusual advantage of Juktan's reservoir design is that you can pump water from Storjuktan-to-Blaiksjön with a lower potential and generate with a higher potential from Blaiksjön-to-Storuman If Juktan is restored as a pumped storage power plant, it will be Sweden's largest project of its kind. The feasibility study is ongoing until mid-2023 and when a decision is made, allowing the restoration to proceed, commissioning is expected to be in 2031.

02.06.2022 Statkraft opens new small hydro plants in Norway

European renewable energy company Statkraft has commissioned two new small hydropower plants in Norway, located at the opposite sides of the Hardanger mountain plateau. The Vesle Kjela power plant is located at the top of the Tokke/Vinje regulated watercourse and utilizes the head from the regulated Kjelavatn lake in the Haukelifjell mountain area. The power plant has an installed capacity of 8.5 MW and provides a production of approximately 40 GWh a year. The Storlia power plant has the same capacity and production and utilizes a head of 75m between the Bjoreio river and Sysenvatn lake in the municipality of Eidfjord as part of the Sima regulation.

"The power plants are good examples of Statkraft's significant investment in upgrading Norwegian hydropower assets," said CEO Christian Rynning-Tønnesen. 'Vesle Kjela and Storlia power plants were built using existing infrastructure remaining after previous hydropower developments, new technology and cost-effective methods executing good cooperation with suppliers."

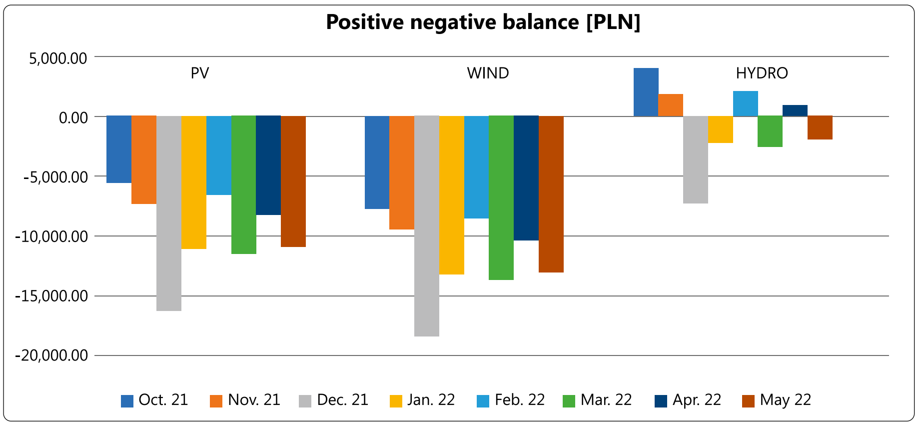
07.06.2022 Scottish micro hydropower plant became fully operational

A 92 kW hydropower plant located on the banks of the River Ness in the Scottish Highlands is now fully operational, providing electricity to local facilities. The Hydro Ness scheme features two 92 kW Archimedes screw turbines which will generate over 500,000 kWh of renewable energy each year. The electricity generated will feed the nearby Inverness Leisure Centre, providing roughly 50% of the site's electricity demand. "Electricity prices are increasing rapidly, and this project, and others like it, are vital in mitigating market prices increases to help ensure the council, and our partners, continue to offer first-class services to the public."

The site will also feature an interactive visitor experience that will showcase how science and nature can work together, and encourage visitors to think about their personal impact on the environment.

Rising electricity prices – an opportunity or a problem for owners of RES installations?

Since November 2020, electricity prices have been rising dynamically, reaching their maximum in December of 2021. Last year's increase was chiefly due to an increase in the cost of CO_2 emission allowances and prices of basic energy resources, i.e. gas and coal. This year, events in Ukraine and a change in the direction from where coal and gas is supplied to Poland have changed the price realities at the wholesale energy market in Poland. This would seem to be a favourable situation for producers of energy. But is it for all of them?



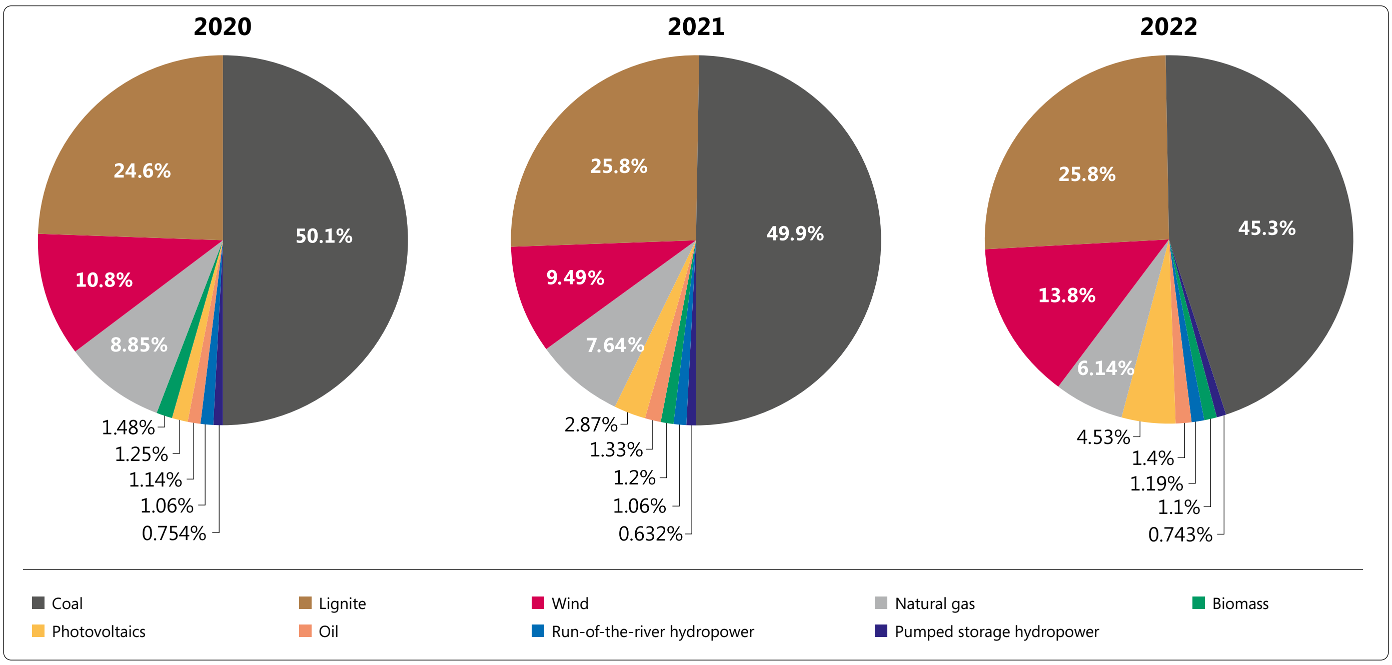
Source: Own study

Fig.1. Comparison of the negative balance for PV, WIND, HYDRO < 0.5 MW in relation to the reference price.

In 2016 Polish Renewable Energy Sources Act introduced the possibility of settling the difference between the reference price and the market price for participants in the auction and feed-in premium support systems. The negative balance is covered by Zarządca Rozliczeń S.A. (the name of the company can be roughly translated as Settlement Administrator – which will be the term used further on) after the producer submits a monthly application. The sharp increase in market prices in Q4 2021 resulted in a situation where the price determined based on the TGEbase index was greater than the reference or bid price submitted in the auction system. It first began to affect owners of photovoltaic and wind power installations that won auctions organized by the President of the Energy Regulatory Authority (pol. Urząd Regulacji Energetyki) in previous years, but in December this problem also affected owners of small hydropower plants participating in the feed-in tariff system. The scale of this phenomenon is evidenced by the fact that PV and onshore wind installations have been permanently generating a positive negative balance (which occurs when the market price is higher than the reference price) since October 2021, and it, in accordance with the provisions of Article 83 of the Renewable Energy Sources Act, must be returned to the Settlement Administrator. The return of the balance shall be made on a cumulative basis in subsequent months, and in the event that this does not occur, the return has to be made at the end of the support period or at the end of the three-year period depending on the applicable regulations in the period when the positive negative balance was generated.

Growth in the amount of electricity generated by renewable energy installations

In 2021, we saw an intensive increase in the number of micro PV installations, whose total installed capacity exceeded 6.1 GW, resulting in the release of about 2.7 TWh of electricity to the power grid. An analysis of the capacity utilization rate for PV micro-installations shows that it is half that obtained for industrial PV installations. This therefore means that prosumers also consumed in the same period approx. 2.7 TWh without taking it from the electricity system. Taking into account



Source: Own study based on ENTSO-E data

Fig.2. Structure of electricity generation in 2020–2022

Source: Own study

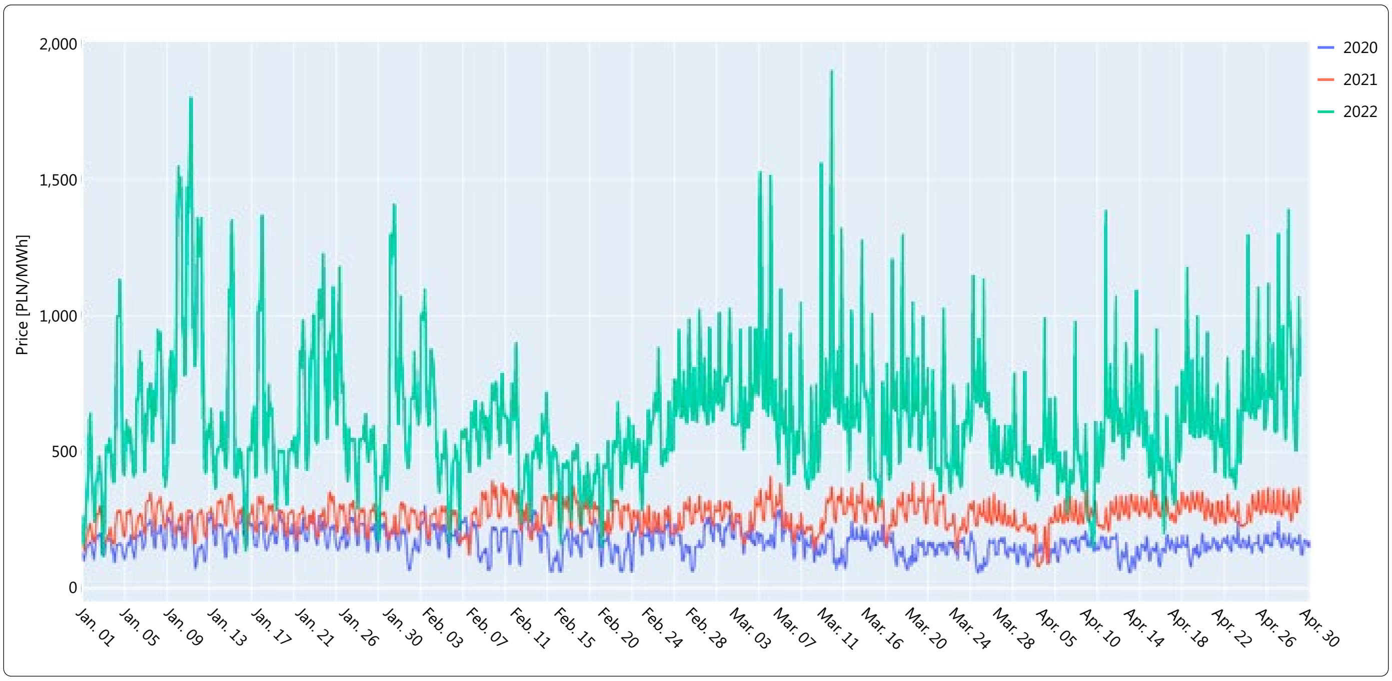


Fig. 2. Minimum and maximum price spread for FIX 1 in 2020, 2021 and 2022 for the period of 01.01–30.04

installations of higher capacity (for which the President of Polish Energy Regulatory Authority has issued licenses or made an entry in the small RES installation register), there are more than 15 GW of capacity installed as a part of weather-dependent RES installations. It is worth noting that the Polish Energy Regulatory Authority issued promises of licenses for installations with a capacity of more than 2.8 GW last year. The variability of weather and time-of-the-day dependent renewables is already clearly noticeable in the wholesale electricity market.

Changing structure of generation

The above summary, compiled on the basis of ENTSO-E data, allows us to note a trend related to the change in the structure of electricity generation in the period between January 2020 and May 2022. The decline in electricity generation in 2022 from coal-fired power plants is being replaced mainly by energy generated by onshore wind and photovoltaic installations. Planned legal changes to allow the construction of new wind installations through the liberalization of the "ten times height rule " onshore will cause this trend to continue in the future. At the same time, this change will result in the emergence of very large price differences in SPOT markets that were not observed in previous years.

High daily price volatility

An analysis of FIX 1 prices listed on the Polish Power Exchange (pol. Towarowa Giełda Energii) for the first four months of the year for years 2020-2022 shows that the increasing share of energy from RES installations significantly affects the structure of prices in particular periods of the day. In addition, a sharply increasing spread, i.e. the difference between the minimum and maximum price on a given day, can be observed. At the same time, with the increase in the production of electricity from photovoltaic installations since March 2022, the daily profile has changed, with a clearly marked price minimum in the midday hours.

Are RES support systems still needed?

The situation in the energy markets reflects many different factors and is characterized by very high volatility. Given the further development of RES installations, a decrease in the price of electricity should be taken into account in the coming years. At the same time, the price in feed-in premium scheme and auctions takes inflation into account, which means that RES producers should care about guaranteeing stable settlement rules. Different types of sales strategies based on contracts for difference or using various market indices will not favourably secure future revenues. At the end of September 2022, the support system for small hydropower plants that began selling electricity before 2005 will finally expire. Currently, electricity prices do not encourage significant capital expenditures, but this seems to be an inappropriate and short-sighted strategy. When taking steps to significantly modernize small hydropower plants, which should partially restore the support system, the installation of electricity storage facilities should also be considered. Battery storage facilities are finding increasing use in RES installations and are being used to provide a variety of services. The most classic one is time-shifting of sales, taking advantage of increasing price volatility throughout the day. Experience with 12 MWh and 6 MW storage units, which are a component of a wind farm installation, indicates that at least two charging and discharging cycles are possible per day. When the hourly billing scheme is changed to fifteen-minute billing, which should happen next year, this frequency will increase many times over. Another service provided by electricity storage will be flexibility-related regulations of the future. Intensive analytical work is currently underway, which should change the legal environment in the near future, thus enabling the provision of these services by alliances of RES producers. This, in turn, will provide financial benefits that may be a significant portion of revenues derived from RES installations and these may be necessary to maintain their profitability in the future.

renpro

Radosław Koropis
RENPRO sp. z o. o.

Challenges in the construction, erection, or rehabilitation phase of a hydro power plant – mitigation strategies

A careful evaluation of the mutual interests and well adapted and thought-out contractual provisions taking into account and balancing these interests can help to minimize the project related risks during the project execution phase.

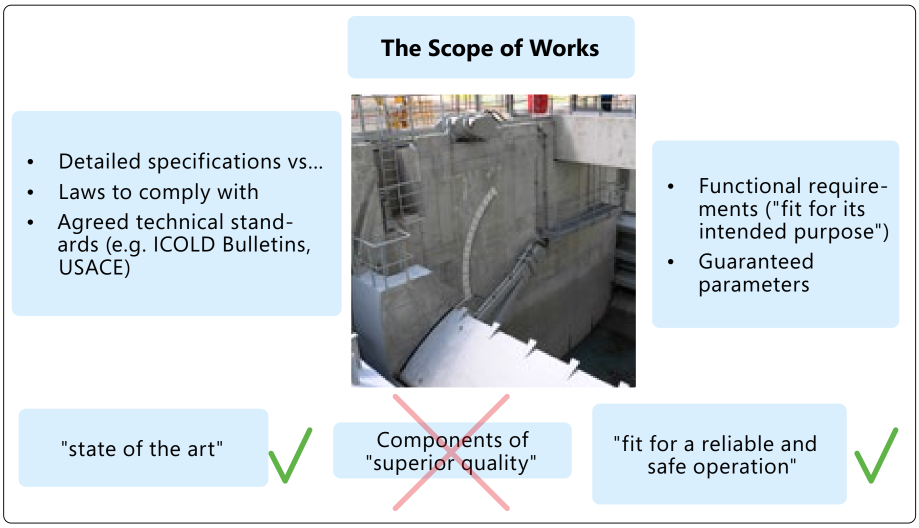
Hydro power plant (HPP) erection or rehabilitation projects are complex, and experience shows that future Owners/ Operators (Employers) and Contractors are often faced with project hindrances causing considerable delays or cost overruns/ additional costs. Thought-out contractual concepts and provisions considering the project specific situation will help to minimise project-related risks.

The most important five critical success factors are [1]:

1. A clear-cut description of the Scope of Works
2. Well thought-out provisions regarding the interface management
3. Balanced provisions regarding the risk allocation to one or both Parties in case of the occurrence of hindrances due to unforeseen events during the project execution
4. A good Quality Assurance Program linked with ample reporting obligations by the Contractor. This should go together with appropriate approval-, inspection- and instruction rights in favour of the Employer
5. And last, but not at all least: a detailed Provisional Acceptance Procedure.

The definition of the Scope of Works

The contractual provision containing the Scope of Works definition is the core clause of the contract. The definition must be clear-cut, avoiding any ambiguity in the wording. The definition of the Scope of Works will be the benchmark for evaluating the quality of the delivered works. There are different approaches to define the Scope of Works. In countries with a long experience in hydro power plant construction projects, state utilities seem to prefer to specify their requirements down to the smallest detail, e.g. down to the properties of the construction material to be used, whereas in World-/ Development Banks-financed projects Employers prefer a functional description of the plant to be delivered - leaving it up to the Contractor how to achieve this.



Source: © Bettina Geisseler

Fig. 1. Defining the Scope of Works

As far as the Contractor shall adhere to specific technical standards and norms such as IEC, ASME or NEMA which do not directly result from the applicable legal norms, those norms should be explicitly listed in the so-called Employer's Requirements. And, last but not least, the parties must agree on the guaranteed parameters such as – in view of a HPP - availability, output, efficiency and accepted losses of the transformers.

The Interfaces and the Interface Management

Coping with interfaces first of all requires both from a technical point of view as well as from a contractual point of view to identify the interfaces. In large scale projects there are many interfaces: the interfaces between the contractual parties, i.e. the Employer (Owner) and the Contractor, the interfaces to the other stakeholders and the interfaces between different Contractors for different parts (lots) of the whole works. The role of the contract is to clearly attribute the respective responsibilities and to define the mutual obligations regarding the interfaces. The parties need to decide who shoulders the risk if one lot upon which another lot is dependent is performed poorly or delivered too late.

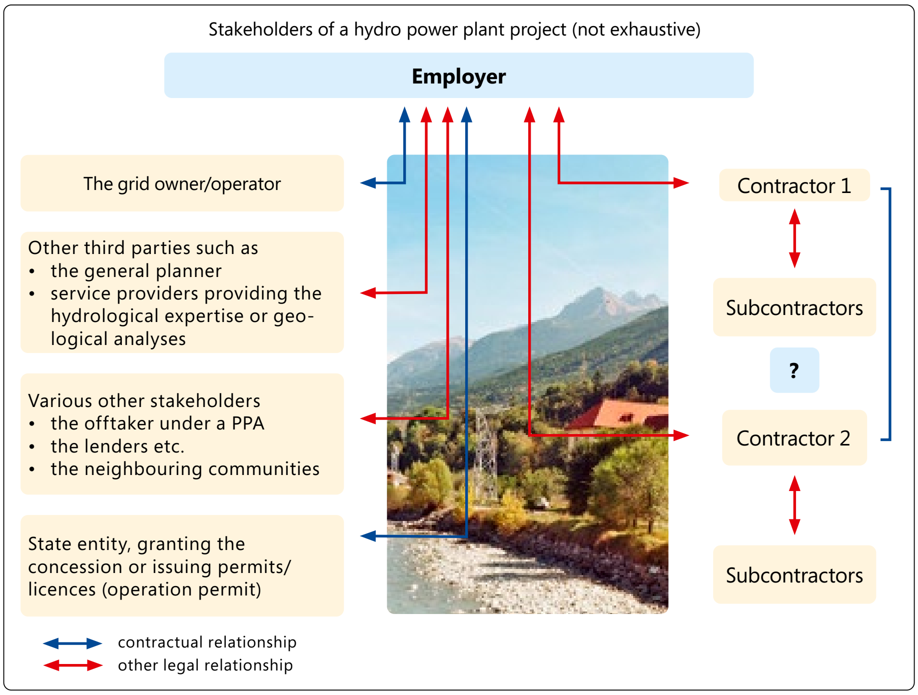
As one of several Contractors has no direct contractual relationship with anyone of the Employer's other Contractors, it is typically - or should be, from a Contractor's perspective - the Employer or his engineer ("Owner's Engineer") who assumes the interface management responsibility.

The Employer himself has various legal relationships to other stakeholders of the project. He must comply with the conditions of the compulsory state permits (construction permit; concession) or the requirements of the financing institutions or the Off-Takers under Power Purchase Agreements.

Unforeseen events – risk allocation

The allocation of risks between the Employer and the Contractor and the balancing of the risks in view of the calculated and offered contract price is one of the most challenging and difficult tasks while drafting and negotiating a hydro power plant erection or rehabilitation contract. Not only might it be difficult to clearly identify the potential risks and evaluate the risk exposure; sometimes it seems that the contractual parties do not have a clear idea of the legal consequences of an agreed risk

[1] The aim of this paper is to alert Owners/ Employers or Contractors of critical issues potentially having a major (financial) impact on the execution of a hydro power project, and to suggest, which critical issues should be considered when drafting the contract. Some issues such as the available remedies in case of defects or delay, termination and suspension, or the applicable law and an appropriate dispute resolution (state courts vs. arbitration) could not be considered. In no way shall it constitute and substitute a specific legal advice, which will depend inter alia on the applicable law.



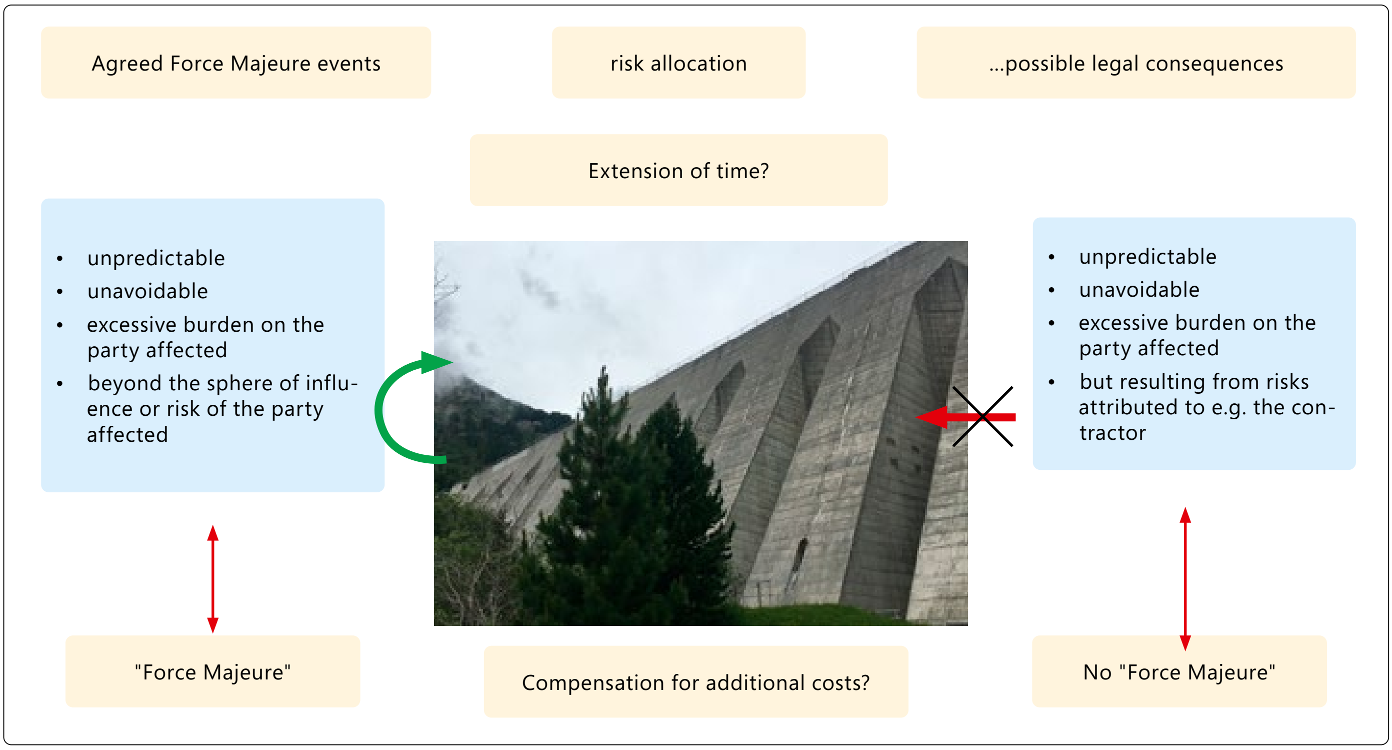
Source: © Bettina Geisseler

Fig. 2. Stakeholders – Interface Management

allocation, and in particular the cross-influence with a typical Force Majeure clause or, respectively, Force Majeure event. A Contractor who accepts a clearly identified risk (a) cannot claim extension of time and / or compensation for higher costs in case of hindrances during the project execution due to the occurrence of that risk, and (b) still has the responsibility for "care and custody" of the plant. In the worst case the Contractor is obliged to rebuild parts of the already erected plant in the event that the risk materialises and leads to the (partial) destruction of the plant.

There are typical risks in HPP projects, or to put it differently: unforeseen conditions, where the risk that they materialise is rather high. The materialisation of these risks might lead to considerable delays and in consequence considerably higher costs. The contractual parties should identify and discuss in detail the major and typical project-related risks, such as the (remaining) risk of different geological subsurface conditions other than those investigated, which might have a major impact on the subsurface structure for the HPP, such as a subsoil headrace tunnel or powerhouse. They should carefully evaluate these risks and then allocate them to one of the parties.

In a well negotiated, balanced contract, the taking over of major risks with at least a medium probability of occurrence will normally lead to a proportionate increase of the contract price. Within this context it should be reminded, that the contract law, i.e. the applicable law governing the contract, sometimes provides for solu-



Source: © Bettina Geisseler

Fig. 3. Allocation of risks – unforeseeable events

tions which the contractual parties do not like. In this case they explicitly have to derogate from the otherwise applicable provisions and stipulate provisions reflecting their intentions.

There is a wide range of possibilities for contractual solutions. Often, the party having better "control" of the risk or the potential event, e.g. the Owner for the site conditions, or the party responsible for performing the environmental investigations in the planning phase of a project, such as the geological or hydrological investigations, will take the risk that the circumstances prove to be different from previously assumed. In recent years the so-called Alliance Agreements are a preferred solution. These agreements typically provide for a risk sharing between both contractual parties, at least above a certain threshold, and are an incentive to quickly find a solution to overcome hindrances.

Project Monitoring and Quality Assurance

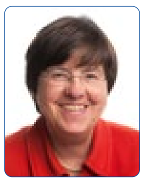
In complex and large-scale hydro power plant contracts, Employers are well advised to require from the Contractor continuous and regular, prompt, complete and accurate information on the stage of completion of the design, manufacturing and erection process and in particular on the occurrence of hindrances having an impact on the price or the time for completion. Employers should reserve themselves large approval (regarding the design and the engagement of subcontractors for major / critical components), inspection and instruction rights. Together with a good Quality Assurance program these rights aim to assure the overall quality of the requested Works. The quality assurance becomes increasingly important in the execution of complex projects, in particular in times when the level of vertical manufacturing integration seems to become continuously lower and supplied parts for key components are sourced in countries all over the world.

The Provisional Acceptance Procedure

I recommend determining in detail the procedure and the Parties' rights and obligations. It should be e.g. determined under which conditions the trial run has to re-start and which is the time frame for the Employer's obligation to cooperate and to approve the delivered works. In order to avoid disputes, the measuring methods for the guaranteed technical parameters should be well defined.

Source: © Bettina Geisseler

Fig. 4. Quality Assurance



Bettina Geisseler
Law firm GEISSELER LAW
www.geisseler-law.com

Improving the efficiency of water pumps and turbines

Many issues concerning technology and operation of machinery and equipment consider in detail the properties of the surface layer and its formation. The surface layer of a material formed as a result of physical or chemical processes, which differs in properties from its substrate, determines the resistance to wear and surface fatigue, i.e. the durability of the surface.

Photo 1. BELZONA(1341) SUPERMETALGLIDE, a coating whose surface is 20 times smoother than polished stainless steel

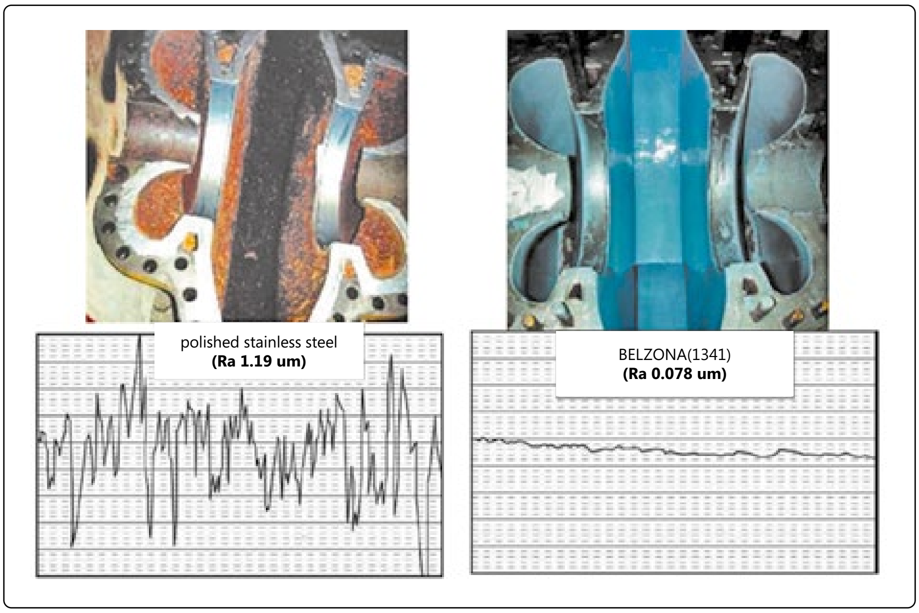


Photo 2. BELZONA(1341) composite coating a) b) summary of other pump components

Characteristics of interatomic interactions include attraction from a greater distance and repulsion from a shorter distance. This 'tug-of-war' is related to changes in the energy (loss-gain) that is involved in the interaction between atoms/particles of the surface and its surroundings. An example of this might be adhesion and cohesion phenomena. The work of cohesion is related to the overcoming of covalent bonds or crystalline structures, i.e. actually breaking the internal cohesion of the material, but it is adhesion that interests us. Adhesion is a phenomenon involving joining of two surfaces of different bodies (phases). The process of their separation requires an expenditure of energy equal to the work named the work of adhesion.

Physical basis of the phenomenon

The value of the work of adhesion is a measure of the intermolecular attraction between two different substances, and is equal to the difference in the free energies of the force of adhesion of bonded substances. For example, in the case of fluid flow - in particular flow of water through a pipeline, pump or turbine, the value of this work is on average between approx. 150 mJ/m² and 250 mJ/m² in channels with a steel surface and below 100 mJ/m² in channels made of plastic. And it is on the basis of certain macroscopic quantities, determined experimentally, that one can programme the surface for a specific kind of interaction with the environment so that the energy expended on molecular interactions (or rather, overcoming them) is as low as possible. If one assumes a flow under regular conditions, the free energy of the water is approximately 70 mJ/m², then if we manage to create a channel with a surface energy of 70 mJ/m², adhesion will theoretically not occur. Such a hydrophobic surface can be obtained by applying BELZONA(1341) polymer composite coating to the metal. Considerable energy reserves found on the metal surface are converted (or actually "exchanged") in this coating process into adhesion, which, in this case, is beneficial and allows for just an appropriate degree of adhesion after the composite has solidified, at the same time the external surface of the coating has a free energy equal to that of water and therefore there is no interaction between the coating and water and thus no significant hydraulic loss in the flow. Such a loss means a reduction in the efficiency of pumps, turbines or hydraulic machines in general, while as far as pipelines are concerned, it affects the flow energy of the fluid. In both cases, more work has to be done (i.e. more energy is needed) to transport the same amount of fluid through bare metal channels when compared to composite-coated channels.

The cost of the electricity consumed by the centrifugal pump over its lifetime is many times greater than the purchase price of the pump. It is assumed that after a 10 years of operation, the decrease in efficiency of the pump can be around 8%, which is mainly influenced by the hydraulic losses already described in the article, as well as disturbances (turbulence) resulting from surface roughness increasing over time due to the operation. Earlier analysis of the causes of hydraulic losses clearly points to two properties that can be optimised, i.e. surface smoothing and the selection of a suitable surface material so that its surface tension is equal to or close to the value of the surface tension of water, which is 70 mN/m. This is confirmed by the experience of those who operate pumps with BELZONA(1341) coating over many years and the obtained laboratory tests results.

Laboratory tests

A detailed study of the changes in pump parameters was carried out at the Pump Laboratory of the Institute of Heat Engineering of the Warsaw University of Technology, comparing the characteristics of the pump with and without the BELZONA(1341) coating. A centrifugal pump with a capacity of Q = (180-210) m³/h was tested. The single-stage monoblock pump is driven by a 22 kW electric motor and achieves a nominal head in the range H = (28-26) m at constant speed n = 1,400 rpm. The cast iron pump impeller is equipped with axial thrust reducing vanes on the rear impeller disc. Comparative characteristics were recorded: head, power input and pump efficiency as a function of capacity. The tests were carried out on the pump in its original configuration and after coating the fluid-flow parts of the pump with BELZONA(1341) composite coating.

Pump with coating

The test results obtained for the centrifugal pump coated with BELZONA(1341), compared with the parameters of the factory configuration, show a decrease in power consumption (Figure 1) and a broad increase in pump efficiency around the optimum point by approximately 5 percent (Figure 2). Therefore, the application of a suitable coating to the pump can be regarded as an efficiency retrofit and contributes to a reduction in the energy consumption of the pump, which has been confirmed by numerous applications of this method in a real industry environment. A few years ago, a coating retrofit of 3 vertical pumps with different efficiency ratings was carried out at a Polish chemical plant. The aim was to reduce the energy consumption of the pumps. These pumps pump water continuously, so energy consumption accounts for a significant proportion of their operating costs. As part of the retrofitting, all components of the pumps, i.e. inlet funnel, impellers, guide vanes, reducing ferrules and discharge elbows, were coated with BELZONA(1341). The idea was to achieve the maximum effect of reducing hydraulic flow losses.

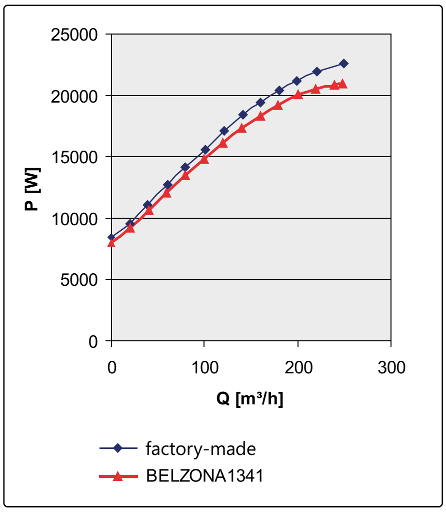


Fig. 1. Pel - Q - pump as manufactured and with BELZONA(1341) composite coating

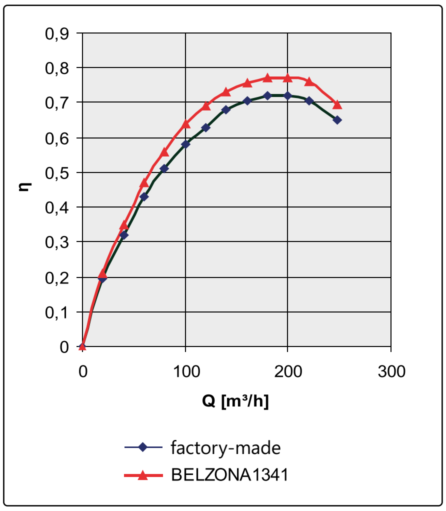


Fig. 2. η – Q - pump as manufactured and with BELZONA(1341) composite coating

Simulation of savings achieved after the application of BELZONA(1341) coating on example of a 90 kW centrifugal pump

Centrifugal pump performance after more than 10 years of operation (Photo 2):

- capacity 370 m³/h
- head H = 55 m
- rotational speed n = 1,450 rpm
- motor power 90 kW

The following parameters were measured (test stand at Leszczyńska Fabryka Pomp, 2013):

- suction pressure ps [kPa] and discharge pressure pt [kPa]
- flow Q [m³/h]
- power of current drawn at the motor P [kW]
- head H [m]
- efficiency η [%]

After the Belzona(1341) coating was applied, the parameters were measured again, and it was found that there was a 3.6 kW reduction in power consumption and the pump efficiency increased by 13%.

Financial calculations:

Reducing the electrical power demand by 4 kW results in a reduction in operating costs per year (8,000 h – operation) by:

(Energy cost [kW/h] x power [kW]) x (operating time [h] x efficiency gain [%]) = savings

(0.68 x 90) x (8,000 x 0.13) = PLN 63,648.00

Belzona(1341) coating costs - PLN 14,500

63,648.00 - 14,500.00 = PLN 49,148.00 savings per year

The results of the renovation

After the retrofitting, the pumps were installed at the same site, in the circulating water system, and were put back into regular operation. After a period of time, the performance of the pumps, such as capacity and energy consumption after pumping 1,000 m³ of water, was measured. Since the same parameters had been measured before, i.e. before the retrofitting, it was possible to make a very detailed comparison of the energy consumption required to pump a given volume of water by a pump without a coating and to compare that data to the parameters of same pump after the refurbishment, i.e. with a BELZONA(1341) coating. It was expected that the pumps would use less energy after retrofitting, and this is exactly what happened. The measurements in Figure 3 show a clear decrease in the energy consumed by the pump with coating compared to the pump without coating. This allows us

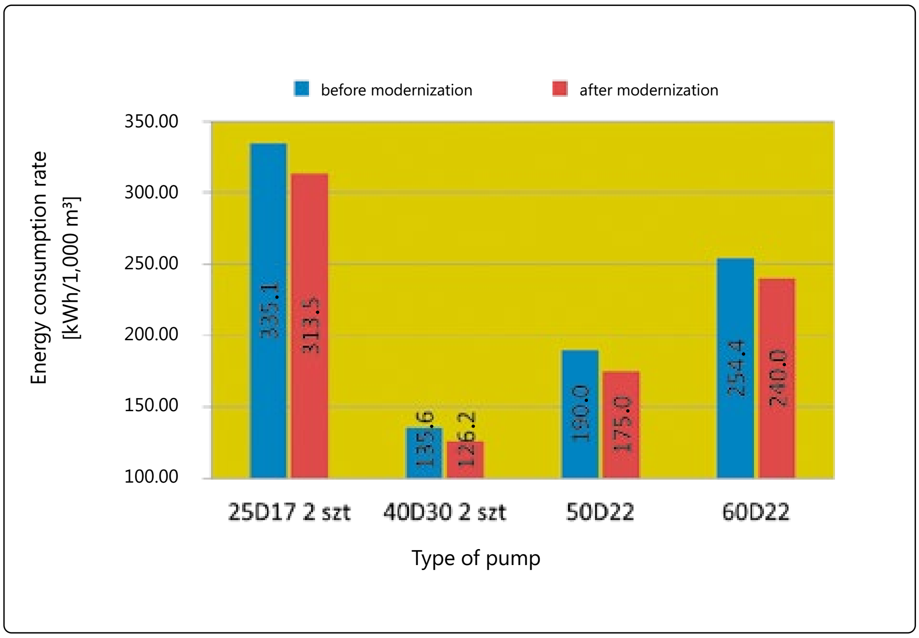


Fig. 3. Summary of energy consumption rate measurements for vertical pumps after pumping 1,000 m³ of circulating water.

Photo 4. 90 kW pump before and after coating with BELZONA(1341)

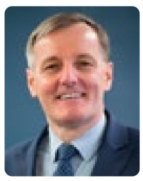
Photo 3. Kaplan turbine guide vane (on the Oder River) with BELZONA(1341) composite coating applied

to determine the so-called energy consumption rate, i.e. the kWh relating to the pumping of 1,000 m³ of water. For example, for a 50D22 pump (manufacturer's designation), the BELZONA(1341) coating reduces the pump's energy consumption by 15 kWh compared to the same pump without the coating. For this pump, the annual reduction in energy consumption of the BELZONA(1341) coated pump was 242,808 kWh! With the specific values of the measured electricity consumption before and after the pump retrofitting, one can easily calculate financial savings, i.e. the amount of money saved on electricity consumption (see frame at page 20).

Conclusions

The use of coatings in fluid-flow machines allows energy savings of 2 to 8% for new pumps (and more so for the used ones). In addition, by lowering the energy of the channel surfaces they become more resistant to corrosion – therefore it increases the life of components (rotors, vanes, guide vanes, etc.) of turbines and pumps, which, at present, with all the enormous struggles in terms of parts supply and galloping steel prices, increases the security of continuity and reliability of production and operation. In general, research results indicate that approximately 95% of machine failures are caused by inadequate properties of the surface layer of their components. The article shows that the condition of the layer determines the free energy of the surface, which has a significant impact on the energy consumption of the device. Furthermore, the impact of the aforementioned factors on the service life of machinery and equipment components operating in different environments must also be taken into account. It turns out that a polymer composite-modified layer of a metal surface improves its load capacity, ensures the continuity of deformations in contact with another component, inhibits corrosion processes and dampens vibrations, in a word – changes the operational quality of machine components. This makes it easy to refurbish parts by rebuilding and applying a new composite surface layer.

The refurbishment, according to research by the Fraunhofer Institute in Munich, reduces energy consumption by 79% compared with the energy required to make the same but new part, and also significantly reduces waiting times for the availability of a machine component. BELZONA(1341) polymer composites can be used to treat damaged shaft journals, fractured housings or bodies, and can also be used to restore surfaces worn by abrasion while increasing their strength.



M.Eng. Roman Masek
Technical Director
BELSE

Graphics and photos come from the archive of **Belse** company.

How do I get started with BIM?

Although digitalisation is invading our lives everywhere and even some fridges can connect to the Internet, the construction industry relies on "classic" methods of implementing construction projects. It's true that computers are now firmly established in design offices, but paper printouts are still the most common on site, and BIM technology has been available for at least a decade.

Building Information Modelling is primarily associated with 3D models. And this is a correct association, but the heart of BIM is information management, which is the most valuable asset of the 21st century. The following article presents the benefits of using the BIM methodology.

What do we need data for?

The answer is simple: to make better decisions. And better decisions mean lower costs. Lower costs mean savings, and savings mean higher profits on the annual balance sheet. BIM methodology is a cost optimization tool that can be successfully applied during the design, construction and operation of buildings. Interestingly, BIM can be implemented at any stage of the building lifecycle. It's not that if a building is designed in 2D it is 'lost' to BIM. With BIM technology, we can convert old paper drawings and plans into digital form and create a 3D model from that. An example of such activities is the visualisation of the Niepołomice Barrage. The concept of building the barrage was born in 1946, but the project was not created until 1974. The investment was not realised and the problems that arose at that time were not solved. These included:

- hydraulic support for the Przewóz waterway stage
- regulation of groundwater levels
- improving flood protection

On the order of Regional Water Management Board of Kraków, an old project from 1974 was digitised and a three dimensional model of an investment designed almost 50 years earlier was made. This is a real and quite spectacular example of using BIM technology to digitise analogue projects

Why BIM at the design stage?

If you are just planning an investment, using BIM methodology in the design phase will give you tangible benefits in the future. Thanks to the integration of GIS (Geographic Information System) data and BIM, the designer has much better opportunities to optimize the project than in a traditional 2D process. This is illustrated by the Mac Leamy curve (Fig.1). The graph shows a comparison of the effects of design changes as a function of cost at successive stages of the building life cycle for traditional and integrated (BIM) processes. The solid line clearly shows how much BIM can contribute at the design stage - from defining requirements to developing documentation. The costs of change are comparable and the results for the BIM methodology are incomparably better. This is because design software in BIM allows GIS spatial data to be integrated into the project. This combination gives an incomparably better chance of locating risks and collisions. This, in turn, allows for a better quality project to be realised.

An example of this is an investment project involving the extension of floodbanks. A coordination project was developed on behalf of the contract engineer. A 3D model of the structure was created and combined with GIS spatial data. This was already enough to conclude that:

- the planned redevelopment goes beyond the project boundary,
- one of the access roads is designed at an angle that makes it impossible to drive through.

The project had already been handed over for construction. What would the contractor do if he came across such errors during construction? At the very least, he would have demanded that they be corrected and waited patiently for a corrected design, eager to charge contractual penalties. Changes to the design were made quickly. The cost of these changes was relatively low and the client avoided significant financial losses and construction delays.

Savings on running costs

When implementing a construction project using BIM technology, the investor has a chance to systematically collect data which is very valuable at the stage of the object's exploitation. In addition to geometric data, the BIM model stores operational information. The detail of geometric data is determined by the LOD (Level of details) classification, while the details of information assigned to the model are determined by the LOI (Level of information). This classification allows better communication between the project stakeholders. A lower level of detail is needed at the concept and design stage, a higher one at the operation stage. In other words, the model is gradually saturated with data. What gives the integrated process an advantage over traditional investment is the unified data exchange environment CDE (Common Data Environment) used in the BIM methodology. This avoids documents scattered in 'hundreds' of binders. The CDE is the central hub of communication between the participants in the construction process and the "only source of truth" - everyone refers to the data available in the CDE and draws the necessary information from there.

The developer/ordering authority defines the CDE and presents its information exchange requirements to the contractor by publishing an EIR (Exchange Information Requirements) document. The contractor, if he wants to carry out the project, must accept the client's requirements. As a rule, the contracting authority knows what performance information it needs in the subsequent phases of the life cycle of the facility and publishes a schedule of successive phases for moving to the next level of information detail. The contractor, according to the implementation schedule, saturates the model with the required data. As a result, the ordering party has complete and up-to-date documentation of the operation of the structure/building when it is accepted. Moreover, it is collected in one place, systematised and with clear access criteria. Such data is appreciated after several years, when decisions have to be made quickly in an emergency situation and one does not know where to look for information.

A customised approach to BIM

BIM is not a universal recipe for solving all problems, but it is a structured methodology of which a parameterised 3D model is a fundamental part. This means that changing any element of the model automatically changes related elements. It is often the case that the visions of the client, the designer and the contractor regarding the construction to be carried out differ significantly. In a 3D model, there is no room for misunderstandings. It is immediately clear what we are aiming at and everyone realises one common vision.

Why this BIM?

Before we decide to implement an investment in BIM, we should first consider what problems we want to solve. The main benefits are time savings, which will be achieved by:

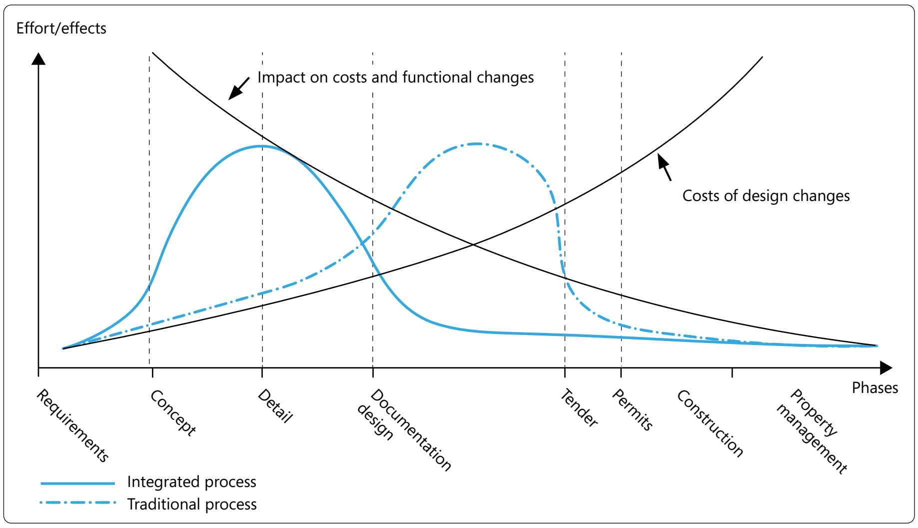
- eliminating collisions and potential risks already at the design stage - there will be no downtime,
- optimal long-term scheduling, taking into account virtually any number of variables,
- centralised information flow under the control of the CDE system,

which in effect provides:

- high quality project documentation,
- the quality and timeliness of the tasks performed,
- improves communication and cooperation between actors in the process ,
- facilitates dialogue and public consultation (for example on environmental issues),
- better asset management.

The more effort we devote at the investment preparation stage, the faster and cheaper the investment will be realised. In BIM, it is crucial to define the project's information requirements (PIR document).

If you decide to go for BIM, you need to know the basics of the methodology. A very common problem is a lot of resistance from investors who simply do not want to learn more about BIM. Despite appearances, it is relatively simple and does not take too much time. The Ministry



Source: WSOWL Scientific Journals, No. 4 (166) 2012

Fig.1. Comparison of the effects of design changes for traditional and integrated (BIM) processes.

of Development and Technology publishes BIM document templates with discussion. There are also a number of BIM consultants to help develop investment documentation and procedures.

How to choose them? The consultant should clearly explain what he wants to do, how and why. The more incomprehensible terminology falls from the mouth of such an expert, the further you should stay away from him. BIM This is not secret knowledge and if someone hides behind the fact that he or she is not revealing the "know how", this should arouse serious suspicion. Employing a BIM Manager or BIM Information Manager, whether as an in-house or contracted employee, will allow for the proper preparation of the main BIM document, the EIR - the Employer's Information Requirements. This is a document that sets out a set of requirements necessary for the effective exchange of information between stakeholders in the construction process from a technical, tactical and strategic perspective. It includes, among others:

- hardware and software recommendations,
- the technical and operational conditions of the CDE data exchange platform,
- definitions for information purposes,
- timetables,
- description of processes.

A contractor wishing to submit a bid to carry out the project must accept the client's requirements and confirm this in the BEP (BIM Execution Plan) document.

Tomasz Rajpold
CEO
HydroBIM

Voith Hydro's future-ready, compact solutions

Voith Hydro develops customized, long-term solutions and services for large and small hydro plants all over the world. Its portfolio of products and services covers the entire life cycle and all major components for large and small hydro stations, from generators, turbines, pumps and automation systems, right through to spare parts, maintenance and training services, and digital solutions for intelligent hydropower. The company's origins date back more than 150 years ago. Still pioneering spirit is part of its DNA. In the last ten years, Voith Hydro has especially been able to advance its offerings in the so-called small hydro range of up to 30 MW.

M-Line Francis

Latest inventions are Voith Hydro's M-Line portfolio as well as the already well-established StreamDiver. The latter enables the usage of hydropower in locations where it had previously not been possible due to the demanding ecological requirements. To expand the range of application even more, the experts at Voith Hydro recently worked on a drop height extension. The result: an entire SteamDiver family.

StreamDiver – tapping new potential

The StreamDiver, launched to the market in 2011, and designed for low-head applications, was an important development in the small hydropower sector. It can be integrated in existing canals and weirs keeping the environmental impact of the addition of electro-mechanical equipment to a minimum. The same is true for its completely oil- and grease-free operation. As it is installed completely underground it is also extremely low in noise emissions.

By reducing complex technology, it was possible to at the same time achieve a compact size and a highly maintenance-friendly and robust machine unit which has established itself step by step on the global hydropower market in recent years with references all over the world. Today, installations from Austria to Indonesia, from Sweden to Brazil prove the efficiency of this approach. Still 64 percent of the world's existing dams and transverse structures are not used to produce hydroelectric power. By increasing the head range up to 12 m, Voith was able to even expand the StreamDiver's range of application. At a test rig in Austria everything has been thoroughly tested to ensure highest customer satisfaction.

StreamDiver

A special highlight from the recent past

Some time ago, the Brazilian specialist for small hydropower stations Energias Renováveis MAZP commissioned Brazil's first StreamDiver power station. The company specialized in environmentally-friendly small hydropower stations, discovered a natural gradient in the state of Parana that had caught their eye due to the stable water supply. They were looking for a technical solution that would cover both environmental and economic needs. The answer: StreamDiver. The seven units were manufactured, assembled and pre-tested in Austria in less than one year before making their way to the power house in Brazil. The advantage of the technology lies, among other things, in the compactness and comparatively low weight of the units.

M-Line – saving time and money

Beside the ecological aspects that are of highest priority also fast and innovative solutions are needed today – still ensuring highest efficiency and reliability. The faster

M-Line Pelton

The M-Line advantages at a glance:

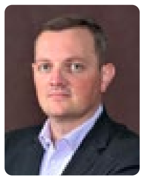
- Short delivery time and proven quality
- Application diagram to check whether an M-Line turbine is applicable
- Minimum powerhouse dimensions
- Powerhouse design is simplified to reduce construction costs
- Pre-assembled modules reduce erection and commissioning time

an operator can connect his machine to the grid, the more likely he is to create the economic conditions for successful operation. Therefore, in addition to investment costs, the aspect of short delivery times is also becoming increasingly important. As this aspect is such a critical one the fundamental idea of a new development of Voith Hydro was primarily to shorten it by modularizing Pelton and Francis turbines resulting in a successful development with several further customer benefits.

The new M-Line is defined as a simplified, largely standardized turbine-generator unit including auxiliary systems. The units are pre-assembled and therefore delivered to the power station as compact, ready-to-use units in up to 30% less time. In this way, it can be installed and commissioned very quickly on site. The know-how of our technicians, decades of experience in turbine construction and the latest technological findings from our R&D center are incorporated in every single turbine.

The customer receives an application diagram at the beginning of the project, which provides information on whether an M-Line component can be used. Based on head and flow, it is easy to identify the optimum size in the application diagram and then immediately start planning the power house based on this recommended layout.

The M-Line Pelton is designed for applications from 80 m to 340 m head, with a flow rate up to 1.60 m³/s. The M-Line Francis is designed for applications from 20 m to 80 m head and a flow rate up to 3.80 m³/s. The units are always delivered in specific modules. In this way, transportation is simplified and on-site work – especially in terms of concreting – is reduced.



Radu Carja
Head of Division Small Hydro
Voith Hydro in St. Georgen, Austria

Graphics come from the archive of **Voith Hydro** company.

EU Restoration Law and small hydropower

The European Commission presented its proposal for a new EU Renaturation Law on 22 June 2022. The new draft law is a central part of the European Green Deal which has the overall goals to transform Europe into a sustainable society and to decarbonise the EU with the aim to reach net zero Greenhouse gas emissions by 2050.

The proposal of a new EU Renaturation Law was announced as part of the EU Biodiversity Strategy and is the first substantial addition to European environmental law since more than 20 years. Before that, the Habitats Directive, Water Framework Directive and the EU Birds Directive, as well as the designation of Natura 2000 protected areas had been the main instruments for environmental protection. Its overall aim is to improve existing EU nature conservation law and to include additional, binding measures to restore habitats that have already been destroyed.

Form of implementation and deadlines

The Commission presented the EU Renaturation Law in form of a Regulation. This means that it will come into force immediately after the conclusion of negotiations in the European Parliament and the Council of Member States and does not need to be transposed into national law. As next steps, the European Parliament and EU Member states will develop their positions on the Commission's proposal. After that, the three institutions will negotiate the final law in so called Trilogue negotiations. This process will take approximately until the end of 2023.

The Commission proposal includes restoration measures on at least 20 percent of land and sea areas in the EU by 2030. To this end, EU Member States will be required to submit national restoration plans to restore at least 30 percent of terrestrial and marine ecosystems that are not in good conservation status by 2030. By 2040, 60 percent and by 2050 at least 90 percent of ecosystems are to be restored. Furthermore, the European Commission demands species-specific measures for biotope connectivity from Member states and sets milestones until 2030 to ensure the success of the renaturation measures and to prevent delays.

Regulations for hydropower

With regard to Europe's water bodies, the European Commission proposes to remove barriers such as dams, weirs and locks that are no longer in use as part of species and nature conservation measures. Overall aim is a renaturation target of at least 25,000 km of free-flowing rivers and streams by 2030.

It needs to be highlighted that the Commission emphasizes the removal of "... obsolete barriers, which are those that are no longer needed for renewable energy generation,..." (Art. 7). Optimistically read for the hydropower sector, this could imply the preservation of the poten-

Source: Statkraft

Foto. SHP Anundsjö in Sweden

tial of existing barriers to be (re-)equipped with small hydro plants. In addition, the Commission wants projects of "overriding public interest" ideally to be exempted when discussing potential removals of small hydropower plants. Furthermore, "The determination of the most suitable areas for restoration measures ... shall be based on the best available knowledge and the latest scientific evidence" (Art. 4.4).

EREF's contribution included

EREF is glad that the Commission followed EREF's position in its proposals under REPowerEU to consider renewable energy projects as "overriding public interest and in the interest of public safety". This implies faster permitting and planning for renewable energy projects and their connection to the grid. EREF calls on the Commission to make changes in EU secondary legislation regarding renewable energy and species protection. This means an explicit exemption clause for all kind of renewable energy plants in the Renewable Energy Directive and/or Habitats, Water and Birds Directives. It also must be more explicitly included in the current proposal for the Nature Restoration Law. Another important aspect is to base any decisions on barrier removal on latest scientific evidence. EREF had submitted in December 2021 a bibliography of scientific articles that demonstrate small hydropower and good ecological status can go hand in hand. EREF's Small Hydropower Chapter reaches out to experts able to shed light on the role of small hydro in the ecological current of "new conservation". This trend aims to approach biodiversity in a positive way by looking to the future, particularly in the context of climate change, and by integrating the societal role of rivers and the relationship with man.

Urgent need for new power

Within the current double crisis with regard to energy security caused by Russia's invasion of Ukraine as well as climate change that appears much faster than forecasted, the EU needs the accelerate its decarbonisation of the European economy by using all available forms of renewable energy, including the small hydropower sector. Quick progress could be made through the refurbishment of some of the estimated at least 200,000 abandoned small hydropower plants in the 27 EU Member states, the installation of kinetic turbines in European lowlands and the exploitation of so called hidden hydro power.

If the basic ecological requirements are met, e.g. sufficient residual flow in diversion power plants and fish migration aids in the fish habitat, then there is usually nothing to prevent good ecological status despite the use of hydropower. Ecological monitoring of watercourses very often reveals stretches of water used for power generation where there is no or only a minimal difference to the unused stretches. An example is the small hydropower plant Sauereggenbach in Austria. Biological assessments of the residual flow section and reference section outside the power plant area show that both sections have the same fauna. Consequently, its management is ecologically compatible.

Hydropower and environment

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

Depending on site specific conditions such as the available quantity of water, several solutions are deployed to ensure river continuity and enable up and downstream movement of migratory fish species and breeding. New management systems for existing small hydropower plants stop the plant during the time of fish migration. Releasing water through the gates attracts migratory fish species such as salmon to pass the plant during their up and downstream migration. An example for these measures is the plant Anundsjö in Sweden[1].

This is combined with by-pass mechanisms for fish and sediment such as natural fishways past the plant, fish ladders as well as guaranteeing minimum ecological flows. Thanks to, among others, EU funding programmes, new solutions to ensure fish migration and river continuity have been developed. Small hydropower plants also create new habitats for rare and precious water plants and waterfowls. With its ditches and dammed water areas small hydropower plants even form diverse and structurally rich additional fish habitats. Small hydropower plants enrich water bodies with oxygen and clean rivers from all sorts of waste floating in the water. A small hydropower plant in Austria for example collects between 7-10 kg of plastic waste on a monthly basis.

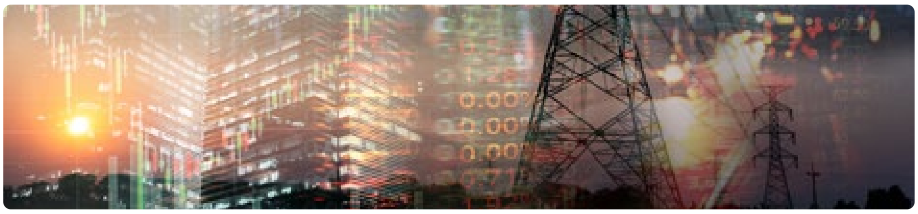
Small hydropower plants do have an environmental impact which however can be strongly mitigated due to latest innovative technical solutions. Like this, small hydropower and good ecological status can go hand in hand without any problems.

Dirk Hendricks
General Secretary
European Renewable Energies Federation (EREF)

[1] The plant is located on the small river Mo in the northern part of Sweden. The interdisciplinary consortium of the EU project FIT Hydro (https://www.fithydro.eu/) used it as a successful test case for these methods.

Polish Energy Policy Until 2040 – what will the Polish Power Industry look like in 2040?

The state energy strategy defines the directions of power industry development in Poland. The unstable political and market situation forced the Council of Ministers of Poland to undertake work on the revision of PEP2040 and to change the course of development. So what can we expect in 2040?


Source: iStock, MadamLead

In 2021, the Council of Ministers adopted the so called "Energy Policy of Poland until 2040" (abbreviated as PEP2040), which is a strategic document setting out the directions of development for the energy sector in Poland for the upcomig years. PEP2040 is a barometer of the Polish government's plans for the future of the energy sector, as well as directions of development and investments in the power sector in Poland. Although the document was adopted only a year ago, the current, swiftly changing economic and political environment made it necessary to start the work on revising the document, which in March 2022 resulted in the adoption of assumptions for changes to the PEP2040.

What does PEP2040 currently assume?

The key objective indicated in PEP2040 is to achieve energy security for the country, while – at the same time – ensuring the competitiveness of the economy, increasing energy efficiency and reducing the environmental impact of the energy sector. Optimal use of domestic energy resources is also indicated as an objective.

The achievement of the above goals, is based today on 3 fundamental pillars: fair transition, zero-carbon energy system and good air quality. Each of the pillars consists of specific actions aimed at achieving the objectives specific to each of them. A fair transition means that everyone will be able to participate in the transformation of the energy sector to a low carbon one. The authors assume that the energy transition will lead to the creation of up to 300,000 jobs within industries specialising in renewable energy sources, nuclear power, electromobility or grid infrastructure. The coal-rich regions, which are likely to be most affected by this new strategy, are to receive support of up to PLN 60 billion (ca. 12,8 billion Euro). The purpose of this planned support is to compensate for the negative effects of the energy transformation in those regions.

As for the second pillar, the achievement of a zero-emission system will be based primarily on nuclear energy and offshore wind farms. In addition, the system will be dispersed and "civic" energy (i.e.: produced by private households) will be strengthened. In the interim period, energy security is to be provided by natural gas solutions.
The last pillar is based on improving air quality, which in a way will already be the result of moving away from emission-intensive energy sources. There will be a transformation of the heating sector, but also the development of passive and zero-emission household buildings.

Assumptions of changes to the PEP2040

Due to the dynamically changing political situation, Polish Council of Ministers recognized the need to adjust PEP2040 and introduce additional assumptions to it.
First of all, in addition to the previously mentioned three pillars, the Council of Ministers intends to add a fourth pillar called "energy sovereignty". A specific and key element of this pillar is to achieve rapid independence of the national economy from fossil fuels imported from Russia.
The other 3 pillars previously mentioned within the original PEP2040, on the other hand, are supposed to be part of such energy sovereignty plan. As a result of the implementation of the assumed changes, the PEP2040 is to provide for further, dynamised development of renewables, with particular emphasis on the utilisation of renewable sources in energy clusters and energy cooperatives. According to the plans, by 2040 approximately half of the electricity supply is to come from renewable energy sources. To this end, power grids and energy storage facilities shall also be developed.

Another aim of PEP2040 is technological diversification and expansion of domestic power sources both by investing in already existing ones, and by implementing nuclear energy by investing in both large reactors (in excess of 1000 MW) and Small Modular Reactors (SMR). Importantly, in light of the recent crisis in the raw materials market, PEP2040 is also expected to provide for continued use of coal-fired generation units – the policy assumes the percentage of energy generated by such sources may periodically be increased in situations of threat to a national energy security. At the other end, there lie investments in gas-fired generation capacity, which is to be revised with accordance to the availability of such fuel, while also taking into account the fact that natural gas prices are currently characterised by volatility and its availability may potentially be limited.

The ultimate target is to reduce the economy's dependence on hydrocarbons, mainly natural gas and oil, but the strategy focuses on energy supply diversification in the interim period. Finally, in addition to investments in generation sources, energy efficiency is to be improved through investments in e.g. thermo-modernisation of buildings, but also by aiming at reduction of energy usage in the industry.

Hydropower in PEP2040

PEP2040 also includes hydropower solutions as one of the elements of renewable energy sources development. However, the authors of the strategy note that the chances for intensive hydropower development in Poland are limited due to Poland's relatively small hydrological resources. The authors emphasize the need to use at least these limited opportunities. Currently, there exist pumped storage power plants, which are important for balancing the National Power System, and run-of-river power plants, whose operation is, however, difficult to regulate. Nonetheless, as the authors of the policy point out, it is necessary to look for new possibilities for the development of hydropower sector.

An opportunity for this sector is seen in the participation of small hydropower plants in the FIT (feed-in-tariff) and FIP (feed-in-premium) systems, which provides incentives for their erection. These programmes in Poland were essentially created as a dedicated support system for hydropower and biogas plants –the support from these programmes is provided at a predeclared rate, and at the same time it does not accommodate any penalties for not producing the declared amount of electricity. On the other hand, the mechanisms are flexible and grant the ability to sell energy at a current market prices rather than at a fixed price (FIT) or by providing a coverage for the negative balance between a declared purchase price and a current market energy prices (FIP). Regardless of the above, we also notice an upward trend in the conclusion of cPPAs (corporate power purchase agreements), where we can also see an opportunity for hydropower in the future. On the one hand, these agreements allow consumers to maintain relatively fixed energy costs, and on the other hand, they guarantee the producers a market at relatively fixed, and therefore easy to calculate prices, allowing them to cover operating costs and make profits, which is in fact also an investment incentive.

It is worth noting that according to PEP2040, there are nearly 13.5 thousand damming facilities in Poland that can be used for energy purposes – which means that there is still a large potential to, e.g.: utilise structures that are part of the flood prevention infrastructure to such an end – and the abovementioned investment facilitation may encourage the development of this branch of the power industry.

Bartosz Piątek
Legal counsel, leader of the regulatory and energy advisory team at PwC Legal

Krzysztof Szyszko
Legal counsel at PwC Legal

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

The hidden potential of the Dunajec River

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

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

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

Niedzica hydropower plant

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

Sromowce Wyżne run-of-river power plant

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

Energy utilisation of all the water

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

Specialists in the service of climate protection

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

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

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

Comprehensive approach to the investment

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

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

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

The interior is important

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

Technical parameters of Sromowce V SHP

- Turbine type: Horizontal S type Kaplan turbine
- Gross head: 5–10 m
- Rated flow rate: 4 m^3/s (min. 0.8 m^3/s)
- Rated turbine efficiency: 91%
- Generator type: synchronous
- Nominal power: 325 kW
- Generator efficiency: 96%
- Number of operating hours per year: 8640 h (24 h x 360 days)
- Operating voltage: 0.4 kV

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

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

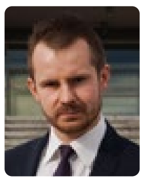
The power plant will operate in automatic mode, transmitting information to a SCADA master visualization system, and its operation will be limited only to periodic inspection and maintenance. The Sromowce V SHP is designed to sustain continuous operation, 24 hours a day, 360 days a year.

On-grid or off-grid operation

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

Was it worth it?

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



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

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

Fig.1. View from the tailwater side on the open section of the fish pass and the outlet section

Fish ladder design in terms of a large difference in water level

One of the projects of Hydroinvest was to develop a concept of a fish ladder in the area of the newly designed multi-purpose 'Kąty-Myscowa' reservoir. The facility includes a 44 meter high dam dividing a river which constitutes a major obstacle for migrating of aquatic fauna. The technical solution for the fish ladder is challenged by huge water level fluctuations in the reservoir, the type of dam, and a variety of fish species and sizes. The reservoir will make a local impact on the natural habitats' character. Moreover, the river's permeability will interrupt migration of aquatic organisms. The designed fishways will minimize negative effects of the new reservoir.

The planned Kąty-Myscowa dam reservoir is located in the Low Beskids (Jasło District, Podkarpackie Voivodeship, Poland). It is impounded by an earthfill dam located at 141+400 km of the Wisłoka River at the biggest narrowing of the river's valley at the Kąty village. The catchment area of the river up to the cross-section of the dam of the future reservoir is 297 km², collecting mainly water from the Magura Range and the Beskid Dukielski Mountains. The springs of the Wisłoka River are located near the former village of Radocyn, right on the border with Slovakia.

Mountainous, the river meanders along the riverbed full of boulders. The most important tributaries of the Wisłoka river to the planned dam are: the right-bank Wilsznia, Krempna, Ryjak and the left-bank Rzeszówka, Świerzówka and Zawoja. A characteristic feature of the rivers in this part of the Wisłoka are large slopes of the channel (over 50‰). In the section of the Wisłoka River, which is to be flooded with the waters of the future reservoir, the drops are between 6.7–5.7‰. The planned reservoir will be characterized by a high variability of water levels, which are: maximum reservoir level MaxPP at 356.0 m AMSL, normal damming level NPP at 350.7 m AMSL, minimum damming level MinPP at 333.0 m AMSL. These differences result from the assumed task of providing alimony to the towns below in the periods of low flows and from the flood protection function.

Dam structure

The designed dam, with a body height of 44.26 m, will be used for permanent damming of water in order to provide water to cities and settlements along the Wisłoka Valley and to protect them against flooding. The damming structure will be erected in changing soil conditions. It is planned to make the embankment of the front dam by sealing the body with a central aluminum core. The height of water damming H in the area of the water outlet from the rapids basin is about 40.4 m.

Variant analysis

As part of the analysis, many types of fishways were considered, such as:

- catching fish and transportation;
- natural ramp;
- fish elevator;
- circulating fish passes;
- slot passes.

The technical-type vertical slot pass, connecting the upstream and the downstream of the dam, located along the designed overflow spillways, was chosen as the most favourable fish migration system.

Characteristics of technical slot fish passes

The slot pass consists of a concrete canal with transverse partition walls. There is a variation of the classic pool pass whereby the cross-walls are notched by vertical slots extending over the entire height of the crosswall, which has one or two slots depending on the size of the water-

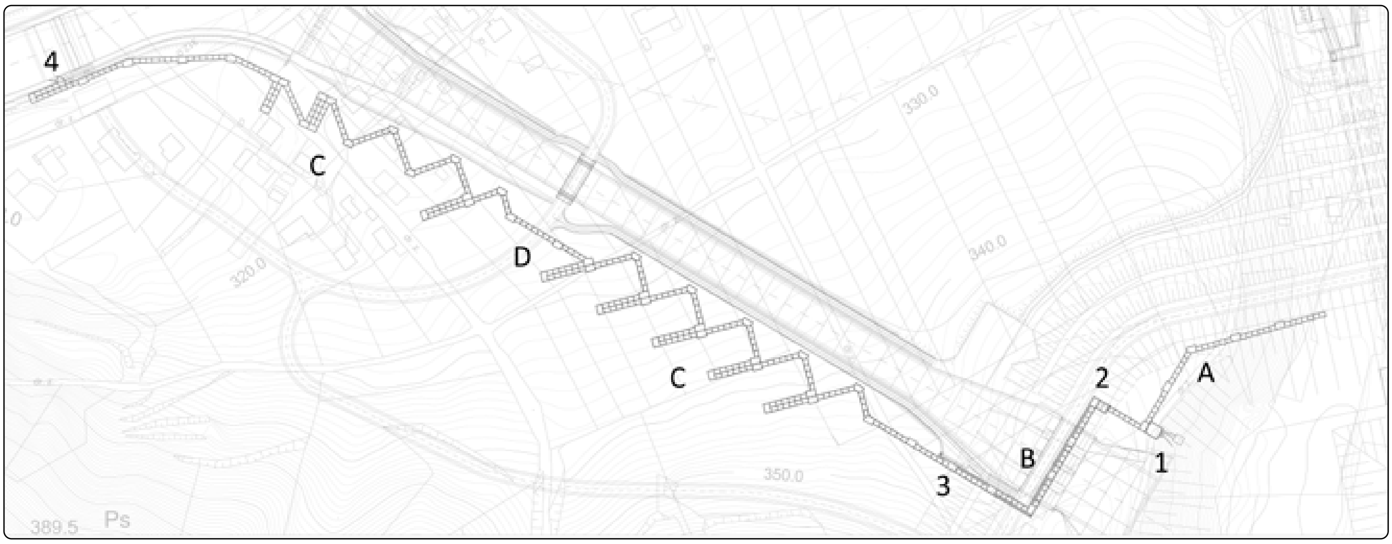


Fig. 2. The fish pass plan

course and the discharge available. These slots are located at the side wall of the fish pass canal. This type of fishways is used for small and medium water level differences, for dams with variable upstream water level. It is most likely the best type of technical fish pass, suitable for all species of fish and invertebrates, thanks to the continuity of the natural bottom substrate.

Description of the slot fish pass concept

The performed hydraulic calculations show that the fish pass will be about 1,350 m long, including the intake section at 125 m. The intake section enables gravity water intake to the fish pass. The water intake will be made through the inlets in every second pool. There are favourable conditions for water intake and fish pass operation in this solution.

The planned fish pass runs through mountainous areas and overcomes the obstacle of a 40 m high earth-filled dam. Therefore, it is a very complex hydraulic facility. Sections with different characteristics and accompanying engineering facilities can be distinguished in this structure (Fig.2).

Along the run of the fish pass, from the water intake from the reservoir to its discharge into the river below the dam, it will be composed of four types of structures:

a) the water inlet (fish entrance) section (Fig.3, Fig. 6.1);
b) fish pass in the gallery crossing the dam (Fig. 6.2);
c) open section running through the territory below the dam (Fig.4, Fig. 6.3);
d) fish pass in the gallery crossing the road embankment of the bridge over the spillway.

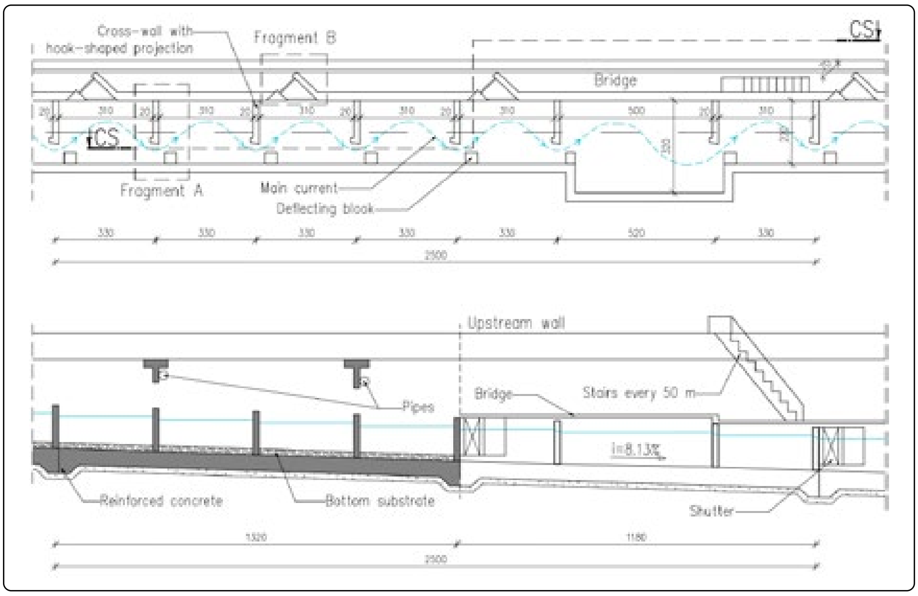


Fig. 3. The inlet section plan and cross-section

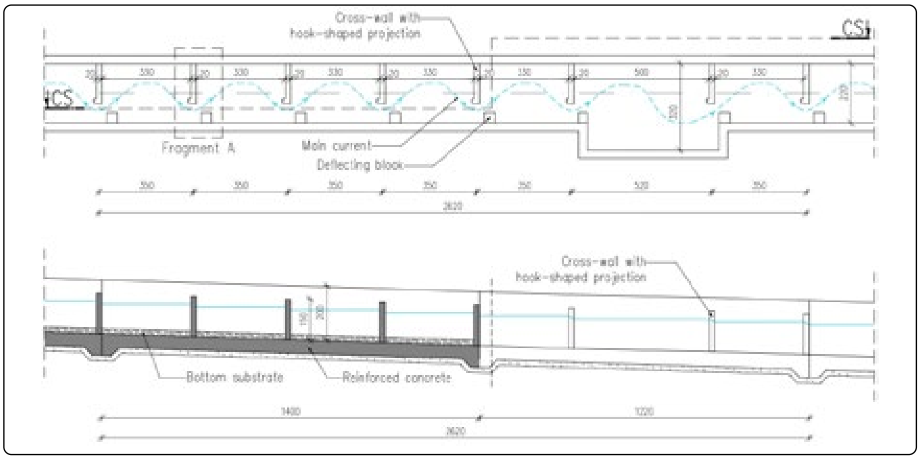


Fig. 4. The open section plan and cross-section

And four engineering structures:

1. water timing structure with a supply pump station;
2. floodgate (entrance to the dam gallery);
3. exit from the dam gallery;
4. water outlet (fish pass exit) at the weir with the discharge to the river at the tailwater.

Basic section geometry

Six passage pools and one resting pool form a basic section, repeatable over the entire length of the fish pass. The typical width of the passage pool will be 2.20 m, resting pool: 3.20 m. The water level difference between pools will be at h = 0.11 m. The fish pass basic section will

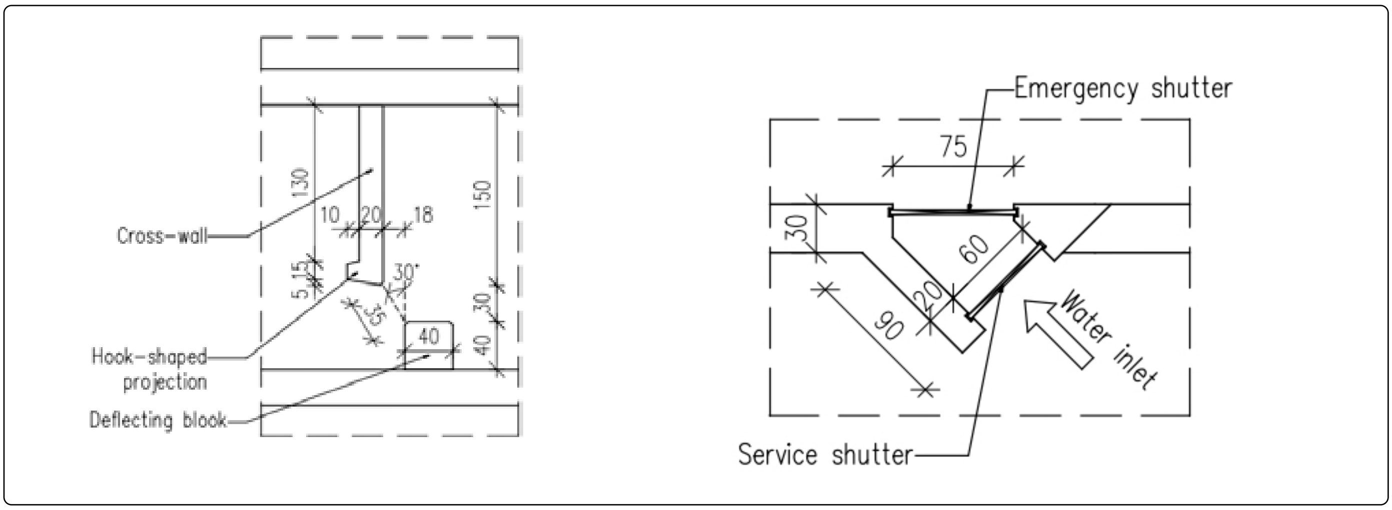


Fig. 5. Fragments A and B

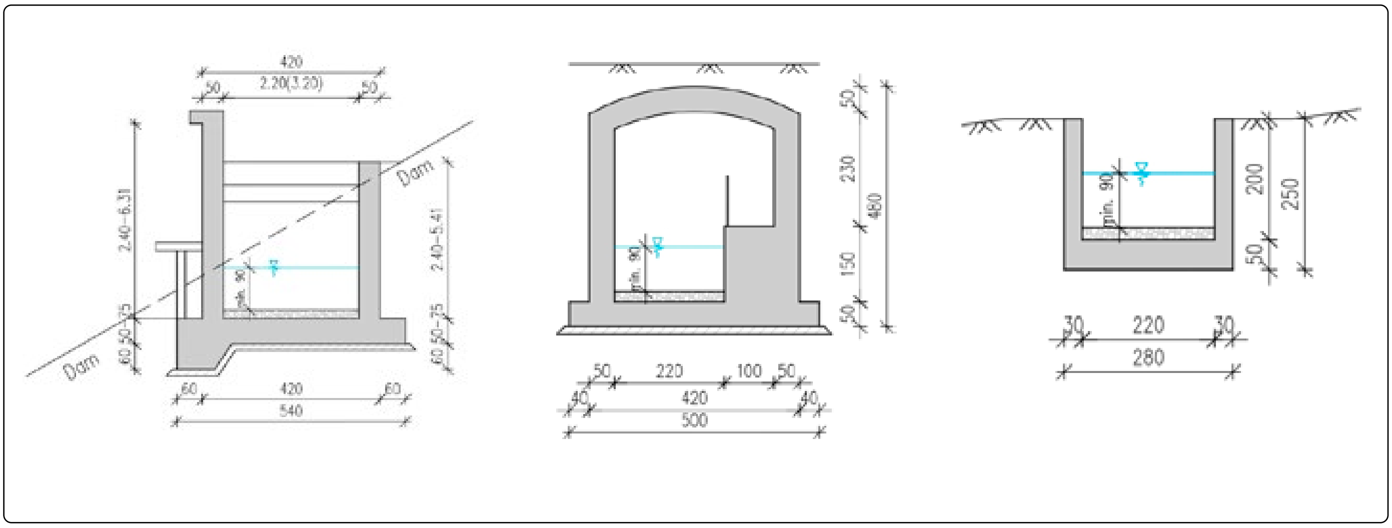


Fig. 6. The fish pass cross-sections. 1 - fish entrance section; 2 - fish pass in the gallery crossing the dam; 3 - open section.

be divided by expansion joints into two parts: 4 passage pools, each with the net length of 3.10-3.30 m, and a resting pool with a net length of 5.00 placed between two passage pools with the net length of 3.10-3.30 m. The basic section will be the above-mentioned two parts with a total gross length of 25.0-26.2 m. The water level difference between two typical sections will stand at 0.77 m. The cross-wall between the pools and the water inlet from figure 5 (fragment A, B).

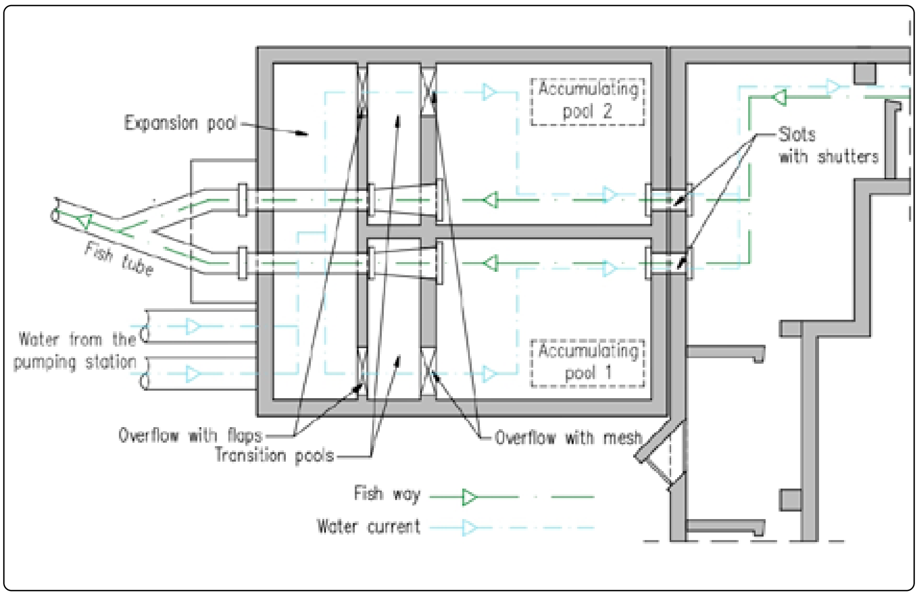


Fig. 7. Water timing structure

Operation principle of the future fish pass

The natural operation of the fish pass in both directions can take place within the water levels ranging in the reservoir between 350.70–346.85, i.e., during the fluctuations period Δh = 3.85 m. The operation range of the fish pass below its natural operation towards head-tail water will be increased with water pumping. For this purpose, an additional water timing structure was designed with a parallel but staggered operation of two accumulating pools. The work of the water timing structure consists in the pump supply of both accumulating pools through the expansion pool and intermediate pool (Fig. 7). Fish flowing from below can only reach the pool of the working stand. From time to time the inlet gate is closed and the accumulating pool is emptied through the outlet (after its opening). The water with gathered fish flows down through a stainless-steel gutter to a tank with a lowered water level. It was assumed that the gutter would reach the level of 340.00, i.e. 1 m lower than the assumed level of the fish pass operation range. The gutter will be attached to the concrete bench placed on the slope. Any additional increase of the operation range would only require the extension of the gutter.

Six passage pools connect the water timing structure with the floodgate. The fish pass floodgate (bulkhead gates) will be located perpendicular to the dam axis at the dam crest. The fishways will pass through the dam in a gallery. In the gallery, in addition to the pools, a 1.0 m wide footbridge will be included in the structure. Above the extension of the resting pools, the footbridge will be led on reinforced concrete support, or a platform made of steel grate. The type of electric lighting and ventilation will be installed in the gallery as agreed with ichthyologists.

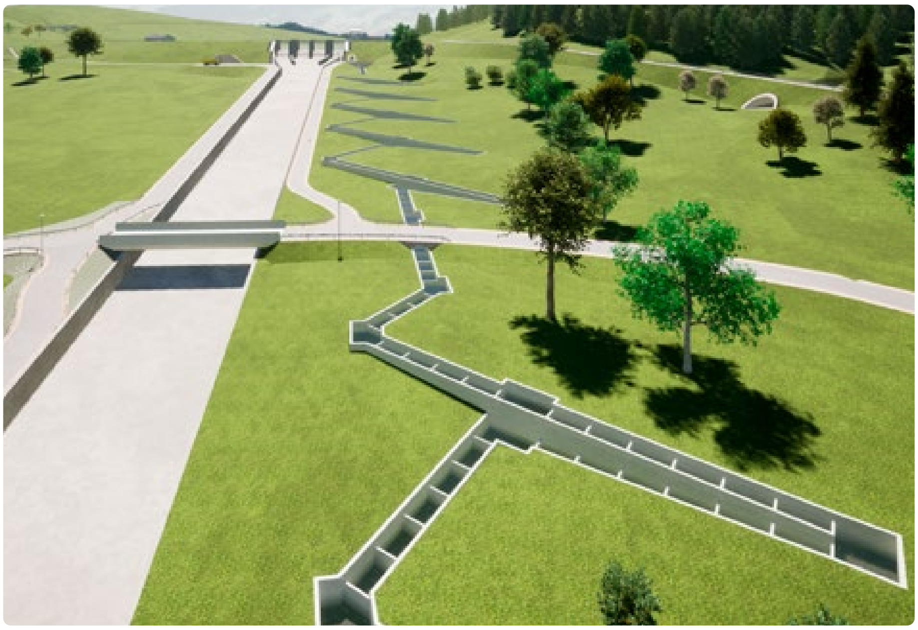


Fig. 8. Open section of the fish ladder along the weir

The open section led by serpentines on the left side of the spillway will end at the stabilizing step. The step will serve as a barrier to the natural migration of the river fauna. It creates conditions enabling the migrating fauna to find their way into the artificial pool of the fish pass in order to overcome the main obstacle, i.e., the dam of almost 40 meters.

On the left abutment of the step, there are three structures for draining water during normal operation. These are: a flushing channel, hydroelectric power station, and a fish pass. All these structures are involved in carrying out an equalized flow of about 2.4 m³/s. The flushing canal will operate sporadically and remove sediments in front of the hydroelectric power station and as a backup discharge during the shutdown period of the facility.

The outlets from these three structures are led to the outlet basin of the step in the sequence from the weir: the flushing canal, hydroelectric power station, the fish pass. The outlets from the canal and the power station should lead to the abutment of the tread, similar to the outlet from the fish pass. It is inclined from the shoreline by 30°, and in front of it there is a slipway that allows a gentle discharge of water from the fish pass to the bottom of the river. If such a solution is used, the water streams from the fish pass and the power station will move in parallel. The fish pass outlet is additionally supplied with the water taken from the pipeline in front of the turbine. This inflow will increase the attractiveness of the fish pass outflow and will effectively attract fish. The attracting water flows to the outlet pool through a surface overflow equipped with a flap and a mesh. At the outlet of the pool, there will be three discharge openings with barrage closures enabling the regulation of the speed of water flowing out of the fish pass.

During the fish pass operation in the pumping mode, when the water level in the reservoir does not allow the fish to use the inlet windows to the fish pass, the downward migration will be additionally secured with a device for catching fish on a floating pontoon. The caught fish will be transported and released to the fish pass.

Conclusions

The proposed fish pass solves extremely difficult technical conditions: the difference between the upstream and the downstream water level of the dam is 40.40 meters, which must be overcome by the fauna: the water level difference in the reservoir is 17.7 m. The problem was solved by providing the two-stage operation of the fish pass, i.e. the gravity feed water supply and the forced water feed through pumping. The proposed design parameters of the fish pass and its planned expenditure provide appropriate migration conditions for species making up the Wisłoka fish diversity. This is indicated by the calculated maximum flow velocities occuring in the slots V = 1.47 m/s (perm. V = 1.5 m/s) and the values of the volumetric power dissipation E = 66.94 W/m³ (perm. E = 100 W/m³).

Using a slot fish pass as a basic solution to ensure fish migration results from the many advantages of this type of structure in relation to other types of technical fish pass. It allows us to guarantee the possibility of migration upstream, both for species with less swimming skills and for small fish. Due to the vertical slots, the bottom of the structure is less susceptible to silting than the traditionally designed pool pass. The designed fish pass can function in a wide range of flows, variable up and low water levels.

Wiesław Wiśniewolski
Support expert in river fisheries
The Stanislaw Sakowicz Inland Fisheries Institute

Igor Suslo
Design engineer
Hydroinvest Sp. z o.o.

Maciej Pilecki
Design engineer
Hydroinvest Sp. z o.o.

Marek Mazurkiewicz
Support expert in hydro engineering
Hydroinvest Sp. z o.o.

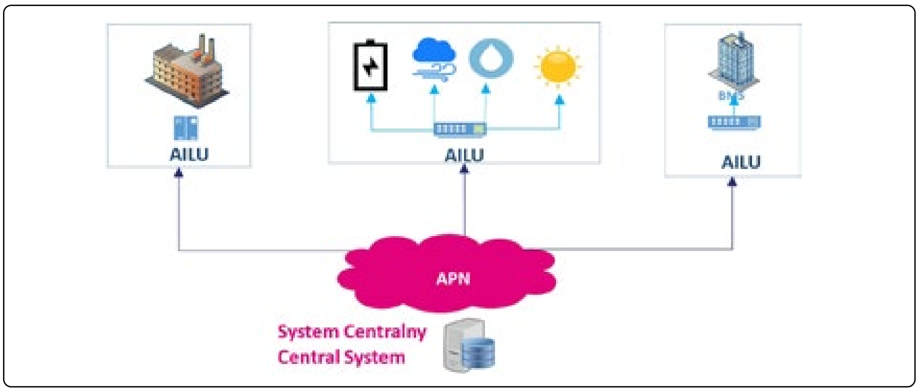
References:

1. FAO/DVWK, "Fish passes – Design, dimensions and monitoring", Rome, FAO. 2002. 119p.
2. Hydroinvest Ltd, „Opracowanie aktualizacji koncepcji rozwiązań technicznych budowy zbiornika Kąty - Myscowa na rz. Wisłoce". Warsaw. 2021.
3. Suslo I., „Projekt konstrukcji przepławki dla ryb ze zbiornika Kąty-Myscowa". Warsaw University of Technology. Warsaw. 2021.

Graphics come from the archive of **Hydroinvest Sp. z o.o.**

Virtual Power Plant of TAURON Ekoenergia sp. z o.o. as a response to the challenges of RES system development

TAURON Ekoenergia sp. z o.o., with its headquarters in Jelenia Góra, is the leading producer of green energy in the TAURON Group. The company operates 34 hydroelectric power plants with 85 turbine generators of a total capacity of 133 MW, 9 wind farms with a capacity of 380 MW, where electricity is generated by 182 wind turbines, and 2 photovoltaic farms with a total capacity of 14 MWp, consisting of 33,000 photovoltaic panels that convert solar energy into electricity. TAURON Ekoenergia produces energy from renewable sources using best practices and many years of experience, thus supporting the development of the TAURON Group.



Source: Tauron Ekoenergia sp. z o.o.

Fig. 1. Simplified diagram of the subsystems of the Virtual Power Plant connected via AILU

Renewable energy sources are a key part of the energy transition, enabling decarbonisation and an effective shift away from carbon technologies. Electricity generation from wind and solar is clean, environmentally friendly and economically viable. Over the last few years, intensive development of the RES sector can be observed as one of the pillars of the desired climate neutrality of many European countries. Forecasting wind power and solar output is a difficult task with a high level of uncertainty. Especially considering a distant time horizon. The level of generation from RES sources is determined by natural weather phenomena and is therefore volatile.

Understanding the challenges of the RES sector, TAURON Ekoenergia has implemented an innovative research and development project to develop a platform to aggregate the generation and regulation potential of distributed renewable energy sources and energy storage systems and selected categories of controllable loads.
The outcome of the project, which was successfully completed in 2021, was the development and implementation of innovative tools and solutions enabling the management of the operation of generation sources, energy storage facilities and controllable electricity consumers for the needs of energy market participants, primarily participants in the Balancing Market. The result of the work carried out was the creation of a Virtual Power Plant platform allowing the optimisation of electricity production based on dedicated IT solutions and artificial intelligence. Efficient aggregation and control of generating units combines energy sources and storage systems.

The development activities covered the Lubachów water power plant (1.2 MW) and a battery storage system (0.5 MW). The success of the development activities allowed the start of the commercialisation phase. 6 hydroelectric power plants (80 MW), 6 photovoltaic farms (5 MW) and 9 wind farms (314 MW) are currently integrated into the Virtual Power Plant platform.

Built from scratch, the customised solution takes into account the specifics of the national energy market and the distribution network. The virtual power plant platform that was created manages, optimises, monitors and remotely controls the generation sources and energy storage units. The 0.5 MW energy storage system with a capacity of 0.5 MWh was built using modern lithium-ion batteries. The storage system has been in use since 2019. The process of forecasting electricity production in the Virtual Power Plant is based on price forecasts in the electricity markets, production costs for a given system, weather forecasts, as well as taking into consideration the need for maintenance work at a particular location.

The solution developed and implemented by TAURON Ekoenergia Sp. z o.o. consists of three main components: Central IT System, Communication System and Local Implementation Layouts (AILU). Work is underway to extend the platform's functionality. A new component will be an ultra-fast generation forecasting module for PV systems, using an optical sensor to allow the Virtual Power Plant to react to sudden changes in solar energy production. In recent months, further hydroelectric power plants owned by TAURON Ekoenergia sp. z o.o. have been incorporated into the system. The Choszczno I photovoltaic farm has been integrated into the Virtual Power Plant system. In the near future, it is planned to integrate the platform with the Company's newest photovoltaic farm, the 8 MWp Choszczno II farm, commissioned this year. All of the Company's wind generators will be switched on by the end of 2022. The total capacity of the sources operating within the Virtual Power Plant platform is 400 MW.

The project also involves cooperation with individual investors. Each owner of a RES source can be connected to the Virtual Power Plant system, which will manage the electricity generated by this source. This enables investors to achieve additional benefits in the form of increased revenues resulting from the use of their generation and regulation capacities to provide additional services to other market participants and customers associated with the platform.

Przemysław Janik
Expert on energy storage systems
Office for Distributed Energy and R&D
Tauron Ekoenergia sp. z o.o.

Utilising external funding to expand the distribution network of ZEW Niedzica SA

In Poland provision of the energy distribution services is an area regulated by the Energy Regulatory Office (URE), which controls, among other things, the level of distribution fees for energy recipients. As such, all investment undertakings should be carried out in a balanced manner and at a pace adapted to the possibility of transferring their financial effects to energy consumers. In other words, the development of distribution services should be as efficient as possible – so as not to lead to excessive increases in distribution fee rates for consumers. In order to achieve such an objective, ZEW Niedzica SA decided to utilise external financing for an investment that almost doubles the length of the owned 15 kV MV grid.

In 2000, a 9.5 kilometer long 15 kV cable was laid at the bottom of the picturesque Czorsztyn Lake. The route ran from the frontal dam in Niedzica to the side dam in the village of Frydman with the cable coming ashore at the villages of Kluszkowce and Maniowy.

After 18 years of operation, it became apparent that due to the intensive development of the RES sources around the Czorsztyn Reservoir, there is a need to expand the main grid system owned by ZEW Niedzica SA. The total power of new renewables is more than a dozen MW of installed capacity. In addition, an important premise was that after fault-free operation of the cable for almost 20 years, the occurrence of a severe failure caused by damage to the cable's underwater section could not be ruled out. For these reasons, ZEW Niedzica SA began to consider the construction of a second cable line so as to connect it to the existing system. Due to the large investment expenditures and the need to pass these expenditures on to customers in the form distribution tariff, the planned investment was postponed until favourable circumstances arose. Such a moment came in 2018, when the chance to start the investment process appeared in the form of a grant competition announced by the Regional Operational Program of the Malopolska Region for 2014-2020 years, Measure 4.1. Increasing the use of renewable energy sources 4.1.1 Development of renewable energy distribution infrastructure.

This is how the project regarding theconstruction of a 15 kV cable line at the bottom of the Czorsztyn Lake has been created. We were able to secure co-financing of the project in the amount of PLN 6.5 million. The decisive factor in obtaining the subsidy was the very efficient preparation of the construction project and obtaining all decisions and permits necessary to receive a construction permit - including an environmental decision and a water law permit. The design work was carried out by a contractor from Kielce – Instytut OZE Sp. z o.o. Timely implementation of the design work allowed the project to obtain sufficient amount of points to be awarded a grant.

The planned investment result are medium voltage (15 kV) cable lines of more than 11.3 km in length, and a fibre optic line (laid along the medium voltage line at the bottom of the Czorsztyn Reservoir) and three container transformer stations located on the banks of the lake. We also carried out adaptation and reconstruction of the existing electrical infrastructure at Frydman and Dębno transformer stations inside pumping station facilities, and the modernization of the RPW15 switchgear centre at the Niedzica power plant. MV cable line is used to deliver power to the transformer stations, while fiber optic cable is used to allow for communication (including visualization and remote control) between the stations and the headquarters of ZEW Niedzica. The power and fiber optic lines were laid as follows: Niedzica Hydroelectric Power Station – transformer station "Zamajerz" – transformer station "Stylchyn" – transformer station "Frydman Podprzylasek" – transformer station "Frydman Pumping Station" – transformer station "Dębno Pumping Station".

The most difficult and important part of the investment execution was the cable-laying operation (of both, 15 kV and fibre optic) at the bottom of the lake. This stage required the preparation of not only technical facilities, but also the maintenance of the appropriate water level in the reservoir. Owing to favourable weather conditions and efficient work of the contractor (MANSTEL Bednarczyk, Słowik, Wiącek sp. j.), this extremely complicated and difficult stage has been carried out successfully. The platforms with drums of cables weighing a total of about 40 tons were placed on the surface of the lake. They were then hooked up to a tugboat and the unwinding of the cables of the first section could begin. In total, cables were laid along a route of more than 11 kilometres, which had previously been designated by survey-

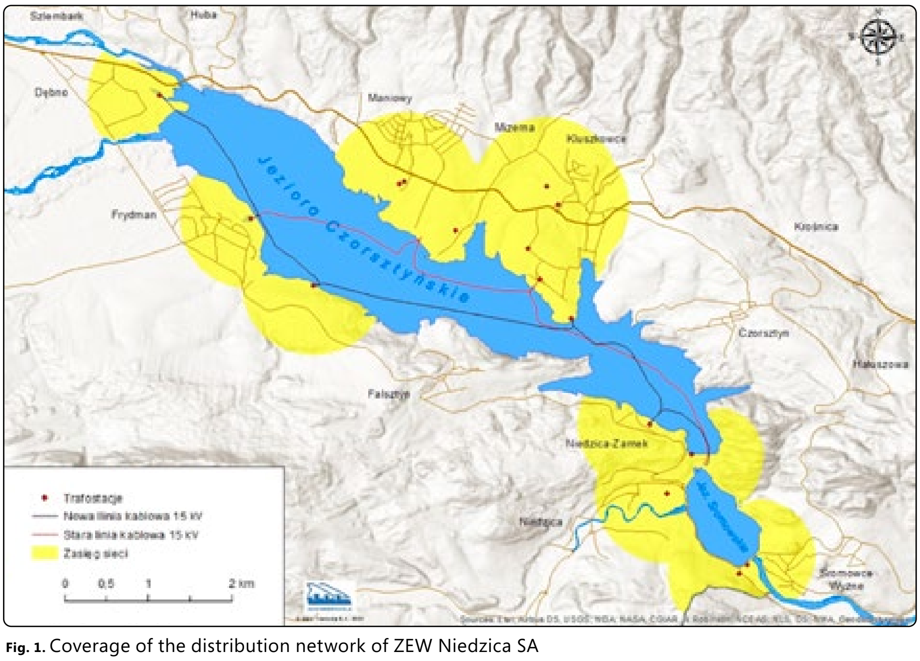


Fig. 1. Coverage of the distribution network of ZEW Niedzica SA

Photo 1. Laying a cable at the bottom of the Czorsztyn Lake

Photo 2. Vehicle charging station near Niedzica beach.

ors. The cables along their entire length were encumbered with concrete blocks, and then their alignment was checked by a diving team.

This is the longest cable route in Poland located at the bottom of a water reservoir. The cable laid at the bottom of the lake, accompanied by the fibre optic cable, created an intelligent network able to reduce losses arising in the process of distributing electricity. The completion of the investment also contributed to increased safety of electricity supply in the region, in case of failure of the first underwater cable. By connecting the new asset to the existing one, the possibility of intelligent network configuration, i.e. such switching of the supply so as to ensure certainty of electricity delivery even during an outage.

After the completion of the investment, the security of power supply to the Frydman Pumping Station and the Dębno Pumping Station – i.e. hydrotechnical facilities responsible for pumping water from areas located in depressions relative to the Czorsztyn Lake – also increased. These pumping stations provide flood safety for the aforementioned villages. The ability to connect new renewables and electric car charging stations has also been secured. The value of the entire project is: PLN 7,794,627 net, of which the subsidy amounts to PLN 6,461,629 (so 83% of the project's budget was obtained in a form of an external non-refundable subsidy).

Agnieszka Szpernoga
Marcin Skórnóg
Józef Wójcik
Arkadiusz Czarnecki
ZEW Niedzica

Graphics and photos come from the archive of **ZEW Niedzica SA**

25 years of operation of ZEW Niedzica SA (1997–2022) in numbers:

- **2,500 GWh of clean energy satisfying each year the needs of more than 100,000 people**
- **emissions reduction:**
  - **CO_2 – 1,745 thousand tonnes**
  - **SOx – 1.27 thousand tonnes**
  - **NOx – 1.31 thousand tonnes**
  - **CO – 0.5 thousand tonnes**
- **strengthening the reliability and security of the national energy system**
- **preventing 27 floods and reducing the effects of drought in the Dunajec Valley**
- **So far more than 5 million tourists visited the Niedzica Dam and the area near Czorsztyn Lake**
- **dynamic development of water sports: more than 10 marinas and infrastructure for sailors and canoeists**

Empirical estimation of the coarse soil hydraulic conductivity in practice

Empirical formulas are often used in the practice of design and construction of hydraulic engineering structures as a quick and simple (cheap) method of determining the hydraulic conductivity. Often overlooked limitations in their applicability depending on the tested material and its condition in situ may lead to underestimation of the desired filtration parameter, which in turn translates into erroneous design assumptions regarding e.g. assessment of the limit state of hydraulic damage or assumptions for dewatering works. For this purpose, a verification of the calculation of the filtration coefficient was carried out for commonly used formulae taking into account the characteristic influence factors, i.e. grain size and porosity.

The results obtained were compared with the results of laboratory tests carried out on soil samples with the same porosity coefficients but different density index. In this paper an empirical formula is proposed to correct the coarse-grained soil permeability coefficient on the basis of grain-size distribution parameters in relation to compaction.

The hydraulic conductivity (k) is a parameter that defines the ability of a soil medium to allow water to flow through it. According to Darcy's linear law it expresses the relationship between hydraulic gradient and water filtration rate [8],[4]. There are many different methods to determine the filtration coefficient, including field methods such as well pumping test, tracer tests, laboratory methods and calculations based on empirical formulas.

Estimation of aquifer properties by field methods is accurate but costly and prone to possible errors due to insufficient knowledge of aquifer geometry and hydraulic boundaries. Laboratory tests allow an accurate description of the test boundary conditions, but are also limited by the ability to obtain representative samples and the time-consuming nature of the test procedure. Estimation of filtration properties based on empirical formulas based on grain size distribution characteristics is used generally to overcome the above-mentioned problems, but it should be clearly emphasised that they have a limited scope of application and limited accuracy of determination. In order to improve this condition and increase the reliability of the empirical approach, validation of selected formulas was carried out for selected geomaterials.

Material and methods

The tests of hydraulic conductivity were carried out on samples of coarse-grained (non-cohesive) soils from the Warsaw area. The sampled soils belong genetically to interglacial and fluvioglacial formations of the Warta or Odra glaciation.

In order to determine the hydraulic conductivity on the basis of empirical formulas the particle size distribution was determined according to PKN-CEN ISO/TS 17892-4:2008 [12]. Based on the particle size curve the parameters characterising the particle size were determined, i.e.: d_{10}, d_{17}, d_{20}, d_{50}, d_{60} (substitute diameters in mm corresponding to weight % of fractions passing through the sieves) and the type of soil. The soil type was determined in accordance with PN-B-0248:1986[10] and PN-EN ISO 14688-2:2019[13].

Based on the test results obtained, the soils were divided into 4 groups:

A. Medium sand:
   MSa (Ps): $A_1 - C_U = 2$ oraz $A_2 - C_U = 3$

B. Coarse sand:
   CSa (Pr); $C_U = 5$

C. Coarse sand with gravel:
   grCSa (Po); $C_U = 2$

D. Fine sand:
   FSa (Pd): $D - C_U = 3$

The averaged results of the grain size distribution are summarised in Table 1. Empirical formulas developed on the basis of Vukovic and Soro [19] studies were used to determine the hydraulic conductivity. The general form of the formula is expressed as:

$$k = \left[\frac{g}{\nu}\right] \cdot [\beta] \cdot [\vartheta(n)] \cdot [d_e^i]$$

where:

k – hydraulic conductivity [cm/s; m/s],
β – constant depending on characteristics of the porous medium,
$\vartheta(n)$ – porosity function,
d_e – effective grain diameter [cm; mm],
g – the gravitational constant [cm/s^2; m/s^2],
ν – kinematic viscosity, $\nu = \frac{\mu}{\rho}$, where:
ρ – the temperature-dependent water density [g/dm^3], μ – the temperature-dependent water density [$g/cm \cdot s$].

In order to assess the suitability of the selected empirical formulas for the determination of the hydraulic conductivity, calculations of this parameter were carried out using the 12 formulas in Table 2.

In order to analyse the results obtained on the basis of empirical formulas, laboratory

Source: Own study

Soil type	Soil type acc. to		Coefficient of uniformity (C_U) [-]	Particle size distribution [mm]				
	PN-B-0248 [10]	PN-EN ISO 14688-2 [13]		d_{10}	d_{17}	d_{20}	d_{50}	d_{60}
A_1	*Ps*	*MSa*	2	0.19	0.26	0.27	0.39	0.43
A_2	*Ps*	*MSa*	3	0.12	0.15	0.16	0.28	0.33
B	*Pr*	*CSa*	5	0.19	0.27	0.31	0.78	0.93
C	*Po*	*grCSa*	2	0.49	0.56	0.59	0.88	0.98
D	*Pd*	*FSa*	3	0.10	0.13	0.13	0.23	0.27

Table 1. Division of the soil according to the grain size composition

Industry catalog

AQUA TECH
MOVABLE WATER DAMS
+48 530 133 269
+48 32 441 77 17
biuro@aqua-tech.info.pl
www.aqua-tech.info.pl
Lipcowa 64
32-540 Trzebinia

ENERKO energy
turn plans
into reality
EPC Contracting of Hydropower Project
Łukasz Kalina
e-mail: lukasz.kalina@enerko.pl
mobile: +48 512 008 805
www.enerko.ioze.pl

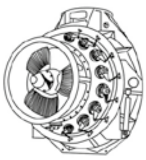
OZE instytut
turn idea
into solutions
Hydropower Engineer
Michał Kubecki
e-mail: michal.kubecki@ioze.pl
mobile: +48 505 176 479
www.instytut.ioze.pl

COMPLEX INSURANCE PROGRAMME DEDICATED TO SMALL HYDROPOWER PLANTS

- All -risk property Insurance
- Compensation of profit loss by randomly occurred events
- Compensation provided in the event of profit loss caused by breakdown on recipient side
- Compensation of profit loss on mechanical devices damage under producer's warranty

KO-RO kancelaria brokerska
kancelaria@ko-ro.pl
ul. Grabiszyńska 200/71
53-333 Wrocław
www.ko-ro.pl
tel. 0 713640376

MAVEL
Hydro turbines
Mavel, a.s.
Jana Nohy 1237
CZ - 256 01 Benešov
sintak@mavel.com
+420 602 317 524
www.mavel.com



Special valves for hydropower plants
20 years experience quality innovation
TBHydro
www.tbhydro.com.pl

WTW POLAND Sp. z o.o.
www.wtw-poland.com

IS YOUR
AD MISSING?
Order an entry in the branch catalog for only 77,5 € net!
Energetyka Wodna
mob.: +48 518 304 194
e-mail: biuro@energetyka-wodna.pl

Source: Own study

Design source:	$k = \left[\frac{g}{v}\right] \cdot [\beta] \cdot [\vartheta(n)] \cdot [d_e^i]$			Scope of application:
	β	$\vartheta(n)$	d_e^i	
Hazen (1892) [5]	6×10^{-4}	$1+10\ (n-0.26)$	d_{10}^2	This formula is used for sands of uniform grain size, but can also be used for fine gravels provided the soil has a coefficient of uniformity $C_U < 5$ and $0.1\ mm < d_{10} < 3\ mm$.
Slichter (1898) acc. to Vukovic and Soro [19]	0.01	$n^{3,287}$	d_{10}^2	The formula is recommended for an effective grain size $0.1\ mm < d_{10} < 5\ mm$
Terzaghi (1925) podstawie Vukovic and Soro [18] and Devlin [3]	C_t – the sorting factor is between: $6.1{\times}10^{-3} < C_t < 10.7{\times}10^{-3}$	$\left[\frac{n-0.13}{\sqrt[3]{1-n}}\right]^2$	d_{10}^2	Use for coarse-grained sand.
Beyer (1964) acc. to Vukovic and Soro [18]	$6 \times 10^{(-4)} \log \frac{500}{C_U}$	1	d_{10}^2	The formula is used for the effective grain size $0.06\ mm < d_{10} < 0.6\ mm$ and coefficient of uniformity $C_U \leq 20$
Sauerbrei (1932) [15] acc. to Vukovic and Soro [18]	3.75×10^{-3}	$\frac{n^3}{(1-n)^2}$	d_{17}^2	The formula is used for the effective grain size $d_{17} < 0.05\ cm$
Kozeny (1953) [7]	8.3×10^{-3}	$\frac{n^3}{(1-n)^2}$	d_{10}^2	The application range corresponds to coarse-grained sands.
Zamarin (1928) acc. to Vukovic and Soro [18] and Devlin [3]	8.64×10^{-3}	$\frac{n^3}{(1-n)^2} C_n$ C_n – factor depending on the porosity, $C_n = (1.275 - 1.5n)^2$	$\left[\frac{1}{\sum_{i=1}^{m} \Delta g_i \frac{\ln\left(\frac{d_i^g}{d_i^d}\right)}{d_i^g - d_i^d}}\right]^2$ d_i^g – the maximum grain diameter in fraction i; d_i^d – the minimum grain diameter in fraction i; Δg_i – the fraction of mass that passes between sieves i and $i+1$ where i is the smaller sieve	The formula is applicable for coarse sands without fractions with $d < 0.00025\ mm$. It can be used for fine and medium-grained sands
USBR [1]	0.0036	1	$d_{20}^{2,3}$	Formula recommended for medium-grained sands with $C_U < 5$
Barr (2001) acc. to Vukovic and Soro [18] and Devlin [3]	$\frac{1}{(36)5C_S^2}$ $C_S^2 = 1$ for spherical grains $C_S^2 = 1.35$ for angular grains	$\frac{n^3}{(1-n)^2}$	d_{10}^2	
Alyamani and Sen (1993) acc. to Vukovic and Soro [18] and Devlin [3]	1,300	1	$\left[I_o + 0.025(d_{50} - d_{10})\right]^2$ where I_o is the intersection (in mm) of the line formed by d_{50} and d_{10} with the grain size curve, d_{10} is the effective grain size (mm) and d_{50} is the median grain size (mm).	

Tab. 2. Summary of the formulas used to calculate the hydraulic conductivity, continued on next page

Source: Own study

Design source:	$k=\left[\frac{g}{\nu}\right]\cdot[\beta]\cdot[\vartheta(n)]\cdot[d_e^i]$			Scope of application:
	β	$\vartheta(n)$	d_e^i	
Chapuis (2004) acc. to Vukovic and Soro [18] and Devlin [3]	$\frac{\mu}{\rho g}$	$10^{1.291\xi-0.6435}$	$d_{10}^{\left(\frac{10^{(0.5504-0.2937\xi)}}{2}\right)}$ Where: $\xi=\frac{n}{1-n}$	The formula is applicable for $0.3 < n < 0.7$ $0.10 < d_{10} < 2.0\ mm$ $2 < C_U < 12$ $d_{10}/d_5 < 1.4$
Krumbein and Monk (1942) acc. to Vukovic and Soro [18] and Devlin [3]	7.501×10^{-6}	$e^{(-1.31\times\sigma_Ø)}$	$\left[2^{\left(\frac{d_{16Ø}+d_{50Ø}+d_{84Ø}}{3}\right)}\right]^2$ $\varphi=\frac{d_{84\varphi}-d_{16\varphi}}{4}-\frac{d_{95\varphi}-d_{5\varphi}}{6.6}$	

$d_{i\varphi}$ = average grain diameter of the fraction $\left(Ø=\log_2\left(d_e/d_o\right),\ d_e mm,\ d_o=1mm\right)$

Tab. 2. Summary of the formulas used to calculate the hydraulic conductivity

Source: Own study

Soil type	Porosity n [-]	Density index I_D [-]	Hydraulic conductivity k_{10} [m/s] assigned:												
			by the empirical method according to the formula:												by laboratory method:
			Hazen	Slichter	Terzaghi	Beyer	Sauerbrei	Kozeny	Zamarin	USBR	Barr	Alyamani and Sen	Chapuis	Krumbein and Monk	Constant head [14]
A_1	0.33	bzg $(I_D=0.90)$	2.81E-04	7.20E-04	-	3.37E-04	1.20E-04	-	-	1.74E-04	8.86E-05	3.27E-04	1.46E-04	3.34E-04	1.00E-04
	0.35	zg $(I_D=0.70)$	3.14E-04	8.74E-05	-	3.37E-04	1.52E-04	-	-	1.74E-04	1.12E-04	3.27E-04	1.91E-04	3.34E-04	1.16E-04
	0.38	szg $(I_D=0.50)$	3.64E-04	1.14E-04	-	3.37E-04	2.13E-04	-	-	1.74E-04	1.58E-04	3.27E-04	2.90E-04	3.34E-04	1.89E-04
	0.40	In $(I_D=0.30)$	3.97E-04	1.35E-04	-	3.37E-04	2.66E-04	-	-	1.74E-04	1.97E-04	3.27E-04	3.91E-04	3.34E-04	2.18E-04
A_2	0.33	bzg $(I_D=0.90)$	1.15E-04	2.96E-05	4.96E-05	1.33E-04	4.02E-05	5.56E-05	1.32E-04	5.27E-05	3.64E-05	1.16E-04	4.71E-05	1.33E-04	1.04E-04
	0.36	zg $(I_D=0.70)$	1.36E-04	3.94E-05	6.77E-05	1.33E-04	5.71E-05	1.81E-04	1.66E-04	5.27E-05	5.18E-05	1.16E-04	7.42E-05	1.33E-04	1.25E-04
	0.38	szg $(I_D=0.50)$	1.49E-04	4.70E-05	8.17E-05	1.33E-04	7.16E-05	9.92E-05	1.92E-04	5.27E-05	6.49E-05	1.16E-04	1.02E-04	1.33E-04	1.47E-04
	0.41	In $(I_D=0.30)$	1.70E-04	6.04E-05	1.06E-04	1.33E-04	9.93E-05	1.38E-04	2.33E-04	5.27E-05	9.00E-05	1.16E-04	1.70E-04	1.33E-04	1.59E-04
B	0.31	bzg $(I_D=0.90)$	2.45E-04	5.81E-05	9.51E-05	2.85E-04	1.01E-04	6.76E-04	5.66E-04	2.48E-04	6.86E-05	5.12E-05	1.12E-04	5.12E-04	1.05E-04
	0.34	zg $(I_D=0.70)$	2.95E-04	7.86E-05	1.33E-04	2.85E-04	1.46E-04	9.75E-04	8.32E-04	2.48E-04	1.21E-04	5.12E-05	2.08E-04	5.12E-04	4.20E-04
	0.37	szg $(I_D=0.50)$	3.44E-04	1.04E-04	1.80E-04	2.85E-04	2.06E-04	1.38E-03	9.13E-04	2.48E-04	1.40E-04	5.12E-05	2.49E-04	5.12E-04	9.58E-04
	0.39	In $(I_D=0.30)$	3.76E-04	1.23E-04	2.15E-04	2.85E-04	2.57E-04	1.72E-03	1.05E-03	2.48E-04	1.75E-04	5.12E-05	3.33E-04	5.12E-04	2.85E-04
C	0.31	bzg $(I_D=0.90)$	1.64E-03	3.88E-04	6.35E-04	2.27E-03	-	9.60E-04	1.50E-03	1.09E-03	4.59E-04	2.46E-03	1.35E-03	1.48E-03	3.41E-03
	0.33	zg $(I_D=0.70)$	1.86E-03	4.77E-04	8.00E-04	2.27E-03	-	1.23E-03	1.78E-03	1.09E-03	5.87E-04	2.46E-03	1.62E-03	1.48E-03	6.38E-03
	0.36	szg $(I_D=0.50)$	2.19E-03	6.34E-04	1.09E-03	2.27E-03	-	1.75E-03	2.25E-03	1.09E-03	8.35E-04	2.46E-03	2.17E-03	1.48E-03	9.96E-03
	0.38	In $(I_D=0.30)$	2.41E-03	7.58E-04	1.32E-03	2.27E-03	-	2.19E-03	2.59E-03	1.09E-03	1.05E-03	2.46E-03	2.67E-03	1.48E-03	9.29E-03
D	0.47	bzg $(I_D=0.90)$	1.52E-04	6.81E-05	-	9.69E-05	1.33E-04	-	-	3.59E-05	1.21E-04	8.83E-05	3.85E-04	8.16E-05	1.06E-05
	0.55	zg $(I_D=0.70)$	1.91E-04	1.14E-04	-	9.69E-05	2.96E-04	-	-	3.59E-05	2.69E-04	8.83E-05	2.56E-03	8.16E-05	1.43E-05
	0.63	szg $(I_D=0.50)$	2.30E-04	1.78E-04	-	9.69E-05	6.57E-04	-	-	3.59E-05	5.98E-04	8.83E-05	2.83E-02	8.16E-05	1.63E-05
	0.71	In $(I_D=0.30)$	2.69E-04	2.64E-04	-	9.69E-05	1.53E-03	-	-	3.59E-05	1.39E-03	8.83E-05	7.10E-01	8.16E-05	1.98E-05

Table 3. Summary of results of the hydraulic conductivity determination for selected soil types

Source: Own study

Formula: $$k = A\left(\frac{g}{\nu}\times[6\times10^{-4}]\times[1+10(n-0.26)]\times d_{10}^{2}\right) \quad [m/s]$$

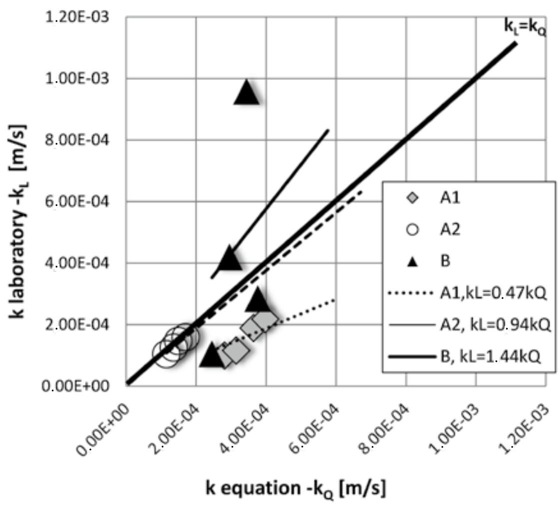
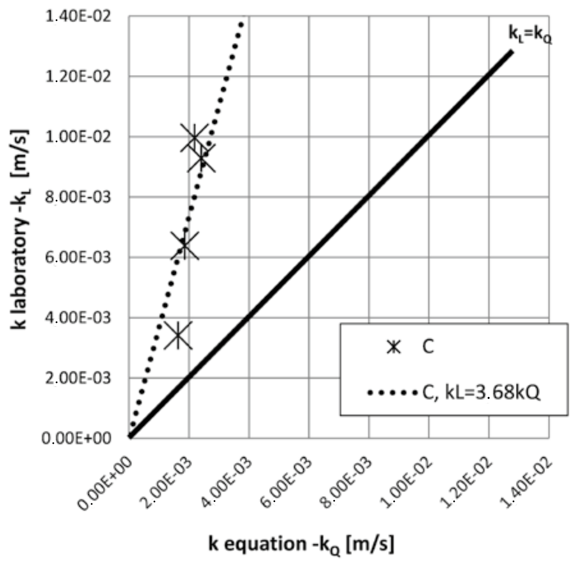
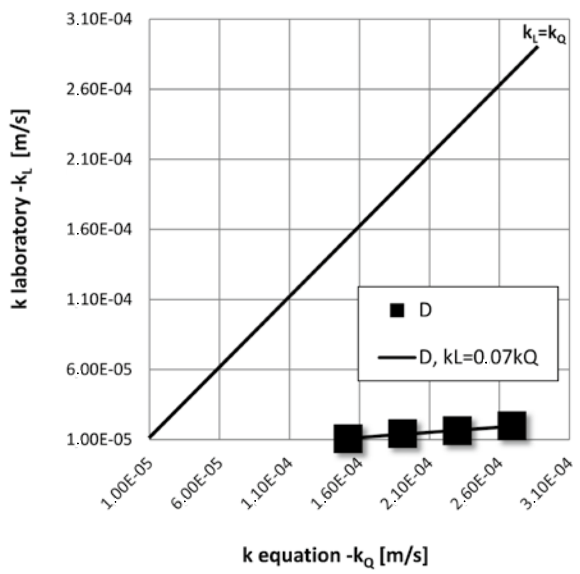
Soil type:	Correction factor A [-]:	Formula validation:
A_1	0.47	
A_2	0.94	
B	1.44	
C	3.68	
D	0.07	

Table 4. Validation of the Hazen formula against the laboratory method, taking into account the density index and soil type.

tests of the hydraulic conductivity were carried out on reconstructed samples. On the basis of maximum and minimum dry density volume of soil skeleton [according to 11] the parameters of forming samples at selected density index: I_D=0.30 – loose, I_D=0.50 – medium dense, I_D=0.70 – dense, I_D=0.90 – very dense). Laboratory tests were performed with apparatus in accordance with PKN-CEN ISO/TS 17892-11 [14] at constant head of filtration, with water flowing in upward and downward directions.

Test results and discussion

The obtained results of the hydraulic conductivity by the laboratory method were compared with the values calculated on the basis of empirical formulas (selected for applicability) for soils characterised by the four above mentioned density index and for the average values of effective diameter equivalents.

The data presented in Table 3 show a clear relationship between the changes in hydraulic conductivity (k) and effective pore diameter caused by increasing the density index (I_D) for each soil group. This indicates that the condition of the soil (density and porosity) must be taken into account when estimating the value of the hydraulic conductivity This relationship is apparent irrespective of the grain size distribution and type of material. Generally, lower hydraulic conductivity were obtained in soils with a higher density index. It should be noted that the permeability coefficient is also affected by the shape of soil particles and their mutual arrangement [9],[16],[17],[18]. This effect can be ignored in this case, as all the sands had the same genesis and age (water-glacial soils) and therefore a similar degree of grain dressing.

Analysing the results given in Table 3, it is possible to indicate the formulas for which the calculated results are close to the measured ones. The most similar values of the coefficient of permeability with laboratory tests at constant hydraulic gradient for non-cohesive soils in group A1 were obtained using the USBR formula, for groups A2 and B: the Krumbein and Monk formula, for group C: Alyamani and Sen and for group D: the USBR formula. On the other hand, in case of consideration of the hydraulic conductivity according to the state of compaction (without taking into account the type of soil) the best fit was obtained using the Terzaghi and Chapuis formula. The universalism of the approach and the practical aspect required the identification of a formula which, once validated, would allow simple and yet correct estimation of the hydraulic conductivity. Therefore, on the basis of conducted analyses an attempt was made to verify the filtration coefficient determined according to the Hazen formula taking into account the degree of compaction [6]. The correction factor related to laboratory tests obtained at a constant slope was determined for each of the studied soil groups (Table 4).

Summary

The most important factors shaping the filtration properties of soils include grain size distribution described by the authoritative diameter di, followed by porosity n and coefficient of uniformity (C_U). These parameters are most often taken into account in the assessment of the filter properties of a soil medium [2]. As it was shown in the conducted analyses, the necessity to take into account the state of soil (which is a parameter related to the described factors) influences the improvement of the description of the phenomenon of filtration expressed by the hydraulic conductivity.

The obtained calculation results were compared with the results of laboratory tests performed on soil samples with the same porosity coefficients (at different compaction levels) as adopted in the calculation method. The formulae based only on grain size distribution (i.e. Beyer, USBR, Alyamani and Sen, Krumbein and Monk) give results both higher and lower than those obtained in laboratory conditions and do not take into account the influence of the compaction in which the soil is located. On the other hand, porosity formulae should not be used if there is no accurate (measured) data for this parameter. The comparison of the results obtained shows the need for individual assessment of the reliability of the formulas used in the evaluation of filtration due to the type of material and its condition. Empirically proposed formulas correcting the filtration coefficient obtained from the Hazen formula allow for more accurate estimation of this parameter, close to the values from direct tests.

It should be remembered that the empirical formulas give only approximate values of the water permeability coefficient, as they do not include all the factors determining the actual flow in the subsoil under in situ conditions [6]. It should be stressed that the formulas have certain limitations and ranges of applicability, which should be strictly observed. In practice, at the stage of construction cost planning, the necessity to implement more labour-intensive (more expensive) methods of direct determination of the filtration coefficient should be taken into account. Limitations of these tests and design based only on the grain size distribution may have measurable effects in the form of defects and errors resulting from underestimation of this parameter.

Źródło: Archiwum autora

Photo. Apparatus to laboratory tests at constant head of filtration in accordance with PKN-CEN ISO/TS 17892-11 and ASTM D2434

BEng. Krystyna Jaśkiewicz
phD, DSc Tomasz Godlewski, Assoc Prof.
Building Structures, Geotechnics and Concrete Department, Building Research Institute, Warsaw

Literature:

1. Białas Z., Kleczkowski A. S. (1970). *O przydatności niektórych wzorów empirycznych dla określenia współczynnika filtracji* k. Archiwum Hydrotechniki TOM XVII, Zeszyt 3, s.405–417.
2. Dąbska A. (2021) Odporność filtracyjna piasków. Warszawa: Oficyna wydawnicza Politechniki Warszawskiej
3. Devlin, J. F. (2015). HydrogeoSieveXL: an Excel-based tool to estimate hydraulic conductivity from grain size analysis. Hydrogeology Journal. doi.org/10.1007/s10040-015-1255-0
4. Head, K. & Epps, R. (2011). *Manual of soil laboratory testing. Vol. 2. Permeability, shear strength and compressibility test.* Dunbeath Mill: Whittles Publishing.
5. Hazen, A. (1892). Some physical properties of sands and gravels, with special reference to their use in filtration. In *24th Annual Report of the State Board of Health of Massachusetts* (pp. 539–556). Boston: State Board of Health of Massachusetts.
6. Jaśkiewicz K., Godlewski T. (2021). Veryfication of determination of hydraulic conductivity for coarse soils by empirical formulas based on the density index. *Acta Sci. Pol. Architectura*, 20 (2) 2021, 83-92; DOI: 10.22630/ASPA.2021.20.2.17
7. Kozeny, J. (1953). Das Wasser im Boden. Grundwasserbewegung. In J. Kozeny (Ed.), *Hydraulik* (pp. 380–445). Vienna: Springer.
8. Myślińska, E. (1998). *Laboratoryjne badania gruntów.* Warszawa: Wydawnictwo Naukowe PWN.
9. Parylak, K., Zięba, Z., Bułdys, A. & Witek, K. (2013). Weryfikacja wyznaczania współczynnika filtracji gruntów niespoistych za pomocą wzorów empirycznych w ujęciu ich mikrostruktury. *Acta Sci. Pol. Architectura,* 12 (2), 43–51
10. Polski Komitet Normalizacyjny [PKN] (1986). *Grunty budowlane. Określenia symbole podział i opis gruntów* (PN-B-0248:1986). Warszawa: Polski Komitet Normalizacyjny.
11. Polski Komitet Normalizacyjny [PKN] (1988). *Grunty budowlane. Badania próbek gruntu* (PN-B-04481:1988). Warszawa: Polski Komitet Normalizacyjny.
12. Polski Komitet Normalizacyjny [PKN] (2008). *Badania geotechniczne. Badania laboratoryjne gruntów. Część 4: Oznaczanie składu granulometrycznego* (PKN-CEN ISO/TS 17892-4:2008). Warszawa: Polski Komitet Normalizacyjny.
13. Polski Komitet Normalizacyjny [PKN] (2019). *Badania geotechniczne. Oznaczanie i klasyfikowanie gruntów. Część 2: Zasady klasyfikowania* (PN-EN ISO 14688-2:2019). Warszawa: Polski Komitet Normalizacyjny.
14. Polski Komitet Normalizacyjny [PKN] (2019). Badania geotechniczne – *Badania laboratoryjne gruntów – Część 11: badanie filtracji przy stałym i zmiennym gradiencie hydraulicznym* (PKN-CEN ISO/TS 17892-11: 2019-05) Warszawa: Polski Komitet Normalizacyjny.
15. Sauerbrey, I.I., 1932. On the Problem and Determination of the Permeability Coefficient. Proceedings VNIIG, No. 3–5. (In. Russian.)
16. Shen, C., Zhu, J. & Gu, W. (2019). Prediction Method for Hydraulic Conductivity considering the Effect of Sizes of Ellipsoid Soil Particles from the Microscopic Perspective. *Advances in Civil Engineering*, 7213094. http://doi.org/10.1155/2019/7213094
17. Wrzesiński, G. (2020). Permeability coefficient tests in non-cohesive soils. *Przegląd Naukowy. Inżynieria i Kształtowanie Środowiska – Scientific Review. Engineering and Environmental Sciences,* 29 (1), 72–80. http://doi.org/10.22630/PNIKS.2020.29.1.7
18. Vukovic, M. & Soro, A. (1992). *Determination of hydraulic conductivity of porous media from grain-size composition* [trans. from Serbo-Croation by Dubravka Miladinov]. Littleton, CO: Water Resources Publications.
19. Zięba, Z. (2016). Influence of soil particle shape on saturated hydraulic conductivity, *Journal of Hydrology and Hydromechanics*, 65 (1), 80–87. http://doi.org/10.1515/johh-2016-0054\

Source: iStock, Olivier Le Moal

We can, with hydropower: how water, wind and sun can combine to meet climate goals

The historic agreement among world leaders at COP26 to phase down coal has intensified the debate about how we will replace fossils fuels in the future energy mix. But if we are to meet our climate goals, we must stop playing favourites and look towards the complementary strengths of all renewable technologies, writes Eddie Rich, CEO of the International Hydropower Association (IHA).

It is beyond any doubt that climate change represents the greatest threat to humanity and the environment. While it has been reassuring to see the global consensus come around to recognise the scale of the challenge, we are simply not making fast enough progress on reducing carbon emissions.

Upon the launch of the third Intergovernmental Panel on Climate Change (IPCC) report in April 2022, United Nations Secretary-General António Guterres emphasised that "choices made by countries now will make or break the commitment to 1.5°C". His words reflect a stark reality that without swift and urgent action to limit global temperature rises, the net zero emissions target will soon slip beyond our reach.

Hydropower can enable wind and solar at scale

Wind and solar power have dominated the conversation in recent years on shifting away from fossil fuels. It is unquestionable that both have a huge role to play in the clean energy transition, and I welcome the investment that is being injected into their growth. However, wind and solar will soon reach their limit if we do not also invest in a reliable backup for the times when the weather conditions are not right.

As the world's largest provider of clean energy storage, hydropower is uniquely placed to fulfil this role. It can be ramped up or down at short notice to stabilise the grid whenever the wind doesn't blow or the sun doesn't shine. There is no other existing technology that can offer backup and grid services at scale to enable the huge amounts of wind and solar power needed to achieve net zero.

Sustainable hydropower is a clean, green, modern and affordable solution to climate change. Once they are constructed, hydropower projects provide society with power and grid services for many decades, and with a lower greenhouse gas emission profile in comparison to other energy sources over a full lifecycle. This is before we even consider the many non-power services hydropower provides, including water resource management, navigation, irrigation and tourism.

The challenge we face is that new hydropower capacity is not being developed quickly enough to support the rapid growth of variable renewables like wind and solar. Factoring in the long lead times and complex legal processes involved, hydropower projects often take more than ten years to build. If policymakers do not make the critical decisions today to spur new hydropower development, the situation will get worse: we will either face blackouts, or we will need to fall back onto harmful fossil fuels.

Development is progressing, but we need to accelerate

New intelligence in the last year has shed light on the immense scale of hydropower development needed if we are to meet global climate goals. The International Energy Agency (IEA) warned in its 2021 Net Zero by 2050 report that global hydropower capacity needs to at least double by mid-century in order to limit the global temperature rise to 1.5°C, while the organisation's Executive Director Fatih Birol described hydropower as "the forgotten giant of clean electricity" that "needs to be put squarely back on the energy and climate agenda if countries are serious about meeting their net zero goals".

Meanwhile, the International Renewable Energy Agency (IRENA) echoed these projections in its Global Energy Transformation: the REmap Transition Pathway, which called for a doubling of global hydropower capacity to around 2,600 GW by 2050.

Describing a "decade of high promise but ultimately uneven and lacklustre growth", IHA President Roger Gill wrote in the last edition of Energetyka Wodna that hydropower's capacity growth was just 1.6 per cent in 2020, far below the 2.3 per cent needed to reach the IEA's net zero pathway. The new data that we reveal in the 2022 Hydropower Status Report shows a slight annual increase in new development, but we are still falling short of what is needed.

Approximately 26 GW of new hydropower capacity came online in 2021, marking a 1.9 percent increase and bringing the global total to 1,360 GW. The geographical distribution of development remains a problem, however; around 80 per cent of last year's new installations were in China, which has dominated new hydropower in the past decade.

Ramping up our progress to meet net zero targets will require tapping into the tremendous potential that exists across much of the world, particularly in Africa and Asia, using the new Hydropower Sustainability Standard certification scheme to ensure it is developed responsibly. We can also supplement new development by modernising our existing stock of hydropower projects around the world, and by retrofitting hydropower facilities into non-powered dams.

We can, with hydropower: a public information campaign

The need for sustainable hydropower as an enabler for net zero could not be clearer. To bring this to the attention of the public and place it firmly on the radar of policymakers, IHA has launched a new campaign in 2022 together with a coalition of developers, operators, manufacturers and industry associations around the world.

We can, with hydropower is a public information campaign that highlights the many benefits that hydropower provides to society when it is developed responsibly and sustainably. The first phase of the campaign has focused on hydropower's role in enabling wind and solar, preventing blackouts, providing affordable energy, decarbonising industries, and protecting communities from floods and droughts.

Leading public figures that have joined the campaign to voice messages of support include former Prime Minister of Australia Malcolm Turnbull, former Prime Minister of New Zealand Helen Clark, explorer and founder of the Solar Impulse Foundation Bertrand Piccard, Swiss State Secretary Benoît Revaz, and former Norwegian Environment Minister Erik Solheim.

The road to COP27

The launch of the We can, with hydropower campaign follows a remarkable year of progress for the sustainable hydropower community. The 2021 World Hydropower Congress last September saw two milestone moments. Firstly, the launch of the Hydropower Sustainability Standard marked the world's first sustainability certification and labelling scheme in the renewables sector. We are now rolling out its implementation with the hydropower community around the world.

Secondly, the San José Declaration on Sustainable Hydropower outlined a new vision for the sector to contribute to climate and development goals, and a series of recommendations for policymakers. At its heart was an assertion that "going forward, the only acceptable hydropower is sustainable hydropower". The Declaration – which was presented to global decision makers at COP26 – also featured a ground-breaking commitment that new hydropower projects must not be developed in UNESCO World Heritage Sites, and that a duty of care should be applied in designated Protected Areas.

With hydropower, the technology that we need to deliver net zero is readily available to us, and we have the knowledge and the tools to develop it in a way that brings net positive benefits to society and the environment. It is now down to governments around the world to incentivise sustainable hydropower by including it in their climate change strategies and providing the regulatory and financial frameworks that can spur new development.

This must be the goal for COP27 in November 2022 if we are serious about phasing down coal and accelerating the shift towards renewables.

How to participate

We welcome participation in the We can, with hydropower campaign from anybody who has an interest in sustainable hydropower and its role in achieving climate goals. A range of social media graphics are available to download in six languages from the campaign website, hydropower.org/wecan, and you can share your own messages of support using the hashtag #withhydropower.

Please also certify your projects with the Hydropower Sustainability Standard at www.hydrosustainability.org.

Finally, your company is welcome to join the global effort to advance sustainable hydropower by becoming a member of the International Hydropower Association at www.hydropower.org.

iha

International Hydropower Association

The fishlift – bridging the ecological gap including electricity production

For several decades now, so-called fish migration aids at weirs or similar barriers have been required by law in most cases. The most recent solutions include mechanically assisted lifts, such as fish lifts of various designs and functions, or fish screws. The concept to be presented in this article enables not only fish migration but also the almost complete energetic utilisation of the operational flow necessary for the function, which largely avoids production losses in existing or planned hydro power plants.

The idea of the fish lift is not new and a number of such installations have been built both in Europe and overseas. However, they differ from each other in several respects. What they all have in common is the arrangement of a central shaft structure in which the fish are lifted. Already in the lifting process, however, there are differences both in the drive and in terms of what is lifted. Some systems lift volumes of water including fish in closed containers. Others fill the shaft and let the fish swim independently. Some systems work under a slight overpressure – others prefer the free water level in the chamber.

The upstream emptying can also be done in different ways. In some arrangements, the lifting takes place above the headwater level and after emptying the tank, the fish are flushed into the headwater via a channel. Other solutions prefer free swimming out.

In the case of the "fish lift", the lifting takes place under free water level and without the use of external energy. A lattice screen is lifted, but not the water volume. In the upstream emptying phase, the fish swim freely but mechanically "motivated" into the upstream area.

Components and operating phases of the "fishlift”

The compressor

One of the major challenges concerning the function of a fish lift is the tailwater swimming in into the lifting system. An important parameter for this is undoubtedly a certain attraction flow, which the fish instinctively follows. In the best case, the fish can immediately swim into the shaft. If, however, the lifting process does not begin immediately, the fish will leave the shaft again, as it cannot see any point in waiting. This behaviour can possibly be limited with the arrangement of a fish trap - however, different fish sizes do not allow for an optimal solution.

In the concept to be presented, a so-called compressor is arranged. This is a grid screen that moves slowly from the beginning of the tailwater channel to the shaft, thus forcing the fish in this section into the shaft. The tailwater section should have a length of about 20 m to be effective. The advance speed of the compressor screen must be coordinated with the "timetable" of the liftings in the shaft.

The shaft and its connections

In the present concept, a vertical, prismatic shaft represents the core of the system. This shaft can either be made of reinforced concrete or steel and is connected to the individual headwater or tailwater via mostly rectangular channels. Rectangular cross-sections are suitable for purely technical reasons, since both channel connections must be designed to be closable, and this can best be achieved with a simple sliding or rolling gate.

The dimensions of the shaft are based on dimensions that are considered sufficient for vertical slot passes. This implies a size dependency on the decisive largest fish species to be assumed at the respective location. The shaft thus has a length of 3x the length and a width of 2x the length of the determining fish species.

The lattice screen

Inside the chamber there is a vertically movable screen. The screen consists of a metal frame and a suitable mesh screen and is guided laterally in rails. The edges of the screen are designed in such a way that fish cannot get caught between the screen and the shaft wall. The screen is connected to suitably dimensioned floats by means of rods, whereby the position and movement of the screen is determined exclusively by the water level in the chamber. When the shaft is fully filled having reached the headwater level, a special mechanism is triggered which, after opening the gate on the headwater side, mechanically expels the fish located above the screen from the shaft. This mechanical process is also driven solely by gravity and requires no external energy. This ensures that all fish have to leave the chamber more or less voluntarily.

The turbine

The turbine is installed in a bypass system running parallel to the shaft and is ideally a simple propeller turbine. Higher qualifications are not required as both flow and head can be assumed to be constant. The design data will be in the following ranges: Q between 0.2 and 2.0 m³/s, H between 4 and 30 m. It is highly unlikely that the system will be suitable for significantly lower heights, as the essential advantage of lower costs will no longer be effective. The necessary equipment such as mechanics, gates and turbine will then be too expensive. The turbine is always in operation. The path of the water inflow and outflow is controlled by gates as well. Turbine regulation is not necessary.

The distributor

The shaft is filled via a separate filling pipe that branches off from the inlet pipe in front of the turbine and leads to the bottom of the shaft structure. Just there, the pipe widens into a distribution system to allow the flow to enter the shaft as turbulence-free as possible. The distribution system must be adapted to the shaft size and the filling time. The flow is controlled by an IDM-controlled valve in the supply line.

The operating phases

The operation of the system can be divided into four main phases:

Phase 1: Fish swimming-in

During the swim-in phase, the lattice screen is in its lowest position and the downstream gate is open. The compressor has reached its final position on the shaft and the fish are forced into the shaft. Immediately afterwards, the underwater gate closes and the chamber is slowly filled with water.

Phase 2: Raising the water level and the fish

The supply pipe to the distributor is opened and the shaft is slowly filled. Held by the water level, the screen slowly moves upwards and takes the fish in the shaft with it. When the chamber is full, the screen reaches its highest position and the supply pipe is closed.

Phase 3: Fish swimming out

When the lattice screen reaches its top end, the upstream gate opens and the function of the "ejector" is activated. This forces the fish to leave the chamber. When the "ejector" has reached its final position, the upstream gate closes.

Phase 4: Emptying the chamber

The downstream gate is opened slightly to empty the chamber. The sinking water level in the shaft brings the "ejector" back into its initial position and also lets the lattice screen sink again. To ensure even emptying, the opening height of the tailwater gate is controlled according to the water level in the shaft. After reaching the lowest position and being level with the tailwater, the tailwater gate opens completely.

A design example

The following numerical example serves to illustrate the quality of the fishlift system. The following data are assumed:

Q = 400 l/s; H = 8 m; length of the relevant fish species: 80 cm.

This results in the following design sizes:

Shaft size: l= 2.4 m, b = 1.6 m

Variable chamber volume: 30.72 m^3

Speed of lattice screen lifting: 2.22 cm/s

Shaft filling time (raising): 6 min

Shaft emptying time (lowering): 6 min

Duration of the swim-in phase: 1.5 min

Duration of the swim-out phase: 1.5 min

Required flow to fill the chamber: 85.33 l/s

According to the times mentioned, four cycles/h result.

The generation losses are as follows: During one hour of operation (4 cycles), the total water demand for the operation of the system is 0.4 m^3/s x 3600 s = 1440 m^3. Filling the shaft four times requires a volume of 122.88 m^3. In a traditional vertical slot pass, the generation loss per hour is thus about 25 kWh. In the "fish-lift", the loss in the same time is only 2.2 kWh, which is 8.7%. Calculated over a year, this results in 219,000 kWh compared to 19,136 kWh.

The investment for a conventionally constructed slot pass would be approximately 1,000,000 €. The estimated construction costs for the "fish lift" are around 500,000 €, i.e. 50%.

Area of application

The "fish lift" is particularly suitable for heads of more than 4 m. This is because the costs for the mechanical equipment such as turbine and gates are hardly height-dependent. The height of the shaft only leads to a subordinate increase in costs, since it is a simple concrete or steel construction. However, the costs for a comparable vertical

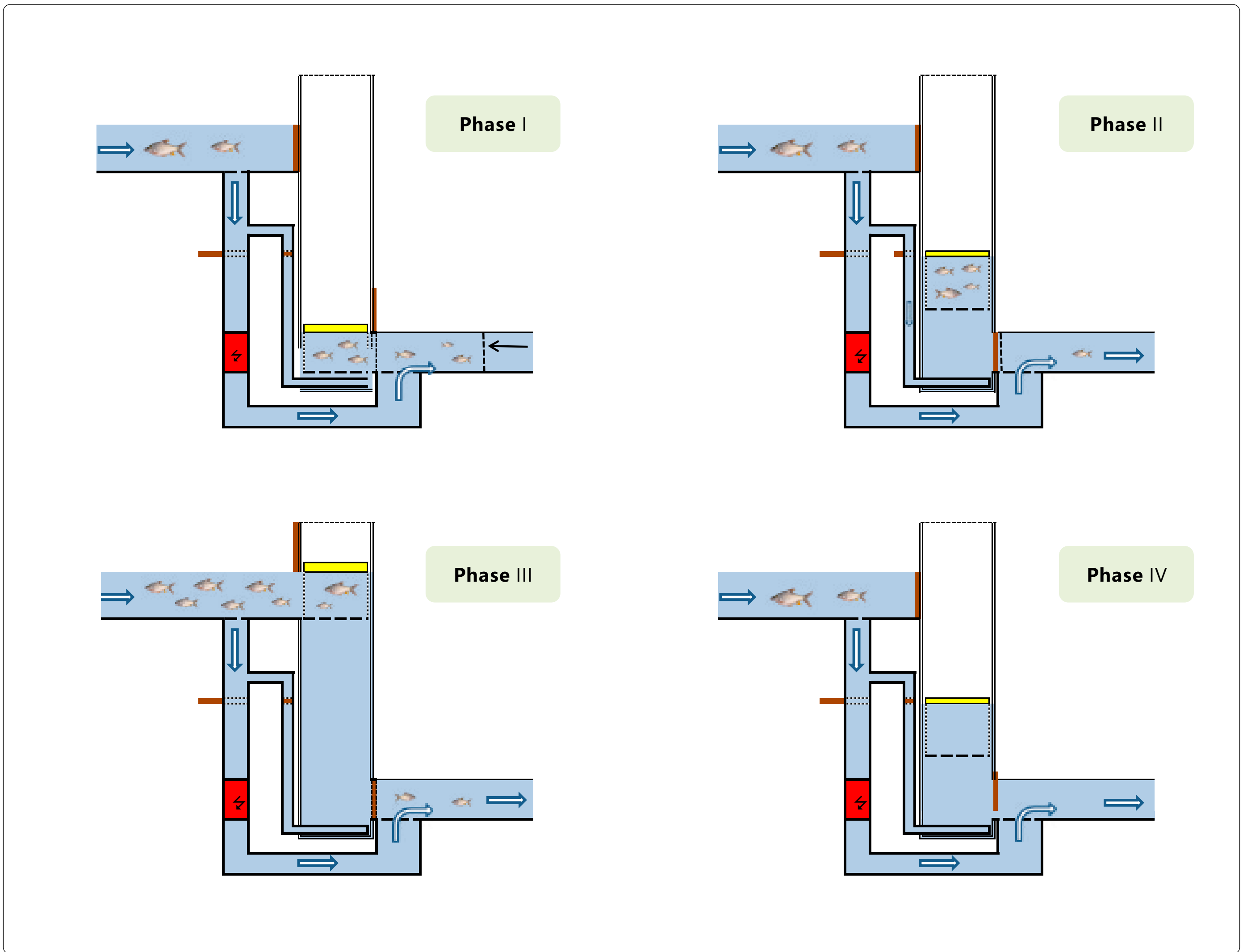


Fig.1. Phases of the fishlift cycle

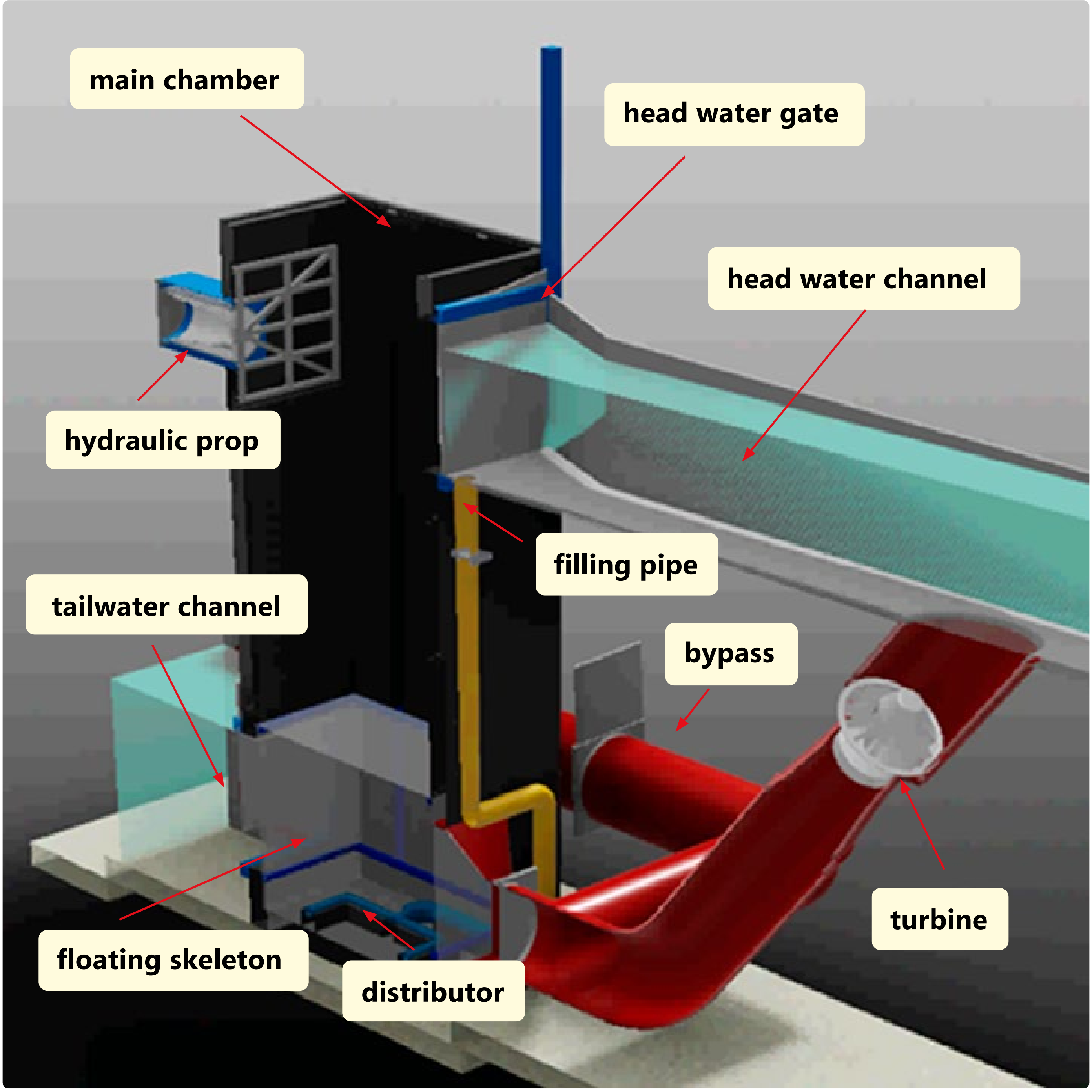


Fig. 2. Main elements of fishlift

slot pass increase approximately linearly with the head. There is no technical limit upwards. However, the question of whether it makes sense for very high heads must be raised in principle, since the upstream habitat at high dam heights is unlikely to meet the requirements of the fish. The size of the relevant fish species is hardly limited. With the exception of the house catfish, which can allegedly grow up to 6 m long, or capital catfish and pike, lengths of 1.2 to 1.5 m will probably rarely be exceeded in European rivers. Consequently, maximum chamber sizes of 3 x 4.5 m will also rarely be needed. A frequently required dimension will be about 2 x 3 m.

Conclusions

Mechanically assisted fish migration aids are currently very much in the ascendancy, and monitoring already carried out has proven satisfactory functionality despite the partly very sceptical or even negative attitude of the authorities. Now it is a question of proving the acceptance of such systems in as many different fish regions as possible and finally declaring them to be state of the art.

The system presented combines the advantages of such by-pass systems with the benefit of simultaneous energy generation. This not only leads to a 90% avoidance of generation losses, but also to a resulting amortisation of the fish by-pass system. No alternative can claim this bonus.

PhD BEng. Bernhard Pelikan, Prof. ret.
Legal advisor for hydropower exploitation and flood protection
Lecturer
Carinthia University of Applied Sciences

Graphics come from the author's archive.

WTW

Water Turbines Works

..................we believe in the power of nature

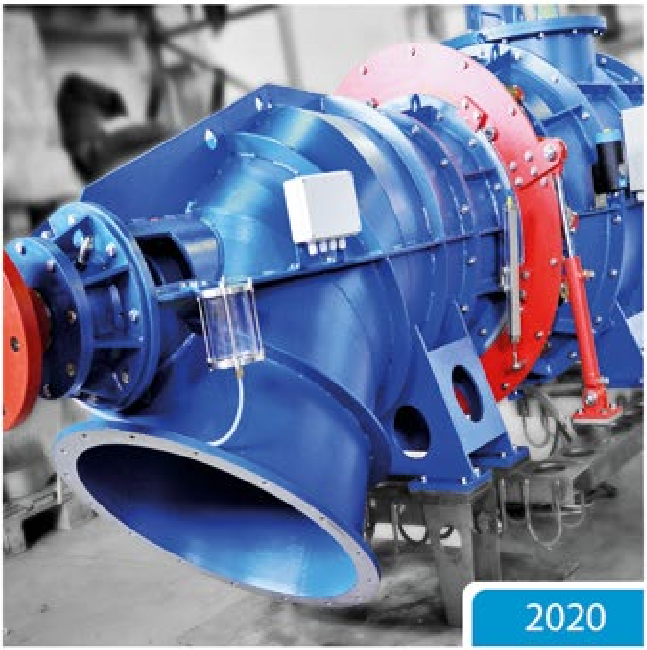
WTW Poland sp. z o.o. is a leading Polish manufacturer of water turbines as well as mechanical and electrical equipment for Small Hydroelectric Power Plants. We have been present on the Polish market since 1989 and so far we have produced 209 turbines with a capacity of> 15.5 MW. Our turbines also work in Italy, Estonia, Ukraine, Belarus and Germany. We provide high efficiency of turbines, professional advice on the selection of devices for a specific location, as well as warranty and post-warranty service. We design and supply Kaplan turbines for heads from 1.5 m to 24 m in many different configurations. Please visit our website where detailed information about our offer is available.

SHP Glebocko, Poland

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

SHP San Secondo, Italy

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



SHP Naviglio, Italy

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

SHP Chancza, Poland

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

+48 695 639 657

info@wtw-poland.com

ul. Konopnickiej 2 F
11-200 Bartoszyce, POLAND

www.wtw-poland.com

Cities of green, blue and energy

More than half of the global community already resides in cities [1]. Urbanization is growing tremendously and with it, significant human interference with nature is deepening. We have realized that we crossed safe boundaries in terms of unrestricted use of resources and transformation of the environment.

Source: Author's archive

Photo 1. Examples of the presence of green-blue infrastructure in Rumia: a) a retention reservoir in the Starowiejski Park; b) small retention in a park in Rumia Janowie

Nature has repeatedly said "check," mercilessly exposing the sad truth that we may not go unpunished in our actions and showing us that despite significant technological progress and tremendous development of knowledge – we are often helpless in the face of the power of natural forces.

Concepts such as "sustainable development," "climate change adaptation," and "energy transition" are nowadays inseparable companions of engineering activities and necessary strategies, indicating courses of action for repairing and mitigating the effects of disturbed harmony in the relationship between man and nature. The rediscovery and maintenance of a balance between human needs (including in terms of developing agglomerations) and the environment's capacity for regeneration and its resilience to anthropopressure, is now among the strategic and priority demands.

The aforementioned attention to sustainability has a very broad context and can be considered at many levels and scales. In addition to economic, climate-related, hydrological and ecological aspects, these activities also have a social, psychological and educational dimension. The functioning of urban agglomerations today is viewed holistically and in the long term - as a kind of natural-technical supersystem, rich in multi-layered interactions between biotic and abiotic elements.

One important trend that fits into the aforementioned strategies is water- and vegetation-oriented urban planning and sustainable stormwater management. In practice, this manifests itself, among other things, in the implementation of the idea of "blue-green infrastructure" in cities, understood as a strategically planned and managed network of natural and water areas in the city to provide a wide range of ecosystem services [2]. These "ecosystem services" are all the functions and benefits for society and the economy that are a consequence of the presence of nature in a city [3]. Thus, the implementation of "blue-green infrastructure" is a set of deliberate, thoughtful and targeted activities (structural and non-structural) aimed at ensuring the optimal functioning of the urban ecosystem.

Water and vegetation in the city

The advantages of the presence of water and vegetation in urban areas cannot be overstated. Among the most obvious ones, there are:

- improving thermal and humidity conditions in cities - reducing diurnal temperature fluctuations, preventing excessive heating of surfaces and air, improving thermal comfort (indoors and outdoors), preventing air drying, thereby weakening the effect of urban heat islands and improving the microclimate in cities;
- improving quantitative relations and equalizing the water balance in the city - retention of rainwater, prevention of rapid rainwater runoff and urban flooding, infiltration of rainwater and groundwater recharge, prevention of urban droughts, reduction of "so-called hydrological stress" in the city, resulting from the uneven distribution of resources in time and space, relieving the burden on wastewater treatment plants and rainwater collectors;
- preservation/improvement of urban biodiversity;
- pollution reduction (including reducing dust formation, pollutant adsorption, etc.);
- creating an attractive urban space, conducive to building social relations, recreation, sports, promotion of pro-environmental behaviour, environmental education, etc.

As a result, the comfort of urban life is significantly improved.

Practical implementation of the idea of "blue-green infrastructure" can be carried out in a variety of ways and at a different scales (from the global one – with respect to the entire city or even the region, to the very local one – related to individual neighborhoods, settlements, or even individual properties). The most common measures include the implementation of solutions to increase water retention (including retention tanks, retention basins, ditches, water squares, green walls and green roofs, rain gardens), the use of solutions using infiltration without retention or with retention (such as. permeable surfaces, infiltration basins, absorption wells, absorption ditches, infiltration boxes, dry rain gardens, etc.), the design of elements that slow down or change the direction of water runoff (the use of rougher pavement, the use of runoff in the form of cascades, appropriate profiling of streets, the use of buffer strips, etc.) and a number of others. Solutions using vegetation additionally affect the increase of interception (retention of water by vegetation), evaporation and transpiration and thus, in practice, affect those component processes of

Source: Wikipedia, Shanta Rohse

Photo 2. View of the green roof of the Canadian War Museum, Ottawa

Source. M. Brzana

Photo 3. Example of extensive vegetation on a green roof model

the water cycle in nature that contribute to reducing the amount of rainwater that forms rapid surface runoff. In turn, solutions that collect water, in addition to serving a protective and recreational function, lead to the formation of water reservoirs for its secondary use (e.g., for watering gardens, parks, lawns, flushing toilets, washing pavements), and these can also function as reservoirs of a heating or cooling medium, or create potential opportunities for use of water for energy purposes.

Green-tinted roof

Among the ideas mentioned, green roofs are an interesting solution. In addition to their primary function of retaining rainwater and thus reducing and slowing the outflow of rainwater into the sewer system, they perform a number of additional functions, such as:

- increasing biologically active area and improving biodiversity,
- lowering the temperature of the roof surface in summer and the temperature inside the building, thereby increasing comfort and microclimate during hot weather,
- thermal insulation of buildings, thereby reducing heat loss through the roof in winter and improving the energy balance of buildings,
- improving insulation against noise,
- absorbing some of the pollution,

and finally

- climate-forming function in the city, improving the attractiveness of urban spaces and, in the case of intensive roofs, also creating additional usable space.

The effectiveness of a green roof is determined by a number of factors [4]. Among the most important is the correct course of the roof structure design stage, adapted to specific conditions and the assumed functionality of the roof (selection of individual layers of the green roof, including the type of vegetation, type and thickness of the plant substrate layer, selection of the drainage layer, etc., as well as the correct design of key construction details). No less important is care at the execution stage of the investment and the selection of the quality of the products used, as well as the course of subsequent operation and maintenance.

Source: Pixabay, VladVictoria

Source: Pixabay, StockSnap

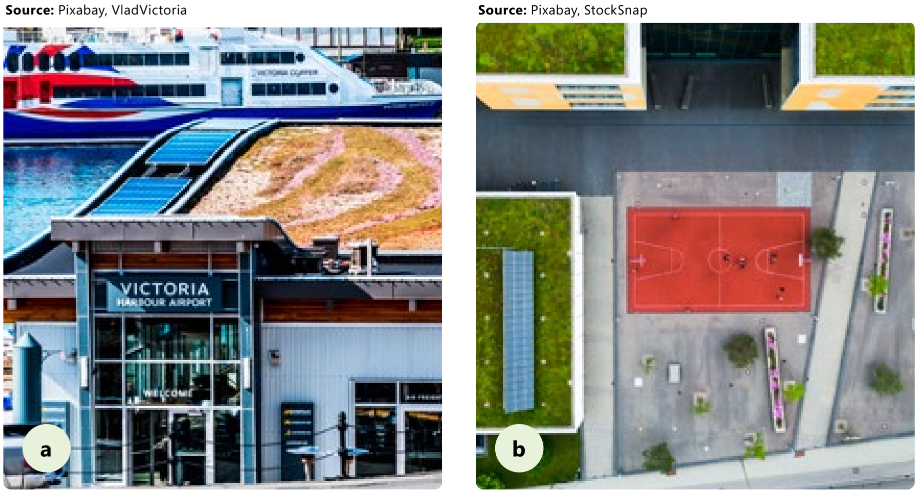


Photo 4. Examples of the use of photovoltaic panels on a green roof

An interesting duo - retention and energy function

An interesting solution is to combine the green roof function with an energy function by using biosolar roofs - green roofs equipped with photovoltaic panels. The literature provides many examples of experimental studies to test the effectiveness of this type of solutions (e.g. [5-9]). The reports from these analyses indicate the occurrence of a synergy effect, manifested by an increase in the effectiveness of the 'dual' solution in relation to the sum of the effectiveness of the individual solutions (according to the reports, approximately 3%, sometimes up to 10% increase in the amount of energy produced). This is due to the positive effect of the presence of vegetation on the thermo-humidity conditions of the roof (lowering the temperature of the vegetated roof, increasing evaporation) and thus increasing the efficiency of the solar panels. Manufacturers of system solutions for green solar roofs (e.g. [10]) additionally point to the important aspect of increasing biodiversity on such surfaces. The different amounts of sunlight and water in the areas under and in front of the panels enable a diversity of plant species on the roof.

The combination of retention and energy functions is also sometimes implemented through the use of floating photovoltaic panels (e.g. [11]). For obvious reasons, such solutions are more justifiable in the case of larger bodies of water, but it seems that similar measures on a smaller - estate or neighbourhood - scale, using urban retention reservoirs, may also prove valuable in the long term.

Some more energy solutions

Water squares and parks in the broadest sense of the term are interesting and very varied in their extent and character. Depending on the geometric and height characteristics of the area, it is possible to introduce a variety of water attractions in such places, usually aimed at the youngest. They mainly have a recreational and/or educational function. They are usu-

Source: Wikipedia, Solar Roadways Inc

Photo 5. Solar car park prototype

ally shallow basins, cascades, water channels with additional infrastructure (e.g. water wheels, fountains, slides, moving surfaces, water curtains, etc.). In a special case, if designed appropriately, they can also potentially provide a visually satisfying source of small-scale energy used, for example, for the illumination of the square.

Developments in technology are constantly providing us with further opportunities to use urban infrastructure for energy generation. A variety of ideas can accompany and enhance elements of blue-green infrastructure. Experimental solutions already include photovoltaic roads and paths, small urban pedestrian power plants (pavements that produce electricity when people walk on them), playing fields that are illuminated by football players running on them and so on.

A separate category is the creation of small urban hydroelectric power plants, using natural watercourses and retention facilities in the form of basins and reservoirs. An example of indigenous solutions is the urban hydroelectric power plant that was established in 2018 at Służewiecki Park in Warsaw ("Energetyka Wodna", issue 2/2019). Experimental solutions involving the insertion of water turbines into sewer lines are also being implemented worldwide. An example is the city of Portland, where the four special segments, equipped with turbines connected to generators, produce the electricity needed to power 150 houses [12].

The need for an energy transition can therefore be seen not only as a challenge to be faced, but also as an opportunity to find creative solutions to enrich and further enhance urban space.

Source: Wikipedia, Anna Regelsberger

Photo 6. Solar tree in Gleisdorf, Austria

Phd Eng. Katarzyna Weinerowska-Bords, Assoc Prof.
Faculty of Civil and Environmental Engineering
Gdansk University of Technology

References:

1. „2014 revision of the World Urbanization Prospects", Report of United Nations, Dep. Of. Economic and Social Affairs, https://www.un.org/en/development/desa/publications/2014-revision-world-urbanization-prospects.html (dostęp: 11 maja 2022)
2. Wagner I., Krauze K. : Jak bezpiecznie zatrzymać wodę w mieście? Narzędzia techniczne. Seria wydawnicza: Zrównoważony Rozwój – Zastosowania, Cz. 5: Woda w mieście, Fundacja Sendzimira, Kraków, 2014
3. Kronenberg J. : Usługi ekosystemów. Seria wydawnicza: Zrównoważony Rozwój – Zastosowania, Cz. 3: Przyroda w mieście, Fundacja Sendzimira, Kraków, 2014
4. Burszta-Adamiak E. (red).: Dachy zielone. Wytyczne dla dachów zielonych. Wytyczne do projektowania, wykonania i utrzymywania dachów zielonych. DAFA. Opole 2021.
5. Chemisana, D. and Lamnatou, C.: Photovoltaic-green roofs: An experimental evaluation of system performance, 2014, Applied Energy Elsevier Ltd, 119, pp. 246–256,. doi: 10.1016/j.apenergy.2013.12.027.
6. Kessling K., Cohen A., Jasso J.: Feasibility of Combining Solar Panels and Green Roofs on the Activities and Recreation Center, Final Report, December 15, 2017, CEE 398PBL
7. Alshayeb, M. J. and Chang, J. D.: Variations of PV panel performance installed over a vegetated roof and a conventional black roof, 2018, Energies, 11(5). doi: 10.3390/en11051110.
8. Baumann, T. I in. : Photovoltaic systems with vertically mounted bifacial PV modules in combination with green roofs, 2019, Solar Energy. Elsevier, 190(August), pp. 139–146. doi: 10.1016/j.solener.2019.08.014.
9. Irga P. i in.: Green Roof & Solar Array – comparative research project – final report July 2021 (2020/037855 / EPI R3 201920005) , University of Technology, Sydney.
10. OPTI_SolarGreenRoof_Bro_210x297_PL_web.pdf (optigruen.pl) (dostęp 21 maja 2022)
11. Jędrzak M.: Przyszłość z energii jest na wodzie, Energetyka wodna, Nr 1 (41), 2022
12. Elektrownia wodna w miejskich kanałach, Elektrownia wodna w miejskich kanałach | Miasto 2077 - Green is Good (https://www.miasto2077.pl/elektrownia-wodna-w-miejskich-kanalach/) (dostęp: 20.05.2022).

EFEKT-AUTOMATYKA

Comprehensive service in the field of electrical and control industry including:

- technical consultancy
- projects
- deliveres and implementation
- starting
- maintenance service

Automatic and control systems for hydropower plants and hydrotechnical structures

- control systems for hydropower structures
- automatic systems for monitoring the stability of dams structures
- electrohydraulic turbine regulators
- control systems for river weirs and dam bottom discharge devices
- diagnostics systems for hydro units
- flood monitoring systems
- balance software for water reservoirs and catchments
- control room systems for hydroelectric power plants

www.efekt-automatyka.com.pl

Headquarters:
Karola Goduli 36 Street
41-703 Ruda Śląska
POLAND

Implementation office:
Niedurnego 99 Street
41-709 Ruda Śląska
POLAND

Phone: (32) 244 58 18
info@efekt-automatyka.com.pl