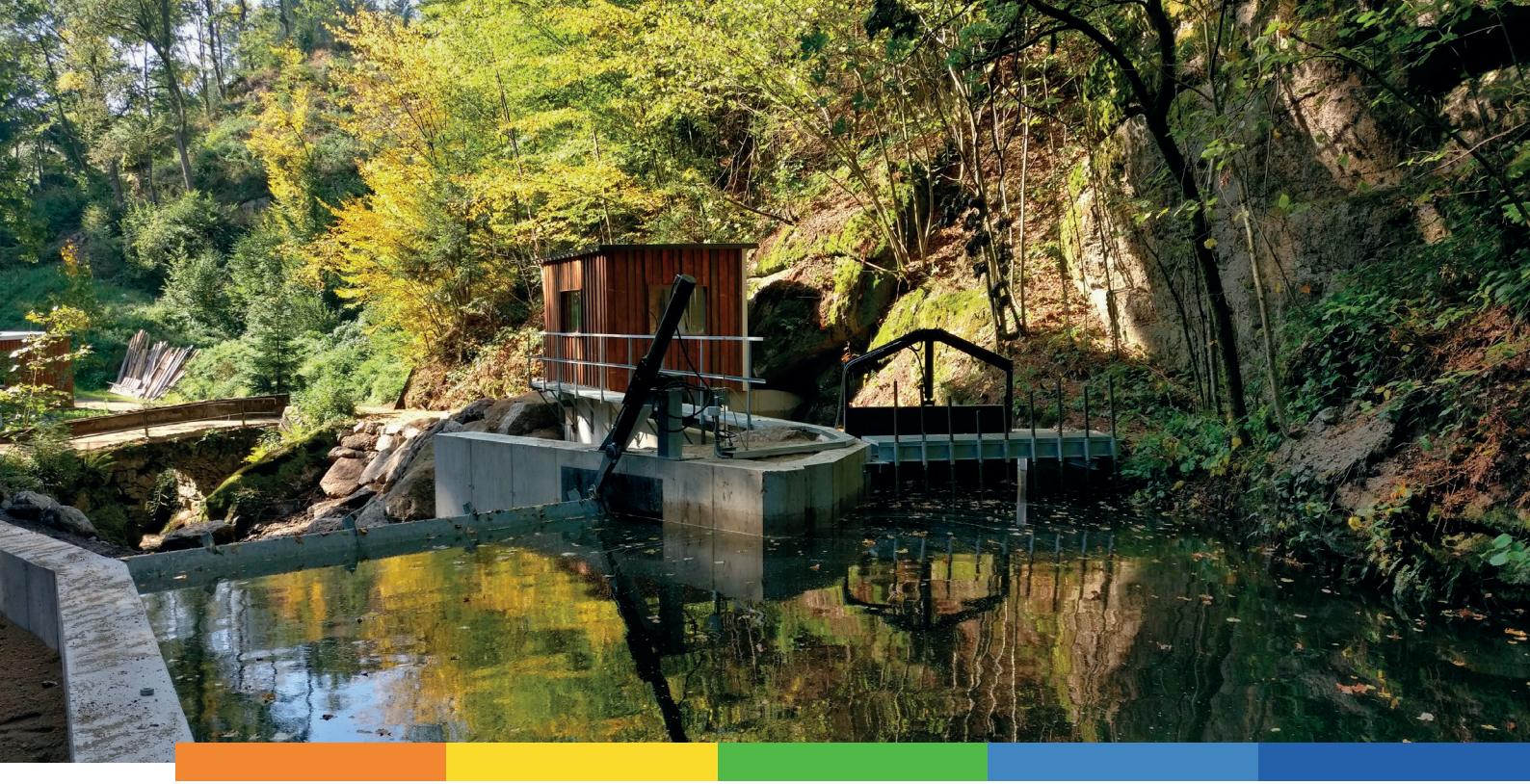


Small hydropower and the EU Green Deal

EREF
European
Renewable
Energies
Federation

Why Europe needs small hydropower

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

The role for small hydropower in prospective European energy systems goes however far beyond the production of renewable electricity. Increasingly important purpose of the energy generated by hydropower plants lies in providing energy system services, most importantly generation flexibility to facilitate integration of large amounts of variable renewable energy sources (VRES) into electricity grids and provide local reliability of electricity supply. The multi-purpose functions of small hydropower plants provide protection against floods and help in drought mitigation. Based on experience from the war in the Ukraine, small hydropower can supply critical infrastructure with electricity in many locations of varying sizes across all EU Member states.

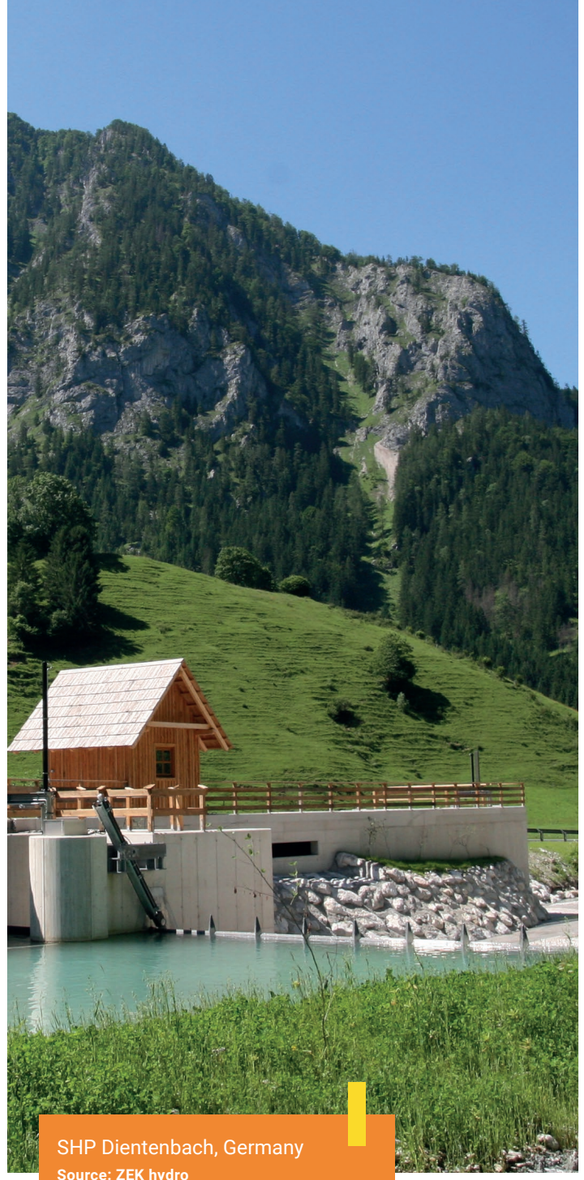
SHP Zabrzeż, Poland – thanks to the appropriate use of the topography of the area, the hydro power plant does not require the use of typical damming, thanks to which the river has retained its natural character and enables full fish migration.

Source: IOZE hydro

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 approximately 1.1°C of warming since the mid-19th century until today. Based on this new information, scientists warn that "unless there are immediate, rapid and large-scale reductions in greenhouse gas emissions, limiting warming to 1.5°C or even 2°C will be beyond 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 ever more people.

Soaring energy prices and potential energy shortages during upcoming winters caused by the Russian invasion of Ukraine painfully illustrate the disadvantages of Europe's dependence on imported fossil fuels. There is no time left 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. For fast decarbonisation of the European economy, all forms of renewable energy, including small hydropower, need to be developed quickly, to create an integrated renewable energy system which provides a reliable power supply.

Potential for generation of electricity by the means of the small hydro industry is still broad in Europe: Besides the refurbishment of some of the estimated 200,000 abandoned small hydropower plants in 27 of the EU Member states, 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]. In this context it is important to point out that the European Small Hydro Industry



SHP Dientenbach, Germany
Source: ZEK hydro

SHP Anundsjö, Sweden – this is an example of new management systems for existing small hydropower plants, which 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.

Source: Statkraft

is fully committed to develop sustainable energy systems. It is adherent to the strict European legislation to protect the environment and contributes to the conservation of Europe's biodiversity.

The European small hydropower sector:

- contributes to the creation of 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, decentralized, crisis-proofed and highly innovative enterprises (mainly SMEs) with more than 60,000 professionals employed;
- is fully committed to the environmental legislation and contributes to biodiversity;
- is considered to be a world technology leader in sustainable hydropower solutions – building tailor-made facilities all around the world.

[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
[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.

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, with its goal to limit global warming to well below 2, preferably to 1.5°C, compared to pre-industrial levels, EU leaders agreed to reduce the GHG net emissions EU-wide by at least 55% by 2030 compared to 1990 levels and to reach net zero by 2050.

More frequent news about extreme weather due to climate change and the conclusions of the IPCC report from August 2021[4] and March 2022[5] urge for a much faster large-scale decarbonisation as means to mitigate the impact of climate change phenomena, such as floods and droughts.

As response to problems in energy security of Europe, caused by Russia's invasion of Ukraine, the European Commission presented the REPowerEU Plan. It includes, among others, proposals for a faster increase of renewable energy share in the energy mix and for means of energy saving.

To reach these goals, EREF advocates for a new European energy system which is based solely on energy efficiency and renewable energy in combination with energy system integration, storage, sector coupling and demand-site 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.

[4] 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

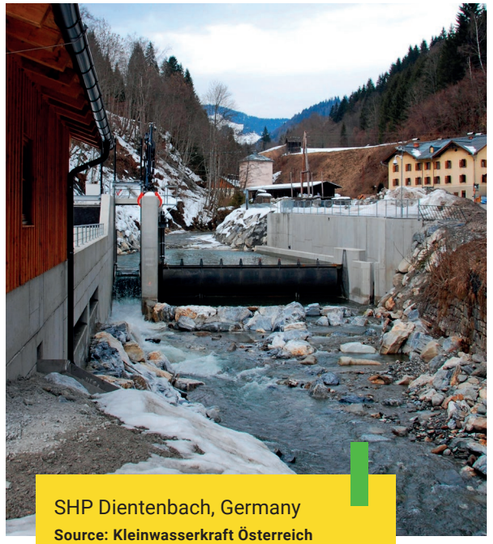
[5] Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, March 2022

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

SHP Besko, Poland - previously untapped hydropower potential of the existing dam, whose primary function is to provide water retention, flood control and drinking water supply has been harnessed by installing a Francis turbine.

Source: IOZE hydro



SHP Dientenbach, Germany

Source: Kleinwasserkraft Österreich

Generation flexibility through hydropower allowing for greater renewable energy integration

Small hydropower production has a low variability and high predictability, moreover it has modulation capabilities in terms of balancing power and allows for voltage control, therefore it can contribute flexibility to the future grid system, which are going to have a much larger share of variable renewable energy sources (VRES) integrated into them.

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 flexibility capabilities in comparison with batteries or other flexibility-providing technologies. These are the reasons, why hydropower plants are being combined with wind power and PV as hybrid solutions increasingly more often nowadays. A case study[6] for France

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

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

shows the benefits hydropower provides for the energy system as a whole. Thanks to its decentralized 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[7] for Germany shows that small hydropower allows to avoid substantial investments in grid amendments and saves network costs.

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

As integration of variable renewable energy (VRES) sources increases, it becomes more and more important to provide the right capacity at the right time, rather than to merely produce large amounts of energy. There is, indeed, a need to sustain a well-integrated mix of renewables – where hydropower has an important role linked to its specific flexibility characteristics. There are few or no renewable-related alternatives to hydropower that can deliver emission-free solutions – particularly over similarly long period as hydropower does. The value of flexibility to the power system and the users of electricity needs relevant valuation to be quantified; it is nonetheless a key factor in the design of the future power system.

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 unrealized potential for small hydropower generation exists in the refurbishment and reactivation of former plants. Europe has thousands of historic mills, water wheels, inoperative hydropower stations, weirs and other lateral structures in rivers. The RESTOR Hydro database, for example, lists more than 50.000 out of 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.

Tapping into so called hidden hydro implies hydropower production through existing unpowered hydraulic systems that are not originally designed for hydropower, like drinking water networks, canalisation, sewage plants and irrigation channels. The exploitation of hidden hydro improves 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 large consumers of energy themselves. Using hidden hydro resources helps improving their net energy consumption. Besides this net consumption reduction, energy recovery in industrial processes could help in reducing the energy consumption of these processes by using the potential excess pressure – as for instance in desalination plants or cooling systems – which would otherwise be wasted.

Kinetic turbines and Very Low Head Turbines are the latest innovation of European hydropower equipment producers[8], among them a number of start-up companies primarily located in the North-Western part of the EU. Those kinds of turbines allow to harness the low head potential 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.

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

Source: Kleinwasserkraft Österreich

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

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

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. The last several decades however saw an intensification of habitat loss in wetlands and natural floodplains due to industrial agriculture and urban development, as well as a sharp increase in chemical, pharmaceutical and organic pollution. Increased shipping and leisure activities such as fishing put further pressure on water 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 in August 2022 their results[9] of the first empirical evaluation for small hydropower plants applying a long-term true "BACI" approach. In this long-term project, they had assessed changes in benthic macroinvertebrate communities along 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 over the 5-year study showed no significant variation in the benthic macroinvertebrate communities stemming from the activity of the hydropower plant. In addition, 41% of water bodies in France for example that include a hydroelectric facility are in good or even very good ecological status, and the ecological status of these water bodies deteriorates from upstream to downstream as soon as other anthropogenic pressures as listed above are encountered.

[9] 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, Austria
Source: ZEK hydro

The existence of barriers and weirs in many areas helps to prevent erosion, particularly in mountainous areas – and thus it helps to protect local habitats and fauna, contributing to maintaining and developing biodiversity. Numerous scientists demonstrate the complexity and particular 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 constitute refuges for a number of plants and animals in the face of climate change, particularly during extreme events such as low water levels.

Small hydropower and the environment

Small hydropower plants do sometimes have an environmental impact which nonetheless can be strongly mitigated due to 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 is not a threat to ecological

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

Source: The Highland Council

SHP Nethermills, Ayr, Scotland
Source: iStock, Sporran

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, which the first works in a turbine mode and the second in a pump mode.

Source: IOZE hydro

status of the 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 Saureggenbach 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, it proves that operation of a properly designed powerplant and environment protection is compatible.

Over the last decades, owners of European hydropower plants have invested billions of Euros in upgrading existing plants with environmental mitigation measures, showing their commitment and support to the ecological requirements of the Water Framework Directive and demonstrating that small hydropower and environment go hand in hand. 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. Releasing water through the gates attracts migratory fish species such as salmon to pass the plant during their upstream and downstream migration. An example of these measures is the plant Anundsjö in Sweden[10].

These measures may be combined with by-pass mechanisms for fish and sediment such as natural fishways past the plant, fish ladders, as well as guaranteed minimum ecological flows. Owing 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 their trash rack systems clean rivers from all sorts of waste floating in the water. A small hydropower plant in Austria for example collects monthly between 7–10 kg of plastic waste. This means a minimum of 23 tons of monthly rubbish collections from Austrian rivers and streams when we take into account 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[10] 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 as the turbine is concealed in a shaft in the riverbed. These mitigation measures notwithstanding, this small hydropower plants produces electricity for 900 people in its vincinity.

[10] 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.

SHP Kronawettwehr, Austria
Source: Kleinwasserkraft Österreich

The innovative strength leadership of the European small hydropower industry

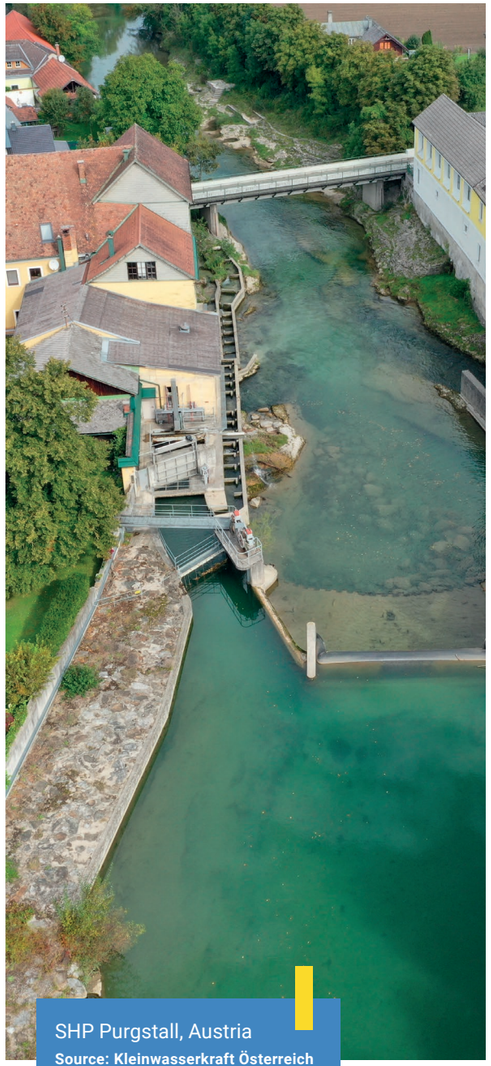
The European small hydropower industry is regarded as world leader, able to build tailor-made hydropower facilities all around the world. European hydropower equipment manufacturing competence accounts for an estimated two-thirds of the world market. European hydropower industry offers the complete range of solutions and services to harness the potential of hydropower in a sustainable way, in almost any conditions. Most importantly, European equipment distinguishes itself with outstanding efficiency and complies with even the strictest environmental laws 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 make business contacts.

Apart from the leadership in manufacturing, many leading universities and research centres specialising in hydropower are located in Europe. They include professional testing facilities for devices ranging in size from miniature, research models to full scale production turbines, tested in order to optimize flexibility, operational conditions, and costs of the devices, as well as to improve R&D capacities of these facilities themselves. The EU project Hydropower Europe just published a Research and Innovation Agenda and a Strategic Industry Roadmap for the European hydropower sector.

The small hydropower sector includes more than 4,500 enterprises (mainly SMEs) with more than 60,000 employed professionals that generates an annual turn-over of around 3 billion €. Small Hydropower development contributes to creating local jobs and activities, especially in rural zones. Small hydropower is an increasingly inherent part of combined local renewable energy-based energy and flexibility systems often paired with community power since hydropower is the oldest community power enabler in Europe.

To establish an entente-cordiale between environmental and sustainable energy objectives for the decarbonisation of Europe we need to:

- start regarding small hydropower as a substantial component of the EU and national renewable energy mix;
- establish a European target for an additional small hydropower capacity of 40 GW until 2050;
- ensure economic viability of and long-term investment conditions for the European small hydropower sector;
- develop fair support mechanisms for the multipurpose features and energy system services of hydropower;
- continue research funding to ensure that European equipment producers maintain their world leadership on 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 Purgstall, Austria
Source: Kleinwasserkraft Österreich

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 EERAJoint 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 unites 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 groundbreaking hydropower plant is intended to raise populational awareness of the possible harmonious interplay between nature and technology.

Source: Helgeland Kraft Vannkraft AS

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