FACTSHEET

GIVING A DAM: HOW HYDROPOWER IS DESTROYING EUROPE'S RIVERS


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THE UNKELMÜHLE SMALL HYDROPOWER PLANT

GERMANY

The Unkelmühle hydropower plant is located on the German Sieg River, a 153-km-long tributary joining the Rhine near the city of Bonn. The Sieg is one of the best rivers for salmon reintroduction in Germany. The Unkelmühle hydropower plant is located 44 km upstream from the Rhine and thus represents a bottleneck for salmon to arrive at potential spawning sites in the upper Sieg section. The Unkelmühle plant is a run-of-river [1] type of hydropower station built in 1921, with an upstream lake-like reservoir. The plant has a 0.42 MW peak capacity and produces 1,500 MWh per year.

AN EXTENSIVE REFURBISHMENT PROGRAMME TO IMPROVE FISH PROTECTION, FINANCED WITH STATE SUBSIDIES

Unkelmühle is now considered one of the "best-practice" micro-hydropower plants in Germany from the perspective of fish protection. Since 2011, it has been extensively refurbished to optimise fish passage, with a focus on safe downstream migration. A number of fishways and bypasses have been built, enabling fish to either swim or be flushed downstream instead of passing through the turbines, including two fishways designed specifically for eels. A narrow (only 10 mm spacing) and sloped metal grid was also installed at the turbine intakes, to prevent fish from entering the turbines and to guide them to one of the bypass routes. The former weir was also reconstructed into a rough ramp, and ecological flow was increased in order to enable also upstream migration. The refurbishment of the Unkelmühle hydropower plant was carried out as a joint project by RWE electricity supplier and the state of North Rhine-Westphalia. **The total cost of those refurbishment measures was €5.5 million.**

THE ATLANTIC SALMON IN THE RHINE RIVER AND SIEG TRIBUTARY

- The River Rhine was once home to several hundreds of thousands of Atlantic salmon reproducing in the river system.
- Being a so-called anadromou species, juvenile salmon grown up in rivers need to migrate (as so called smolts) downstream to the ocean for further growth. Mature salmon will then swim up the same rivers where they have have born in order to reproduce there.
- Populations of Atlantic salmon in the Rhine started to decline during the late 19th century due to hydropower plant construction in the Upper Rhine and massive water pollution in tributaries. At the end of the 1950s, the Rhine salmon became extinct.
- Atlantic salmon have been reintroduced into several tributaries of the Rhine, including the Sieg. In the Sieg, salmon reproduce naturally, but a self-sustaining population is not yet re-established.
- Re-establishing the Rhine salmon is still hindered by hundreds of barriers impeding upstream and downstream migration, especially hydropower plants, and by the lack of spawning and juvenile fish habitat.
- The Unkelmühle hydropower plant on the Sieg River represents a best-practice case study from which important lessons can be learnt from for salmon reintroduction in the whole Rhine river basin.

LARGE INVESTMENTS, LIMITED BENEFITS

Fish mortality remains significant

The refurbishment was followed by an intensive monitoring phase and scientific evaluations [2, 3]. The fish migration monitoring programme performed for three years after the refurbishment showed that the mortality of young salmon (smolts) and silver eels during downstream migration through the hydropower plant could be reduced by several optimisations to a few percent (for salmon 3–4%).

However, it was found that additional significant mortality of smolts occurred as they tried to swim past the 2 kilometre impoundment upstream, probably due to predation by stocked predatory fish as pike or sander and by birds such as herons or cormorants. In total, the additional mortality due to the hydroelectric power plant installations was estimated to amount at least at 25.1% for a year with low discharge conditions [2], but which could be only 7.2% in a year when downstream migration of smolts coincided with high water levels [2, 3]. Those figures are minimum estimates, because injured fish can survive the monitored stretches, but may die later.

Those results obtained from radio-tagged salmon smolts provide reliable estimates on mortality associated with a best-practice hydropower plant. Formerly mortality rates of fish were only published for the passage of standard turbines, which varied very much due to different local conditions.

However, this mortality occurred despite the power station being refurbished with a number of different fishways and narrow-spaced racks in front of the turbine intakes. Knowing that Germany has about 7,700 hydropower plants means that migratory fish usually have to pass several hydropower plants, or even many. **Assuming a site-specific mortality of 25.1% (at low flow conditions), this means that after swimming through of eight best-practice hydropower plants 90% of salmon smolts will have been killed.**

In addition, it is quite unlikely that the 7,700 hydropower plants will be upgraded in terms of fish passability in near future, as so far only two dozen have undergone an upgrade like the Unkelmühle. **Hence, re-establishing Rhine salmon (and similarly conserving eels) will be impossible with a hydropower related mortality at the level of the Unkelmühle**.

Overriding public interest seems largely absent

The Unkelmühle hydropower plant receives feed-in tariffs based on Germany's renewable energy law (EEG) and is in the EEG register. Amounts of aid received by Unkelmühle are not made public, but according to our own estimates, the annual feed-in tariff is probably around 225,000 euros/year.

According to the current EU State Aid guidelines, this aid should be in line with article 4 (7) of the Water Framework Directive and therefore should not contribute to a deterioration of the ecological status of a water body. Deteriorating the ecological status of a river by using its hydropower is only acceptable if the hydropower

plant is of "overriding public interest". **However, the little production of small hydropower plants like Unkelmühle (1,500 MWh per year) makes overriding public interest very difficult to justify.** By comparison, one average onshore wind turbine with a capacity of 2.5–3 MW can produce more than 6,000 MWh in a year – enough to supply 1,500 average EU households with electricity.

Upgrading the fish passability of small hydropower plants seems to be sub-optimal by an additional reason: if one divides the investment costs (say €5 million) by the electricity production of the Unkelmühle hydropower plant within say 10 years, this results in a price increase per kWh of electricity of €0.33. This means that upgrading fish passages at a hydropower plant to best technical standard has made the plant economically unviable.

HYDROPOWER DEVELOPMENT IN GERMANY

Germany is one of the largest producers of hydropower in Europe. However, most of its hydropower plants are small, and only contribute marginally to this production while causing significant damages to freshwater ecosystems.

- **Germany has around 7,700 hydropower plants.**
- **7,300 of those hydropower plants have a peak capacity of under 1 MW.**
- **Together, those 7,300 very small hydropower plants contribute only <0.5% to total German electricity production.**

STATE AID TO HYDROPOWER IN GERMANY

According to the 2014 German Renewable Energy Law, hydropower plants built before 2009 can only get state aid (additional payments per kWh) if they were repowered after 31 July 2014. Hydropower plants constructed after this date are generally eligible for state aid. Support rates are set according to the plant's installed capacity. Plants >5 MW only get additional state aid for the electrical power generated due to repowering, in contrast to plants <5 MW that get it for the full production. Thus large plants often do not get this state aid, but nearly all small ones do.

Plants that are repowered must take the necessary measures to comply with the Water Framework Directive objectives. However, this supposedly only happens in very few cases. From the hydropower plants in Germany that started to receive state aid between August 2014 and January 2019 due to repowering, it is likely that 53% are not passable for fish, 6% are insufficiently passable, 20% are restrictedly passable and 20% are freely passable.

Sources: Keuneke 2019, Wasserkraft im EEG – Aktueller Stand, Wasserkraft & Energie, 2019; German Federal Grid Agency, EEG system master data.

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CONCLUSIONS

Two lessons can be drawn from this case study. First, upgrading fish passages at a hydropower plant to best technical standard like in Unkelmühle for 5 Mio €, is still insufficiently protecting fish (in the respective reservoir), while making small hydropower plants uneconomic.

Second, the reference to the Water Framework Directive in the current EU State Aid Guidelines for Environmental Protection and Energy (EEAG) is not sufficiently implemented to ensure that hydropower installations do not induce deterioration of the ecological status.

Although the refurbishment programme was motivated by the wish to reduce the ecological impact of the Unkelmühle hydropower plant and therefore to improve compliance with the Water Framework Directive, the results have proven unsatisfactory. This costly refurbishment programme was not able to eliminate substantial impacts on migratory fish, but has prolonged the use of this almost one-century old hydropower plant, despite its quite negligible contribution to electricity generation.

In conclusion, the management option that would comply with both the Water Framework Directive and the EEAG, and at the same time would be a much better alternative for the affected freshwater ecosystem, would consist in the decommissioning of small hydropower plants. In the Rhine catchment area, decommissioning of hundreds of dams (with and without hydropower plants) would be an important leap forward for re-establishing a viable Rhine salmon population, and additionally support to the declining eel population.

Sources:

[1] These types of plants channel a portion of a river through a smaller canal and do not require the construction of a reservoir.

[2] Bezirksregierung Köln, Innogy SE, Ministerium für Umwelt, Landwirtschaft, Natur- und Verbraucherschutz Nordrhein-Westfalen, Abschlussbericht zum Projekt Fischschutz und Fischabstieg an der Pilotanlage Unkelmühle, 2019

[3] Havn, T. B., Thorstad, E. B., Teichert, M. A. K., et al. Hydropower-related mortality and behaviour of Atlantic salmon smolts in the River Sieg, a German tributary to the Rhine, 2017, Hydrobiologia, 805(1), 273–290.

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2014-2020 STATE AID GUIDELINES FOR ENVIRONMENTAL PROTECTION AND ENERGY (EEAG)

"(117) With regard to aid for the production of hydropower, its impact can be twofold: on the one hand, such aid has a positive impact in terms of low GHG emissions. On the other hand, it might also have a negative impact on water systems and biodiversity. Therefore, when granting aid for the production of hydropower, Member States must respect Directive 2000/60/EC and in particular Article 4(7) thereof, which lays down criteria in relation to allowing new modifications of bodies of water."

This case-study was drafted on the external science-based advice of PD Dr. Martin Pusch, Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB).

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