Cost-effective environmental mitigation measures i hydropower rivers

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Abstract

It is well known that hydropower may have a strong impact on the aquatic environment, and both new and existing hydropower need to mitigate negative environmental impacts. Hydrological as well as market and grid situations are changing, leading to a need for re-design of many hydropower facilities. Further, modern requirements to include environmental and social aspects of hydropower re-design, re-licensing and expansions will lead to new solutions. At the same time the environmental consequences need to be carefully evaluated and mitigated. Impacts on fish species receives much attention, and the EU-funded research project FIThydro (Grant Agreement number 727830, duration 2016-2020) is focusing on developing methods, tools and devices for solutions to improve conditions for fish and at the same time maintaining the hydropower production. This paper describes methods to find cost-effective mitigation measures to inform decision support for improving fish conditions in hydropower rivers.

In order to achieve cost-effective mitigation of negative impacts on the fish fauna in hydropwer rivers, it is important to identify the bottlenecks for improving conditions for fish. This can be done by finding a diagnosis for the fish population. Several tools and methods are developed to assess the river regulation and its fish species with classification systems for characterisation of the ecological state of river reaches and identification of the main bottlenecks to give the diagnosis. Mitigation measures are grouped into the following categories:

I. Flow measures (environmental flows, downstream flows, freshets, minimum flows)
II. Habitat measures (constructed habitat, installations in the river corridor)
III. Sediment management (to support habitats)
IV. Measures for downstream fish migration (including turbine passage)
V. Measures for upstream fish migration (fishways and more nature-based solutions)

For each type of mitigation measures, different solutions are described. A range of different methods, tools and devices can be used to plan, implement and monitor mitigation measures. FIThydro will establish a web-based service or a Wiki with a catalogue of mitigation measures including information about relevant methods, tools and devices to use.

Having a suite of different mitigation measures to choose from, we have developed tools to evaluate the most cost-effective mitigation measure aiming at improving conditions for fish without reducing hydropower production significantly. This includes estimations of costs for implementing the measure and potential lost or gained income from power production if the measure includes changes in the operation of the hydropower plant. We will use Bayesian belief networks to assess and find the most cost-effective option for mitigation.

The aim of optimizing hydropower as well as fish production with the most cost-effective combination of mitigation measures and environmental flows will also be demonstrated in several examples.

FIThydro is also developing a Decision Support System (DSS). The proposed DSS framework is aimed at regulators and operators and orientated around a single, risk-based, planning structure for both new and existing hydropower

schemes. The DSS will be linked to the internet-based solution for mitigation measures, and it will guide the user directly towards finding the most cost-effective mitigation measure.

The Authors CVs:

Atle Harby is a senior research scientist at SINTEF Energy Research in Norway. He has more than 20 years of experience in research and environmental engineering with emphasis on environmental impacts of river regulations, water resources problems, climate change impacts and energy storage technologies. His main interest is in environmental conditions in regulated rivers, aquatic ecosystem modelling, stream habitat modelling, hydropeaking impacts and hydrological analyses. Since 2009, he is the Director of the research centre CEDREN (Centre for Environmental Design of Renewable Energy), an interdisciplinary research centre for the technical and environmental development of hydropower, wind power, transmission lines and the implementation of environmental and energy policy.

Ana Adeva-Bustos graduated in Environmental Science from the University of Alcala de Henares with a Master in Ecosystem Restorations by University of Alcalá, Compluentese, Rey Juan Carlos and Politécnica de Madrid. She has recently completed her PhD in environmental design in regulated rivers at NTNU. She has recently joined the Water Resources team at SINTEF Energy in Trondheim as a Researcher.

Bendik Torp Hansen graduated with a B.Sc. in Environmental Science from the State University of New York (SUNY) Plattsburgh in 2015. He studied a M.Sc. in Hydropower Development at the Norwegian University of Science and Technology (NTNU), and he started working with water resources at SINTEF Energy Research in 2018. He has experience with modelling of hydrology and water resources, and he is currently working on a range of projects covering sediments, hydro-morphology, and flood reduction.

Richard A.A. Noble graduated in Aquatic Biology the University of Hull, UK, and was awarded his PhD in Fisheries Science studying the ecology of fish communities in wetlands and their management for the conservation of the bittern (*Botaurus stellaris*). After his PhD he has worked as a Research Associate for the University of Hull International Fisheries Institute on a variety of national and international projects related to fisheries and environmental science and management. He has specialised in the development of ecological assessment methods for aquatic environments using fish, assessment and management of conservation species, river restoration, the hydro-ecology of fish communities and the impact of hydropower facilities on migratory fishes. He is currently contributing to the EU-funded FIThydro project, developing tools to assess the cumulative impacts of hydropower schemes on fish populations and a decision support system to improve decision making in hydropower planning and mitigation. He is a Chartered Environmentalist and Fellow of the Institute of Fisheries Management.

Terese Rutkowski is a PhD candidate in the department of Production and Resource Economics at the Technical University of Munich. Her research focuses on the socio-economic and political dimension of ecological hydropower production, particularly in the Alpine region.