SCIENTIFIC RESEARCH FOR DEFINING THE SUSTAINABLE USE OF HYDROPOWER

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Summary

The concept of green hydropower needs an evaluation procedure for the ecological upgrading of hydropower plants based on scientific criteria [1]. For the planning and evaluation of river-restoration programs, concepts like “ecosystem integrity” or “river health” have been proposed and empirically tested. Computer programs have been developed, which allow the testing of alternative restoration concepts and a quantification of hydrological regimes for minimal flow requirements. Such generalized approaches are needed to focus a multidisciplinary effort to quantify the detrimental ecological effects of hydropower use on a local level and to determine promising upgrading pathways. In this paper we discuss the experience of a large-scale pilot study of a hydropower plant in the Southern Alps. The study was designed as a test site for the evaluation procedure for green hydropower. It should allow at the same time to gain scientific insight into the network of ecosystem processes affected by hydropower use. Three main conclusions can be drawn from the experiences so far:

1) Scientific ecosystem studies and evaluation procedures for hydropower plants are characterized by very different time horizons. It is a complex challenge to ensure solid scientific activities on annual cycles in river ecosystems in a transdisciplinary project together with partners from the hydropower industry, where mergers and acquisitions change to economic landscape within weeks.

2) As a consequence, the development of an evaluation procedure for hydropower plants has to be based on incomplete scientific knowledge, which is confronted with a complex set of political and economical boundary conditions of the hydropower industry, regulators and NGO’s. Although the recent scientific literature on stream assessment demands input from social sciences, only limited experience for a real stakeholder involvement in structured decision processes has been published in this field so far.

3) Green hydropower certification belongs to a growing class of activies in water management, which can be described as large-scale experiments. This metaphor can help to deal with the dilemmas of “just in time production” of scientific solutions based on incomplete knowledge.

Evaluating the ecological performance of hydropower plants

An expert panel lead by a full time scientific collaborator was responsible in the project to elaborate a first draft for an ecological evaluation procedure. The group based its work on published concepts for the classification and evaluation of rivers, with an emphasis on integrated approaches [2,3]. The conceptual framework for the procedure proposes a stepwise approach [4]:

- A rapid assessment on a catchment – scale provides an overview of the affected river system with the relevant technical data of the hydropower plant. This assessment estimates the rough costs for a green certification of the power plant and identifies river sections with high restoration potential.

- A set of basic criteria ensures compliance of a certified power plant with the latest ecological regulations. However, the procedure avoids the complex legal struggles of a formal renewal of the license.
- Green power investments provide additional flexibility for locally optimized solutions. The decision on alternative upgrading paths is based on a round table process involving the different stakeholders.
- The formal licensing can follow established procedures of quality management systems (ISO).

The detailed procedures have to bee both simple enough to encourage interested hydropower plants and detailed enough to allow ecological upgrading in a regional context. Due to the complexity of aquatic systems, such a procedure demands more information on the local ecosystem (down to the level of different organisms) than life cycle analyses, which are designed primarily for comparative purposes.

Two different modeling approaches are used in order to integrate the different ecological effects of hydropower generation, such as hydrology, sediment transport, temperature, biogeochemical processes, ecosystem structure and functioning. AQUASIM – a general-purpose modeling tool for aquatic systems [5,6] was used to simulate and predict the effects of different minimal flow regimes on water temperature and other physical and chemical parameters. CASIMIR (Computer Aided Simulation Model for Instream flow Requirements in diverted streams, [7,8]) was implemented for alpine rivers. This simulation tool predicts changes in habitat quality for aquatic organisms and can be used to optimize flow requirements when the habitat preferences of the relevant organisms are known.

Calibrating evaluation procedures

For a first calibration test of some of the evaluation procedures a large-scale field study was organized in the Valle Blenio – a river basin with a typical alpine hydropower plant. The Blenio hydropower system consists of a reservoir of 197 Mio m^3 and two power stations with an average annual production of 930 Mio kWh. The multidisciplinary study involved detailed physical, chemical and biological analyses with a special focus to provide basic information for modeling the effects of different minimal flow regimes. This case study has been enhanced with a cooperation with private consulting companies analyzing the conditions and prospects for the riparian vegetation in a large alluvial plain.

A first serious problem of two different time scales became evident during this case study: “Real” scientific analyses on ecosystem processes require at least two annual cycles. On the other hand a rough testing of evaluation procedures was needed already within one year.

A second line of conflicts evolved by confronting rough concepts of stream assessment with the complexities of a real case. This resulted in additional challenges for the communication process within the project. The need of “order of magnitude estimates” based on small data sets in a context of large scale hydropower production can only be justified if the whole process of green power licensing is understood as a social learning process.

Large scale experiments

Green hydropower certification belongs to a growing class of experiences in water management, which can be described as large-scale experiments. A typical example has recently been described by Tockner et al. [9] and the artificial flood in the Colorado River is probably the best-documented scientific experiment in this category [10]. The metaphor of an “ecosystem experiment” can help to deal with the dilemmas of “just in time production” of scientific solutions based on incomplete knowledge.

An experiment has to be planned with the highest possible standards of scholarship and know-how. Its outcome should be predicted with available software tools. Alternative experimental designs should be considered. However, an experiment is always a learning experience to generate an

improved knowledge base for further experiments. However, in contrast to “pure laboratory experiments”, the large-scale restoration experiments in water management are running in an intense dialog with NGO’s, regulators and business managers. It will be a central requirement for successful activities in river management to develop a structured approach of integrating the stakeholders from the beginning in the design of such experiments. We hope, that there is a new experimental science developing in this field…

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