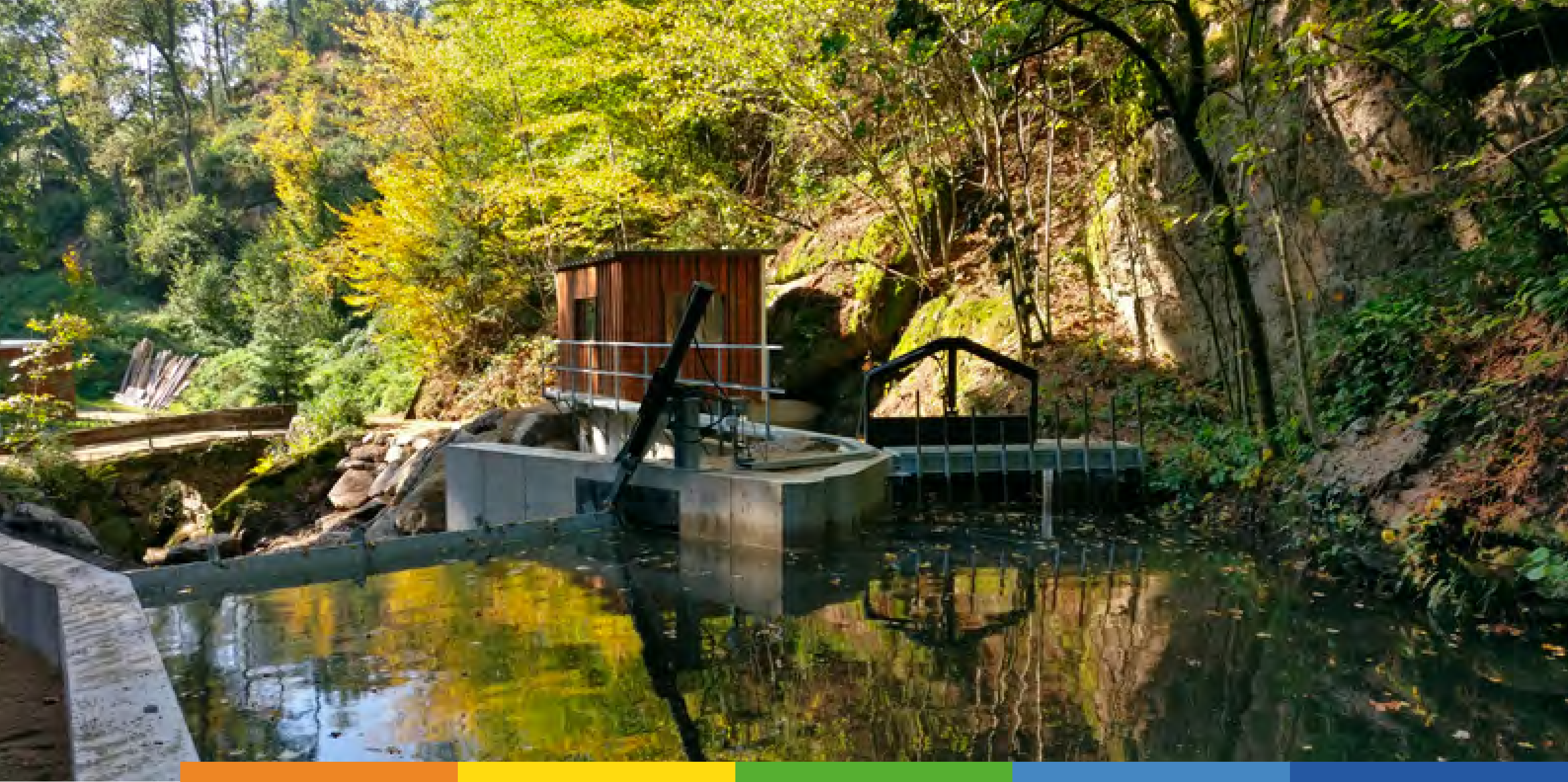


Small hydropower and the EU Green Deal

EREF European Renewable Energies Federation

Why Europe needs small hydropower

In the 27 EU Member States, around 25,000 small hydropower plants, defined as plants with an installed capacity of less than 10 MW, provide 13 million households with renewable electricity each year and contribute significantly to the EU's decarbonisation policy by reducing CO_2 emissions associated with energy production.

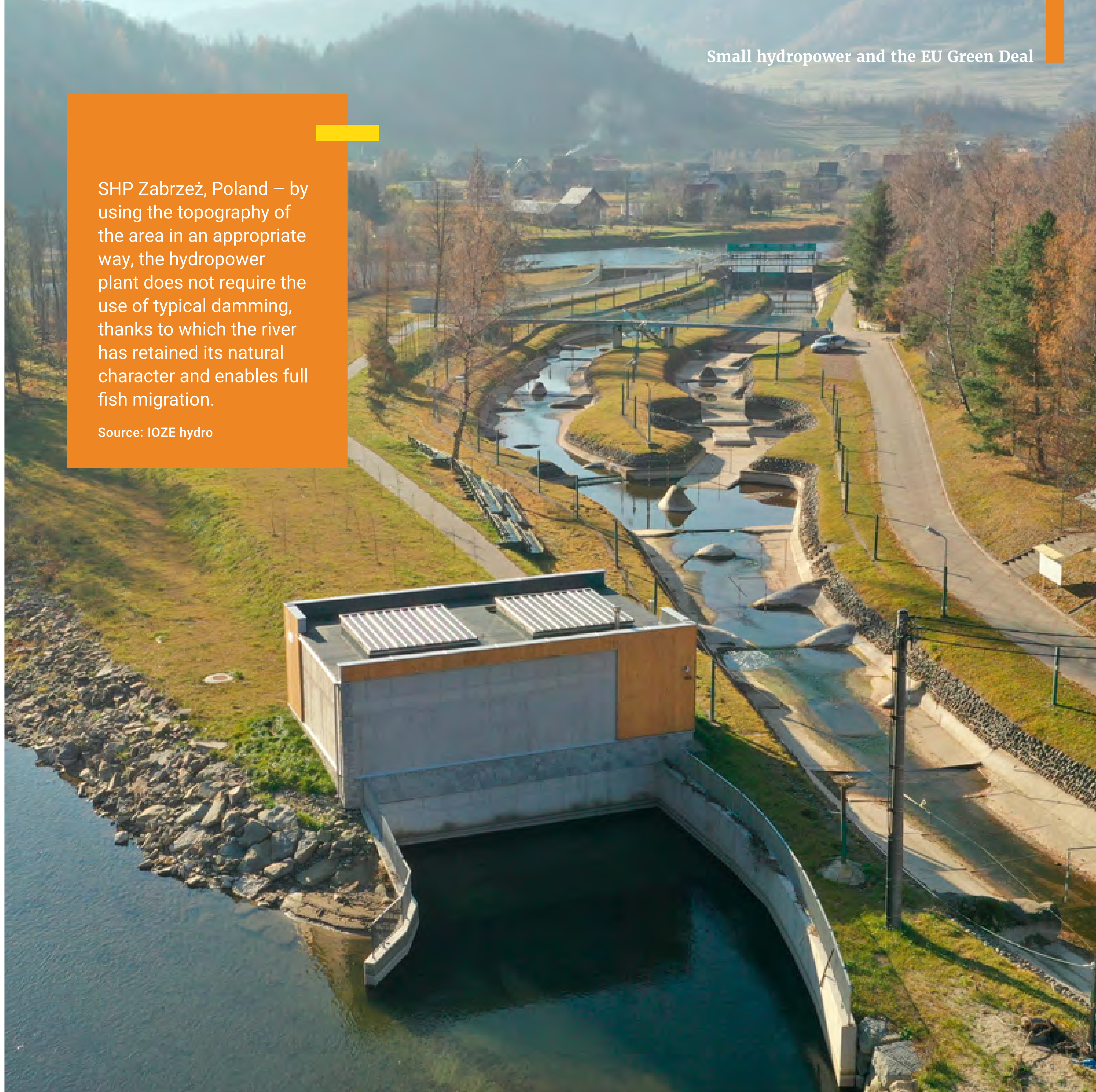
However, the role of small hydropower in Europe's prospective energy systems goes far beyond the production of renewable electricity. An increasingly important purpose of hydropower is to provide a services to the energy system, primarily the flexibility of generation that facilitates the integration of large volumes of variable renewable energy sources (VRES) into electricity grids and ensures the local reliability of electricity supply. The multi-purpose functions of small hydropower plants provide protection against floods and help mitigate the effects of drought. Drawing from the experience of the war in Ukraine, small hydropower can supply electricity to critical infrastructure in many locations of varying sizes.

The report of the Intergovernmental Panel on Climate Change (IPCC) of August 2021[1] concludes that emissions of greenhouse gases from human activities are responsible for about 1.1°C of warming from the mid-19th century to today. Based on this information, the scientists warn that “unless there is an immediate, rapid and large-scale reduction in greenhouse gas emissions, limiting warming to 1.5°C or even 2°C will be out of reach”. The IPCC report[2] of March 2022 grimly pictures our planet’s climate emergency, issuing an alarming plea that climate change impacts are rapidly building up and hitting us earlier than expected, aggravating the lives of more and more people.

Soaring energy prices and potential energy shortages during the coming winters, caused by the Russian invasion of Ukraine, painfully illustrate the

[1] Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, August 2021.

[2] Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, March 2022.



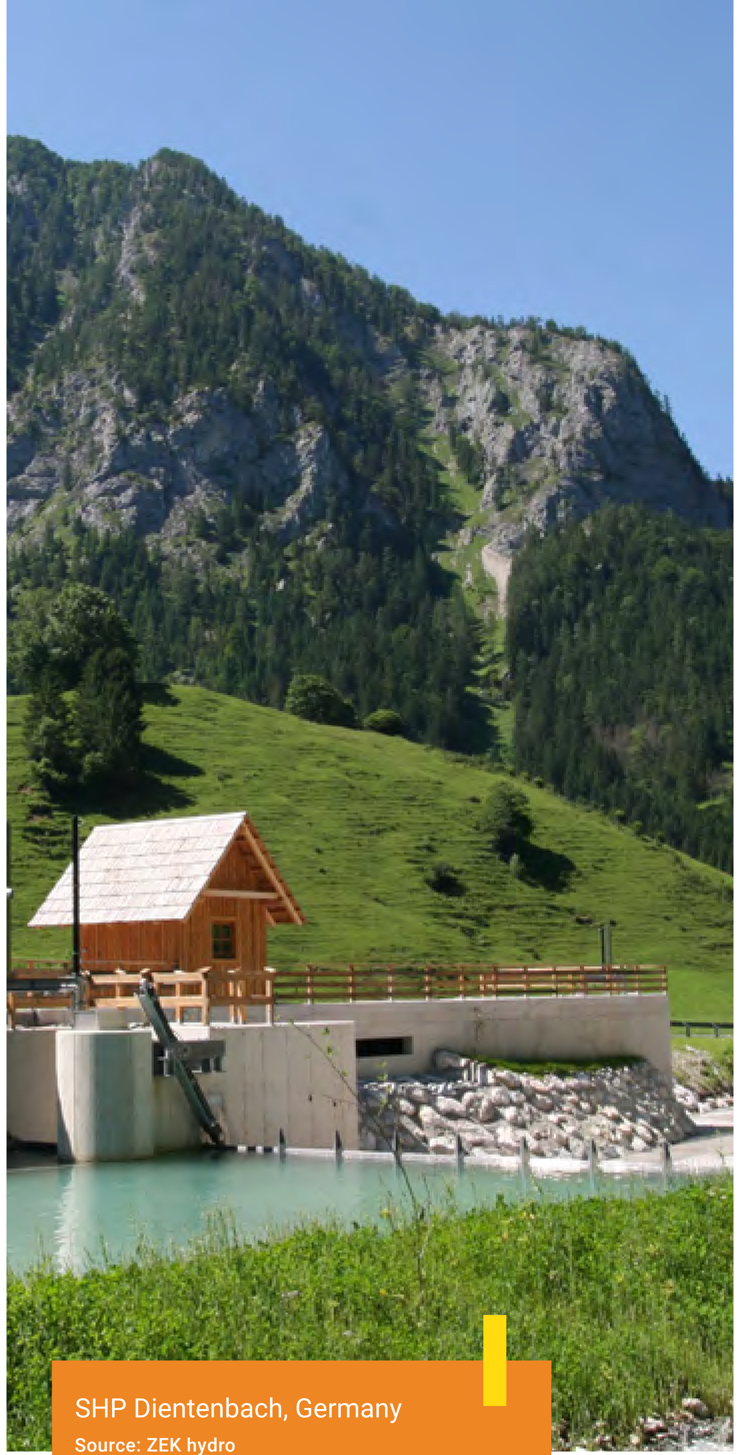
SHP Zabrzeż, Poland – by using the topography of the area in an appropriate way, the hydropower plant does not require the use of typical damming, thanks to which the river has retained its natural character and enables full fish migration.

Source: IOZE hydro

drawbacks of Europe's dependence on imported fossil fuels. There is no more time for delay or hesitation, the time for meaningful action to reduce CO_2 emissions and to achieve greater energy independence is now. This decade is a make-or-break moment. It is crucial to rapidly develop all forms of renewable energy, including small hydropower, in order to rapidly decarbonise the European economy and create an integrated renewable energy system that ensures a reliable energy supply.

The potential for electricity generation through small hydropower is still extensive in Europe: in addition to the refurbishment of some of the estimated 200,000 abandoned small hydropower plants in the 27 EU Member States, the hope lies, among others, in repowering of the existing small hydropower plants by equipping them with the latest technology, system design improvements to increase the generation capacity, the installation of the innovative kinetic turbines in European lowlands, or the exploitation of so-called hidden hydropower[3].

A recent assessment of the remaining and latent potential of small and micro hydropower in the EU estimated an additional annual production of 79 TWh of green electricity under the strictest environmental constraints[4]. This would be an additional significant contribution of the small hydropower sector to



SHP Dientenbach, Germany

Source: ZEK hydro

SHP Anundsjö, Sweden – this is an example of new management systems for existing small hydropower plants that stop the plant during the time of fish migration. Releasing water through the gates attracts migrating fish species, such as salmon, to pass the power plant during their upstream and downstream migration.

Source: Statkraft

the REPowerEU goals of increasing Europe's energy independence and accelerating its decarbonisation. It would also help to combat soaring energy prices and potential energy shortages during the coming winters. In this context, it is important to point out that the European Small Hydropower industry is fully committed to developing sustainable energy systems. It complies with strict European environmental legislation and contributes to the preservation of biodiversity in Europe.

The European small hydropower sector:

- contributes to the creation of a secure and local supply of renewable electricity;
- enables easier and far less expensive integration of variable renewable energy sources (VRES) into electricity grids;
- consists of more than 4,500 sustainable, decentralised, crisis-proof and highly innovative enterprises (mainly SMEs) employing more than 60,000 professionals;
- is fully committed to the environmental legislation and contributes to the preservation of biodiversity;
- is considered to be a world technology leader in sustainable hydropower solutions – building tailor-made facilities all around the world.

[3] Hidden hydropower is defined as new plants equipping non powered dams, environmental flow outlets, and existing water infrastructure, such as drinking and wastewater networks, ship locks, irrigation canals, tailrace channels of large hydropower plants, desalination stations, cooling and other industrial systems allowing either additional electricity production or energy recovery.

[4] Request to include small hydropower in "go-to" / "acceleration" areas– respecting EU Commission's proposal (https://eref-europe.org/request-to-include-small-hydropower-in-go-to-acceleration-areas-respecting-eucommissions-proposal/).

The new energy system under the EU Green Deal and REPowerEU

Following the Paris Agreement of December 2015, a legally binding international treaty on climate change that aims to limit global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial levels, EU leaders agreed to reduce EU-wide net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels and to achieve net zero by 2050.

More frequent news about extreme weather due to climate change and the conclusions of the IPCC report from August 2021[5] and March 2022[6] urge for a much faster large-scale decarbonisation as means to mitigate the impact of climate change phenomena, such as floods and droughts.

In response to the problems in Europe's energy security caused by Russia's invasion of Ukraine, the European Commission has presented the REPowerEU plan. It includes, among others, proposals for a faster increase of renewable energy share in the energy mix and new ways to save energy.

To reach these goals, EREF advocates for a new European energy system based solely on energy efficiency and renewable energy combined with energy system integration, storage, sector coupling and demand-side management. As decarbonisation needs to happen very quickly and at a large scale, EREF regards all forms and sizes of renewable energy as necessary, with a preference for decentralised renewable energy production. The benefits and opportunities of small hydropower play an important role in this energy system transformation.

[5] Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, August 2021.

[6] Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, March 2022.

Strom-Boje (Current Buoy) is one of the most successful hydrokinetic projects. The Strom Boje 3 unit is designed for large rivers such as the Danube, Rhine or Inn. With its 250 cm rotor, it delivers up to 100 kW of rated power at a flow rate of 3.6 m/s. Depending on site quality, it can deliver up to 350 MWh per year.

Source: Aqua Libre Energieentwicklungs GmbH

SHP Besko, Poland – the hitherto untapped hydropower potential of the existing dam, whose primary function is water retention, flood protection and drinking water supply, was exploited by installing a Francis turbine.

Source: IOZE hydro

SHP Dientenbach, Germany

Source: Kleinwasserkraft Österreich

Generation flexibility through hydropower enabling greater integration of renewable energy

Small hydropower generation has a low volatility and high predictability, moreover, it has modulation capabilities in terms of power balancing and makes it possible to regulate voltage, so it can contribute to the flexibility of the future grid system, in which a much higher share of variable renewable energy sources (VRES) will be integrated.

With increasing shares of VRES in the system, various capabilities of hydropower become relevant to support the integration. Unlike many alternatives, hydropower offers a significant range of possible

SHP Slizza, Italy
Source: Troyer AG

flexibility capabilities compared to batteries or other flexibility-providing technologies. These are the reasons why hydropower plants are now increasingly being combined with wind power and photovoltaics as hybrid solutions. A case study[7] for France shows the benefits that hydropower provides for the energy system as a whole. Thanks to its decentralised contribution to electricity supply, small hydropower contributes to the reduction of losses related to electricity transmission and to voltage control in localised grids. A study[8] for Germany shows that small hydropower helps avoid substantial investments in grid changes and saves grid costs.

High-quality and secure electricity supply for all citizens at a local level

With the increasing integration of variable renewable energy sources (VRES), it is becoming increasingly important to provide the right capacity at the right time, rather than just producing large amounts of energy. There is indeed a need to maintain a well-integrated renewable mix, in which hydropower plays an important role due to its particular flexibility characteristics. There are few or no renewable-related alternatives to hydropower that can deliver emission-free solutions – particularly over similarly long periods as hydropower does. The value of flexibility to the energy system and electricity users needs to be properly valued, but is nevertheless a key factor in the design of the future energy system.

[7] COMPASS LEXECON, L'hydroélectricité au défi de la flexibilité. Modèles économiques, December 2020.

[8] Prof. Dr. Markus Zdrallek, Bergische Universität Wuppertal: Grid Contribution of Small Hydroelectric Plants in Germany, July 2018.

Small hydropower development potential in the EU

Contrary to general assumptions, there is still development potential for the small hydropower sector in the EU. The largest unrealised potential for small hydropower generation is in the refurbishment and reactivation of former plants. There are thousands of historic mills, water wheels, disused hydropower plants, weirs and other lateral structures on rivers in Europe. The RESTOR Hydro database, for example, lists more than 50,000 of the estimated 200,000 abandoned and potential small hydropower sites in EU Member States. The AMBER Atlas provides an actual inventory of lateral structures within European rivers.

Utilising the so-called hidden hydro refers to the production of hydropower through existing non-powered hydraulic systems that were not originally designed for hydropower, such as drinking water networks, canals, sewage treatment plants and irrigation channels.

SHP Waidhofen, Austria – an example of harmonious integration of the hydropower plant with the urban architecture.

Source: Kleinwasserkraft Österreich

The exploitation of hidden hydro improves the energy efficiency and sustainability of water resource management and water-intensive industrial production. Hidden hydro exploitation in existing hydraulic infrastructure is inherently a prosumer activity, as the sectors involved (water supply, mining, irrigation etc.) are themselves large energy consumers. The use of hidden hydro resources helps to reduce their net energy consumption. In addition to this net consumption reduction, energy recovery in industrial processes could help to reduce the energy consumption of these processes by utilising potential – such as in desalination plants or cooling systems – that would otherwise be wasted.

Kinetic turbines and Very Low Head Turbines are the latest innovation of European hydropower equipment producers[9], among which there are many start-up companies located mainly in the north-western part of the EU. These turbines make it possible to exploit the potential of low groundwater levels in European lowlands and canals. Instream turbines, which are submerged in a river and generate electricity from the flow velocity of water, work well with low heads, do not require extensive construction work to place them and are suitable for remote areas.

[9] The HYPOSO Handbook illustrates latest European expertise. It has been developed as a part of the HYPOSO project.

SHP Sulejów, Poland – this hydropower plant utilises ultra-low head (1.8 m) on existing correction barrage, below a large body of water. Such a location has nearly no disadvantages. It provides stable and even flow, no pollution and a low risk of freezing.

Source: IOZE hydro

Biodiversity and nature conservation under the EU Green Deal

The EU's biodiversity strategy for 2030 is a long-term plan to protect nature and reverse the degradation of ecosystems. The strategy aims to increase Europe's biodiversity and contains specific actions and commitments such as the restoration of 25,000 km of free-flowing rivers. Human activities have always shaped the landscape around rivers. However, over the past few decades there has been an intense loss of wetland and natural floodplain habitats due to industrial agriculture and urban development, as well as a sharp increase in chemical, pharmaceutical and organic pollution. Increased shipping and recreational activities such as fishing put further pressure on the aquatic environment and its species.

While some argue that "energy-related pressures and hydroelectric facilities are the greatest threat to these important ecosystems", an empirical evaluation applying a long-term true "Before-After-Control-Impact (BACI)" approach has never been conducted. Researchers of the Institute for Alpine Environment (Eurac Research) published the results[10] of the first empirical assessment for small hydropower plants using a long-term true 'BACI' approach in August 2022. In this long-term project, they assessed changes in benthic macroinvertebrate communities at six sites located in the glacier-fed Saldur stream in the Italian Alps before and after the installation of a small "run-of-river" hydropower plant. The results of the 5-year study showed no significant variation in the benthic macroinvertebrate communities stemming from the activity of the hydropower plant. Furthermore, in France, for example, 41% of the water bodies where a hydropower plant is located have a good or even very good ecological status, and the ecological status of these water bodies deteriorates in an upstream to downstream direction as soon as the other anthropogenic pressures mentioned above occur.

The existence of barriers and weirs in many areas helps to prevent erosion, particularly in mountainous areas – and thus helps to protect local habitats and fauna, contributing to the maintenance and development of biodiversity. Numerous scientists demonstrate the complexity and particular

[10] Frontiers | Small Hydropower—Small Ecological Footprint? A Multi-Annual Environmental Impact Analysis Using Aquatic Macroinvertebrates as Bioindicators. Part 1: Effects on Community Structure (frontiersin.org).

SHP Hallstatt, Austria
Source: ZEK hydro

SHP Hydro Ness, Scotland – the eye-catching structure will help create a welcoming new place for locals and tourists to spend time and learn about the role of hydropower in the clean-energy transition.
Source: The Highland Council

SHP Nethermills, Ayr, Scotland
Source: iStock, Sporran

richness of the biotope in the vicinity of hydroelectric facilities. Since the beginning of hydropower's history over a hundred years ago, small hydroelectric plants have established their own ecosystems, known as ecotones. Their reservoirs provide refuges for many plants and animals in the face of climate change, especially during extreme events such as low water levels.

Small hydropower and the environment

Small hydropower plants occasionally have environmental impacts that can, however, be strongly mitigated by the latest innovative technical solutions. In this way, small hydropower and good ecological status of a river can go hand in hand harmoniously. If the basic ecological requirements are met, e.g. sufficient environmental flows (minimum water flows) and fish migration aids are installed, then hydropower does not pose a threat to the ecological status of rivers. 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 of such a case is a small hydropower plant in Sauereggenbach in Austria. Biological assessments of the residual flow section and reference section outside the power plant area show

SHP Smrock, Poland – this is an example of ensuring the biological continuity of a river using an active fish pass, equipped with two Archimedean screws, the first operating in turbine mode and the second in pump mode.
Source: IOZE hydro

that both sections have the same fauna. Consequently, this proves that the operation of a properly designed power plant and environmental protection are compatible.

Over the past decades, European hydropower plant owners have invested billions of euros in retrofitting existing plants with environmental mitigation measures, demonstrating their commitment and support for the environmental requirements of the Water Framework Directive and proving that small hydropower and the 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 upstream and downstream movement of migratory fish species and their breeding. New management systems for existing small hydropower plants stop the plant during the time of fish migration. The release of water through the gates attracts migrating fish species, such as salmon, to pass the power plant during their upstream and downstream migration. An example of this is the Anundsjö power plant in Sweden[11].

[11] The plant is located on the small river Mo in the northern part of Sweden. The interdisciplinary consortium of the EU project FIT Hydro used it as a successful test case for these methods.

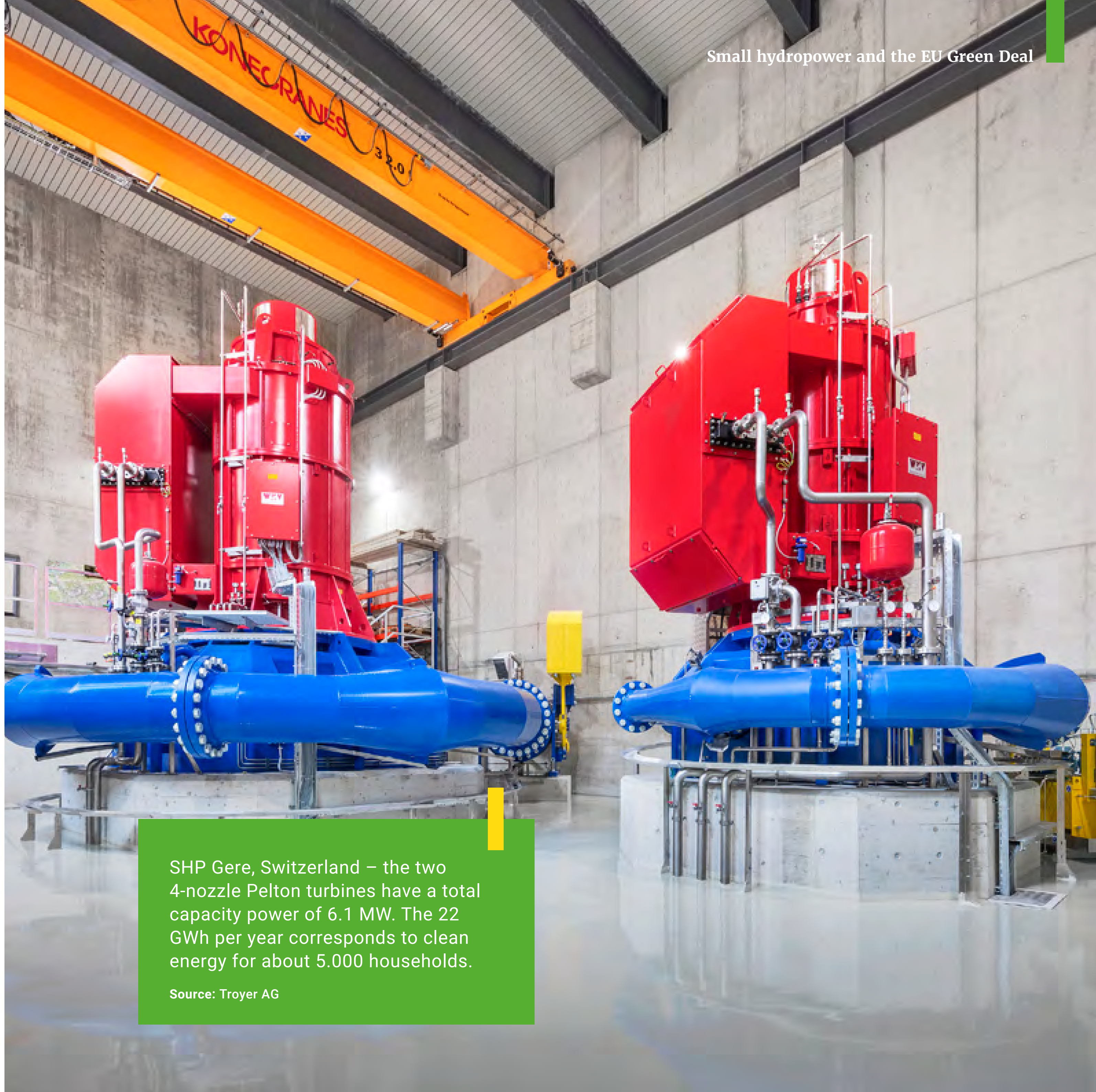
HP Sohlstufe Lehen, Salzburg, Austria
Source: Philipp Habring / MZS

These measures can be combined with fish and sediment bypass mechanisms, such as natural fishways next to power plants, fish ladders, and guaranteed minimum ecological flows. Thanks to EU funding programs, among others, new solutions have been developed to ensure fish migration and river continuity.

Small hydropower plants also create new habitats for rare and valuable aquatic plants and waterfowl. Through their ditches and water damming areas, small hydropower plants even create diverse and structurally rich additional fish habitats. Small hydropower plants enrich water bodies with oxygen and their trash rack systems clean rivers from all sorts of waste floating in the water. For example, a small hydropower plant in Austria collects 7 to 10 kilograms of plastic waste per month. This translates to a minimum of 23 tons of monthly garbage collected from Austrian rivers and streams, if we consider the total number of hydropower plants in Austria.

Newly built plants use modern turbines such as instream submersible turbines that are less harmful to fish and produce more electricity. Kinetic turbines for example have a fish mortality of less than 0.1%.

Another example is the recently developed first shaft hydropower plant in Southern Germany, developed by the Technical University of Munich (TUM). It allows fish to freely pass over the power plant on their migration downstream, since the turbine is hidden in a shaft in the riverbed. Despite these countermeasures, this small hydropower plant produces electricity for 900 people in its vicinity.



SHP Gere, Switzerland – the two 4-nozzle Pelton turbines have a total capacity power of 6.1 MW. The 22 GWh per year corresponds to clean energy for about 5.000 households.

Source: Troyer AG

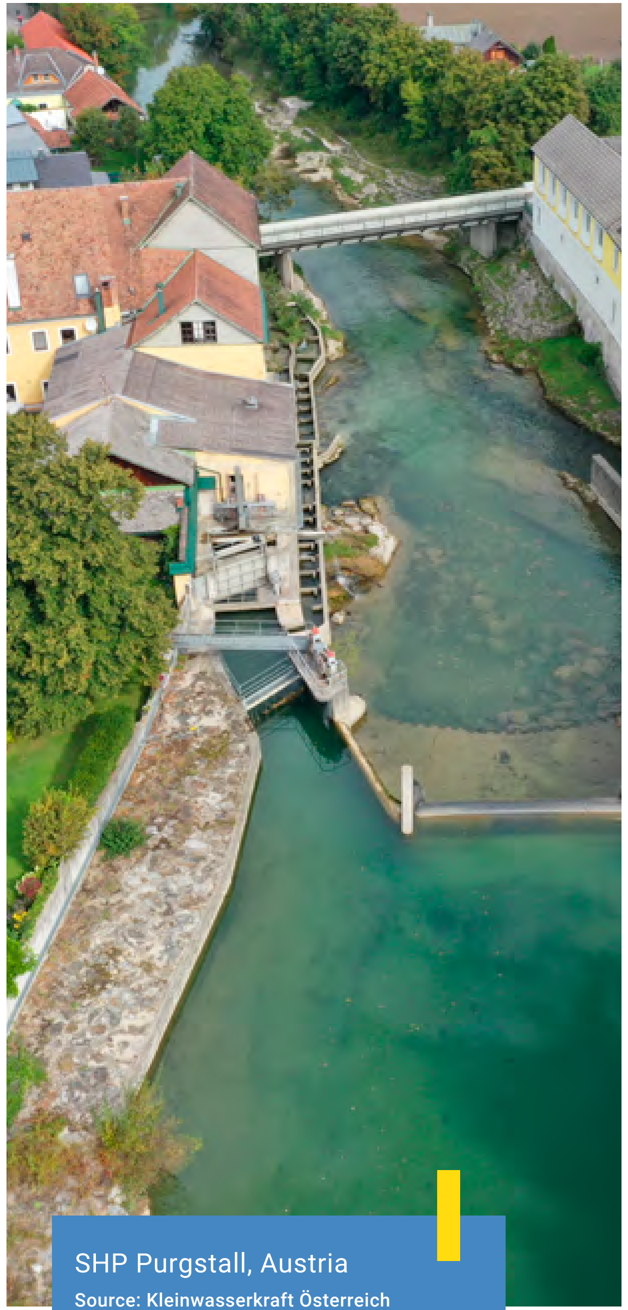
SHP Rechtenstein, Germany
Source: Arbeitsgemeinschaft Wasserkraftwerke Baden-Württemberg

The innovative strength leadership of the European small hydropower industry

The European small hydropower industry is regarded as world leader, able to build tailor-made hydropower facilities all around the world. European competence in the production of hydropower facilities accounts for around two-thirds of the global market. The European hydropower industry offers a full range of solutions and services to harness the potential of hydropower in a sustainable way, under almost any conditions. Most importantly, European equipment stands out for its exceptional performance and meets even the most stringent environmental rules and regulations. The HYPOSO Platform lists companies and organisations from Africa, Latin America, and Europe, that are active in the hydropower sector. This database provides a meeting platform for hydropower stakeholders to establish business contacts.

In addition to its leadership position in manufacturing, Europe is home to a number of leading universities and research centres specialising in hydropower. These include professional test centres for equipment ranging in size from miniature research models to full-scale production turbines, tested to optimise the flexibility, operating conditions and costs of the equipment, as well as to improve the R&D capacity of the centres themselves. The EU Hydropower Europe project has just published a research and innovation agenda and strategic roadmap for the European hydropower sector.

The small hydropower sector comprises more than 4,500 companies (mainly SMEs) with more than 60,000 professionals employed and generates an annual turnover of around €3 billion. The development of small hydropower creates local jobs and activities, especially in rural areas. Small hydropower is an increasingly integral part of interconnected local energy systems based on renewable energy and flexibility, often in combination with municipal energy, as hydropower is the oldest enabler of municipal energy in Europe.

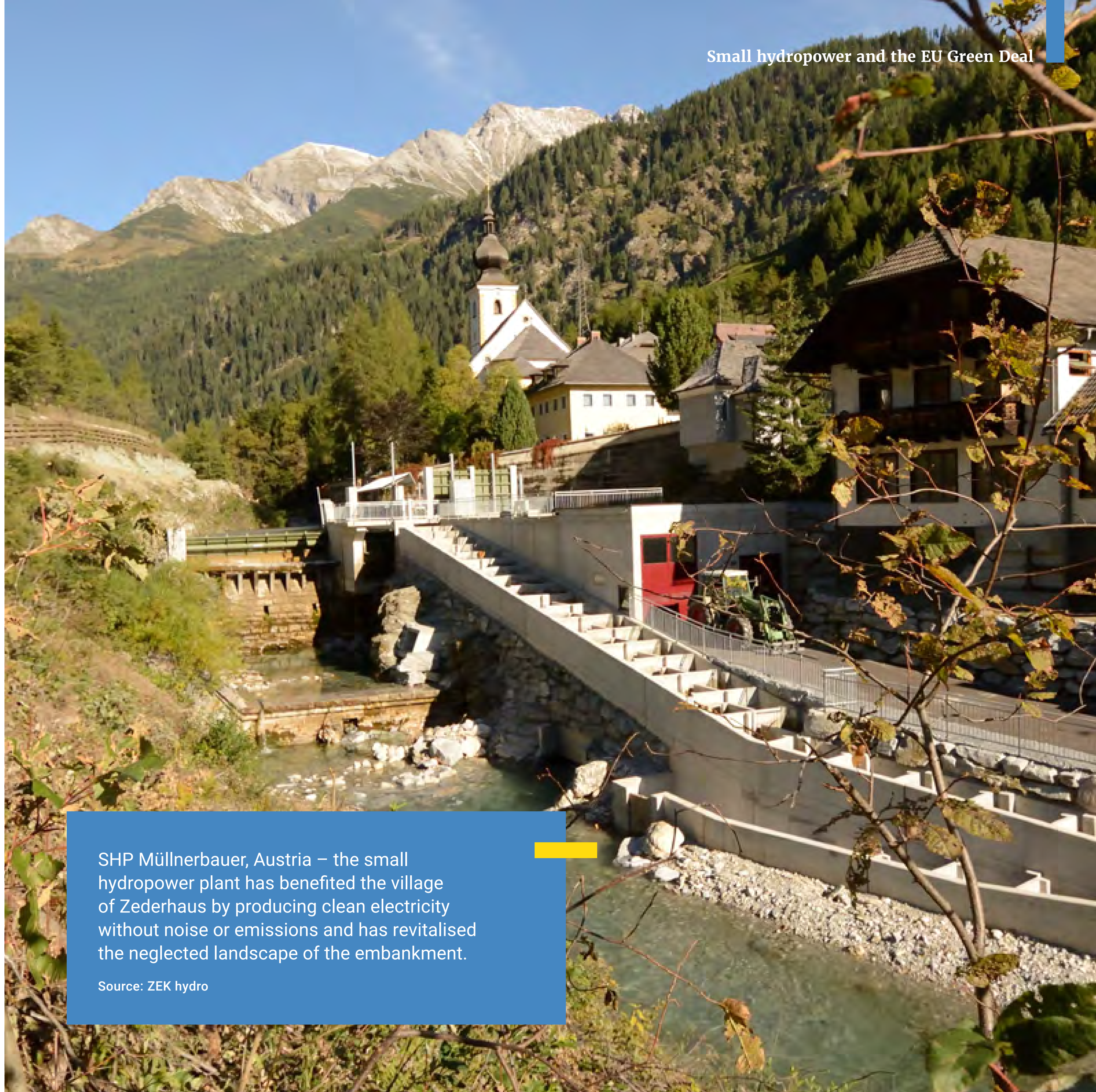


SHP Purgstall, Austria
Source: Kleinwasserkraft Österreich

SHP Hagendorn, Switzerland
Source: ZEK hydro

In order to establish an entente-cordiale between environmental and sustainable energy goals for the decarbonisation of Europe, we must:

- start treating small hydropower as an important component of the EU and national renewable energy mix;
- set a European target for additional small hydropower production capacity of 40 GW by 2050;
- ensure the economic viability and long-term investment conditions for the European small hydropower sector;
- develop fair support mechanisms for the multi-purpose features and energy system services of hydropower;
- continue to fund research to ensure that European equipment manufacturers remain world leaders in innovative hydropower solutions;
- build consensus and cooperation between energy and environmental policies and actors;
- base environmental policies on sound scientific assessment, clear definitions and a cost-benefit analysis;
- develop a harmonised framework for interpretation of European policies with site specific evaluation for small hydropower projects taking into account all dimensions of sustainability;
- use small hydropower as part and solution for water management policies;
- align the objectives of the Renewable Energy and Water Framework Directives.



SHP Müllnerbauer, Austria – the small hydropower plant has benefited the village of Zederhaus by producing clean electricity without noise or emissions and has revitalised the neglected landscape of the embankment.

Source: ZEK hydro

EREF

The EREF Small Hydropower Chapter

The Small Hydropower Chapter of the European Renewable Energies Federation (EREF) represents the small hydropower sector at EU level. Its members are national (small) hydropower associations. The Chapter hosts and moderates several networks of equipment producers and industry stakeholders. EREF cooperates with the International Centre on Small Hydro Power (ICSHP), the International Renewable Energy Agency (IRENA), the International Hydropower Association (IHA), the Working Group Hydro of Eurelectric, the VGB, the EERA Joint Programme Hydropower and REN21 to collect data on and to promote the European hydropower industry.

EREF's website (https://eref-europe.org/) contains databases and information on the EU small hydropower sector and links to EU projects and other hydropower organisations and initiatives under the Small Hydropower Chapter section of our website.

SHP Wdecki Młyn, Poland

Source: iStock, Piotr Borkowski

SHP Grossweil, Germany – the Hydroshaft concept was developed at the Technical University of Munich and combines two of the greatest challenges of our time in a completely new way: the protection of freshwater ecology and the reliable power supply from renewable energy source.

Source: Technical University of Munich

SHP Øvre Forsland, Norway – the technologically and architecturally ground-breaking hydropower plant aims to raise public awareness of the possible harmonious interaction between nature and technology, as well as to explore the role of hydropower.

Source: Helgeland Kraft Vannkraft AS

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