FIThydro Market Conditions Brief

Scoping the market for fish-friendly hydropower technologies: recent developments, future expectations

What are the current market conditions for innovative fish-friendly hydropower technologies and what can be expected in the near future?

KEY MESSAGES

- Hydropower currently produces 36% of EU's renewable electricity. The European Green Deal, which supports economic development and decarbonisation, ensures that **hydropower will remain a relevant source in the energy mix**.
- However, **increasing social concern about hydropower's negative environmental impacts** on free-flowing rivers, river ecosystems and natural fish populations is translating into social resistance, shortened hydropower concessions, and other legal restrictions.
- Researchers and developers are making **progress on innovative solutions, methods, tools and devices to reduce the negative impacts of hydropower on fish**.
- Green finance and historically low interest rates create **favourable conditions for hydropower investment in Europe**, especially in new technology uptake and environmentally friendly upgrades to existing plants.
- The current political conditions combined with increasing social awareness and demands create a favourable landscape for the uptake of **innovative fish-friendly technologies** – but these **will have to be validated, easy to use, affordable and scalable**.

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This FIThydro Brief examines the future demand for fish-friendly hydropower in Europe by examining the impact of EU-level and national policy changes, international economic developments and rising social and environmental concerns.

Introduction

Hydropower's future in Europe appears promising as long as the sector continues to innovate to protect freshwater biodiversity, aquatic habitats and the communities that depend on them. New applied research on fish-friendly hydropower technologies is yielding practical outputs and advances at a time when European Union (EU) policy is initiating a transition towards climate-friendly energy sources. At the national level, legislative changes are setting the stage for more sustainable hydropower operations. Moreover, as the effects of climate change on everyday life become tangible and access to information becomes more widespread, awareness and engagement of civil society on environmental issues is on the rise. The combination of these developments could present opportunities for the uptake of innovative hydropower solutions. To successfully exploit them, developers will have to effectively demonstrate the cost-effectiveness and readiness of novel technologies as well as communicate their benefits for society and the environment.

Amidst high economic uncertainty, green growth is set to keep hydropower strong

The demand for fish-friendly hydropower innovations is inextricably linked to the evolution of the energy sector, which is closely linked to the state of the overall economy. The European Commission's EU Reference Scenario (De Vita et al., 2016) describes possible developments of the energy industry and economy until 2050. It forecasts slowing growth in EU energy prices and a slight decrease in current levels of energy consumption due to improvements in energy efficiency. While it predicts that renewables will meet a growing share of energy demand, hydropower's share will remain at its current 11-12% of Europe's energy production until 2050.

However, this projection was made in 2016, before the EU Commission, Parliament, and Council committed to increasing their renewable energy provision target to 32% by 2030 (European Commission, 2018a); and to achieving a climate neutral Europe by 2050, which aims for fully decarbonised power generation by 2050 and 80% of power generation coming from renewable sources (European Commission, 2018b).

1. Diversion-weir of the hydropower plant Aue, Switzerland
2. Bajina Bašta hydropower plant, Serbia

The effects that these subsequent commitments may have on hydropower's share in total energy production are highly uncertain. At the same time, the COVID-19 crisis has shown, the economic situation can quickly and dramatically change. Indeed, in some countries COVID-19 related quarantining and economic shutdowns led to energy price and demand decreases of 20% (IHA, 2020). While COVID-19 has interrupted deals and slowed reneweable energy expansion in 2020, the EU's economic and policy settings suggest that as soon as the economy recovers, hydropower investment will recover alongside (McCrone et al, 2020).

Favourable investment conditions are there for sustainable power generation

It has never been cheaper to borrow money in Europe, which means it has never been cheaper to make long-term investments, such as those associated with hydropower refurbishment. Setting interest rates at or below zero, the European Central Bank's extensive quantitative easing programme is keeping borrowing costs low. In addition, the European Commission has earmarked significant planned investment to achieve its climate neutral 2050 goals - over €10 billion in low-carbon technologies through its Innovation Fund for climate action, including support for innovative renewable energy generation and energy storage (European Commission, 2019a). Hydropower will also be underpinned by the EU's development of the Sustainable Finance Taxonomy. The Taxonomy aims to funnel investment finance to sustainable activities by setting standards that define which economic activities are in line with the EU's Net Zero 2050 target (EU Technical Expert Group on Sustainable Finance, 2020). Currently, it categorises any power generation that produces less than 100g CO2-e/kWH of lifecycle emissions as sustainable. This threshold will decline towards zero in line with the net zero path to 2050. The average global hydropower plant produces 18.1g CO2-e/kWh over its lifetime, which indicates a high likelihood that investment in the sector would be classified as sustainable and thus be eligible for green finance schemes (IHA, 2018).

Greening and growing Sweden's hydropower sector

Recent developments in the Swedish hydropower market illustrate increased commitment to environmental protection – and the challenges and opportunities this creates. In 2017, hydropower represented more than 40% of Sweden's total energy production (Swedish Energy Agency, 2019). The vast majority of Sweden's hydropower plants were built prior to modern environmental legislation, which resulted in 90% of the country's plants being granted unlimited legal concessions to operate. It also meant that there were few fish passes and that the statutory minimum water flow requirements were often insufficient to ensure good environmental status (Lindstöm and Ruud, 2017). Following criticism from the EU Commission and local stakeholders, the Swedish government has engaged industry and stakeholders to redesign Swedish hydropower legislation since 2012. The result has been that all existing hydropower licenses will be reviewed over the next 20 years. Unlimited concessions will no longer be granted, with a maximum new concessions of 40 years. Additionally, a greater focus will be placed on environmental goals, including minimum environmental flows and the installation of fish passes (Swedish Agency for Marine and Water Management, 2019). This will generate demand for fish-friendly hydropower solutions. These developments have not limited growth - between 2019 and 2023, Sweden will add 800 GWh through efficiency upgrades – equivalent to 5% of its current capacity (IHA, 2020).

While hydropower is a renewable energy, the significant impacts hydropower plants can have on river ecosystems have also frequently resulted in resistance and even conflict (Moran et al., 2018). Thus, future investments are likely to be aimed at addressing ecological issues.

Hydropower's ambiguous environmental record raises concerns

By altering or blocking water flow, hydropower plants can hinder fish migration, destroy habitats and obstruct sediment movement, affecting biodiversity, water quality and water quantity in inland, transitional and coastal water bodies. Wolter et al. (2018) considered 148 native European fish and lamprey species and found that 47 of them were sensitive or very sensitive to hydropower plants. However, there are significant knowledge gaps about target species and suitable mitigation measures. To improve evidence-based policy-making, there must be standardisation of data generation and reporting (Smialek et al., 2019). Hydropower plants also affect habitats, some of which are part of valuable protected areas: of the more than 21,000 existing hydropower plants in Europe, 3,936 are found in protected areas – with an additional nearly 2,500 hydropower plants planned or under construction in protected areas (WWF, 2019).

Concerns over these environmental impacts pose the most significant limit to hydropower growth in Europe and are visible in EU policy. The Water Framework Directive (WFD) is the overarching water management directive in the EU. As part of its aim to achieve "good status" in European waters, it sets provisions for restoring river continuity and habitats. While the WFD has been in place since 2000, there are concerns that implementation is lagging and must accelerate. For example, the recently released EU Biodiversity Strategy to 2030 identified the need to restore natural river function by improving water flow and the passage of migrating fish, specifically aiming to restore at least 25,000km of European rivers to free-flowing state by 2030 (European Commission, 2020). This builds on previous reports, including the 5th report on progress in implementation of the WFD Programme of Measures (European Commission, 2019c), which highlighted the need for certain Member States to implement measures for reviewing hydropower permits in order to ensure achievement of WFD objectives. Finally, the European Environment Agency report on the status and pressures of European waters (EEA, 2018) noted the importance of ensuring compatibility between EU policies aiming to increase renewable energy targets and WFD objectives. Heeding these calls could drive increased demand for development, demonstration and uptake of fish-friendly hydropower technologies.

In addition to environmental concerns, hydropower's expansion is limited by the dynamics of competing water uses – including agriculture, industrial operations, domestic water use, and alternative energy generation (e.g. nuclear). Fluctuations in water availability and shifts in seasonal

3. Hydropower plant Altusried, Germany

variations driven by climate change will further challenge the balancing of these competing uses. Europe's Alpine region offers a stark example. There, water supply relies largely on alpine precipitation and glacier volume, both of which are predicted to decline under climate change (Stucchi et al., 2019). This will increase competition for available water resources between agriculture, energy, and other sectors.

Addressing the complex challenges described above in combination will require the adoption of systemic approaches whose practical operation will be strongly reliant on integrated technologies (modelling, remote sensing, real-time monitoring and control, etc.).

Restoring Alpine habitats to protect fish populations

Low-tech solutions can also help make hydropower plants more fish-friendly. At six test sites across the Alpine regions of Germany, Austria and Switzerland, FIThydro scientists have investigated how restoring habitats and building nature-like fish passes can support fish migration and maintain local fish spawning grounds, when combined with other measures. In addition to modelling and innovative scientific testing, these test sites demonstrate that relatively simple interventions – such as replenishing gravel in fish passes – can improve the ecological condition of degraded and highly modified rivers and thereby the availability of habitats for various fish species at different life stages. For information about the costs of these measures collected with FIThydro, see Venus et al. (forthcoming).

A wavering social license for hydropower expansion?

The challenges mentioned have long triggered public concern about the potential environmental and resource impacts of hydropower, especially those related to new hydropower developments in previously unexploited rivers. Riverwatch (2019) reported a wave of protests across the Balkans in response to new hydropower development in the region. This included demonstrations in Greece, as well as Albania, Serbia, Montenegro, amongst others, where local stakeholders resisted the development of new hydropower sites in valuable environmental areas. The resistance has had impact: in 2019, Montenegro halted small hydropower concessions and Bosnia-Herzegovina backtracked on a 93 MW project (IHA, 2020). Similar concerns are present in other European countries, as explored in the box below on Spain and Portugal. Compounded, these local developments can shift the policy agenda at the European level: the non-profit organization, World Wide Fund For Nature (WWF), calls for a full ban on hydropower development in protected areas and to deny or reconsider the construction of hydropower plants in Europe's last remaining free-flowing rivers (WWF et al, 2019). This builds on increased public interest in protecting the environment, with 94% of EU citizens in 2017 reporting that this is important to them personally, and 36% selecting pollution of rivers, lakes and ground water as an important issue (European Commission et al., 2017). While the construction of new plants is controversial, FIThydro researchers found that the modernisation of existing ones is less disupted. Surveys in Portugal, Germany and Sweden found that communities near existing plants supported their modernisation, particularly for ecological restoration (Venus et al., 2020).

Social pressure related to new hydropower plants demonstrates that the sector will have to take decisive action to curtail its worst potential impacts. Hydropower projects create gains for some and losses for others. Gains are often unevenly distributed, with large investors and operators benefiting and only small numbers of jobs to benefit local communities. Losses, on the other hand, are often localised at the site due to displacement of communities or flooding of valuable cultural sites. Internationally and historically, indigenous communities have in particular borne

localised costs (Moran et al., 2018). Thus, in addition to biodiversity concerns, hydropower must minimise and compensate for the potential social impacts of hydropower projects.

More stringent legal requirements to mitigate negative hydropower impacts are expected

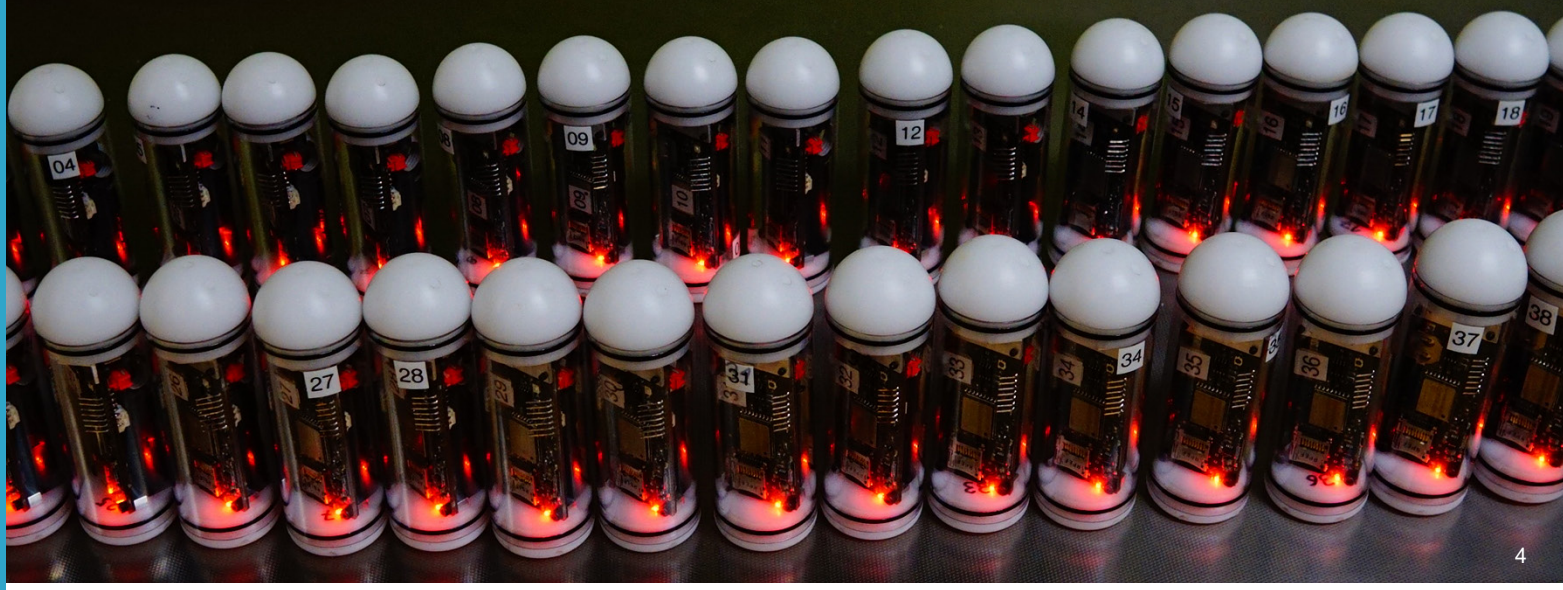
Social and political concerns have already translated into legal requirements to mitigate environmental impacts, especially related to upstream fish migration and river water flow conditions. These requirements are already increasing demand for fish-friendly technologies, and additional mitigation requirements are expected to be introduced as research advances on other impacts such as disrupted downstream migration and sediment transport or hydropeaking (Kampa et al., 2018).

Environmental restrictions are often established when hydropower concessions (i.e. the right to operate) are given or renewed. In part due to stricter environmental regulation, governments are decreasing the length of concessions for new or renewing hydropower plants. In Germany, for example, new concessions are for 30 years, in comparison to older plants, many of which have "ancient rights" and indefinite terms (Kampa et al., 2018). Spain, Portugal and France also reflect this difference in concession length between new and existing hydropower plants, though these will align as old concessions expire and old plants have to meet modern environmental requirements in line with the WFD (Kampa et al., 2018).

To support hydropower operators to decrease their environmental impact, many countries have strategic planning instruments to guide future hydropower development. Some of these include river restoration or continuity considerations, supported by national financing to help hydropower plants achieve environmental aims (Kampa et al., 2018). Generally, this financing supports the modernisation of existing plants through direct funding, feed-in tariffs, or green power labels. Some countries, such as Portugal, offer no incentives to hydropower plants to meet ecological criteria. Even in countries where national financing support is available, funding is still considered a bottleneck limiting environmental mitigation (Kampa et al., 2018).

Hydropower expansion in the Iberian Peninsula – Environmental concerns

Spain was the fifth most expansionary country for hydropower in 2019 (IHA, 2019), while Portugal is one of the last countries in Western Europe planning construction of new large dams (WWF, 2019). However, there is ongoing concern about the potential environmental impact of these hydropower dams on local fish populations. An Iberia-focussed FIThydro stakeholder workshop in 2018 featured scientists, hydropower operators and regulators, and other stakeholders, who discussed environmental challenges of hydropower in the Iberian peninsula, and potential solutions (Kampa & Tarpey, 2019). While fish passes were seen as crucial to enable up- and downstream fish migration, stakeholders identified a lack of Iberia- specific research as a challenge, in particular related to minimising invasive alien species and small hydro plants. Participants also discussed techniques for managing hydropeaking and ensuring sufficient water flow to meet environmental goals, as well as cost-effectiveness. The workshop participants were predominantly researchers, hydropower consultants, operators, authorities and an NGO (Kampa & Tarpey, 2019).



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Carefully oriented technological innovations can enable low-impact hydropower

Industry and academia are collaborating to develop fish-friendly innovations and identify ways to adapt, retrofit and design hydropower stations with reduced negative impacts, cost-efficiently. The outputs of this collaboration include technological developments such as fish-friendly turbines, waterproof autonomous sensing arrays, fish screening and guiding devices, and fish behavioural barriers. The maturity level of the different solutions at the frontier of the technological development varies, but significant investment from both public and private entities, combined with forecasted growth of hydropower at the global level, lay out a promising landscape for the further demonstration and uptake of new and innovative technologies. For example, since 2016, the FIThydro project has investigated the hazards that hydropower places on Europe's aquatic biodiversity, enabling wide stakeholder involvement and more informed decision-making in four hydropower-rich regions in Europe, and demonstrating and developing a set of solutions, methods, tools and devices to make fish-friendly hydropower operational. Similarly, the AMBER project, also running since 2016, has aimed at producing guidance for more efficient restoration of local river ecosystems through an adaptive management approach that addresses the impacts caused by river fragmentation. Another example is the Hydropower Europe project, launched in early 2019, which offers a forum for Europe's hydropower community and establishes a research and innovation agenda as well as a technology roadmap to support the hydropower sector (IHA, 2019).

Advancing scientific understanding of the impacts of turbine passage

During migration periods, fish traveling downstream and passing through turbines and other hydropower structures can suffer injuries and death. To assess the impacts of turbine passage and define where turbine operation might have to be adapted, scientists have developed a Barotrauma Detection System (BDS). In tests conducted at four hydropower sites in Belgium, Switzerland and Spain, multiple BDS units (pic. 4) were passed through hydro turbines to gather data on the rapid changes in pressure that endangered eels and other migrating fish experience as they cross these structures. The research is enabling safer turbine operation to increase fish survival.

Creating conditions for widespread uptake of fish-friendly hydropower solutions

Given the favourable economic conditions and growing regulatory requirements for fish-friendly solutions, as well as increasing scientific research on the topic, what is needed to enable widespread uptake? In 2020, a FIThydro workshop explored exactly this question with hydropower stakeholders, European policymakers, and technical

4. The innovative Barotrauma Detection System sensors measure the pressure fish experience during turbine passage

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experts. The collaborative approach identified the following key issues:

- Tools have to be easy-to-use and scalable - collaborative approaches between researchers and industry can help
- To enable widespread uptake, fish-friendly solutions must be cost-efficient, as well as effective.
- Fish-friendly solutions, methods, tools and devices need to align with regulatory requirements – here, standardised methodological approaches and validation are necessary
- Industry representatives identified a need for technical and financial support to support uptake, especially for small hydropower plants.

Overall, the workshop concluded that the key to widespread uptake of fish-friendly technologies is ongoing, Europe-wide exchange and communication between the different stakeholders – scientists, authorities and policy makers, operators. By working together, these groups can develop more practical solutions, lift industry knowledge and capacity, and identify new opportunities for making hydropower more environmentally friendly and socially acceptable.

Conclusions

The EU's commitment to carbon neutrality, the resource efficiency provisions of the European Green Deal, and the new framework for investment under the European Sustainable Finance Taxonomy set the scene for ongoing hydropower generation and moderate growth. Nevertheless, the hydropower sector will have to address the persistent environmental and social concerns through concrete action if it is to continue to operate and exploit future opportunities. Fortunately, European scientists and engineers are already developing fish-friendly solutions to improve hydropower's green credentials. Ongoing, collaborative approaches to develop and implement fish-friendly technologies will enable the sector to take advantage of favourable economic opportunities and increasing social pressure to make hydropower more environmentally friendly and socially acceptable.

In the midst of the COVID-19 pandemic, as governments around the world seek to reboot their economies through investment, many are calling for a green recovery. That is, investment that reorients our economies to a Net Zero Carbon future, whilst also efficiently creating jobs and economic growth. Experts have identified that clean physical infrastructure investment – such as fish-friendly hydropower – can deliver on those green growth goals (Hepburn et al., 2020). This is even truer for environmentally friendly expansions or retrofitting of existing hydropower plants to protect biodiversity. These will deliver renewable power, jobs, and investment whilst protecting Europe's rivers and biodiversity – and protecting hydropower's social license to operate.

5. The northern pike is a freshwater fish common in the Northern Hemisphere

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6. Fish pass at the hydropower plant Edling, Austria