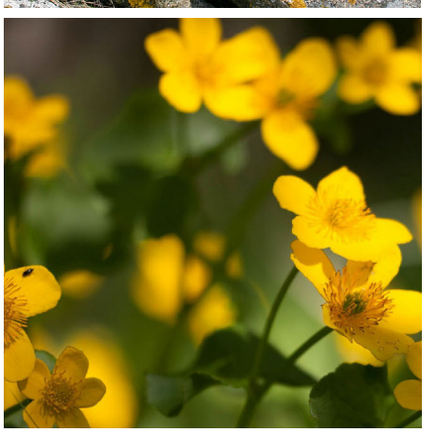
POWER AND AQUATIC LIFE

KLIV



Energiforsk

BACKGROUND

Almost half of the electricity we use in Sweden comes from hydropower. Hydropower is a renewable energy source with low emissions and a minimal impact on climate. Hydropower provides an efficient resource with the capacity for continuous regulation between the production and the consumtion of electricity. However, the expansion of hydropower does have an effect on, for example, boglands, periodically flooded areas, migratory fish and other aquatic organisms, and all of these factors need to be taken into consideration. Regulating water flows across reservoirs and watercourses (rivers, streams etc.) has an affect on the plants and wildlife in those areas.

Some of the current environmental challenges faced by electricity production include complying with the EU Water Framework Directive, the Renewable Energy Directive, meeting climate targets, meeting national environmental goals and increasing the proportion of electricity generated by wind power. These challenges are best addressed by adopting a system perspective, which involves a variety of areas such as hydrology, biology, ecology, hydropower engineering and economics. Many of these challenges can be aided by knowledge generated by research and development. The successful application of newly generated knowledge requires commitment from researchers, initiators and even the eventual benefitting parties.

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Power and Aquatic Life in our Waters

Increasing electricity production while at the same time sustaining life in Swedish waters is the vision of this research program. The program's purpose has been to facilitate and encourage hydroelectric companies and authorities to cooperate in developing the knowledge and methods needed to come closer to this vision. The program has included three development projects.

The three development projects are named: FRAM-KLIV, PRIO-KLIV and EKOLIV. Final reports were submitted in September 2017. The results of the research were presented at a seminar in the autumn of 2017. Education programs based on the research results were organised in September and October, 2017.

The program was paid for by the Swedish Agency for Marine and Water Management, the Swedish Energy Agency, as well as by a number of hydropower companies. The KLIV program group, which has followed the programs activities, was also represented by the Swedish Agency for Marine and Water Management. Energiforsk has been instrumental in the Power and Aquatic Life program.

Photo: Jakob Bergengren

Thick shelled river mussels (Unio crassus), occur in large numbers in the Emån river, downstream from Kvillsfors, Vetlanda.

Photo: Peter Johansson

Lillån, an artificial tributary built for the Emån river at Kvillsfors, Vetlanda. Initial digging for the Turefors circulation, began in June 2015.

Photo: Roland Jansson

Environmental improvements in regulated rivers – prioritisation of restoration measures taken

- The project has developed a method of quantifying the costs and benefits of environmental measures taken in rivers with hydropower. The methodology is important for determining which measures should receive the highest priority and which are the most important to change and adjust.
- By collecting data on conservation, technical conditions and the effects of regulation, environmental measures with the highest potential can be identified. Data collection requires a systematic method and is partly done out in the field to ensure that data is of highest quality and that different areas can be compared easily.
- The costs and benefits of environmental measures need to be calculated across the entire watercourse because hydropower facilities create effects both up- and downstream. Evaluation of various measures which affect the production of hydropower, including regulating and controlling power, must take into account the daily, seasonal and annual variations in rivers.
- By identifying which watercourses and ecosystems have disappeared or are being affected by hydropower, a basis can be developed for which measures should be prioritised. In order to make comparisons between the different measures, we propose determining the total surface area of aquatic habitats that any individual measure is expected to generate.

Report: Identification of impact, need for action and action potential in rivers affected by hydropower
Energy Research Institute report in 2017: 429
Report: Evidence-based measures to restore natural environments in regulated watercourses; What's in the toolbox?
Swedish Energy Research Centre Report 2017: 430 and Ecological Regulation (documentation)
Acronym: PRIO-KLIV
Project manager: Roland Jansson, Umeå University

The project has developed a process for prioritising various environmental measures in water courses affected by hydropower. Key goals are for the measures to be efficient as well as practical to handle, to be accepted by all parties involved, and to lead to a consensus on what actions are most effective in improving the environment.

Hydropower was built at a time when the environmental impacts were not fully understood. Environmental improvements may need to be made in order to meet the requirements expressed in, for example, the EU Water Framework Directive. However, since hydropower is Sweden's main source of renewable energy, it's in society's interest that environmental measures are implemented with as little impact on electricity generation as possible, while at the same time maximising environmental improvements.

PRIO-KLIV consists of several work processes, one of which includes possible environmental measures that have been identified in a systematic way, and describe the scientific evidence so that each different measure can succeed as intended. Estimating and prioritising the environmental cost and benefits associated with each measure is an important process. The project shows how to calculate environmental costs and benefits of, for example, reducing hydropower generation across an entire watercourse. As mentioned prioritisation should be given to the watercourse as a whole. It's also important to understand how different environmental measures affect each other. One of the programmes conclusion's is that combining several environmental measures offers a greater cost/benefit than than when applied separately. The study includes a description of methods in the former Umeälv project and the expected outcomes.

In the project group are Birgitta Malm Renöfält and Åsa Widén, Umeå University, Erik Degerman, Sweden's Agricultural University, Örebro and Dag Wisaeus, ÅF.

Photo: Tore Söderqvist

User-friendly tool for evaluating environmental measures

- A tool for making assessments on the socio-economic profitability of environmental measures has been developed. Assessments are made using a cost-benefit analysis.
- The tool consists of a program designed in Excel and user support (help texts and help models). The tool also analyses how costs and benefits are distributed among different actors, as well as analysing how different actors are negatively affected.
- A cost-benefit analysis has clear theoretical and ethical starting points, which minimises the risk of double counting and facilitates a better interpretation of the results.
- The results of a cost-benefit analyses assists decision makers in prioritising environmental measures based on their degree of socio-economic profitability. These results can be included as part of a broader decision making process developed using multi-criteria data.
- The tool facilitates the uniformity and transparency of the cost-benefit analyses. This allows for comparisons between analyses performed by different actors.
- For some environmental impacts, there is a relatively high value in using cost-benefit analyses, for example, in estimating the value of improved salmon stocks. For others, often site-specific, natural and/or cultural environmental impacts, there is a need for supplementary valuation studies.

Report: Socio-economic profitability assessment of environmental measures in watercourses
Energy Research Report 2017: 428
Acronym: FRAM-KLIV
Project leader: Tore Söderqvist, Anthesis Enveco AB

FRAM-KLIV aims to develop a user-friendly tool for the socio-economic profitability assessment of hydropower-related environmental measures using a cost-benefit analysis. The goal is to create a tool that can be anchored to stakeholders. The tool should also be theoretical and empirically relevant, as well as capable of dealing with inevitable uncertainty.

The project has clarified which questions a cost-benefit analysis tool can tackle and which questions should be answered by a supplementary analysis, in particular, a multi-criteria analysis.

Jesper Stage, Luleå University of Technology, Per-Olov Johansson, Stockholm School of Economics, Bengt Kriström and Kjell Leonardsson, both at the Swedish University of Agricultural Sciences, Umeå have also participated in the project.

The work has been linked to a user group. A cost-benefit analysis is a way of evaluating the economic viability of various environmental measures, where the cost/benefit of measures are weighed together in, for example, reduced energy production. This provides an important basis for prioritising between the various measures.

Photo: Peter Johansson

Ecological and economic strategies

- *Holistic working methodology across a entire watercourse perspective*
  Environmental measures in regulated water should be planned using the perspective of the entire watercourse. Dams in watercourses have extensive and often unexpected effects on the entire watercourse. The holistic approach includes not only the drainage area but is also concerned with users and other aspects such as structures, processes, fauna and flora as a whole.

- *Gap Analysis and critical habitats*
  As part of a holistic way of working, a Gap Analysis should be established. Which habitats, processes and species were once prominent in an area and but are greatly impaired today? The Gap Analysis should primarily take place across the entire watercourse and should take into account not only the watercourse itself, but also the condition of endangered species.
  A classification that takes place at national level. Focus should be given to endangered species that require stability in shoreline and watercourse environments.

- *Identify and chart natural values and initially invest in so called core values*
  As part of a holistic analysis, an inventory of all available information about life and living systems, as well as the natural value of the landscape, should be gathered prior to hydro-power expansion. It is important to invest in major restoration projects because they enable better prospects of success. It's additionally important because many species require a large geographical area in order to maintain viable populations. At the overall level, it's important to identify areas that have retained their natural state, the so called core "natural value".

- *Stability building measures yield the best results in watercourses with fish that migrate long distances*
  Research into environmental measures is relevant in general, but especially relevant for migratory fish. Results show that environmental measures deliver the strongest results in watercourses with migratory fish, where nursery habitats remain intact and undisturbed. Environmental measures taken in relation to salmon were often adequate, particularly with the construction of migration routes. A reasonable explanation is that salmon migrate long distances and are strong swimmers, which means that within their natural range there are fewer migratory routes where the fish are disturbed. Earlier studies found that watercourse habitats with that are undisturbed up and downstream, were a scare resource. In this study we have seen that shorelines are critical environments because disturbances in these areas reinforce the negative effects of other impacts.

- *Better follow-up of restoration projects is required*
  Focus is often too narrowly aimed at only one target species, and occurs within too short time periods, as well as limited geographical areas. Studies are often concentrated on a single habitat and a single organism group. This leads to a poor understanding of species interactions and wider biological processes that affect results. Research projects working in cooperation, including hydrology, biology and cost effectiveness, are important for ongoing future-optimised and evidence-based environmental sustainability.

Report: Ecological and economic strategies for optimising environmental measures related to hydropower
Swedish Energy Research Centre Report 2017:450
Acronym: EKOLIV
Project leader: Leonard Sandin, Swedish University of Agricultural Sciences

The project analysed the ecological and socioeconomic aspects of hydropower environmental measures that have already been implemented. The project has been founded on an entire ecosystem perspective. In short, EKOLIV aims to summarise current knowledge, evaluate measures implemented and disseminate the results of these evaluations to the relevant parties.

EKOLIV has focused on activity around environmental measures that have already been implemented in the form of biotope care, local environmentally adapted rivers and continuity improvements. The project mainly deals with the removal of dams, natural and artificial migratory routes, dry river beds, natural spawning ground improvement, biotope restoration (including introducing decomposing wood) and measures for migratory channels.

The evaluations are based on relevant scientific studies, analyses of relevant data linked to implemented actions, and data from the national database on environmental improvement measures in water.

In addition to the project manager, the project has been conducted by:
Erik Degerman, Ing-Marie Gren, Peter Carlson, Serena Donadi, Stina Draker, Emma Göthe, Richard K. Johnson, Maria Kahlert, Brendan McKie, Joel Segersten, Wondmagek Tafes Tirkaso, Cristina Trigal, Eddie von Wachenfeld, Sveriges lantbruksuniversitet, Jakob Bergengren and David Spjut, County Administrative Board of Jönköping County.

Synthesis in Power and Aquatic Life

The purpose of the synthesis study is to investigate what future steps and measures should be taken for continued sustainable environmental improvement surrounding hydropower.

The synthesis study is being conducted by Sweco and was finalised at the end of September 2017. The study developed some preliminary conclusions, briefly summarised below.

Contextual analysis

Contextual analysis reveals a number of intensive ongoing projects on issues related to the areas covered by KLIV, both nationally and internationally. There are many parallel inquiries in Sweden, and any conclusions drawn today could well be invalid (fully or partially) shortly after completion of any project and research. It's also apparent that this can affect decision making in the Land and Environment Court (and/or others). For example, hydropower-related judgments and associated conditions issued in 2015, have not resulted in significant investigations regarding hydropower regulations and the national energy agreement, presented in 2016/2017. This is inevitable but also highlights the importance of national coordination, especially between different authorities.

Calculating budget contributions

Currently calculating budget contributions for entire watercourses and adopting them to seasonal fluctuations (or even weekly fluctuations) is both desirable and possible. One issue is that although figures for previous regulatory contributions exist, it's difficult to know what level of regulation and financial contributions will be required in the future. This is in part because the energy system in Sweden is constantly changing. But additionally, because energy needs are dynamic and vary over time, it's difficult to accurately determine, within the overall regulatory capacity, how close hydropower is to those limits. Nor is it known at the present time how a national target or minimum requirement for hydroelectric regulating power could be defined.

Relevant environmental legislation

Relevant environmental legislation includes a call for action from several more directives than the Water Directive, such as the Species and Habitats Directive. Therefore, a national review is needed to clarify the link between the Water Directive's intentions and, for example, the Species and Habitats Directive, in the conservation plans covering limetone ecosystems.

Cost-benefit analysis tools

Within FRAM-KLIV, a cost-benefit analysis tool has been developed. Sweco welcomes these kinds of tools to properly quantify environmental benefits, and further recommends testing the tool in pilot projects involving a number of watercourses with varying conditions. In this context, Nordic cooperation is desirable in order to better understand wider conditions than those of Sweden alone.

Fish Migration

Fish migration is an area where resources have been reduced,

Photo: Leonard Sandin

both in terms of scientific research and practical measures. There are certainly still shortcomings in knowledge surrounding upstream migration for a number of species, but knowledge about downstream migration, especially in larger watercourses , might be applicable. Therefore a major need exists for increased research on downstream areas, where factors such as the width of the waterway, flotsam and ice problems, can create completely different conditions for fish compared to smaller watercourses.

Environmentally-Friendly Watercourses

Environmentally friendly watercourses (ecological rivers) could be a way to improve the status of regulated water systems, as changes occurring in regulated water can affect aquatic organisms and reduce the frequency of suitable habitats. The likelihood is that it's not applicable to use catchall measures in relation to large scale hydroelectric power, plus it's also difficult to make generalisations about smaller watercourses. Knowledge about the long-term effects of regulation also appears to be limited, suggesting the need for further research on the overall effects on regulated watercourses. Studies should also address the improvement of distribution channels and environmentally adapted river management, as well as taking a more holistic approach and assessing the entire watercourse's drainage area.

Methodology

Methods for evaluating environmental measures and incorporating historical data should be developed. It's clear from reports in both EKOLIV and PRIO-KLIV that current methods for evaluating outcomes are insufficient. Additionally, it's not obvious how to rectify this, i.e. what targets should apply in any particular measure. One of the common reasons is that ongoing conditions are more or less unknown, and there are already pre-existing concepts concerning habitat for soils and aquatic organisms. One proposal for future development is to not focus primarily on individual species but instead to develop additional ways of monitoring hydro-morphology and other processes.

Climate change

Climate change is expected to cause changing conditions for regulation and energy generation, as well as changing the material conditions for biodiversity in lakes and rivers. This is a research area that requires extensive effort, not least because climate-driven processes are characterised by a high degree of complexity with difficult-to-predict consequences.

Project leader: Anna Rönnlund, Sweco Energyguide. In the project, Peter Rivinoja, Andreas Aronsson, Tove Nordling and Emma Hagner.
Project time: May - September 2017

Communicating and circulating the findings is a goal in itself

The Power and Aquatic Life research program provides training courses on environmental issues within hydroelectric power designed for companies and authorities. Below are some examples of the training courses.

Training: Simultation of environmental measures

EnergiForsk runs a training course that simulates environmental measures, and has a modelling tool that illustrates the connection between environmental measures and fish stocks.

The tool makes it possible to show how any particular measure can affect fish migration including a timescale on how any measures effect on fish stocks. The original tool was developed and taken from Krafttag ål and has now been further developed within the Hydro-power Environmental Program.

The course is part of the educational package held within the research program Power and Life in our Waters (KLIV). The program is funded by hydropower companies, the Swedish Agency for Marine and Water Management and the Swedish Energy Agency. The KLIV program group, also includes the Swedish Water Authorities.

Kjell Leonardsson, Senior Lecturer at the Swedish Agricultural University, SLU at the Department of Wildlife, Spatial Affairs and Environment in Umeå, who developed the tool, will run the training course. During the day, Kjell will also go through examples that course participants can use as a learning device.

Training: Profitability assessment of environmental measures in hydropower

The course is based on the results of the FRAM-KLIV project. The agenda contains a general section on the basics of socio-economic profitability assessments using cost-benefit analysis (CBA). A tool including an Excel program for implementing CBA on environmental measures has been developed, plus the course covers how the CBA tool can be applied to concrete cases.

Training: Prioritising hydropower related environmental measures

The goal is to develop cost-effective measures that maximise environmental benefits, while minimising the impact on energy production. Working with a cost benefit analysis in a river basin perspective provides a basis for calculating total profits and costs, which provides a useful tool for prioritising what actions should be taken. The course is given as a combination of lectures and work to be done alone with exercises related to the theories.

Photo: Wikimedia

Read more about the courses at www.energiforsk.se/konferenser/

POWER AND AQUATIC LIFE

Power and Aquatic Life is a scientific collaboration between hydropower companies and Swedish government agencies. New findings and new knowledge acquired through the program will provide guidance for managing current environmental and energy challenges, include complying with the EU Water Framework Directive, the Renewable Energy Directive, meeting climate targets, meeting national environmental goals and increasing the proportion of energy generated by wind power. Here, we outline the program's project for developing environmental improvements in watercourses (rivers, streams etc.), as well as the tools available for evaluating environmental measures and strategies for optimising environmental measures within hydropower.

KLIV

– a programme about power and aquatic life

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