
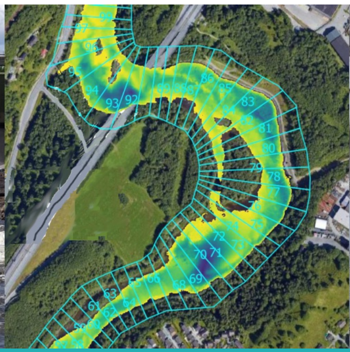

Increased flexibility of hydropower: Social acceptance and Mitigation of Environmental impact

A HydroFlex policy brief

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A new role for hydropower

Hydropower is increasingly used as provider of flexibility to enable the deployment of more intermittent renewable energy sources in the European energy system. One aspect of this change is larger, more frequent, and rapid changes in discharge. The HydroFlex project has investigated environmental and societal impacts of these changes and identified mitigation measures. This policy brief summarizes the results and some guidelines from the project. In addition, it draws on previous research on mitigation of environmental impact from the research centre CEDREN.

Key questions

What are the environmental effects of increased flexibility?
What are the societal concerns related to increased flexibility?
How can practitioners and policymakers mitigate environmental impacts and address societal concerns?

Who is this for?

Power companies, power plant developers, TSOs, regulators, environmental agencies, politicians, and governments all have impact on development of operating requirements and restrictions for existing and new hydropower plants. Familiarity with research and best practices can improve knowledge-based management of hydropower resources.

Mitigating environmental impacts

Effects of more frequent and rapid changes in discharge on the environment will be increased risk of dewatering of juveniles and eggs, increased risk of stress for older individuals. Short reductions in spillway discharges may in some locations aid upstream migrating fish to find the bypass channel. There are three types of relevant mitigation measures

- Operational measures,
- Physical changes in the river (habitat improvements)
- Technical changes on the power plant

Measures that prevent stranding of juveniles and dewatering of spawning areas are particularly important. Release of more water adapted to specific periods (spawning period) or habitat measures such as making spawning and rearing habitat in safe locations can reduce stranding and consequently mortality risks. Often a combination of the three categories of mitigation measures will be the best solution, both for the ecosystem and for the power producer.

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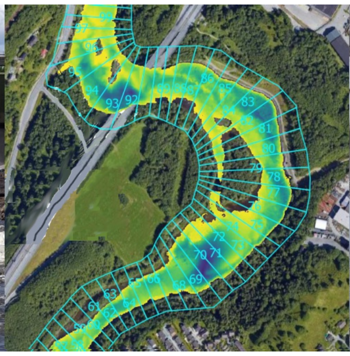

Social acceptance

The HydroFlex project investigated the community acceptance dimension of social acceptance based on interviews with citizens living close to the hydropower plant and river. Reasons for support and resistance towards increased flexibility were assessed through discussions of scenarios for increased flexibility with and without the ACUR mitigation technology. Informants were generally positive towards hydropower and increasingly flexible operation schemes as enabler of the deployment of intermittent renewable energy and, thus, as contribution to the mitigation of climate change. Environmental impacts of hydropeaking were of major concern to the citizens living close to the river. Further, they mentioned a range of practical concerns connected to their specific uses of the river, such as safety concerns related to ice crossing as well as erosion and landslides, access to facilities for recreational purposes and difficulties for boating and kayaking activities. Power plant operators should also be aware of the importance of public participation and dialog in decision-making prior to shifting to a highly flexible operation scheme.

Social acceptance

To address societal concerns, we recommend:

- Recognition and inclusion of the diversity and concerns of all stakeholders
- Early and continuous involvement of all stakeholders about the operation scheme of the power plant, mitigation, and compensation measures
- Establish a communication arena between all stakeholders and the power company
- Identify a person from the power plant operators as responsible for public contact and outreach
- Stronger focus on information to the public
- Use of media to explain reasons for more flexible operations and information about public safety (e.g. water level changes)
- Actively engage with local organizations to make powerplants, riverbanks and viewpoints attractive tourism and recreation sites
- Follow existing environmental recommendations and standards
- Actively compensate the local community (e.g., infrastructure with local value, not necessarily money)

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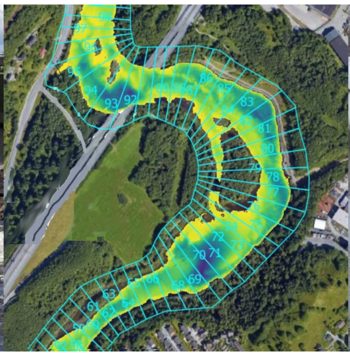


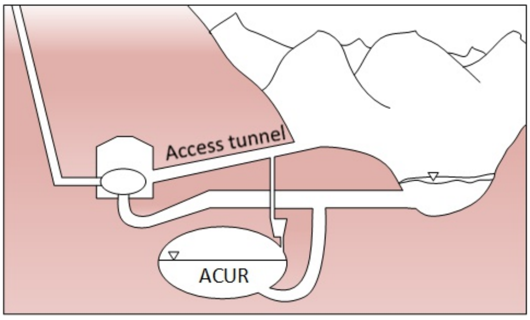
Table 1:. Overview of physical measures to mitigate unwanted environmental effects from hydropower production. Some measures may have unwanted side effects. These are indicated by a minus signs in parentheses after the description. The table is adapted from the Handbook of hydropeaking (Norw.) (Bakken, Forseth & Harby 2016).

Physical measure	Effect
Weirs	Reduced · stranding of juvenile fish and invertebrates · fluctuation of water levels, stress, and mortality for fish/invertebrates · conncetivity, such as access to spawning areas (÷) · May lead to increased sedimentation and modification of habitat. Should be thoroughly evaluated (÷)
Increased use of side channels	· Increased access to spawning and rearing areas with more stable water flow · Reduces stranding and stress / behavior-related effects by ensuring continuous water flow. Requires access to land areas if old side channels are no longer in use
Modification of the river bed; smoother and steeper sides: to reduce stranding hazard	· Reduced stranding of eggs and fish by avoiding dewatering and / or avoiding trapping fish in pools · Creates a more homogeneous habitat (may be negative for benthic invertebrates) (÷) during reductions in water flow
Habitat improvement measures (hides, rocks, streamers) for juvenile fish on permanently water-covered areas	· Reduces stranding by offering optimal habitat in safe locations · Compensates for increased fish mortality by improving habitat conditions and fish production
Restoration or construction of safe spawning areas	· Reduces egg mortality · Increases fish production on river stretches with limited spawning opportunities
Remove spawning gravel from areas often dewatered	· Reduces egg mortality by limiting spawning opportunities in stranded areas

The ACUR mitigation technology

The Air Cushion Underground Reservoir (ACUR) is a new technology to reduce negative impact on aquafauna in hydro power plants with high ramping rates. The concept is based on an underground cavern downstream of the power plant. A compressor and expander control the air pressure and volume of water in the cavern.

ACUR smooths out the flow variation downstream of the power plant under normal hydro peaking and emergency shut down. When the output of the turbine increases, part of the increased discharged is fed into the cavern. When output reduces, the reduction in discharge is compensated by releasing water from the cavern. The highest benefit of an ACUR installation will be in high head, reservoir power plants. This type of plant has the highest potential for flexible operation. For low head plants and run of river plants, the volume needed in ACUR is large, and the installation becomes very big and expensive.



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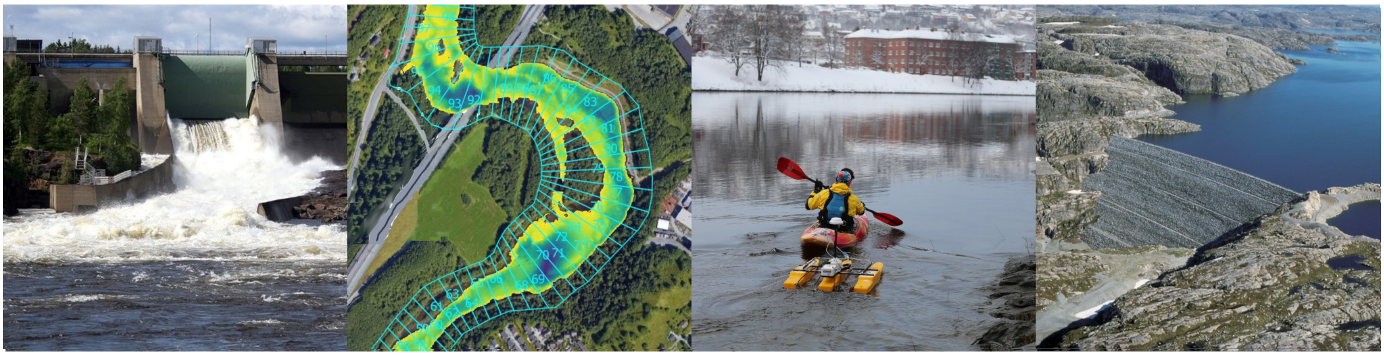

Table 2. Overview of operational and technical measures to mitigate negative environmental effects by flexible power production and description of operation. It is emphasized that the measure to achieve the desired environmental impact may have disadvantages or costs for power plant operation. The operational measures is adapted from the Handbook of hydropeaking (Norw.) (Bakken, Forseth & Harby 2016), while technical measures is produced within the Hydroflex-project.

Operational measures	Effect
Avoid power production at certain periods of the day and year	· Gradual reduction in release of water from the hydropower station · Will reduce ice break-up during winter
Increase the lowest water flow or reduce maximum water flow	· Will reduce size of variation in discharge/water level and reduce areas at risk of stranding · Will impact hydropower producers and reduce opportunities to produce power when prices are optimal
Reduce power production gradually over time	· Waterflow out of the hydropower station can be reduced gradually to reduce risk of stranding for fish and benthic invertebrates · Slower start-up of the hydropower station can reduce the risk of unwanted drift of benthic invertebrate and juvenile fish, rapid changes in water temperature, as well as ice breaks and ice floods.
Optimize number of starts and stops with respect to the environment with the use of hydraulic modelling	· For certain conditions and sections of the down-stream river it can be of advantage to increase the start & stop frequency. This is due to the natural damping of the river.
Technological measures (technical changes on the power plant)	**Effect**
Install ACUR technology	· Increased possibility to decouple production of electricity from environmental flows · Operational measures can be applied to a larger extent Many start-stop of turbine possible without major impacts on the environment

HydroFlex

www.h2020hydroflex.eu

References

Andersen, Oddgeir & Sara Heidenreich, 2022. Deliverable 5.6 Assessment of social acceptance of 30 starts/stops in Ume River. HYDROFLEX report Deliverable 5.6 – HydroFlex (h2020hydroflex.eu)

Forseth, Torbjørn. & Atle Harby, (red.). 2013. Håndbok for miljødesign i regulerte laksevassdrag. - NINA Temahefte 52. 1-90 s.

Sundt-Hansen, Line-E. Richard Hedger, Anton Burman, Kjell Leonardsson, Gunnar Hellström, Anders Andersson, Staffan Lundström 2021. Assessment of environmental impacts of flexible operations in Ume River.

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