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How are environmental measures realized in European hydropower?

A case study of Austria, Switzerland and Sweden

Berit Köhler & Audun Ruud

NTNU SINTEF NINA

HydroCen

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The research areas include:

Hydropower structures
Turbine and generators
Market and services
Environmental design

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AUTHOR/S
Berit Köhler
Audun Ruud

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Øystein Aas

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Abstract

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This report explores how environmental measures are realized in European hydropower production, how they are financed, and how trade-offs between hydropower production, environmental restoration and value creation are considered. How do other European countries deal with the challenges that the conflicting objectives of (increased) production of renewable energy on one hand, and of improving environmental conditions of the regulated watercourses on the other hand, pose? We are seeking more knowledge of how "greener" solutions are implemented in other European countries, and if such efforts can be a valid reference for Norwegian hydropower producers and exporters. In this study we map the current situation related to hydropower production, environmental status of the regulated water bodies and implemented measures, management practices, methods to assess trade-offs and funding mechanisms in three European countries that are amongst the larger producers of hydropower in Europe in terms of installed capacity - Austria, Switzerland and Sweden. We used desk-top document studies and conducted structured interviews in the respective countries during spring/summer 2018. As the report clearly shows, the challenge and need to balance the complex nexus of trade-offs between energy services and environmental objectives is quite similar in the analysed case countries. All three countries have made legal revisions and set new environmental goals. There exist now legal references enabling the enforcement to realize environmental mitigating measures, but the types of mitigation measures and their actual implementation varies. In all countries, efforts by single hydropower companies and NGOs were documented, with support of local, regional and national administrations, to implement environmental mitigation measures on a voluntary basis. Market-based, private funding solutions such as support schemes of the eco-labels Naturemade star (origin: Switzerland) and Bra Miljöval (origin: Sweden) play a role, but also EU public funding sources such as the EU LIFE-program contribute to such endeavours (e.g. in Austria). Private, voluntary schemes such as the Bra Miljöval and Naturemade Star eco-labels provide additional funding for environmental measures by addressing the environmentally conscious customers willing to pay an additional fee for "greener" hydropower. Such eco-labels appear to be win-win solutions for hydropower companies that are also concerned with reputation management as an integral part of a more diversified European energy market.

Berit Köhler, NINA Lillehammer, berit.kohler@nina.no
Audun Ruud, NINA Oslo, audun.ruud@nina.no

Content

Foreword

HydroCen has been established with an aim of doubling the value creation from the Norwegian hydropower sector within 2050. In such as context it is relevant to execute a project with a focus on "market opportunities for profitable environmental design solutions" which is the title of the research activities for WP 4.1 in HydroCen.

Currently, the European electricity market is undergoing significant changes – particularly due to the efforts of promoting increased shares of renewables in the energy consumption basket to combat climate change, but also to limit the loss of biodiversity. Interesting initiatives are taken in a number of European countries. Innovation is stimulated, and this can also be directly related to local environmental mitigating measures.

As a first deliverable in this HydroCen WP 4.1 on "market opportunities for profitable environmental design solutions", we focus more generally on the realization of concrete environmental measures outside Norway in order to document interesting initiatives, efforts and measures that might be of relevance for the Norwegian hydropower industry. We have studied these aspects in three European hydro-producing countries that could and would be of interest for Norwegian stakeholders in general and the Norwegian hydropower industry in particular.

The work has been conducted by NINA, the responsible scientific partner for this sub-project, but discussions and adjustments have been made in close dialogue with SINTEF Energi, the other research partner involved in work package 4.1.

12. Februar 2019,

Berit Köhler and Audun Ruud

1 Introduction

HydroCen WP 4.1. explores opportunities and barriers for realization of value creation resulting from environmental measures within watersheds affected by hydropower. While the concept of environmental design is well developed, and will be expanded within HydroCen, implementation, funding and execution of improvements remain a challenge.

This report summarizes the finding of the first part of HydroCen work package 4.1., i.e. sub-project 4.1.1. The aim was to study how environmental solutions are realized in European hydropower production and how trade-offs between sustainable production, other societal interests and value creation are considered. As part of this mapping, existing and relevant market-oriented certification and labelling systems have been identified and are documented. This mapping and exploration of other European cases conducted in task 4.1.1. has been discussed and agreed upon with the HydroCen Technical Committee. The results from this first sub-project will be an important basis for further activities for the remaining 4.1. project period, in close dialogue with the Technical Committee.

Norwegian hydropower producers intend to increase export of electricity to European markets in the future. Given this growing interest it is important to understand the preferences and dynamics of these markets, but also the reputation of hydropower in general and Norwegian hydropower in particular. In many countries this reputation is likely less positive than in Norway. Therefore, the "greening" of hydropower could be important and commercially beneficial. A better knowledge of drivers and barriers influencing implementation of environmental measures in Europe will enable Norway to meet a potentially more diversified marked where many customers are becoming more environmentally concerned.

It is possible to seek solutions that cover both economic, social and ecological needs and this could be done through less conflicts both nationally and locally. Such solutions, however, can be costly to realize, and new remedies and approaches should be found that easier can balance these different needs and requirements. There exists a potential conflict between renewable energy objectives as set by EU Directive on Renewable Energy Sources (RES) and environmental objectives as set by the EU Water Framework Directive (WFD) as well as other biodiversity guidelines (e.g. the EU Habitat Directive, which so far has not been approved by Norway), that pertain also to rivers impacted by hydropower production. This is further elaborated and discussed in this report.

The study draws on complementary projects such as CEDREN`s SusWater project and the European FIThydro project. In SusWater (www.cedren.no/Prosjekter/SusWater) studies have mainly focussed on Norway, but some international comparisons were made – particularly of Sweden which this report also draws on. A brief study of environmental measures in Austria's implementation of the EU Water Framework Directive is also reflected. Our mapping is coordinated with and expands data from the FIThydro-project (www.fithydro.eu/), specifically deliverable 5.1. "Review of policy requirements and financing instruments"[1]. While FIThydro has a focus on types of measures related to fish and fish migration, we attempt to cover all relevant types of environmental measures implemented. Besides, we aim at relating our focus to the extended environmental design concept to be developed in HydroCen 4.3. We apply a more bottom-up approach compared to the FIThydro methodology by choosing as our vantage point concrete measures that have been implemented or at least initiated. In comparison, the FIThydro focuses on "types of measures" as shown in figure 1:

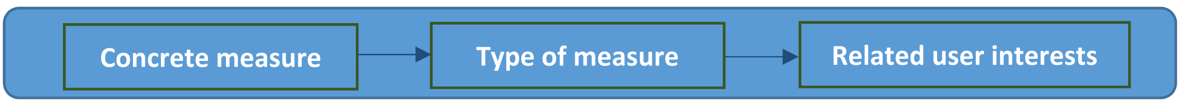


Figure 1. *Cascade of scales of measures.*

[1] (www.fithydro.eu/deliverables-2-2/)

The FIThydro report referred to above, operates on the “type of measure” level such as downstream and upstream migration, hydropeaking, gravel transport, or habitat enhancement. By approaching concrete measures rather than type of measures, we aim at documenting activities and efforts beyond those that are merely planned.

In our study, we focus on environmental measures for existing concessions (versus new concessions) and primarily for large hydropower (versus small hydropower). We have done so in order to contribute to the challenges of upcoming revisions of a large number of existing licences in Norway. We think that here lays most potential for knowledge transfer from the case study countries to the Norwegian context. Revision of licences is also central to other work of the HydroCen research center, specifically to work package 4.3 on the extension of the environmental design concept (Forseth & Harby 2013) and its application (e.g. Skår & Köhler 2018).

In our attempt to map the existing funding solutions for implementing environmental measures in the three case studies, we looked not only for public, but also private sources, such as eco-labels that reach beyond a guarantee of origin. These could provide a promising, additional financing solution for environmental measures in watercourses impacted by hydropower production. Thus, we have aimed to give a detailed description and assessment of these labels and certification arrangements. We think that this information can be especially beneficial for hydropower companies and exporters in Norway for developing and using new marketing and financing solutions for environmental measures in impacted watercourses.

2 Methodology

For the mapping of public and public-private governance schemes, management practices, trade-offs and funding mechanisms in Europe we chose a comparative case-study design (Bartlett & Vavrus 2017) and the countries Austria, Switzerland and Sweden as the primary cases. This choice of case studies was on one hand due to the fact that all of these countries have large shares of hydropower production, also in relation to their own energy production portfolios. Further, we considered it important to study countries with a spectrum of different statuses and requirements related to EU membership and EU directives, such as the EU Water Framework Directive (WFD) and the EU Directive on Renewable Energy Sources (RES). This could be beneficial for comparison with Norway as a country that is not an EU member, but still has adopted both the EU WFD and EU RES. Sweden is an interesting case, not just as a neighbouring country but also as a close electricity partner to Norway. For the cases of Sweden and to a limited degree also of Austria, we use earlier work from the CEDREN SusWater project (Lindström & Ruud 2017; Ruud & Lindström 2018) as points-of-departure. It was also advantageous for the cases of Austria and Switzerland that we were able to employ in-project team language competency to study documents and conduct interviews in the German language.

Our study included both a desktop study, a project-internal workshop and field interviews in the respective countries. In the desktop study, we collected all relevant reports, articles and aspects of interest and designed a first version of an interview guideline. We discussed this outline in a project-internal workshop with key personnel in order to specify it and to prepare the execution of the European mapping. In spring 2018 we analysed public documents, reports and relevant scientific publications that were accessible online in order to get an overview over the regulatory situation and policy schemes in the relevant European countries. This helped us to refine our interview guideline and prepare us for the field work visits to the three counties in early summer 2018 (Austria and Switzerland: Berit Köhler; Sweden: Audun Ruud) where we conducted structured interviews with relevant stakeholders and resource persons from public administration (both national and regional), hydropower industry, research, industry organisations, environmental organisations and communication fora (see interview guideline in the appendix). We conducted 8 interviews in Switzerland, 8 in Austria, and 7 in Sweden. Based on the interview data we examined remaining open questions by a following second desktop study phase and follow-up personal conversations by phone or by email with some of our interview partners.

Fish pass at Hüttener Wehr (EKZ) in the river Sihl, Canton Zürich/Switzerland. Photo: André Springer.

3 Austria

Hydropower plays a major part in Austria`s electricity production. With an installed hydropower capacity of 14,130 MW and 38,54 TWh hydropower generation, approximately 56 % of the country`s annual electricity supply comes from hydropower (IHA 2018). Austria has rich water resources due to its alpine topography, high precipitation and numerous rivers and a long history with hydropower production (IHA 2018). Hydraulic energy has been utilized for many centuries to power mills (Giesecke et al. 2009), and the first documented hydropower plants were already developed in the middle of the 19th century (Habersack et al. 2011).

Hydropower production, and the issue of how to possibly utilize Austria's remaining potential has been a source for public debate and political conflict since the 1980s (Pflüglmayer et.al 2008; WWF 2011). It is the EU RES Directive (RES) on the European level that defines binding targets in relation to the required share of renewable energy that each member state should achieve in its energy mix by specific dates (European Union 2009). According to this directive, Austria is bound to increase its renewable energy share from 23 % to 34 % by 2020 (Wagner et. al 2015). To accomplish these EU requirements, the Austrian government has formulated national energy targets in 2010 and amended the Federal Green Energy Act in 2012[2]. Hydropower and biomass resources make a substantial contribution to energy supply in Austria, whereas all other renewables still play a minor role (Stocker et al. 2011). The total national hydropower potential is estimated to be 56,1, TWh and the remaining economically and environmentally feasible potential 12.8 TWh (VEÖ 2008). The Austrian Electricity Strategy "Empowering Austria" (BMWFJ and BMLFUW 2010) and the Federal Green Energy Act (2012) state that besides other renewable sources, hydropower generation should be extended by 3,5 TWh until 2015 and 4-7 TWh until 2020, including the effects of rehabilitation measures, expansions and improvement in energy efficiency of existing installations.

As in the case of Scandinavia, Austria's electricity market is characterized by strong interconnection with the neighbouring countries – especially Germany, Switzerland, Czech Republic and Slovenia (Wagner 2015). The exchange of electricity across national boundaries is of significant importance for the national security of supply (BMWFJ 2011).

Both existing and new hydropower plants have potentially negative consequences for river ecology and morphology. According to the 2nd national River Basin Management Plan (RBMP), there exist 2882 hydropower plants in Austria – 2722 (ca. 94%) of them with a capacity < 10 MW (84% < 1MW), 56 (1,9%) with a capacity between 10-20 MW and 104 (3,6%) between 20 – 300 MW. However, the large hydropower plants entail 84% of all installed capacity and generate 79% of the yearly production (BMLFUW 2015). According to WWF Austria (2010), there exists a hydropower plant on average every eight kilometres on Austrian waterways. More than 62 new large powerplants are planned (see Fig. 2). Of the existing hydropower plants, 71% of Austria's hydropower plants are run-of-river plants, 18% are storage and 11% are pumped storage plants.

[2] The Federal Green Act was launched in 2002 as a measure to implement the EU Directive RES.

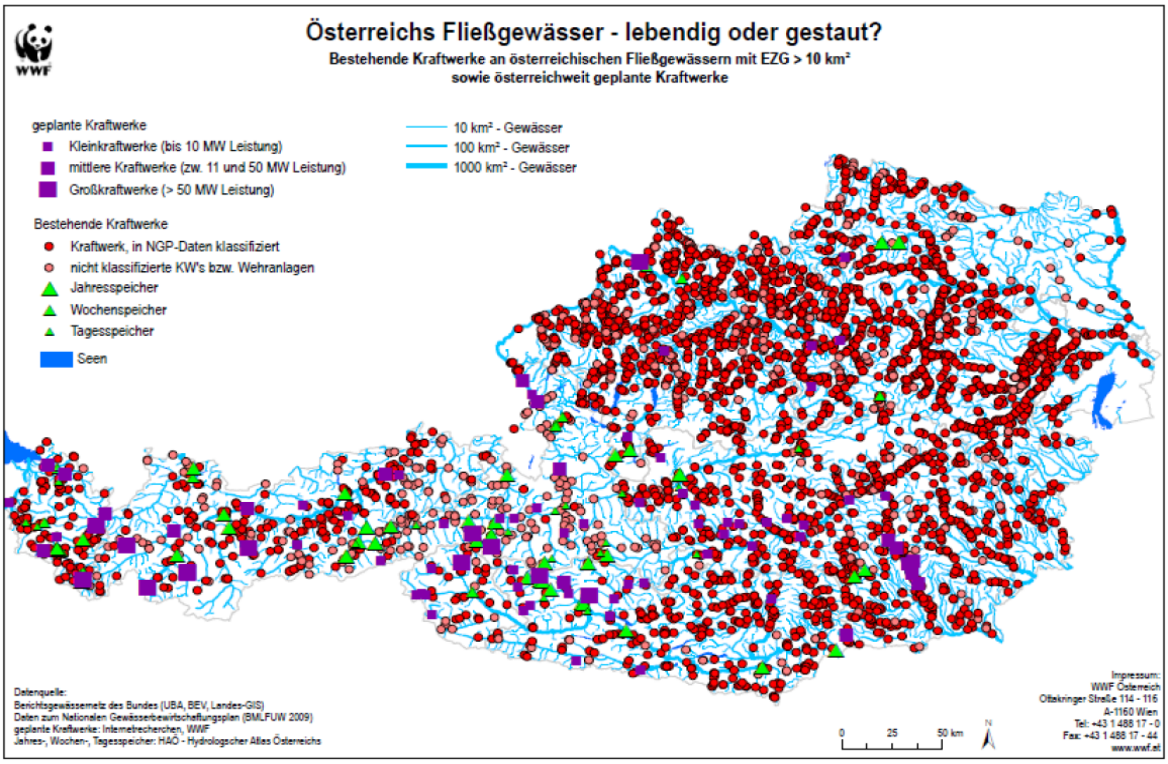


Figure 2. *Existing hydropower plants with catchment area > 10 km2 and planned hydropower plants in Austria. Source: WWF Austria (2010); original heading of the figure: "Austria`s watercourses – living or dammed?"*

Besides flood security measures the main reasons for poor ecological condition are related to hydropower, such as damming, hydropeaking and residual flow. Run-of-river plants entail a substantially modified condition of the water bodies related to modified bed-load discharge, discharge dynamics, sedimentation conditions and barriers to connectivity for fish and other water organisms. Mostly, also the floodplain habitats adjacent to the regulated watercourse are strongly modified. Of the ca. 30.099 transverse structures in Austrian water bodies that hinder migration of fish and other water organisms, ca. 11% (~ 3.310) are due to hydropower production (BMLFUW 2015; WWF 2010). Table 1 gives an overview over significant pressures on the number of water bodies differentiated by type of pressure.

Table 1. *Overview over significant impacts on number of water bodies in the catchment areas of Donau, Rhein, Elbe and the total of Austria`s watercourses differentiated by type of impact (impacts are at least partially due to hydropower production).*

Catchment area	**Water withdrawal – number of residual flow stretches without environmental flow**	**Number of stretches with significant hydropeaking**	**Number of impoundment stretches**	**Number of stretches with structural intervention**	**Number of localised transverse structures (not passable for fish)**
Donau	2.250	57	1.368	18.455	32.077
Rhein	85	8	13	505	1.098
Elbe	33		34	149	327
Total Austria	**2.368**	**75**	1.415	19.109	33.502

Of the overall 627 water bodies that are currently defined as "heavily modified water bodies" (HMWB), hydropower production is the pivotal use in 372 (59%) and flood protection in 244 (39%) of the objects. Related to the length of the respective water bodies ca. 2.605 km (79%) of total 3.317 km that are defined as HMWB are modified by means of hydropower utilization. Table 2 gives a more detailed overview over the types of uses that are decisive for the classification as HMWB.

***Table 2**. Summary of utilizations and related impacts that are decisive for classification of water bodies as HMWBs. Source: BMLFUW (2015).*

Cause for classification as HMWBs	Number	Number (%)	Length (km)	Length (%)
Hydropower - impoundment	111	18	1.295	39
Hydropower – residual flow	204	33	748	23
Hydropower - hydropeaking	57	9	563	17
Total Hydropower	**372**	**59**	**2.605**	**79**
Flood protection - morphology	206	33	606	18
Flood protection - barriers	38	6	70	2
Total - flood protection	**244**	**39**	**676**	**20**
Other	11	2	35	1
Total	**627**	**100**	**3.317**	**100**

Environmental mitigation measures in areas with existing hydropower plants have been demanded by environmental NGOs (WWF Austria 2011; Umweltdachverband 2007). However, their implementation has until now been less contested in the public, compared to the debate over realisation of the remaining, unrealised hydropower potential (pers. conv. Urbanek 2018), and many large hydropower projects have been postponed or even cancelled (Wagner 2015).

3.1 Environmental legislation

Similar to renewable energy development strategies, there are also strategies and legal frameworks active at EU and national levels regarding environmental and water quality targets and standards to be achieved. The major piece of legislation steering this for the member states of the European Union is the EU Water Framework Directive (WFD) and the associated mandatory national River Basin Management Plans (RBMP) that all member states are every six years obliged to formulate and implement (Abazaj et.al 2016). The 1st RBMPs, due in 2009, were to include so-called Programmes of Measures (PoMs), that is actions that are planned to implement in order to prevent deterioration of the aquatic environment and to achieve good status of all water bodies by 2015. These WFD PoMs should have been made operational and reported to the EU by December 2012.

In general, the legislative responsibility for water affairs lies in Austria at the national level. However, according to the Austrian constitution, the federal states are in charge of many water-related issues, including nature protection and spatial planning (Feichtinger & Pregernig 2016; BMLFUW 2009). The Federal Water Act (FWA) of 1959, is the central law regulating water management in Austria. It has its origins in 1869 and was last amended in 2018. Its main content are regulations concerning the utilization and protection of waters, protection of man against damaging effects of waters and the provisions for projects having a potential impact on watercourses. In 2003 the EU WFD was incorporated in the FWA. The 2010 federal ordinance on the quality objectives for ecological quality elements in rivers and lakes "Quality Objective Ordinance – Ecological Status of Surface Waters" is based on the concrete EU WFD objectives and complemented the first Austrian RBMP of 2009 (BMLFUW 2010). This ordinance contains legal requirements to ensure river continuity and to ensure ecological flow in case of water abstraction (Wagner et al. 2015). Related measures can be imposed all existing hydropower concessions. The related guiding values for ecological flow are set to ensure that the biological values defined for good ecological status are met with very high confidence (Ruud & Lindström 2018; pers. conv. BMNT).

In terms of mitigating impacts of hydropeaking, operators should carry out feasibility studies before 2021 that demonstrate the technical feasibility of mitigation measures at the specific site, ecological effectives, effectiveness of measure combinations, economic costs and other socio-economic impacts. These will form the basis to define good ecological potential by the water authorities. These measures would only be set by 2021, in close cooperation with the regional governments and the responsible ministry BMNT[3].

3.2 Reconciling efforts between the diverging interests of energy production and ecology

In Austria, as in the other studied countries, it is a key challenge to find the balance between increasing renewable energy production on one hand and safeguarding and enhancing the ecological quality of the watercourses on the other hand. The European Directives RES and WFD require a balance that needs to be assessed, negotiated and operationalised on the national level.

According to information from our interview partners, there has been established a long-standing network between responsible governmental agencies (especially the BMNT), research institutions and hydropower companies that created trust and a common understanding of the challenges. This network was to a large extend responsible for a widest possible implementation of environmental measures in Austrian rivers that are impacted by hydropower. Joint workshops series were conducted in order to develop e.g. the relevant guidelines and standards for connectivity and sediment transport. Current work relates to the issues of hydropeaking and dynamic residual flow requirements[4]. The hydropower sector has thus from early stages actively been involved in a continued dialogue process and knowledge generating activities, managed by the BMNT.

In terms of an expected loss in hydropower production through the implementation of the EU WFD, the 2nd Austrian RBMP works with the results of a scenario study by a working group of the Institute for electricity economics and energy innovation at the Technical University Graz (Stigler et al. 2005) and a study by the consultant company VEÖ (2008). As shown in table 3, it is assumed that production losses of small hydropower and run-of river plants (> 10MW) will occur from the year 2011 until 2027. They are expected to increase linearly in that period of time. The losses related to storage plants will eventuate only after 2021. It is further assumed that existing potential for the optimization of existing small and run-of-river power plants will be utilized. The loss in production of 1.489 TWh, as calculated by Stigler et al. (2005), will thereby be roughly compensated by the optimization potential of 1.400 GWh, according to the study by VEÖ (2008). Hereby, ca. one half of the optimization potential relates to small hydropower plants, and one half to large hydropower, of which three quarters relate to run-of-river plants (BMLFUW 2015; Baumann and Lang 2013).

[3] There was a change in ministerial structure as per January 8, 2018. The former Federal Ministry BMLFUW received the new name Federal Ministry for Sustainability and Tourism (BMNT). It joins now both the water and energy sectors (www.bmnt.gv.at/english/).

[4] Pers. conv. with expert at BMNT (June 2018).

Table 3. *Effects of implementing the EU WFD in Austria – foreseeable losses and optimization potential in the period from 2011-2027. Ssource BMLFUW (2015), Baumann and Lang (2013).*

Type power plant	Expected losses (GWh)	Optimisation potential (GWh)	Period
Small hydropower	832	700	2011-2027
Run-of river	377	525	2011-2027
Storage	280	175	2021-2027
Total	**1.489**	**1.400**	

The WFD triggered also a stream of public-private interactions in the field of hydropower. From 2008-2009 different master plans[5] were elaborated that attempted to assess a feasible balance between hydropower and ecological interests and to set a strategy in relation to the WFD objectives, i.e. to reduce the hydromorphological pressures on regulated watercourses. A study by Feichtinger & Pregernig (2016) analysed these masterplans. The responsible administrative division at the BMNT had planned to develop a comprehensive 'master plan for WFD implementation' in 2008. With this master plan, the authorities intended to bring on board all relevant stakeholders and, in the end, integrate ecological and economic interests - with an opportunity for all stakeholders to bargain different interests. While the Austrian large-scale hydropower actors declared some interest in the intended master plan in an early phase, they turned down the invitation to contribute with their perspective later on finally refused to participate in the process. When the federal states also showed no interest to pursue the further elaboration of such a “master plan for WFD implementation”, the BMNT ultimately gave up its idea. Instead, the Austrian Association of Electricity Utilities (VEÖ) hired an independent engineering firm to explore the potential expansion of hydropower in Austria on its own. Their results became known as the 'hydropower master plan' (VEÖ 2008). This plan foresaw a rapid expansion of hydropower for Austria, placing its main line of argumentation on the EU RES and thereby climate protection. The WFD was only mentioned as an obstacle to hydropower expansion. The industry's master plan found strong support from the Federal Ministry of Economics and Labour. By means of this alliance with the Federal Ministry of Economics and Labour the plan was forged into national policies and was taken up into the 2008-2013 Austrian government programme (Bundesregierung Österreich 2008). Thus, the industry “bypassed the water administration by managing to integrate their master plan into national policies by forging an alliance with the Federal Ministry of Economics and Labour” and can be regarded as an example of successful lobbying for energy sectoral interests (Feichtinger & Pregernig 2016).

As part of its early master plan activities, however, the BMNT prepared a 'list of rating criteria for the sensitivity of water bodies to hydropower utilization'. The representatives of the federal states agreed to engage in the further development of these rating criteria, partially due to the fact that the rating criteria did not designate any specific water bodies as potential areas for hydropower expansion, and thus did not infringe on the powers of the federal states. In a next step, the federal rating criteria were integrated into so-called 'regional programmes' of the federal states. Such regional programmes are administrative orders from the governors of the federal states to implement the programme of measures of the WFD. Through these orders, the federal states kept (with exception of state-owned rivers) a flexible suite of decision-making powers.

This power struggle between the BMNT, on the one hand, and hydropower actors and the federal states, on the other hand, finally brought environmental NGOs onto the scene. NGOs heavily criticized the 'hydropower master plan' for not considering protected areas (with the exception of the Danube Wetlands National Park and the prestigious Wachau region), and because the national rating criteria left too much action to discretion because they made no binding planning statements. As a reaction, the NGO World

[5] Master plans are voluntary agreements by means of which different parties develop guidelines and strategies (Gouldson et al. 2008). “The master plans initiated by the water authorities in Austria were supposed to deal particularly with hydromorphological deficits. The master plans were supposed to feed into the river basin management plans and become a legally valid part thereof (Feichtinger & Pregernig 2016)”.

Wide Fund for Nature (WWF) of Austria presented its own master plan, the so-called “ecological master plan” (Ökomasterplan) in 2009. This was supposed to provide a basis for decisions on the utilization of rivers and their ecological compatibility. The WWF document evaluated the 53 largest rivers in regard to their ecological sensitivity and the related necessity of protection. The plan took into account the ecological status of water bodies, the morphological evaluation of the WFD, protection areas and the length of freely flowing river stretches (WWF Austria 2009, 2010). As for its public and political impact, the 'ecological master plan' did not receive as much response as the 'hydropower master plan'. Its impacts remained more on a technical level. Water experts from the federal level stated that the plan was actually used in the development of the criteria catalogues to recheck and verify the statements (Feichtinger & Pregernig 2016; Feichtinger 2013).

An important regulator for implementing the EU WFD requirements related to environmental objectives in hydropower-producing watercourses is the declaration of heavily modified water bodies (HMWBs) and the affiliated definition of “good ecological potential” (GEP)[6]. As illustrated in table 2, there was a large number and share of waterbodies categorised as HMWB. Regarding the first RBMP from 2009 and the implementation report from 2012 (EC 2012), Austria was commended by the EU Commission for having adopted approaches consistent with international coordination, not least with regard to aligning designation processes of HMWB and artificial water bodies with the European Common Implementation Strategy (CIS) guidance[7]. It was further acknowledged that the plan showed a clear understanding of vital issues including hydromorphological pressures related to hydropower generation in Austria (EC 2015). However, Austria also received criticism from EU for failing to provide enough details on the justification for applying time exemptions in relation to water bodies with significant hydromorphological modifications (EC 2015; Ruud & Lindström 2018). The EU Commission recommended that Austria in the next cycle RBMPs specifically prioritise to improve the revision of the designation of HMWBs and methodologies for establishing GEP. Water Bodies below storage lakes or dams for hydropower production are automatically classified as HMWB according to the Austrian RBMPs provisions. There is a significant number of water bodies with water flow and morphological alterations due to hydropower plants (nearly 56 % of the water bodies). It recommends further to “provide a clear commitment in the 2nd RBMPs to properly prioritize hydromorphological measures and to a review of hydropower permits as restoration measures and the establishment of an ecological flow downstream of hydropower plants will be necessary to achieve good surface water status (EU 2015:86)”. In 2015, the 2nd Austrian RBMP was published and after extensive discussion sent to the EU commission by the end of June 2017. The reaction of the EU Commission to this report is still outstanding.

3.3 The funding of environmental measures to mitigate effects from hydropower production in Austria

In Austria, there are no direct financial costs for hydropower companies of using water resources per se (Oberleitner & Berger 2007). However, there are negative ecological consequences due to abstraction, hydropeaking and impoundment caused by hydropower production. In order to minimize negative effects on the ecology as well as production patterns, Austria is following what the representative of the BMNT terms "a phased approach based on ecological as well as administrative and economic criteria". Efforts have been made to share the financial burden on hydropower producers through limiting the costs of improving the ecological impacts.

There has been a broad consensus and acceptance of public financing subsidies to the hydropower industry to implement environmental measures in the time period of the first RBMP. In its implementation phase from 2009-2015, the Federal Environmental Aid Act (UFG) had a total of 140 million EUR

[6] GEP becomes applicable in cases of HMWBs instead of the general EU WFD objective “good ecological status”(GES).

[7] http://ec.europa.eu/environment/water/water-framework/objectives/implementation_en.htm

earmarked for the financing of environmental improvement measures for the rehabilitation of degraded hydromorphological conditions related mainly to hydropower and impacts of flood protection measures" (Ruud & Lindström 2018; WWF 2017; BMLFUW 2015).

A phased approach is applied for environmental flow restoration. In the first step a base flow has to be provided also guaranteeing the passage in rivers for fish and in a second step a more dynamic flow. Losses of electricity production due to restoration of environmental flow were not refunded by the subsidies. In the first RBMP (2009), a prioritization approach was applied for implementing measures to improve hydromorphological conditions such as establishing river continuity, a base flow and eventual morphological measures (pers. conv. BMNT). In this context, priority rivers (or defined stretches of rivers) were defined and identified (see Fig. 3). In these priority areas, obligatory restoration of river continuity and base flow was defined to be implemented by 2015. According to the 2nd RBMP were investments of 234 million EUR supported by 90 million EUR from funds earmarked in the Environmental Aid Act (UFG). However, morphological improvements were only realized on a voluntary basis. Specific ordinances on provincial levels defined the frame conditions for the obligatory measures (for example the fish species for which the fish migration aids have to be designed for or the concrete base flow requirements). They also include a deadline for submitting the restoration project – otherwise permits would expire (Ruud & Lindström 2018).

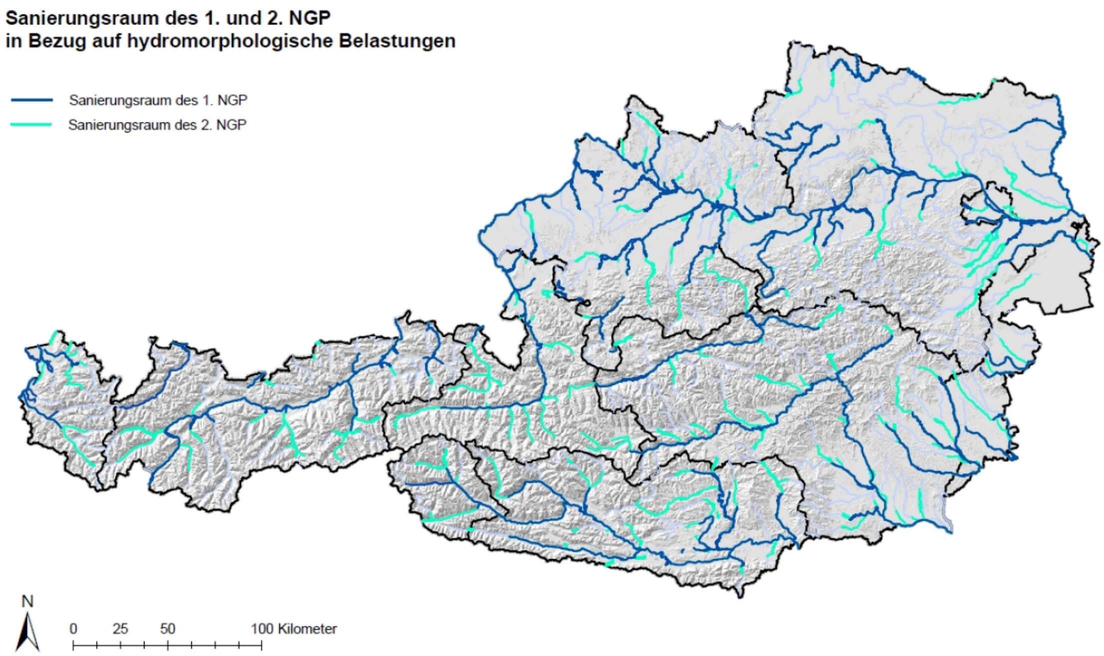


Figure 3. *Priority rivers for restoration related to hydromorphological measures in the Austrian 1st RBMPs (2009) (blue) and the 2nd RBMP (2015) (green). Source: BMLFUW (2015).*

Priority rivers were also defined for the second RBMP, but only for voluntary measures to improve hydromorphological conditions. In addition, the public funding mechanism came to an end in 2015. While 150 million Euro were originally budgeted in the updated Federal Environmental Aid Act, they were, however, cut by the government in 2017. Only remaining financial means from the budget of the first RBMP can now still be used for ecological mitigation measures. That is, a public funding scheme for structural mitigation measures to improve river continuity and the river morphological situation is currently missing for the implementation of the second RBMP cycle i.e. the time period from 2016-2021. Therefore, those restoration/mitigation measures will have to be done only voluntarily or if a new permit is needed (due to expiration of date or change in use) (pers. conv. BMNT). This has caused great concerns as expressed both by environmental NGOs in Austria as well as the EU-Commission (EU 2015; WWF 2007; Umweltdachverband 2018).

State financial support (from remaining public funds as accrued in the first RBMP cycle) in form of investment subsidies for mitigation measures for private companies lies currently by max. 25% (BMLFUW 2017a) and for communal actors, i.e. communities or NGOs max. by 60% (BMLFUW 2017b). Since 2009, a total of 329 cases has been supported by ca. 31 million EUR. for private companies (total investment volume 167 million EUR), and a total of 196 cases by 85 million EUR for communal actors (total investment volume ca. 145 million EUR) (BMNT 2018 a; b).

According to the 2nd RBMP circa 59% of the investments for measures related to establishing connectivity were done by the hydropower sector, circa 33% by the municipalities and federal states and ca. 8% by the state (BMLFUW 2015). Fig. 4 shows how this related to the number of implemented connectivity measures. Measures aiming to enhance river morphology were supported by state financial means earmarked by the Environmental Aids Act with 45 million Euro. The total investments in morphological measures of a total of ca. 97 million EUR were carried to 70 % by the communal sector.

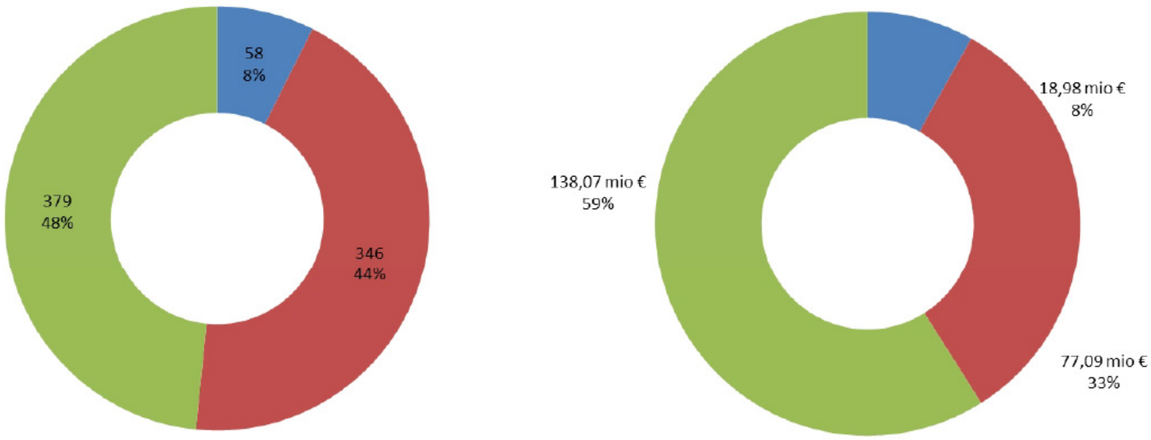


Figure 4. *Measures for establishing connectivity (left diagram): number of the measures that were supported by funds earmarked in the Environmental Aid Act; divided into measures financed by the state (blue), the municipalities and federal states (communal) (red) and the hydropower sector (green). Investment costs for connectivity measures for same categories (right diagram). Source: BMLFUW (2015).*

Additional financing of environmental measures has been possible through EUs LIFE programme. The LIFE programme was launched in 1992 and after an impact assessment and modification, prolonged as the LIFE + programme for environment and climate protection until 2020 (http://ec.europa.eu/environment/life/index.htm).

Financial support lays normally by 50% while the national funding came from the state and the federal states. Through the LIFE and LIFE+ programmes were and are numerous measures financed related to enhancing aquatic ecology and connectivity of habitats (for example the projects Obere Drau II, Mostviertel-Wachau, Traisen, Untere Marchauen, MurErleben II).

3.4 Status of implemented measures

As the 2nd Austrian RBMP (2015) states, ca. 1000 hindrances of connectivity were removed, and residual flow was introduced in ca. 200 reaches to grant enough flow for fish migration and to ensure water-course-typical habitats.

The energy producers' association Austrian Energy (Oesterreichs Energie) gives in its report from 2016 an overview over all implemented measures that the producers of large hydropower have implemented across the country from 2009 until 2015 (**Fig. 5**). The loss in hydropower generation of altogether 133 measures is estimated to be 160 GWh/year. Projects were implemented in almost all federal states, on all major watercourses (Danube: 27 projects; Enns: 8; Traun: 12; Salzach: 19; Mur: 36; Drau, 19, Inn 9; Ill: 5) (Oesterreichs Energie 2016).

Number of measures	133
▪ Ecological connectivity	68 %
▪ Morphology	19 %
▪ Residual water	13 %
Total investments	189,469,497 €
Total funding (UFG (Environmental Aid Act), states, others)	37,801,790 €
Total monitoring expenses	10,104,621 €
Yearly operating expenses	1,059,160 €/a
Yearly generation losses	160,209 MWh/a

Figure 5. *Overview over implemented measures by the Austrian large hydropower producers. Source: Oesterreichs Energie (2016).*

One of these projects: The EU LIFE restoration project at river Traisen

The Traisen is one of the largest rivers in Austria, situated in Lower Austria (Niederösterreich). The construction of the Donau hydropower plant Altenwörth in 1973-76 lead to a prolongation of the Traisen by 7,5 km by a straight channel through the former wetland area between Traismauer and Zwentendorf. This area lies within the NATURA-2000 site "Tullnerfelder Donauauen", the largest connected floodplain area in Austria. These river engineering measures caused the diversion of the Traisen estuary in the section below Altenwörth power plant. The regulated river dug itself very deeply into the ground, which led to a negative impact on the ecosystems; natural structures and habitats were restricted, and the biodiversity was reduced accordingly. The newly constructed channel offered very poor conditions for typical animal and plant species, it was hardly passable for fish, and it was not connected to the surrounding landscape and wetland. The typical floodplain landscape was lost.

First ideas to create a new Traisen river in this area started in 2005. A project idea that aimed to better all types of impairments was proposed to the EU LIFE+ programme and received funding in 2008 (https://www.life-traisen.at/en-at/life-traisen). It involved relocating the course of the Traisen. The new bed of the Traisen has a total length of 12.2 km and, in accordance with the bends of the river, is divided into four construction sections. By means of alternating fords and channels with flat sand or banksof gravel on the slip-off banks and steep undercut banks, the newly created Danube tributary offers an ecologically diverse habitat and transition region. The goal was the greatest possible protection of the existing natural environment in the floodplains area through the creation of a meandering river, which will be able to continue developing dynamically in the future and offer new riverine habitats. A floodplain foreland with frequently flooded areas has been created along a new river course, creating thus constant conditions at high water levels, accounting for the measures implemented in conjunction with the old Traisen.

The increased frequency of flooding along the new course of the river, the installation of diverse standing bodies of water around the marshland and the new bed of the Traisen provide ideal site prerequisites for the development of a soft marshland (with a typical silver willow population). Stream hydromorphology was restored and migratory barriers eliminated, aiming to give migratory species access to 59 km of stream habitat – resulting in more viable fish and invertebrate communities. The restoration of fish spawning areas is expected to lead to 8.800 m2 of physically functioning spawning bottoms substrate increasing the fish population size. The freshwater pearl mussel was introduced in order to restore a typical and more balanced community of species. Twelve floodplain ponds measuring between 0,6 ha up to 1,6 ha were created. The project included further dissemination and capacity-building activities, project seminars and publications aiming to raise awareness among land owners and other local stakeholders, and thus more sustainable use of land and water. The Danube cycle path underwent small-scale relocation and a new cycle path bridge was built.

The costs of the Traisen project was a total of 30 million EUR. The EU LIFE+ programme contributed with 5,4 million EUR. Financial support from the Austrian state, the federal state Lower Austria, the regional and local Fisheries Associations, the Landscape Find Lower Austria and Via Donau - a subsidiary of the Austrian Ministry for Transport, Innovation and Technology - amounted to 5,1 million Euro. The sales revenues of the excavated gravel from the project accounted for 4,5 million EUR. The remaining 15 million EUR were covered by the responsible hydropower company VERBUND Hydro Power.

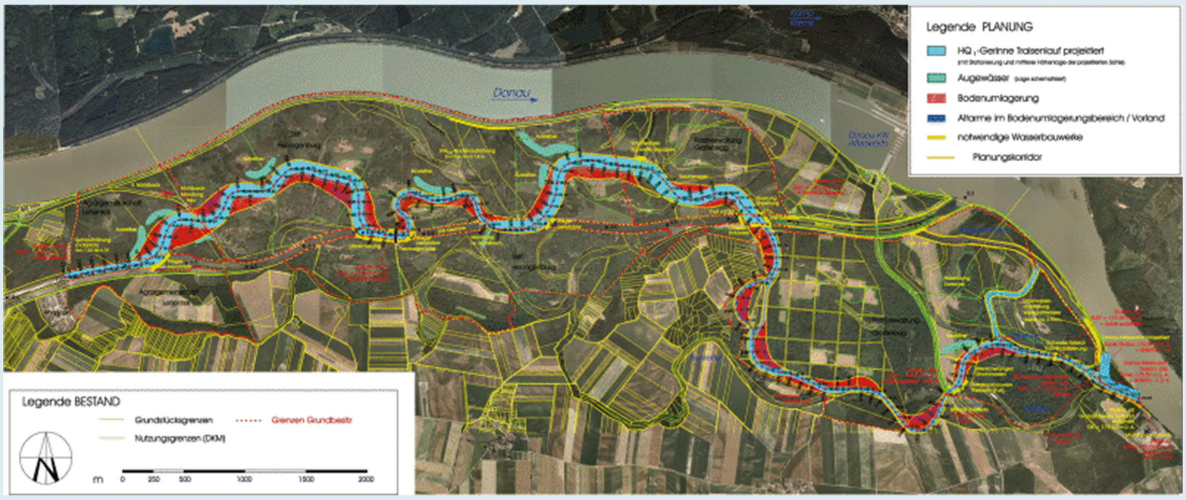


Figure 6. *Project option for a near-natural Traisen lower reach as proposed in a feasibility study in 2005. Source: Kaufmann et al. (2018).*

Figure 7. *Aerial photo of a section of the new 9,5km long river landscape after project completion. Source: Verbund AG; www.life-traisen.at/en-at/life-traisen/current-news.*

3.5 Summary

In Austria, as in the other member countries of the European Union, the objectives of increased production and supply of renewable energy, as given by the EU RES – stand partly in conflict with the implementation of a good ecological status, as demanded by the EU WFD. Austria has started to address this problem, and especially the responsible Ministry for implementing the WFD, BMNT, has successfully created a constructive and productive network together with actors from hydropower industry and research sector that has contributed to establish mutual trust amongst them. Together with rather substantial funding opportunities from the Austrian state and the federal states as well as occasionally from the EU LIFE programme for environmental measures during the time of the 1st RBMP (2009-2015), this network has been beneficial to realize some important headway towards reaching WFD objectives. A substantial number of environmental measures related to increased connectivity and environmental flow could be realized in this period.

Even though the 2nd RBMP shows that expected losses in hydropower production due to the implementation of environmental can be compensated with gains through the optimization of existing power plants, the reactions of the EU Commission (EU 2015) to the 1st RBMP show clearly that the basic conflict between the objectives of energy and ecology related to Austrian watercourses persist. Criticism was mainly related to the massive assignment of HMWBs, the vague descriptions of methodologies on criteria for designating HMWBs and deciding on GEP, as well as the use of the extension clause. In fact, Austria has continued to designate more HMWBs according to the criticized standards since the last assessment with the number of total HMWBs amounting to 7,7 % of the total number of water bodies[8] (BMLFUW 2009; BMLFUW 2015).

The extensive application of the paragraph 4.4 exemption (the extension of the deadline of implementation) is presumably also related to the massive number of restoration projects that are needed and associated permitting processes. The implementation of measures to mitigate the negative environmental impacts of hydropeaking on 800 km of Austrian watercourses with a large expected effect on the energy system and security of supply has been postponed to 2021. The argument here is to provide for ample time to increase knowledge and test the effectiveness of potential measures.

Austria at least seems to have identified key conflicts between objectives for renewable energy production and environmental objectives as expressed in the EU WFD. Despite a relatively high exploitation of the hydropower potential in Austria, the hydropower industry has plans for further development, not least due to implementation of targets in the EU RES (IHA 2018; VEÖ 2008). However, due to political conflicts in realizing new power plants, Austria seeks to achieve gains primarily through refurbishments and efficiency improvements in existing plants including strategic use of pumped storage hydropower schemes (Wagner et.al 2015; Ruud & Lindström 2018). Given the fact that Austria must stay committed to the obligations of the EU WFD, the formal achievement of implementing the WFD objectives will also largely depend on the further refinement of the directives regarding how good ecological potential will be elaborated and defined in HMWBs and when exemptions can be applied.

[8] The number increased from 567 in 2009 to 627 in 2015 for running watercourses > 10 km^2 and remained equal between 2009 and 2015 for lakes > 50ha (number = 6). There was a small decrease in artificial lakes from 15 in 2009 to 13 in 2015.

4 Switzerland

Switzerland is known as the "water tower of Europe" since its significant water resources accounts for around 6% of the continent's freshwater (OECD 2017). Thanks also to its topography and high levels of annual rainfall, Switzerland has very good conditions for the utilization of hydropower. Towards the end of the nineteenth century, hydropower underwent an initial period of development and expansion, and then between 1945 and 1970 it experienced a genuine boom during which numerous new power plants were constructed and opened in the lowlands, together with large-scale storage plants.

Hydropower accounted for almost 90% of domestic electricity production at the beginning of the 1970s but following the commissioning of Switzerland's nuclear power plants this figure fell to around 60% by 1985. It is now around 57% (SFOE 2018b). Hydropower therefore remains as Switzerland's most important domestic source of renewable energy. Its share is envisioned to be increased rather substantially until 2050, due also to the planned abandonment of nuclear energy in the medium term (SFOE 2018a; OECD 2017).

In total, there are 1365 hydropower plants in Switzerland with a production of 36.561 TWh/y (SFOE 2018, status 1.1. 2018). 48,3 % of this is generated in run-of-river power plants, 47,4 % in storage power plants and approximately 4,3% in pumped storage power plants. Table 4 gives a more detailed overview over their distribution according to their production capacity. It is interesting to note that the 188 largest plants (> 10MW) produce 94%, all plants with a capacity > 1 MW even 98% of the expected production, while the share of the large number of 940 plants with low capacity (< 0.3 MW) contribute with only 1.2%.

***Table 4**. Hydropower plants in Switzerland (source: SFOE (2018b)[9], status 1.1.2018)*

Number of HP plants	Size range according to capacity	Share in (expected) production
188	> 10 MW	93.9%
237	1-10 MW	4.9%
225	0.3-1 MW	0.8%
715	< 0.3 MW	0.4%

Roughly 63 % of the hydroelectricity is generated in the mountain cantons of Valais, Uri, Ticino and Grisons, while Bern and Aargau also generate significant quantities (SFOE 2018b). With a total installed capacity of 16,657 MW, Switzerland holds the 6th place in Europe in front of Sweden and Austria (IHA 2018) [10]. The hydropower production is estimated to be worth 1,8 billion Swiss francs[11], and is therefore an important segment of Switzerland's energy industry (SFOE 2018b).

In a 2012 study, the Swiss Federal Office of Energy (SFOE) found that Switzerland would have the capacity to increase its hydroelectric production to 37.4 TWh/y in 2035 and to 38.6 TWh/y in 2050, without contravening current water protection regulations. These numbers were put forward in the Swiss Energy Strategy 2050 and agreed upon by a public referendum in May 2017. This resulted in an amendment of the Federal Energy Act in January 2018. Consequently, by 2050 Switzerland will aspire a further increase in hydropower production up to 38.6 TWh/y[12] (Federal Council 2013), an increase of 5.5% compared to current production.

[9] https://www.swv.ch/fachinformationen/wasserkraft-schweiz/kraftwerkspark/

[10] Norway holds the 1st place with 31,837 MW installed capacity.

[11] Estimate based on the delivery from power plant at 5 cents per kilowatt hour

[12] This number is not part of the current Energy Act.

Some 70% of the increase would come from new large and small installations, with the rest from expansion of existing large plants. The federal government wants to promote the future use of hydropower to a greater extent through a variety of measures. In order to exploit the realizable potential, existing power plants are to be renovated and expanded while taking the related ecological requirements into account. The instruments to be used here include for example cost-covering remuneration for feed-in to the electricity grid for hydropower plants with a capacity up to 10 megawatts (OECD 2017). However, hydropower production influences the water bodies in very similar ways as in Austria, due to the same topographical conditions. The main impacts are caused by residual flow, hydropeaking and changes in the sedimentation process (FOEN 2018; Kunz et al. 2016). There are hardly any rivers left with a natural flow regime in Switzerland as a result of regulated flows downstream from lakes or river power plants.

The Swiss Federal Office for the Environment (FOEN) has a residual flow map and database (Fig. 8) showing where water is withdrawn from rivers and streams in Switzerland, what it is used for, how much remains in the river at specific points, and where water withdrawals are causing ecological problems. Of the total of 1488 withdrawals, 1406 are related to hydropower production[13]. Of these, 1262 are presumed to be extremely relevant from an environmental perspective, since the various withdrawn quantities account for more than 50% of the average low flow volume of the respective watercourse. Alpine rivers downstream from storage power plants are particularly affected by changing flow rates all the way up to their mouths in Pre-Alp lakes (Kunz et al. 2016).

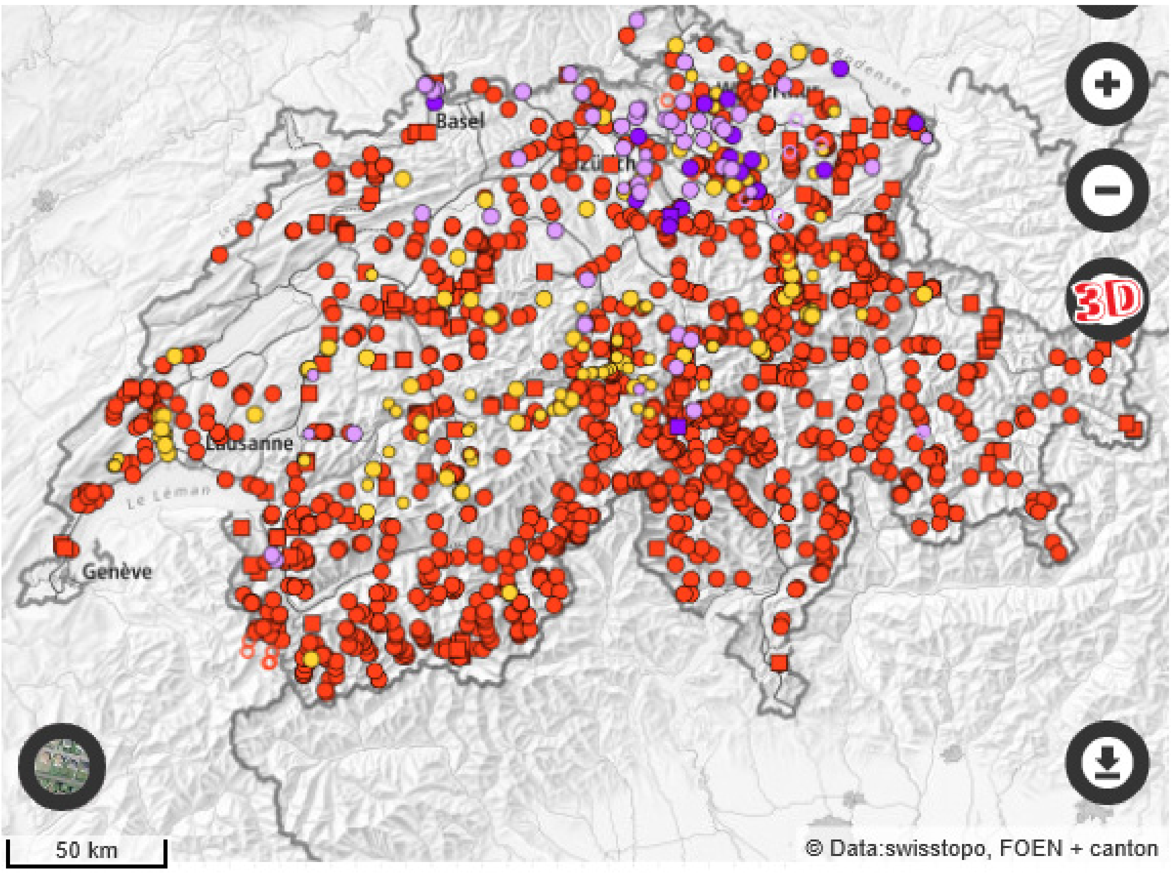


***Figure 8.** Residual flow map and database (FOEN 2018)*

Around 40% of Swiss rivers - 50% of those below 600 m.a.s.l. - have a poor morphological status and about a quarter have a high degree of fragmentation due to artificial structures that affect the passage of migratory fish, change the natural habitat distribution within rivers and modify their ecological

[13] In addition to electricity production, water is also withdrawn for the purposes of irrigation or cooling.

capacity. According to FOEN, restoration measures are needed for 1000 hydropower installations related to fish migration barriers, 100 installations related to hydropeaking and 500 installations related to changes in sediment transport (FOEN 2015).

Since Switzerland is not a member state of the EU, it does not have to follow EU directives and report implementation progress related to objectives for renewable energy development (EU RES) and ecological quality in water bodies (EU WFD). But the following sections will illustrate that the same conflict lines between these interests exist also here, only with anchoring in the national legal and political systems as well as in public discourses.

4.1 Environmental legislation

Even though Switzerland is not bound to implement the EU WFD, the Swiss legal system sets high and even more specific targets regarding water protection and management, and Swiss legislation has binding requirements, including a set of national limits that must always be met. As a member of the International Commissions for the Protection of the Rhine and of the commissions for the protection of Lake Constance, Geneva and as well for the protection of the Swiss-Italian transboundary waters, Switzerland collaborates with its neighbouring states to achieve water protection goals and to implement endorsed programmes. Switzerland supports EU-member states in coordinating their activities to implement the WFD in international water basins within the framework of these commissions (OECD 2017).

Switzerland has embarked on an innovative approach to the rehabilitation of the 40 % of its rivers that have been altered, with adverse consequences for nature and the landscape (OECD 2017). The policy of river rehabilitation was triggered by a public referendum initiative, “Living Waters”, proposed on 3 July 2004 by the Swiss Fishing Federation (FSP) to strengthen the biological functions of watercourses by creating habitats and managing riparian zones. It demanded that all degraded watercourses should be ecologically restored. In 2010, the FSP announced the conditional withdrawal of the public referendum initiative following an indirect counter-project that was adopted at the end of 2009 by the Swiss Federal Assembly to encourage river rehabilitation and reduce the negative effects of hydropower production. The counter-project was not challenged during the five-month prescribed referendum period, i.e. it was accepted, resulting in the addition of Article 38a, “Rehabilitation of waters”, to the Federal Waters Protection Act (WPA). Paragraph 1 of this article calls on the cantons to ensure that waters are rehabilitated. In doing so, the cantons must take account of the benefits to nature and the landscape as well as the economic consequences of the rehabilitation. Already by the end of 2018, the cantons must provide sufficient space for all surface waters to ensure their natural functioning. There must be a reduction in the negative impact of hydropower production on downstream waters by 2030, and some 25 % of waters with poor morphological status must be rehabilitated over the longer term (EEA 2018).

The approval of the counter-project to the public referendum “Living Waters” from 2004 led in 2011 to an amendment of several federal laws relating to river rehabilitation, including the WPA, WMA, Energy Act and Rural Land Act. These amendments define two main orientations:

- Encourage river rehabilitation and guarantee a space reserved for water.
- Ensure the ecological improvement of installations related to hydropower use. (OECD 2017)

In regard to the latter point – to ensure the ecological improvement of hydropower installations - measures related to 1) minimum flow regulations, 2) removal of migration barriers, 3) hydropeaking and 4) sedimentation effects are relevant.

1. Minimum flow: The OECD Environmental Performance Review on water management in Switzerland (OECD 2017) gives a good summary of the minimal flow requirements regulated by the WPA14: “Since 1991 there have been three levels of minimum flow requirements for new water use rights. The ten-year average of the flow reached or exceeded 347 days per year (Q347 flow rate) is used to determine the first level. For small rivers (with a Q347 flow rate up to 60 l/s) this level is relatively higher than for larger rivers. For small rivers, water use is possible only if a minimum flow of 50 l/s is maintained, taking into account that the ecological balance for this type of river is especially fragile.

The minimum flow requirements must be increased to a second level (WPA Article 31, para. 2) if the WPA requirements are not satisfied in terms of i) water quality (e.g. low dilution of sewage), ii) groundwater supply, iii) protection of biotopes whose existence is directly related to the nature and size of the watercourse and iv) free migration of fish. The minimum flow must also increase in the case of rivers crossing inventoried landscapes and biotopes or in case of “overriding public interest” (e.g. landscape criteria such as presence of a waterfall).

These two levels do not take into account the ecological differences of the various rivers (i.e. the same requirements apply for all rivers). This is why the WPA provides for a third level of minimum flow requirements (WPA Article 33), which consists of setting “acceptable” minimum flows after a weighing of economic and environmental interests, including landscape protection, biotope protection, long-term water quality, and long-term groundwater protection. The third level must be at least as high as the second level (preferably higher).

In Switzerland, concessions for hydropower use are granted for 80 years, pursuant to the Act on Hydropower Use. Articles 31-33 of the 2011 WPA apply only to concessions renewals or granting of new concessions, i.e. they “do not apply to water use rights granted before 1991, where the much less stringent Article 80 applies (Figure 9). Article 80 (1) specifies that minimum flow requirements only apply if they do not infringe upon existing user rights to such an extent as to justify compensation. Under Article 80 (2), stricter minimum flows apply to watercourses crossing landscapes or biotopes listed in a national or cantonal inventory, or where overriding public interest requires, even if they infringe upon existing user rights to the point of justifying compensation. By end 2016, about 25% of hydropower plants built prior to 1991 did not meet the 2012 deadline for complying with Article 80 requirements (FOEN, 2017b). One of the few examples of Article 80 (2) being implemented is on the River Doubs, where authorities compensated a hydropower plant operator for income loss so as to increase residual water use for nature conservation.

Some very old rights of water use for hydropower are unlimited in time. That prevents enforcement of the minimum flow standards set in 1991. This is the case for most smaller hydropower installations (around 1 000, out of a total of 1 150). For these, minimum flow is not regulated other than by Fishing Act provisions. (OECD 2017)

[14] The Waters Protection Act (WPA) can be found at: https://www.admin.ch/opc/en/classified-compilation/19910022/index.html.

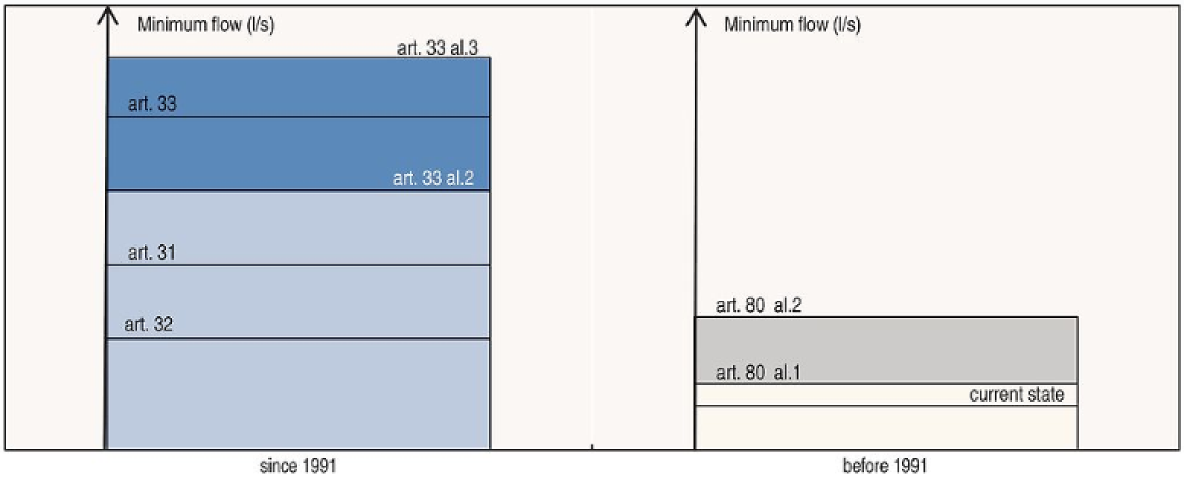


Figure 9. *Differences in minimal flow regulation depending on the year water rights were granted (before or after 1991). Note: The minimum flow levels are given for illustrative purposes. In practice they vary according to the local conditions. Article 31: no weighing of interests. Article 32: derogations. Article 33: weighing of interests. Article 33 alinea 2: economic interests that must be taken into account. Article 33 alinea 3: ecological interests which preclude the taking of water. Article 80 alinea 1: ecological improvement not infringing existing user rights. Article 80 alinea 2: additional ecological improvement required. Source: Michel et al. (1997) in OECD (2017).*

Since 2011, all installations related to hydropower use have had to meet three types of requirements to ensure their ecological improvement, in addition to the Articles 31-33 minimum flow requirements. These new requirements are regulated in the Fishing Act Article 10 (relating to obstacles to fish migration; affecting 1000 installations), WPA Article 43a (relating to changes in sediment transport; affecting 500 installations), and WPA Article 39a (relating to hydropeaking; affecting 1 00 installations). All installations built since 2011 must comply with these new standards. All installations built before 2011, whatever their size, are eligible for financial support to facilitate their upgrading (i.e. ecological improvement) by 2030 (OECD 2017) (see for further information section 4.3. on the challenge of financing)

4.2 Reconciling efforts between the diverging interests of energy production and ecology

The Swiss Federal Office of Energy (SFOE) deals with policy-related aspects of hydropower (promotion, strategies, perspectives) as well as technical and safety aspects, while the Swiss Federal Office for the Environment (FOEN) is responsible for environmental aspects (including the separate sections for Hydropower-related restoration and for Restoration and watercourse management within the Water Division[15]). Much decision-making competency lays also in the hands of the cantonal authorities. The national target of restoring about 4000 km of rivers until 2090 prompted for example the preparation of restoration plans by the single cantons, which were due by end of 2014 (OECD 2017).

These cantonal restoration plans aimed to "designate priority stretches of rivers and lakeshores, i.e. to act first where the benefits to nature and landscape are most important in relation to rehabilitation costs. Specifically, the priorities for rehabilitation over the next 80 years are defined in two steps (Figure 10)." (OECD 2017)

[15] FOEN: https://www.bafu.admin.ch/bafu/en/home/office/divisions-sections/water-division.html

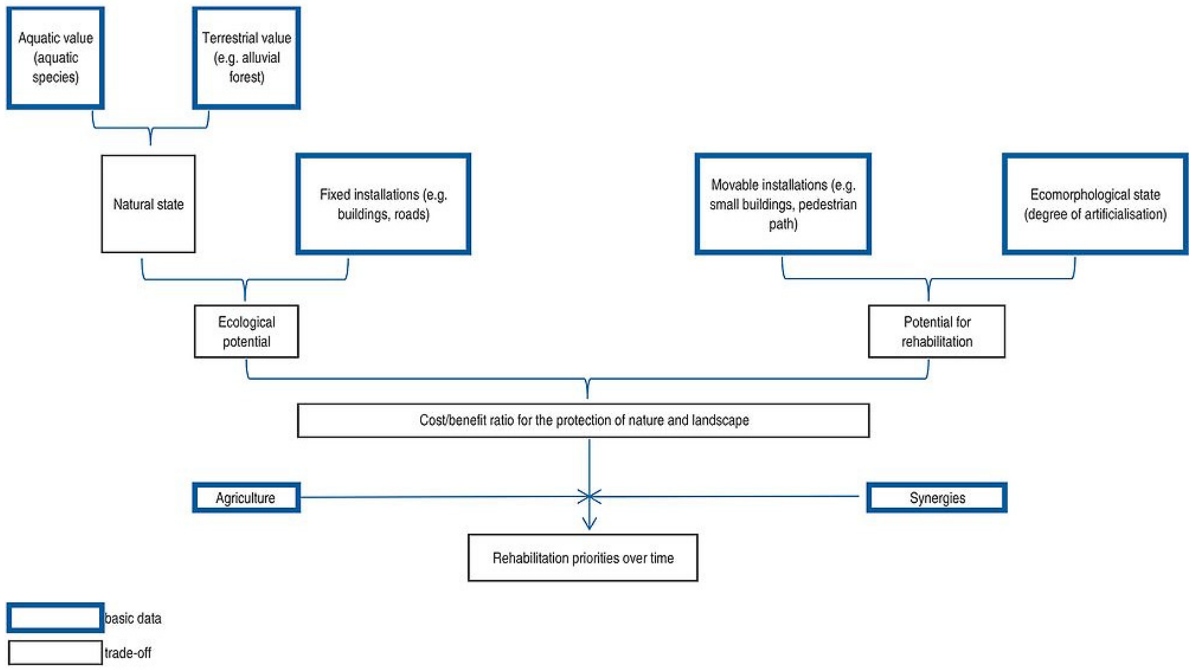


Figure 10. *Scheme for prioritization of river rehabilitation involving cost-benefit analysis and managing synergies and trade-offs. Source: Canton of Fribourg (2015) in OECD (2017).*

First, cost-benefit analysis considers the ecological interest of rivers, both aquatic and terrestrial, their ecomorphological state as well as the presence of infrastructures likely to limit the space available to the waters (e.g. roads, buildings). The analysis results from a matrix of the "ecological potential" and the "rehabilitation potential" of stretches of rivers and lakeshores. In a second step, the outcome of the cost-benefit analysis is weighed against agricultural constraints and possible synergies in areas such as land improvement, recreation promotion, ecological improvement of installations related to hydropower use, remediation of polluted sites and management of biodiversity hotspots. The resulting priority-setting corresponds to the stretches of river and lakeshore with the most synergies and least constraints. The constraints imposed on agriculture are evaluated on the basis of the encroachment of the space reserved for the waters on the utilized agriculture area and the resulting economic loss to the farmer (OECD 2017)." By means of the cantonal restoration plans and their prioritization strategy, the two main objectives regulated by Swiss law since 2011 – river rehabilitation through space for the rivers and ecological improvement of hydropower installations – are thus attempted to be coordinated.

A communication forum is supporting the development and exchange of knowledge related to these challenges as well as the dialogue between the differing interests. The so-called "Wasser-Agenda 21" (Water Agenda 21) was founded as an association in 2008 by all important actors of water management in Switzerland from industry, research, environmental NGOs, regional and national administration. It presents a platform for the exchange of information and experiences, for active dialogue between the differing user interests, and for initializing, supervising and implementing integral water management projects. It is based on and financed by membership commitment and receives some additional financing from FOEN. According to several of our interview partners, this platform has been highly successful in contributing to functioning communication network between the relevant actors and a wide implementation of environmental measures in Switzerland.

Another communicative and participatory means of allowing the weighing of interests in concrete cases, specifically related to minimum flows, are roundtables. They are often initiated by environmental NGOs, such as the WWF Switzerland and have successfully contributed to finding and setting "acceptable" minimum flows after a weighing of economic and environmental interests, including landscape protection, biotope protection, long-term water quality, and long-term groundwater protection, as specifically required by the third level flow requirements after WPA Article 33 (as described in section 4.1.) (OECD 2017). The roundtable procedures are frequently accompanied by joint field visits of the involved stakeholder groups with trial regulation observations in the respective river stretch. According to our interview data these roundtables with participatory trial regulation have until now resulted in joint agreements on effective residual water flow regimes in at least 40 cases. (pers. conv. WWF Switzerland; see also OECD 2017 for description of a constructive roundtable process in canton Grisons).

While there are concrete successes in negotiating the differing interests of energy production and environmental quality, there is currently a re-fuelled debate about the reconcilability of the objectives of the Energy Strategy 2050 and minimal flow regulations serving the protection and improvement of ecological conditions[16]. A current study by Pfammatter & Semadeni Wicki (2018) of the industry association SWV argues that the pursuit of these two objectives will clash. The arguments are based on own data collection and from the hydropower companies, and the calculation of different development scenarios. The loss in hydropower production through implemented environmental measures according to the WPA (see section above) is a decisive variable in these calculations. These losses, estimated until 2070 and illustrated in Fig. 11, have been controversially discussed in the last decades reaching from estimates of 800 GWh/y by an intergovernmental group (Akeret 1982), 1600 GWh/y by the Ministry for Energy (SFOE 2012), 2000 GWh/y by the Federal Council and the FOEN (Federal Council 2003; Kummer 2002), and up to min. 2630 GWh/y and max. 5040 GWh/y in a study commissioned by the industry association SWV (EWI 1987). The official number of the Swiss Confederation for the expected loss until 2070 lays by 1350 GWh/y. This estimate is based on a production loss of 560 GWh/y for the time period from 1992-2017, including 350 GWh/y for restorations based on WPA Art. 80, and 210 GWh/y for concession renewals based on WPA Art. 31-33 (Pfammatter & Semadeni Wicki 2018). These numbers were extrapolated by the hydropower companies.

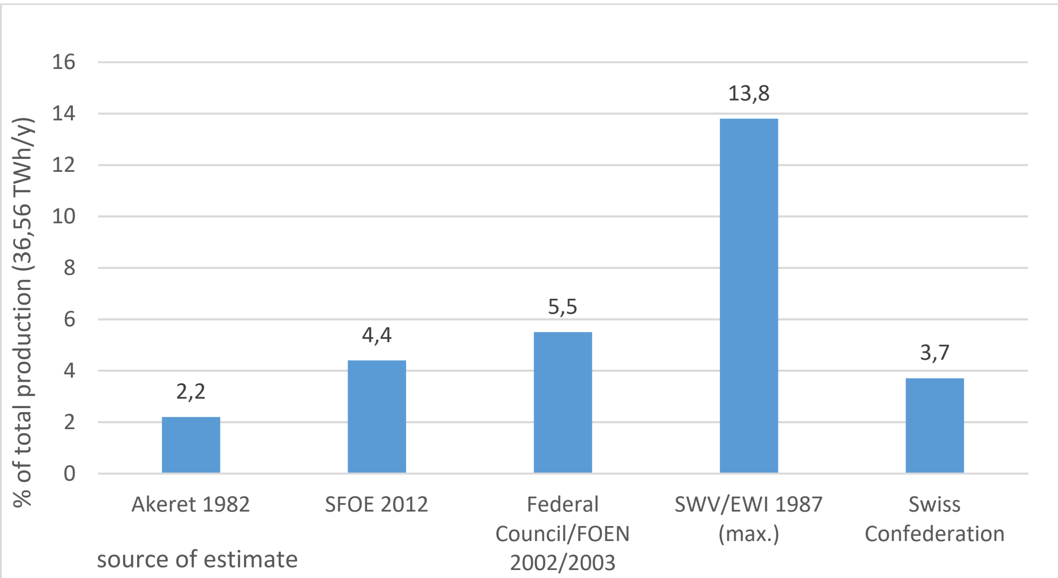


Figure 11. *Estimates of hydropower production loss in percent of total production (36,56 TWh/y).*

Scenario 1) describes a continuation of the status quo regulations related to minimal flow. Scenario 2) includes increased flow requirements for protecting brown and lake trout and a related necessary minimal water depth according to new guidelines produced by the FOEN (Dönni et al. 2016). Scenario 3)

[16] See e.g. the recent newspaper articles: https://www.nzz.ch/schweiz/stromer-machen-druck-auf-restwassermengen-ld.1424911; https://www.infosperber.ch/Umwelt/Mehr-Restwasser-weniger-Stromwasser;

incorporates increased requirements if hydropower installations are situated in the area of influence of floodplains of national or potential national relevance, taking into account new guidelines (Flussbau AG et al. 2017). Finally, scenario 4) translates the demand for a process-oriented functional floodplain flow based on the study of Hayes et al. (2018). The results of the scenario estimations indicate that effective hydropower production would need to be increased by 139 GWh/y for scenario 1); 146 GWh/y for scenario 2; 180 GWh/y for scenario 3) and 264 GWh/y for scenario 4) in order to fulfil the Energy Strategy 2050 objectives. The authors conclude that stringent interpretations of minimal flow requirements are not in line with the Energy Strategy objectives and demand measured interpretations in future concession renewals and still pending restorations of existing concessions, and an even better weighing of the interests of energy and ecology (Pfammatter & Semadeni Wicki 2018).

The environmental organisation ProNatura (the equivalent to Norway`s Naturvernforbundet) replies to this study by Pfammatter & Semadeni Wicki (2018) that it has to be interpreted in the context of a long-term strategy of the hydropower industry to secure its existing privileges across concession periods. Pronatura argues that the prognosed production losses must be seen in the correct context of chosen reference production, namely the status in 1991. 1992 were the new quantitatively regulated minimal flow requirements introduced. Before 1992 was the benchmark of the concessions almost always the total utilization, to a large extent without any minimal flow. This utilization was thus almost equal to the technically maximally possible full utilization. Compared to this, a production loss of 10% for the scenario with an increased protection objective for floodplains (i.e. scenario 3) means relatively little. In this scenario, still 90% of the water energy potential would be useable in the turbines, and only ca. 10% would be running down the natural river bed. This value should nature have to us, states ProNatura (pers. conv. ProNatura). More important than the quarrel over single per cents of production is thus the basic question of what nature and biodiversity are worth for us. Since there exists a conflict between climate and biodiversity compatible hydropower production, they have to be tackled fundamentally before a quarrel over concrete numbers. According to Pronatura, the study by Pfammatter & Semadeni (2018) is in that regard a welcome opportunity to lead this discussion openly. One difficulty hereby is, however, the comparison of quantities (loss in production) with qualities (nature and floodplain protection). As Pronatura claims further, the study by Pfammatter & Semadeni (2018) excludes on the other hand in its calculations the increase in production that was attained in many new concessions in Switzerland, thus overcompensating possible losses due to minimal flow requirements. Further, it assumes 11% as standard for production loss, resulting from the increased minimal flow requirements for concession renewals of diversion plants. For Pronatura, this is problematic since only a very small fraction of installations received a new concession while this percentage is not representative for the large fraction of remaining large installations. This shows clearly that the results of a scenario study depend heavily on the scenario assumptions (pers. conv. ProNatura, Dec. 2018).

4.3 The funding of environmental measures to mitigate effects from hydropower production in Switzerland

As described in section 4.1. in more detail, since 2011 hydropower plant operators are obliged to limit the negative impact of obstacles to fish migration (Fishing Act Article 10), changes in sediment transport (WPA Article 43a) and hydropeaking (WPA Article 39a). All installations built since 2011 should comply with these new standards. All installation built before 2011, are eligible for financial support to facilitate their upgrading (i.e. ecological improvement) by 2030, disregarding their size. Ecological improvement measures are entirely financed via a tax of 0.1 Rappen/kWh on all consumers` electricity bills, in accordance with the Energy Act (Article 15). Since this tax is specified for the use of the Swiss grid the resulting amount is also called the "Swiss Grid Fund". It is set to raise up to max. 50 million CHF/year[17] and 1 billion CHF over 20 years. While this support or "compensation" does follow a kind of "electricity

[17] This relates to ca. 425 Mill NOK/year and 8.500 Mill NOK over 20 years. 1 Rappen/KWh = 0,085 NOK/KWh.

pays for electricity" principle, it seems to contravene the polluter-pays principle, which would require plants' operators to cover the ecological improvement cost. However, the provision takes into account operators' acquired rights, which ensure full compensation for any limitation of hydropower use that entails excessive costs (OECD 2017).

The hydropower companies are given incentives to implement restoration measures with funds from this so-called Swiss Grid-Fund by stating that the available financial means are usable on a first-come-first-serve basis until 2030 when this program will end. The current state of communication is that all measures implemented after 2030 will have to be financed by the hydropower company themselves (pers. conv. FOEN).

The Swiss Grid Fund is a result of the public referendum "Living Waters" that recommended establishing funding mechanisms for watercourse rehabilitation. Further funding support schemes resulting from this, are based on public taxes and have been in place since 2011 for rehabilitation work (via environmental policy) and for provision of space for waters (via agricultural policy). These instruments are combined with direct regulations on minimum flows (as described above) and come in addition to the public financial support for flood control that was in place before 2011 (OECD 2017). Figure 12 gives an overview of the financing mechanisms at place for watercourse rehabilitation.

Policy aim	Financing		Rationale
	Confederation	Cantons and/or municipalities	
Rehabilitation projects	2/3 (CHF 40 million/year)	1/3 (CHF 20 million/year)	The Confederation is mostly responsible for biodiversity protection
Space for waters	1/1 (CHF 20 million/year)		Farmers are rewarded for managing riparian land as biodiversity promotion areas
Flood control	1/3	2/3	Flood control particularly benefits the cantons
Ecological improvement of installations related to hydropower use	100% via a tax on the electricity bill (up to CHF 50 million/year)		Compensation by virtue of the rights acquired following the granting of a concession for hydropower use

Source: FOEN (personal communication).

Figure 12. *Overview of the financing mechanisms that have been established for watercourse rehabilitation in Switzerland. Source: OECD (2017); FOEN.*

Financial support for ecological improvement of hydropower installations comes on top of other financial incentives for hydropower development as part of Swiss energy policy. As part of the first phase of the above-mentioned Energy Strategy 2050, financial support has been able to cover part of the investment in new plants, the aim being to increase hydropower's share in the renewables mix. This incentive is financed since 2013 via additional levies on electricity bills: 0.1 cent/kWh for large plants, 0.03 cent/kWh for small ones. Since 2013 and until 2018, a market premium of 0.2 cent/kWh is granted to existing large plants. Electricity consumers also subsidize hydropower development via market price support. New and upgraded plants of less than 10 MW capacity have been eligible for feed-in-tariffs (FITs) since 2008. The smaller the plant, the higher the FIT rate. The rates are lower for installations on natural watercourses than for those on watercourse stretches already in use as an incentive to protect natural watercourses from too much hydropower development. FITs were granted for 25 years for installations built before end 2013, and for 20 years since then. FIT policy, however, is currently under review. (OECD 2017)

On the other hand, as OECD's report (2017) underlines, "hydropower plant operators are subject to a tax for the use of water to produce electricity (the tax is combined with water use rights). The tax rationale is the use of a public resource. Revenue from taxation of hydropower production totals around CHF 550 million a year nationwide and accrues to the cantons where the hydropower is produced. The tax is designed so that the more hydropower is generated, the higher the tax amount, which creates incentives for cantons to develop hydropower. This is particularly the case in the Alpine cantons, where the proceeds make up a significant share of cantonal budgets. The amount of the tax is obtained by multiplying the theoretical installed capacity (kWB) by a tax rate (CHF/kWB) the maximum of which is set by law. Hydropower plants above 1 MW of installed capacity are subject to the tax, whose rate can also vary by type of plant. A higher rate for plants requiring dams is environmentally justified because dams entail risk of hydropeaking, changes in sediment transport, obstacles to fish migration and eutrophication. In some cantons, the tax is based on power generated and water withdrawn. For example, in Jura canton the rate decreases when large diversion facilities take more than three-quarters of the average annual river flow and when large impoundment facilities make higher withdrawals in summer than in winter. Such regressive taxation (the tax rate decreases as withdrawals increase) is a disincentive to comply with minimum flow rules."

Another source for financing restoration measures hydropower-producing watercourses is the certification label "Naturemade star". It is described in detail in chapter 6.3.

4.4 Status of implemented measures

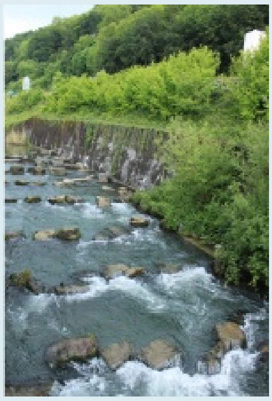
A first survey of data from the single cantons on implemented measures regarding minimal flow shows that by end of 2016 the number of sites where minimal flow requirements were established is 732. This relates to 75% of the 980 sites where minimal flow adjustment was required. Further restorations were expected for the years 2017 (141), 2018 (11), 2019 (12), 2020 (10), 2022 (7), 2025 (7), 2030 (1). This would lead to 94% of accomplished restorations by 2030 (Baumgartner 2016).

FOEN is currently conducting a survey to get an overview over implemented measures from the single cantons. This data is not accessible yet but expected to be collected by March 2019 and published by September 2019. Most of the measures pertaining to river continuity, sediment transport and hydropeaking are under planning and not yet implemented (pers. conv. Kummer and Baumgartner/FOEN). Nevertheless, Wasser Agenda 21 has launched a website on its "Platform Restoration" [18] where implemented measures for these types are mapped. Currently, there are 4 projects registered for upstream fish migration, 2 for downstream fish migration, 2 for sediment transport; 1 for hydropeaking (status Jan, 15th 2019).

Case example wetland restoration at hydropower plant Ruppoldingen

The original plant was built in 1896 on a side canal of the Aare River. With the renewal of the concession it was replaced in 2001 by a new run-of-river power plant. The mean yearly production was increased from 40 GWh/y to 114 GWh/y. A bypass river was constructed to mitigate impacts of hydropower, enabling free fish migration, to compensate for lost reproduction habitats of endangered species and to create a small river that created habitats for typical fish species in this area.
The scheme was two-fold: A 155 m long natural fish pass was constructed close to the turbines, with a mean gradient of 3.8%. A second bypass was created further downstream of the plant with a length of 1,2 km and a mean gradient of 0,5%. 2-5 m^3/s environmental flow are lead through the bypass channel. A rock cascade fish pass connects this bypass to the power plant. This channel comprised two arms – a shallower one with installed gravel riffles and a deeper channel for migration. The aim was to re-create a natural alpine stream.

[18] https://plattform-renaturierung.ch/fallbeispiele-wasserkraft/#



Photos: Nature-like bypass channel for fish, and rock-cascade fish pass (both photos Pinja Kasvio)

Photo: Illustration of the restoration area in Ruppoldingen.

According to monitoring, juveniles of grayling have been found in the bypass channel and big fish species like pike, carp, barbel and wels catfish have used it. This suggests that the bypass channel is providing a new reproductive area. The planning and construction of the bypass at Ruppoldingen served as the first example to gain experience for similar constructions in other power plants and especially for the large facilities in Rheinfelden.

Additionally, two alluvial forest areas were created and restored (5,2 ha in the so-called Planie area, and 1,65 ha in the Sandmatten area). The water level in the area above the dam is not kept constant but regulated dynamically in dependence of the Aare flow. 150.000 m^3 gravel were introduced above the dam to mitigate the damming effect and to protect the Boninger Islands with an area of 4.000 m^2. Without protecting measures and lifting them by 2m, these islands would have been flooded by the damming.[19] By means of these restoration measures at the Ruppoldingen hydropower plant, the power company Alpiq received the certification Naturemade "star".

[19] See more detail and pictures in Canton Aargau (2015). 20 Jahre Auenschutzpark. Special Issue 43/March 2015, pp. 78-81.

Case example: Restoration hydropower plant Rheinfelden:

The hydropower plant at the border between Switzerland and Germany had its original concession from 1884 with a duration of 90 years. In 1989, a new concession was granted with the condition to build a new hydropower plant with higher production capacity. A new dam was constructed by 2007 and a new machine station was built. The new hydropower plant officially opened in 2011 with a production of 600 GW/y. Ecological restoration and compensation measures included building two fish ladders and a newly created watercourse for fish migration and as spawning area, resembling in its size and design a typical regional river. This by-pass channel is 900m long and 60m wide (photo).

A special local landscape feature is “Gwild” – the natural limestone formation below the dam where rare moss species grow. A special turbine provides a minimal flow for this habitat. Along the riverbanks above and below the dam, new and diverse habitat structures were created by means of jetties, shallow water areas and gravel banks, and new recreation space was created (new tour path and transition path over the dam).

4.5 Summary

Switzerland does not follow the same implementation and reporting duties as the EU members Austria and Sweden related to directives on increasing renewable energy (EU RES) and the ecological qualities of water bodies (EU WFD). However, the country has set own goals and pursues objectives that are at least as ambitious as their European counterparts. Both the renewable energy targets and river ecology objectives are democratically anchored in the general Swiss public, as documented in public referenda on those topics. Much progress has already been made in terms of establishing the necessary legal frameworks, financing instruments, knowledge bases and fora for dialogue (e.g. Wasser Agenda 21; practice of round tables) for implementing measures aimed at achieving those objectives.

There is, however, still potential to improve the intersectoral integration and coordination at both the state and the cantonal levels between administration of the two main orientations - to restore river spaces and rehabilitate hydropower installations - as well as between renewable hydropower production and improved ecological quality (pers. conv. FOEN and Canton Thurgau June 2018). The Swiss Biodiversity Strategy for example states that “as a result of the more intensive promotion of renewable energies, watercourses – including those previously unused for this purpose – are under increasing pressure due to the growing use of hydropower. For this reason, a cross-sectoral approach should gradually replace the sectoral approach with integrated watercourse management. (FOEN 2012)” This seems to be also specifically relevant in regard to the rehabilitation of small rivers since the OECD (2017) report on the state of the environment for Switzerland recommends explicitly to “consider revising long-standing rights of water use for power that impede rehabilitation of small rivers and designating selected river stretches as being of national importance, thereby triggering the weighing of interests between hydropower development and ecosystem rehabilitation for these river stretches". Along the same lines it calls for considering "the whole range of water-dependent ecosystems when selecting stretches of river and lakeshore for rehabilitation; in particular, foster the role of well-functioning river systems as connection areas within the ecological infrastructure concept called for by the Swiss Biodiversity Strategy". Further, there should be ensured "synergies and coherence between the different river rehabilitation objectives (e.g. in terms of hydrology, flood protection, protection of nature and landscape, farmland improvement); in particular, evaluate the additionality of ecosystem services and the overlap of policy objectives related to the rehabilitation of the Swiss river system" (ibid).

The newly fuelled controversy around minimal flow requirements and their practicability between the hydropower industry and environmental NGOs illustrates also clearly that there is still a more basic discussion needed about how to identify and agree on sustainable solutions for the future that take into account and weigh both climate friendly energy production and monetary values on one hand, and the often non-monetary values of nature and biodiversity in and around watercourses, on the other hand.

5 Sweden

Sweden is among the countries with the largest number of identified surface water bodies in Europe, numbering 23.418 (Drakare 2014), and approximately 1.200 water bodies have hydropower installations (SwAM 2012a). The total number of hydropower plants in Sweden is currently 2.057, but 1.615 have an installed capacity below 10 MW.[20] The total electricity production was 62 TWh/y in 2018 which represents around 40 % of total electricity production in the country (Energimyndigheten 2018). A total of 208 of the hydropower plants with an installed capacity larger than 10 MW produce 94 % of the total hydropower production, while ca. 1.700 plants with capacity lower than 1,5 MW generate only 2,6 %. There are in addition 1.000 dams used for water regulation (Lindström & Ruud 2017). The construction of new hydro plants has largely ceased due to environmental and political considerations, regarding the relatively limited remaining unrealised potential. Future activity is likely to be primarily confined to the modernisation and refurbishment of existing capacity.

Photo: Stornorrfors dam, Umeå. Source: sv.wikipedia.org

A key issue in Sweden, as in Austria and Switzerland, is how to safeguard energy security while preserving and enhancing other ecosystem goods and services. The regulatory frameworks related to these two concerns appear to be in conflict, with overlapping directives, policies and laws. However, recently political efforts are made to reconcile energy- and environmental policy concerns in general, with potentially significant implication for Swedish hydropower and the realization of environmental measures.

Sweden consists of the following five water districts; Bothnian bay, Bothian sea, Northern Baltic Sea, Southern Baltic sea and Skagerak/Kattegat as shown in the following map (**Fig. 13**).

[20] https://www.worldenergy.org/data/resources/country/sweden/hydropower/

Figure 13. *Map of the five water districts used in Swedish water management. Source: Lindegarth et al. (2016).*

Bothnian Bay water district is in the northernmost part of Sweden. The district covers 30 river basins in Norrbotten County and most of Västerbotten County. In the south it borders the Gulf of Bothnia's Water District, whose border runs along the southern boundary of Umeälven and Öre river basins. The total area of the district amounts to almost one-third of Sweden's land area.

The Bothnian Sea water district is located in the middle of Sweden and constitutes about 31% of Sweden's land area and here is about a third of the country's lakes and watercourses. The area extends from Leduån in the north to Dalälven in the south (which is referred to later in this chapter) and thus covers the whole of Jämtland, Västernorrland and Gävleborg County, but also large parts of Dalarna and parts of Västerbottens, Uppsala and Västmanland County. More than half of the district's surface water bodies are physically affected, mainly through changes in flows, the presence of migratory obstacles and changes in form and structure, largely due to the current hydro power production and the fleet management of the time in connection with forest logging.

The northern Baltic Sea water district is the smallest in the area in Sweden and affects seven counties and 74 municipalities. The area stretches from Älvkarleby in the north to Oxelösund in the south and from Kilsbergen in the west to the archipelago in the east and here there live 2,9 million people. In the district there are 1.214 surface water bodies, which include lakes, watercourses and coastal waters. Mälaren 22.600 km2 large catchment area comprises a significant part of the northern Baltic Sea water district. There are also thousands of obstacles within the water district that affect the natural migration path of fish and other aquatic animals. It can be anything from mirror ponds, hydroelectric ponds and road drums that have been installed incorrectly.

The southern Baltic sea water district consists of 10 counties, 91 municipalities and 2,2 million inhabitants and is located in Sweden's southeast corner. it has 30 main catchment areas of which Motala stream, Emån and Helgeån are distinguished as especially extensive for Southeast Sweden. Many of the watercourses have a large socio-economic value; for example, for water outlets for household purposes, industrial purposes and for irrigation and for power production.

The Skagerrag and Kattegat water district is Sweden's westernmost water district and comprises the entire county of Värmland, Halland and Västra Götaland and to some extent Skåne County. The district comprises 772 lakes, 1.671 watercourses, 110 coastal waters and 478 groundwater designated as water bodies.

5.1 Environmental legislation

Sweden adopted new environmental legislation in 1999, the Environmental Code (Miljöbalken; Statute 1998:811), and a new type of legal instrument was introduced: environmental quality standards which are divided into subcategories, each with different sets of indicators. The most relevant to hydropower impacts is Objective 8, “Flourishing lakes and streams”, which has 11 indicators. These existing indicators have, however, been deemed too vague and unsuitable to provide an overall assessment of the current state of Swedish lakes and water bodies, and thus for assessing progress towards water targets (Degerman et al. 2015).

The WFD was transposed into Swedish law, and specifically the Environmental Code, in 2004 through the Ordinance on Water Quality Management. Then the first official planning cycle of WFD implementation (2009–2015) was launched. The five districts had decided on River Basin Management Plans (RBMPs) for all districts, including environmental quality standards to reach water quality objectives for all surface and groundwater resources in Sweden (Lindström & Ruud 2017). The water quality classification system of the WFD was adopted for these environmental quality standards, but until the energy policy accord, was made in 2016 (described in the following section) there remained a profound challenge of finding mutually acceptable solutions to reconcile energy and environmental policy concerns and claims.

5.2 Reconciling efforts between the diverging interests of energy and ecology

The energy policy accord - a long-term agreement on energy between major Swedish political parties was struck in 2016 (Swedish political parties 2016). It cites the central role of hydropower in Sweden's renewable energy generation and points out that high production of hydropower will remain necessary to enable expansion of other renewable sources of electricity production such as solar and wind power which also is triggered due to Sweden's commitments of the EU RES Directive which was implemented in 2009 (Lindström & Ruud 2017). The energy policy accord signals a crucial future role for hydropower in the Swedish and shared Nordic electricity mix – particularly as a balancing source for intermittent supplies of renewable electricity. This reflects the finding that large-scale hydropower is the only feasible option to meet the need for regulation capacity in a future all-renewable Swedish power sector (SEA [Swedish Energy Agency], Svenska kraftnät [the grid regulator in Sweden] and SwAM [Swedish Agency for Marine and Water Management] 2016). However, the energy policy accord stipulates that the hydropower sector must abide by EU requirements such as the WFD and the requirements of introducing "modern" environmental standards (Swedish political parties 2016).[21]

Most of the hydropower concessions active today in Sweden were granted at a time when modern environmental legislation for hydropower generation did not exist (Rudberg 2013). The regulatory reference is the Water Law of 1918, but this was designed largely to enable rapid development of hydropower generation to satisfy increasing industrial demand. This Water Law however, still regulates most of the current hydropower capacity in the country, and permits granted prior to the introduction of the Environmental Code are essentially eternal (Lindström & Ruud 2017). As a consequence, environmental measures proposed in modern hydropower practice–such as minimum flow rates and fish migration passages, are not very common among the active concessions in Sweden. Particularly relevant to this is the interpretation of "good ecological potential" (GEP) which was introduced in the WFD and the Swedish Ordinance on Water Quality Management (ibid).

In 2011, the Swedish government asked the Swedish Agency for Marine and Water Management (SwAM) to initiate a broadly-based national dialogue on the future of Swedish hydropower. As a consequence, a consultative process was initiates involving diverse stakeholders. This ran from 2012 to 2016 to exchange and share perspectives on the current state of hydropower governance and particularly what is needed to make it more ecologically sound.

Another process affecting the governance of hydropower in Sweden was the Water Activity Review (WAR). This included a governmental inquiry regarding new and changed legal frameworks for water activities and it ran from 2012 to 2014. It was carried out by an expert group representing a broad spectrum of actors engaged in hydropower development in Sweden, including representatives of the hydropower industry. The WAR inquiry came in response to EU criticism of a perceived lack of Swedish commitment regarding aspects of implementing the WFD. Its report (Water Activity Review 2014) included some recommendations for the hydropower industry that have proven to be controversial. The WAR recommended that all hydropower plants should be asked to seek new permits in accordance with the Environmental Code, and this should also involve those hydro power plants operating in accordance with licences based in the Water Act of 1918. The WAR recommendation has been interpreted as an environmental demand for minimum flows of water in river systems. This could significantly reduce the potential variability and management of water levels in water storage reservoirs and thus the hydrobalancing capacity. The WAR review also suggested compulsory use of fish ways, which currently

[21] The energy policy accord of 2016 agreement states that the target for a 100% renewable energy mix by 2040 is a "goal not a deadline that forbids nuclear power" and that nuclear generation capacity will not be shut down by a political decision. Nevertheless, hydropower may eventually have to make up much of the shortfall in generation capacity if the phase-out of nuclear power is realized. Nuclear powercurrently accounts for around 41% of Swedish electricity generation – almost equal to the share of hydropower.

only exist in about 10% of Swedish hydropower plants (Jensen 2012). Another recommendation proposed in the WAR inquiry was that hydropower concessions should be time-limited rather than eternal, as is currently the situation.

In 2014, The SEA (the Swedish Energy Agency) and SwAM (the Swedish Agency for Marine and Water Management) jointly published a report called: Strategy for Measures in the Area of Hydropower: Balancing Energy Targets and the Environmental Quality Objective “Flourishing Lakes and Streams” (SEA and SwAM 2014). In this report it was assumed that the EU directives on energy (EU RES) as well as environmental (EU WFD) were of equal importance for Sweden. Meeting the joint policy objectives for environmental quality and renewable energy will demand some far-reaching societal and political decisions. This should be based on open consultation and transparent exchange of public opinions, the report suggested. Based on a system designed to determine the respective energy and environmental values of major Swedish river basins, the proposed national strategy of 2014 aims to provide a framework for prioritization in regulated Swedish river basins. The box below gives a summary of the Swedish national strategy for determining significant adverse effects of mitigation on hydropower.

The Swedish national strategy for measures on Hydropower for determining significant adverse effects of mitigation on hydropower (SEA and SwAM 2014)

A multi criteria analysis method was used, i.e. the energy and environmental values were composed of many different parameters which were combined by using weights. They were based on specific Swedish environmental and energy targets.

In a first step, energy and environmental values were assessed for all catchments in Sweden. For the energy values, they were assessed on individual hydropower plants level and combined into one value per catchment. The used indicators were capacity, production, and regulation capacity. The environmental values were evaluated by a large number of parameters such as present ecological status, number of localities of species of the EU Habitats Directive, amount of protected water, number of river length or lakes in high status, amount of lakes and rivers with functional riparian buffer zone c (altogether 8 of the 11 water quality indicators from the national “Environmental Quality Objective Flourishing Lakes and Streams”). All parameters were normalized and combined using weights. Finally, each catchment was characterized with a value between 0 and 1,0 regarding energy value and conservational value.

In a second step, all catchments were clustered into seven groups[22]. Each cluster group was provided with a strategy regarding environmental measures, but also measures in respect to achieve additional hydropower production and water regulation. In the majority of the catchments, the suggested focus was on reaching good ecological status, whereas in ca. 10 catchments, the regulatory power of the hydropower should be maintained or even increased. In addition, a calculation of hydropower production loss was carried out using the above strategy. The result indicated that 1,5 TWh out of 65 TWh would be needed to implement environmental flows to reach GES and to provide for sufficient water in 1.600 fish passages. The report also suggested that environmental measures in 120 hydropower plants with a production > 10 MW would be limited due the very high value in these energy systems. In these water bodies, the use of HMWBs or even less stringent requirement from GEP might be needed.

By implementing this strategy, only limited adverse effect on total production of regulatory power in Sweden would arise. Some of the production loss might be compensated by efficiency increases in large hydropower plants in HMWBs. *Source: 1) National strategy (in Swedish)* https://www.havochvatten.se/hav/samordning--fakta/samverkansomraden/energi/nationell-strategi-for-vattenkraft-och-vattenmiljo.html

[22] using K-means cluster analysis based on all parameters

A very important reference in the national strategy is the operationalisation of *significant adverse effect* on power production and the need to specify a maximum level. As a consequence, the strategy proposed a thres-hold of 2,3% or 1,5 TWh loss of annual national hydropower power production as a maximum level when measures to improve water quality are taken. Further, these measures also need to take into account and hopefully avoid that there is no major disturbance to delivery of regulation and balance power. The calculations underlying the suggested 1,5 TWh threshold were based on simulated power production losses from different typical environmental measures. This suggested cap implied that strategic reasoning is needed when implementing environmental intervention measures. Thus, those river basins of less importance to the energy system and with lower energy values, should be prioritized for environmental measures.[23]

In 2016, SwAM published a Guidance for Heavily Modified Water Bodies with Application to Hydropower (SwAM 2016a). It builds on work under the Common Implementation Strategy (CIS) for the Water Framework Directive and European Commission Guidance Document 4 on the Designation of HMWBs (European Commission 2003a). This Swedish guidance document suggests **five steps A - E** as part of a unified approach to identify HMWBs and consequently how to assess Good Ecological Potential, as illustrated in the conceptual model Fig. 14[24].

[23] More info on the strategy can be found (in Swedish): https://www.havochvatten.se/hav/uppdrag--kontakt/publikationer/publikationer/2014-07-04-strategi-for-atgarder-inom-vattenkraften.html

[24] More info on the HMWB guidance can be found (in Swedish): https://www.havochvatten.se/hav/vagledning--lagar/vagledningar/vattenforvaltning/om-vattenforvaltning/kraftigt-modifierade-vatten/vagledning-om-kraftigt-modifierade-vatten.html

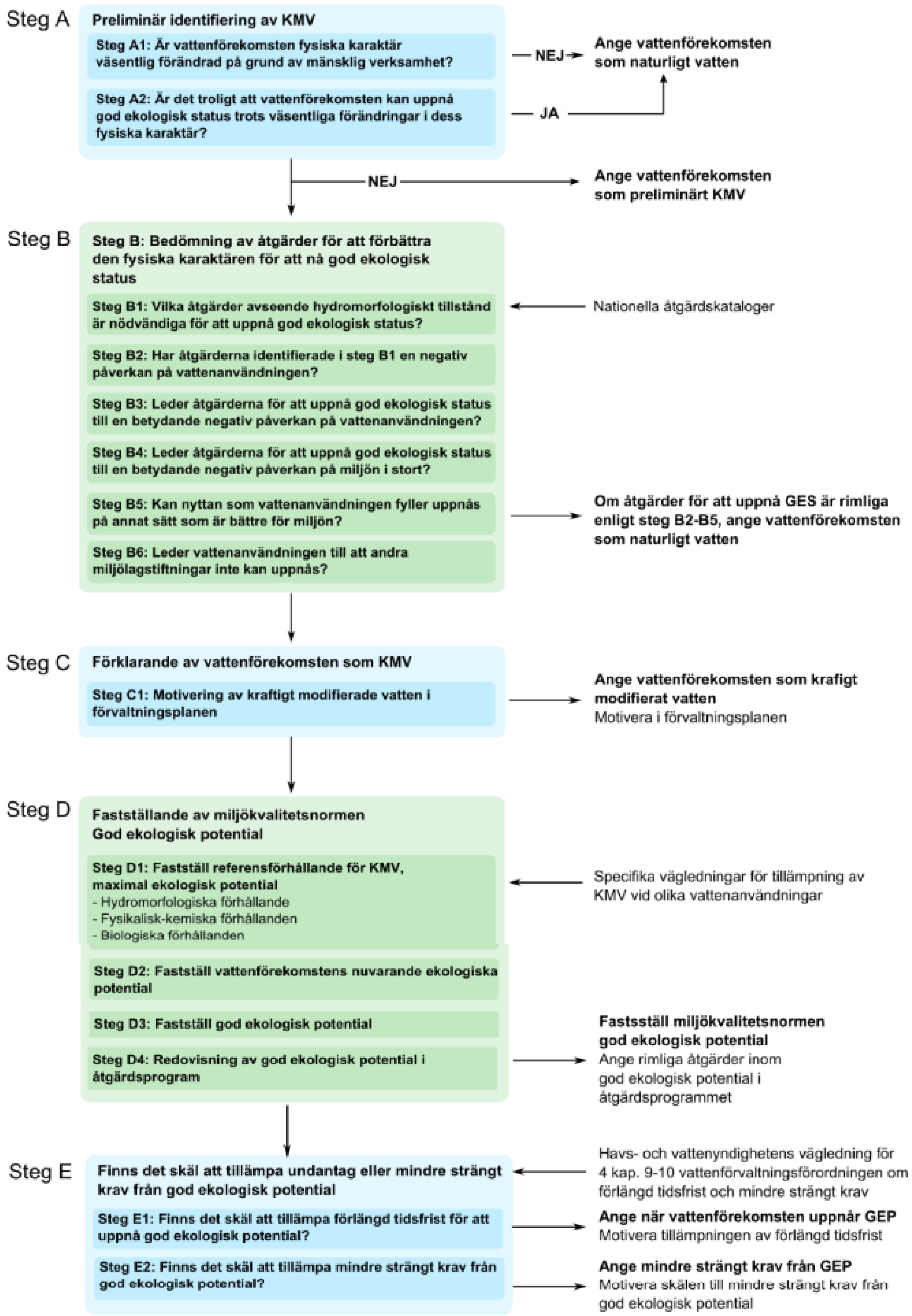


Figure 14. *Conceptual model with five suggested steps to identify HMWBs and assess GEP. Source: SwAM (2016a).*

With a current assignment of 4%, Sweden has among the lowest ratio of designated HMWBs compared to total water bodies in the EU (Fortum Generation AB 2015, Kampa et al. 2011), and all current HMWBs are of moderate ecological potential (OECD 2014). It is therefore likely that the option of designating water bodies as HMWBs due to hydropower, is underutilized in Sweden (Lindstrom & Ruud 2017)

SEA and SwAM built further on the strategy for hydropower, as proposed in 2014, by addressing some remaining issues in a new document published in December 2015 that suggested how the review processes for hydropower operating licences can be harmonized with modern environmental requirements (SEA & SwAM 2015). The document also provided suggestions for how this revised process can be financed (Lindström & Ruud 2017). The suggested timeframe for when all Swedish hydropower should be brought up to modern environmental standards, in line with EU standards and with regular check-ups at the end of each six-year cycle of WFD implementation, is 20 years. In many regards, the proposal addresses many of the elements highlighted in the WAR review, but at the same time it makes some different recommendations.

As elaborated by Lindström & Ruud (2017), the strategy for hydropower proposed that individual reviews should be carried outreflecting the specific water-using activity (e.g. hydropower plant) and local conditions. Further, it also recommended that although existing permits can be subject to complete reassessment, it would be most efficient only to review their conditions. However, specific conditions must be added – given that they do not already exist, that would allow - if found necessary - to decommission the hydropower plant. It also recommended that the scope of the review should not be determined solely by the applicant (i.e. power plant operator), but that the supervisory authority should be able to influence it. In contrast to the WAR review, however, the SwAM-SEA proposal of 2015 recommended that it should be possible for new environmental requirements to be added to existing permits, except in areas covered by a new review, where they would be superseded or complemented by new permits. A final decision on the question whether it will be the case that environmental requirements can be imposed on all existing hydropower concessions, is currently pending. It is expected that the so-called national plan drawing directly on the proposed strategy for hydropower of 2015 as well as the SwAM-SEA proposal of 2015, will be accepted by the Swedish government in fall 2019.

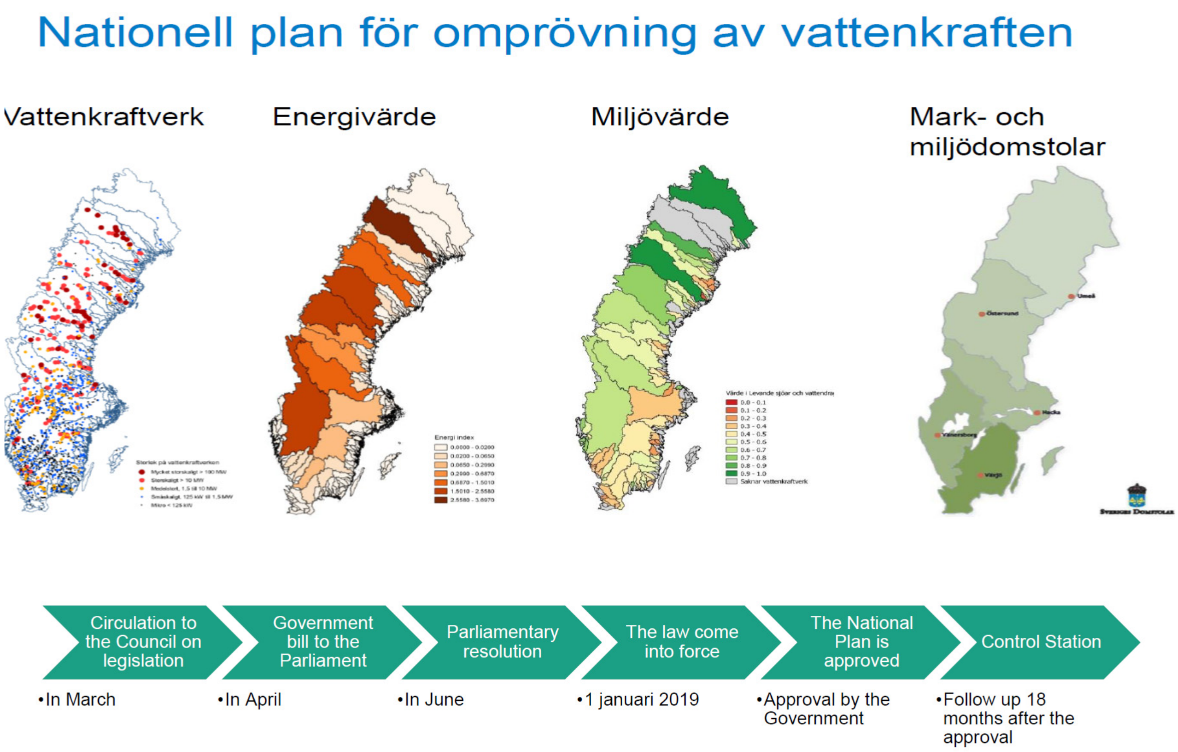


Figure 15*. Illustration of the Swedish National Plan for modern environmental standards and hydropower. Source: Svenske Energimyndigheten & HaVS (2018).*

5.3 The challenge of funding

The 2015 policy proposal from SwAM-SEA recommends a financing approach that will share the costs related to environmental measures needed to achieve required ecological status between the state, the affected producer and a special fund established jointly by hydropower producers (Lindström & Ruud 2017). These costs will reflect both costs of actual implementation, any needed structural changes to the power plant, and loss of revenue due to any reduction in power generation that is accepted within the suggested cap of 1,5 TWh. The total assessed cost or loss to the hydropower industry was subsequently assessed to 13 billion SEK, of which one-quarter each would be financed by the state and the special fund, while the remaining half would be funded by the hydropower industry (ibid).

Under existing legislation, the industry is protected from shouldering costs corresponding to a production loss above 5%, and the state should cover any costs exceeding this limit, along with 85% of “tear-down” costs (e.g. removing physical structures that hinder environmental flows and fauna passage) in existing installations. The proposal of 2015 recommended keeping this rule until alternatives are further explored. Although establishment of the special fund might be seen as removing the need for this protection, the hydropower industry argues that it should remain in place in case the fund should collapse for any reason (Swedish Hydropower Association 2015b).

In the key agreement struck between major political parties about Sweden’s long-term energy development in 2016, Lindström & Ruud 2017 confirm that hydropower producers should carry costs related to legal and relicensing procedures. The same agreement concluded that the property tax imposed on hydropower producers should be lowered stepwise, starting in 2017. This action attempts to free up capital for hydropower producers enabling them to better manage the costs of implementing modern environmental standards (Swedish political parties 2016)

As a direct consequence of the political energy accord in 2016, legal changes were made on June 13, 2018 to seek environmental mitigating measures in Swedish hydropower sector. In parallel, based on the 2015 proposal, the industry pursued a specific funding scheme. This was announced in April 2018 – Vattenkraftens miljöfond.

Figure 16. *Vattenkraftens miljofond as presented by Svenske Energimyndigheten og HaVS 2018.*

Eight major hydropower producers representing 95% of the production capacity have signed this agreement to establish an environmental fund to make environmental mitigating measures possible (**Fig. 16**). A total of 10 billion SEK is included in the fund which will be operational in the coming 20 years.[25]

However, the actual implementation of the fund depends on the national plan (**Fig. 15**) which currently is being developed. This is also related to regional efforts that for instance have been made in Dalälven in which concerns for energy and environmental have been negotiated in a proposed mitigation plan.

5.4 Status of implemented measures

The national hydropower strategy presented in 2014 as well as the SwAM-SEA proposal of 2015 both emphasized the need for balancing environmental mitigating measures with the value of energy and electricity provision and the need for making these considerations and assessments at the national level. In addition, the importance was emphasized to keep in mind the balancing capacity provided by hydropower in times when new intermittent renewables like wind power are being realized. Hydropower is important to safeguard the security of supply – also in times when nuclear power is under scrutiny.

The national strategy established a planning target of limited energy losses to 2,3% or around 1,5TWh. In the regional initiative coordinate by the county council of Dalarna, this planning target was also used as an instrumental reference for the proposed mitigating measures. The national strategy divided Swedish watercourses in six groups given an assessment of the balancing of energy versus environmental values in which Dalälven was placed in group 3 among the rivers assessed for energy and environmental values (group 1 has the highest energy value). Still, there was a need for regional analyses and a pilot study was proposed.

[25] Further info in Swedish: https://vattenkraftensmiljofond.se/

Case example: Environmental efforts in the Dalälven:
The County Governor of Dalarna took the lead to coordinate the efforts which ended in a proposed mitigation plan for Dalälven. This was developed together with the other relevant county governments of Uppsala and Gävleborg and the major hydropower companies involved in Dalälven; Fortum and Vattenfall. The aim was to strengthen regional collaboration, to develop feasible methods to prioritize measures and to propose mutually beneficial mitigating measures balancing energy and environmental concerns and commitments.

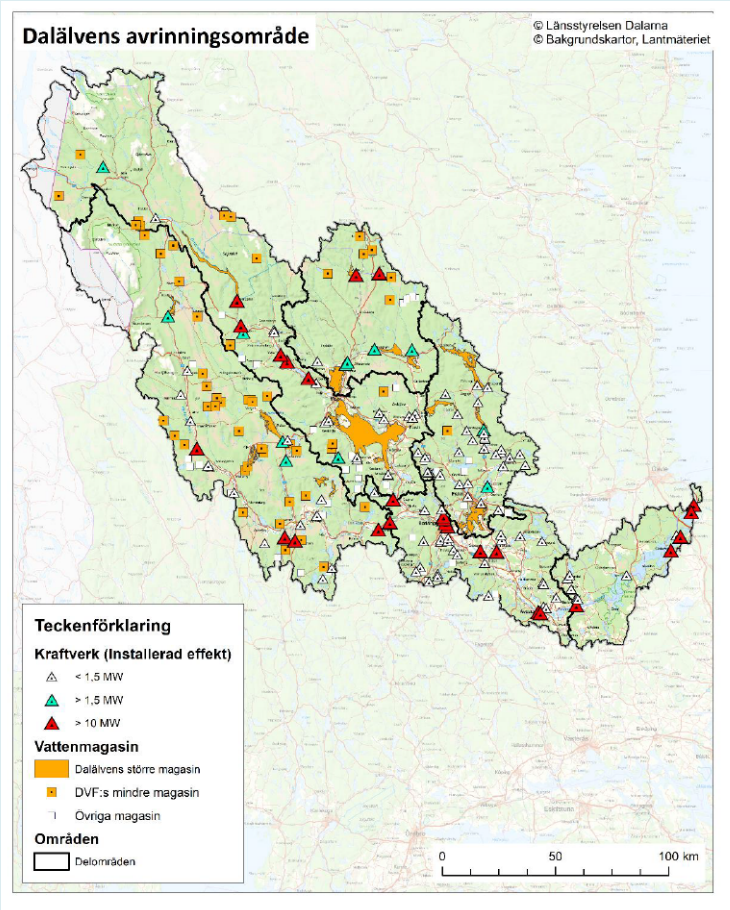


Figure. 16. *Overview over Dalälvens hydropower plants and regulation reservoirs. Source: Länsstyrelsen Dalarna/Bakgrundskartor, Lantmäteriet (https://www.havochvatten.se/download/18.4c271c50163bf560e38305f3/1528104186791/pp-9-hallbar-vattenkraft-i-dalalven.pdf)*

A core reference through the project – which lasted from 2015 - 2018 – has been dialogue and efforts to strengthen collaboration between stakeholders who traditionally have not been very involved in exchange and discussion of opinions. There was a basic need to establish a better base for mutual understanding and hopefully more trust among traditionally conflictual themes. Around 10 working groups addressed specific challenges in which a lot of resources were used to develop joint knowledge and mutual acceptance of core challenges along and within the river of Dalälven.

The final outcome, published in 2018, presents a number of consolidated mitigating measures[26]. This is illustrated in Fig. 17:

***Figure 17**. Strategy for implementing environmental measures for hydropower in Daälven. Source: Länsstyrelsen Falun (2018).*

A number of measures was identified in which environmental values were assessed towards energy losses. The chosen procedure was first to identify the environmental values and whether and to what degree hydropower was causing damage. Based on this assessment, the identification of potential measures were done and sorted in various mitigating package proposals. These packages were then related to the environmental values and whether proposed measures would actually make improvements and to what cost particularly in terms of needed increase in hydrological flows.

Based on these assessments, discussions were made in working groups consisting of various stakeholders in which priorities were made. The outcome was a total of 45 measures for the Dalälven. These include a number of proposed projects to increase connectivity for fish both through more water coverage as well as higher water flows. New breeding grounds were also identified as well as locally specific hydro-peaking to stimulate reproduction and survival. A general management plan for short term hydropeaking was also proposed to take into account recreational interest and other environmental and cultural needs along the Dalälven.

[26] More details on specific measures and the regional process at large, can be found at: http://www.dalarnasvatten.se/Sv/hallbar-vattenkraft/Pages/default.aspx

A governance council has been proposed both to coordinate the implementation of the formulated measures and to enable further assessment when necessary. However, the actual realization of these measures depends on the national plan (**Fig. 14**) for retrial, court decisions and implementation of the new funding scheme which still is pending.

5.5 Summary

During the last decade, the hydropower sector has been under intense scrutiny in Sweden (Lindström & Ruud 2017). Rather recently, however, regulatory and government agencies, diverse interest groups and the hydropower industry have engaged through consultations in a reform process that is likely to change the current modus operandi of Swedish hydropower governance. This discussion is particularly focussed on finding mitigating measures of combining energy and environmental concerns. A crucial concern has been to understand and agree on the maximum acceptable loss to the energy system from hydropower due to environmental mitigating measures. This achievement has been made by the national strategy (SEA & SwAM 2014), and this has been a major step towards possible implementation of environmental improvements in line with the commitments of the EU WFD. The proposed cap on production capacity loss of 1,5 TWh is a core reference point to initiate the current national plan, taking into account actual hydropower plants, the energy production, environmental values and the actual regulatory agencies to enable and realize the wanted hydropower changes (Lindström & Ruud 2017).

Simultaneously, concerns are still remaining with respect to the commitments of the EU RES Directive. When the negotiating boundaries are better known as the threshold of acceptable production loss is specified, it is easier to design suitable adjustments and measures in specific regulated and impacted rivers. This proposed threshold was also instrumental in the proposed plan of Dalälven. At this stage, however, no final decision has yet been made on what the cap would be on specific production losses in specific water courses, but there are clear expectations that mutually beneficial outcomes will be created thanks to the national energy policy accord of 2016 as well as the established environmental fund proposed by the major hydropower companies in Sweden.

6 Added value and funding schemes for environmental mitigation measures through eco-labels for renewable energy

Besides novel public funding possibilities, we identified in our case countries examples of eco-labels as private, market-based instruments as an interesting and rather novel source for funding of environmental mitigation measures in hydropower impacted watercourses beyond legal requirements. In addition, eco-labels have potential to create added value for producers and suppliers, as well as benefits to consumers and regulators. They should not be confused with, but instead can be combined with the so-called “Guarantees of origin” (GoO) - the existing European system for tracking certificates that ensures the traceability and guarantees the origin of electricity generated from renewable energy sources (Pwc 2009) (see section 6.1.).

There exists a range of renewable or “green” electricity product types that include besides environmental or eco-labels also environmental claims and environmental product declaration. A general classification can be found within the standards of the international organisation for standardization (ISO):

- **Environmental labels or eco-labels** are defined by the standard ISO 14024 as “voluntary systems operated by a third party organisation, which allows the use of a specific environmental label on products (such as electricity products) that comply with certain ecological criteria”. The labelling body must be a third party, meaning a person or body that is recognised as being independent of the supplier (“first party”) and purchaser (“second party”) interests. The labelling body establishes environmental criteria assessing the environmental performance of the product during its life cycle. The aim is to differentiate environmentally sound products from others in the same product category, based on a measurable difference in the environmental impact. It is important that environmental labels should demonstrate transparency through all stages in order to achieve credibility among the consumers.

- **Environmental claims** are statements or symbols that indicate an environmental aspect of the product (such as green electricity, eco-electricity or even 100% hydropower) commonly used to indicate less environmental impact than a standard product. In the case of electricity, such products are usually production-declared electricity, such as wind or hydropower, commonly marketed under a brand. In most countries, there is no specific law concerning environmental claims on electricity. However, the legal restrictions are specified in national marketing laws which usually comply with the guidelines issued by the International Chamber of Commerce (ICC). (ISO 14021)

- **Environmental product declarations** provide, similar to labels, standardised information about the environmental impact of a product; however, the actual assessment of the product is left to the consumer. (ISO/TR 14025) (Pwc 2009, Willstedt & Bürger 2006)

The renewable energy products that we found in our case studies to be highly relevant for further analysis and of potential benefit for larger-scale employment in the Norwegian hydropower sector belong all to the first group of environmental labels/eco-labels. We will therefore focus specifically only on this type. Before we describe in more detail the specific eco-labels in use in our two case study countries Sweden (Bra Miljöval) and Switzerland (Naturemade), we will give a short summary of the state of art on GoO as they are related to the granting of eco-labels. Thereafter, we give a short list of a variety of European eco-lables and a comparative overview of the sustainability aspects that they consider.

6.1 Tracking certificates for renewable energy – Guarantees of Origin

The EU RES[27] came into force in June 2009 as part of the EU energy and climate change package. The Directive states that Guarantees of Origin (GoO) should prove to the final customer that a given quantity of energy was produced from renewable energy sources. They are market-based instruments intending to increase the market momentum for renewable energy. The tracking system GoO was established to trigger greater environmental awareness, provide customers with an opportunity to choose renewable energy and signal this choice to the market. They provide credible and verifiable documentation for a sustainability report or an environmental audit, and to help stimulate further renewable energy production. In addition, they give power producers an extra income source, making it even more appealing to build more renewable energy production (ECOHZ 2018).

GoO for renewable energy have become obligatory for all EU member countries through the EU RES, and the Norwegian parliament endorsed the GoO system when ratifying the new Energy Bill on June 13th, 2016. They are traded, documenting the electricity delivered or consumed and managed in an electronic certificate registry. The standardized system aims to make it easy to track ownership, verify claims and ensure that GoO are only sold once, and that there is no double counting. The national Guarantee of Origin registries are run by state appointed entities such as regulators or grid operators. (EKOenergy 2018, ECOHZ 2018)

The EU regulation and particularly the steep price development of GoOs as demonstrated in figure XX from Oslo Economics report 2018-30 to the Ministry of Petroleum and Energy, has motivated a number of commercial initiatives enabling consumers to choose energy labels verifying that the electricity supplied is renewable. Since October 2016 have prices of Norwegian GoO of the type "Large Nordic Hydro" significantly increased by more than 600 % from the average price of 0,26 EUR/MWh to 1,65 EUR/MWh in the period from October 2016 until October 2017. Since 2006 the price has varied substantially and is now on a historical peak. The very strong increase in 2018 can partially be explained by reduced offer of GoO from hydropower due to low amounts of precipitation and possibly also speculations related to the new renewable energy directive proposal that could cause a higher demand for GoO, in general[28]. (OE 2018)

Figure. 18. *Price development (EUR/MWh) for GoO from Norwegian hydropower based on data from ECOHZ, interviews and Oslo Economics. Source: Oslo Economics (2018).*

[27] The Directive 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources.
[28] OE (2018) describes a range of factors of uncertainty related to future price development and their potential effects in section 6 (pp. 30-34).

However, beyond the concern and the focus on renewable energy production through GoO, there are efforts of developing voluntary eco-labels that require - in addition to GoOs - that the hydropower electricity adheres to other environmental standards and even social concerns. Some of these eco-labels include additionally financial support schemes for the further promotion of renewable energy production as well as additional funding of environmental mitigation and restoration measures that are of specific interest for this study. Two such eco-labels are Bra Miljöval and Naturemade star that originate in our case study countries Sweden and Switzerland. Before we will describe them in more detail, however, we will clarify the existing spectrum of certification criteria.

6.2 Certification criteria of eco-labels

There is a variety of eco-labels covering a wide spectrum of certification criteria - or sustainability criteria - that can be combined with GoOs for renewable hydropower energy to address environmental and social concerns in the impacted watercourses. In addition, there are certain criteria referring to the process of the certification. As shown for the examples Bra Miljöval and Naturemade star, eco-labels can additionally encompass financial support schemes for both more renewable energy production and environmental measure implementation.

6.2.1 Sustainability and process criteria of eco-labels

The broad international comparative study by Pwc (2009), mentioned earlier, gives a good overview over the wide range of sustainability criteria that have been found included in eco-label schemes (**Fig. 19**). According to these criteria, 19 eco-labels for hydropower energy were compared. Besides sustainability criteria there are certain criteria referring to the process of certification (**Fig. 20**). Both types of criteria are listed below.

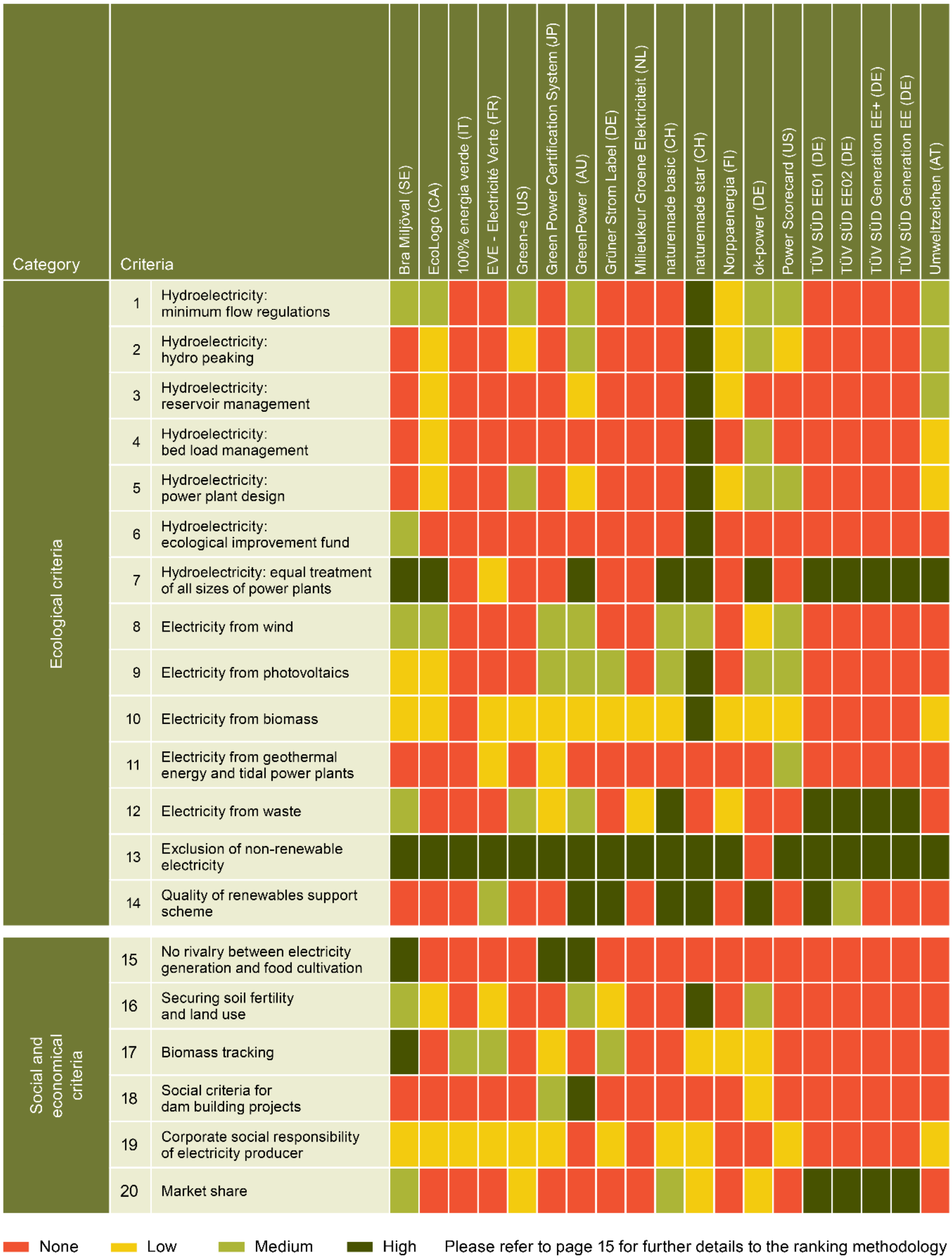
No.	Title	Details
1	Hydroelectricity: minimum flow regulations	Ensures a discharge regime that closely reflects the natural characteristics of the river system involved (such as preventing any unnatural isolation of fish and invertebrate fauna, guarantee connectivity of river systems and others). For a detailed description see the study "greenhydro".
2	Hydroelectricity: hydro peaking	The aim here is to prevent negative effects of discharge fluctuations and to concentrate on its moderation (such as to avoid organisms getting stranded). For a detailed description see the study "greenhydro".
3	Hydroelectricity: reservoir management	Concentrates on the ecological management of large annual storage reservoirs, river impoundments and sand traps. Includes for example the avoidance of sudden flushing. For a detailed description see the study "greenhydro".
4	Hydroelectricity: bed load management	The aim of ecologically based bed load management is to establish regulations to ensure that the budget of solid materials is geared towards the natural characteristics of the river involved (such as to enable sediment transport, channel re-arrangement and so on). For a detailed description see the study "greenhydro".
5	Hydroelectricity: power plant design	Deals with the design of the technical installations: The aim is to avoid emitting toxic lubricants, damaging organisms in turbines or mechanically disturbing sediment transport. For a detailed description see the study "greenhydro".
6	Hydroelectricity: ecological improvement fund	Ecological and sustainable operation of hydroelectric plants is linked to high investments. Is it necessary to establish a fund for ecological improvement measures for the plant's surroundings? If so, how big are the payments and what are the rules for the use of them?
7	Hydroelectricity: equal treatment of all sizes of power plants	Usually small hydroelectric plants are treated as inherently ecological. This is a misinterpretation as one can only speak of a reduction of environmental impairment compared to a "normal plant". This criterion looks at whether there is equal treatment of small and large hydroelectric power plants (including special criteria for small plants, threshold
13	Exclusion of non-renewable electricity	Evaluates if renewable energy sources alone are eligible for certification, such as the exclusion of fossil powered CHP.
14	Quality of support scheme	The label's contribution to increasing the electricity production from renewable energy sources is analysed (and the different schemes are described in the label reports). Criteria for the support scheme are evaluated; these might be the object of the support scheme (new plants or efficiency), quota for building new plants, if calculations concerning the effectiveness of the support schemes exist.
15	No rivalry between electricity generation and food cultivation	Evaluates criteria used by the label to ensure that biomass used for electricity generation does not come from arable land that should be used for food production.
16	Securing of soil fertility and land use	Evaluates criteria regarding soil fertility, sustainable land use, exclusion of genetically modified organisms, obligatory FSC certification for wood and safeguarding of biodiversity.
17	Biomass tracking	Usually the trade in biomass passes through numerous hands. Declaration of the origin of the biomass and tracking systems that record the whole process from production to consumption are evaluated.
18	Social criteria for dam building projects	The WCD Guidelines serve as the standard to analyse the label's criteria. The guidelines require: efforts to gain public acceptance for the dam project, the assessment of alternatives to the dam projects, improvements to existing dams, sustaining rivers and livelihoods, recognising the rights of people involved and sharing the benefits of the dam project with them, ensuring compliance with governmental regulations, respecting transboundary issues for rivers and their role for peace, development and security.
19	Corporate social responsibility of electricity producer	Evaluates criteria for social responsibility, such as obligations for an environmental management system, if sustainable provision and efficient use of energy is part of corporate policy, if the enterprise applies the ILO conventions, protection of cultural assets and landscapes or human heritage, improvement of health and safety issues for local population, working conditions, poverty alleviation, improvement of access to essential services and educational offers for local society.
20	Market share	Market share serves as a proxy for economical sustainability as few suitable criteria were available for the labels. Market share = division of "the amount of renewable electricity labelled by a label" with "the total renewable electricity produced in the same country". The rationale of this criterion is that the basic function of a label is to provide a potential consumer with distinctive information about a product. A label serves as a tool to reduce complexity in a market for every single consumer and therefore lowers the transaction costs. A label with a big market share lowers the transaction costs of many consumers and provides economic value.

Figure 19. *Sustainability criteria related to hydropower employed in eco-labels. Source: Pwc (2009)*

No.	Title	Details
1	Representation of industry	Representation of key players in the electricity market in the responsible labelling body is evaluated. The presence of electricity producers and suppliers is seen to be beneficial.
2	Representation of pressure groups	Representation of electricity market's pressure groups in the responsible labelling body is evaluated. The presence of public authorities, consumer organisations, environmental organisations or social organisations is seen to be beneficial.
3	Guarantee of legal compliance	Evaluates whether the label complies with the requirements for an electricity generator as a prerequisite for labelling eligibility and that the use of the label by suppliers and producers is based on a contract.
4	Audit by independent third party	Evaluates if the label is audited by an independent third party.
5	Periodical revaluation of certification	Evaluates if there is a time limit on the validity of the certification and if there are processes in place for controlling audits and re-certification.
6	Declaration of origin	Evaluates if the electricity can be traced back to the generating plant.
7	Avoidance of double counting	Consumers must be sure that the added value they are paying for is exclusively reserved for them. The processes are evaluated that guarantee that the labelled electricity produced exceeds, or at least is equal to, the labelled electricity sold (such as via a balancing system).
8	Regulation for deficit in supply	Evaluates the rules for a deficit in supply (such as prohibition of deficit in supply, compensation within a certain time period, allowed deficit limited to a certain percentage and so on)
9	Only net energy permitted	Evaluates criteria requiring electricity generators to subtract their own electricity consumption and losses at the generation plant from the amount of certified electricity, such as by subtracting pumping electricity.
10	LCA verification	Evaluates if the label requires calculations based on LCA that define maximum eligible threshold values for the gobal impact of the energy systems (such as the Eco Indicator 99).
11	Availability of information on electricity quality	Evaluates criteria concerning the obligation to inform consumers, such as if the origin of the electricity is communicated to the end consumer, if the consumer can choose between electricity of different origin, if the consumer receives information on the added value of the certified electricity and an annual report.
12	Communication and availability of criteria	Evaluates if the label's criteria are publicly available (for example on the web site).
13	Protection of consumer rights	Evaluates the guarantee of availability for the contracted electricity, terms of cancellation for the supply contract between supplier and customer and obligation of the electricity supplier to communicate about the use of the logos and wording of agreements.

***Figure 20**. Process criteria. Source: Pwc (2009)*

The ranking of both types of criteria for all 19 assessed labels is shown in **figur 21**.



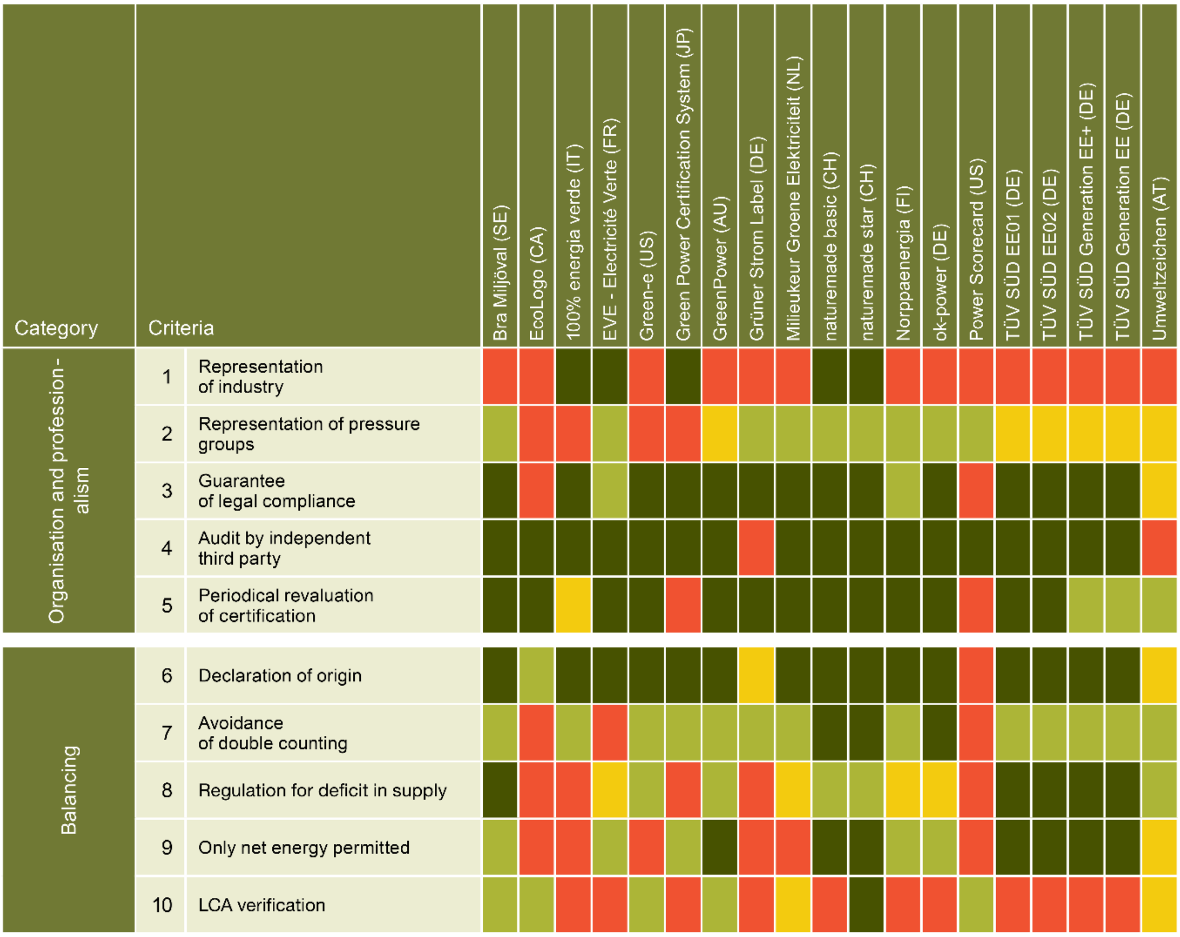


Figure 21. *Ranking of sustainability and process criteria in the sample of eco-labels in the Pwc (2009) report.*

Only the eco-labels Naturemade star and Bra Miljöval have associated requirements for an ecological improvement fund. In the following will we give more detail on these two eco-labels.

6.3 Bra Miljöval[29]

Bra Miljöval was established by the Swedish Society for Nature Conservation (Naturskyddsforeningen) during the 1980s as an effort of labelling and certifying environmentally proven selected food products sold in super markets. Later, the eco-labelling has been extended to other goods and even services. Currently this ecolabel is applied on biofuel, district heating, insurance, cosmetics, chemical products, textiles, transport services of goods, super market products, mobile subscriptions as well as provision and supply of electricity.

In 1996, with the liberalization of energy markets in Sweden, new, more market-based options for electricity sales were created and the Bra Miljöval ecolabel was extended to provision of electricity. The first guidelines were introduced to verify the provision of eco-labelled electricity from renewable sources including hydropower. The discussion within the Swedish Society for Nature Conservation, however, on whether or not to include hydropower was intense. In line with the historically strong concern and skepticism on environmental impacts caused by hydropower, many argued strongly for not including

[29] Based on oral and written information provided by Jesper Peterson (Bra Miljöval) as well as information available at https://www.naturskyddsforeningen.se/bra-miljoval.

hydropower at all. However, a compromise was sought. Acknowledging the economic value as well as the provider of energy security, hydropower was included. However, no new projects and installations set up after 1995 would be eligible for ecolabelling. The focus was merely on already existing plants and regulations and efforts were made to strengthen environmental mitigating measures in impacted water courses.

The guidelines for eco-labelling electricity supplied from hydropower was further specified and strengthened in 2001 when efforts were made of connecting environmental mitigating measures to energy efficiency goals. This is also manifested in the guidelines introduced in 2001 underlining that district and solar heating and bio fueling could be better and cheaper sources for heating purposes than electricity. Still, the eco-labelling was further promoted.

As part of the eco-labelling, a funding scheme was introduced by the Swedish Society for Nature Conservation. A share of the traded hydropower electricity is to be allocated to a funding mechanism which aims at addressing negative impacts caused by hydropower production. Environmental measures were not limited to negative impacts caused by the certified powerplants supplying the eco-labelled electricity. However, efforts should be initiated within 6 months of being granted an eco-labelling licence. The current procedures of granting eco-labels and allocating means to the funding schemes was finally revised in 2009 when the financing mechanisms, auditing procedures and verification mechanisms were further specified. The Bra Miljöval criteria are performance-based, and certain conditions must be approved before granting a certification. For the concrete certification criteria see:
www.naturskyddsforeningen.se/sites/default/files/dokument-media/bra-miljoval/El/elkriterier%202009_4.pdf

The guidelines were revised and strengthened in 2002 and the volume of certified electricity dropped significantly in the subsequent year. It lay by ca. 3,7 TWh in 2004 and increased in the subsequent years. In 2011, 8 TWh electricity were certified and, according to Naturskyddsföreningen, the volume in 2017 was 9,3 TWh[30] (see **Fig. 22**).

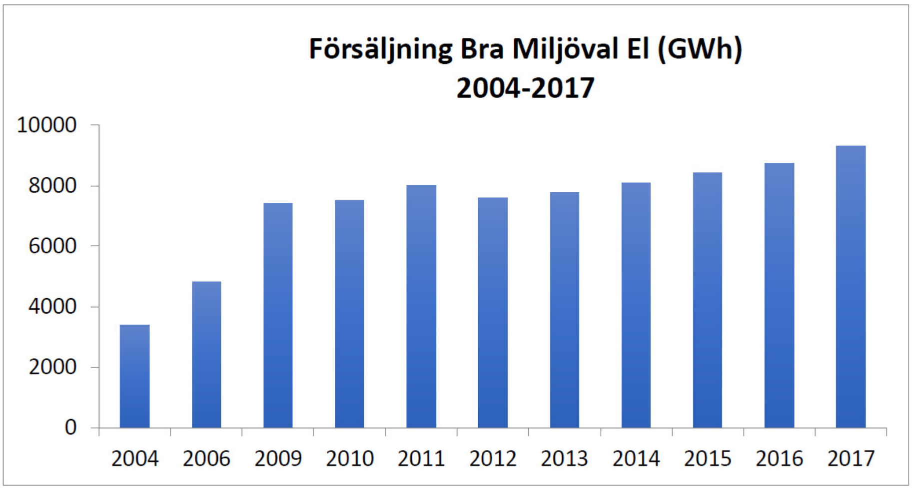


Figure 22*. Historical sales of Bra Miljöval energy (GWh). Source: Naturskyddsföreningen (2019)*

A total of 15 persons are working on the different labels of which four are particularly concerned with energy. This is related to the general certification and verification, to the environmental fund, but also on energy efficiency which has been sought interested as part of granting ecolabel to electricity

[30] Skype interview on October 11, 2018

producers. The idea is to motivate the producers also to take a more active stance in promoting energy saving among those demanding the certified electricity provided.

The Swedish Society for Nature conservation got the invitation to join EKO Energi, but decided to remain committed to their own eco-label and funding scheme.

6.3.1 Current activities

A total of 170 projects have been funded by Bra Miljöval of which almost all are located in Sweden (**Fig. 23**). Beyond these – as illustrated below, one project is located in Finland with the focus of re-establishing the connectivity for salmon in the Oulu river.[31] Three projects are realized in Norway in dialogue with Agder Energi[32] and BKK[33], while as many as 166 projects are located throughout Sweden.

***Figure 23**. Overview over projects financed by Bra Miljöval.*
Source: https://www.naturskyddsforeningen.se/bra-miljoval/miljofond)

One project is directly related to the regional planning that took place in Dalälven, the project "Liv i Nedre Dalälven" initiated in 2015 and finalized in 2018. In this project a comprehensive analysis has been undertaken to assess the opportunities for increased connectivity – particularly for salmon.[34] Other projects have focussed on eel and biological diversity more in general. These studies were included in the assessment of the 45 mitigating measures proposed in the Dalälven and are currently an input and reference to the national plan currently undertaken in Sweden to reconcile energy and environmental concerns related to hydropower.

[31] More info: https://www.naturskyddsforeningen.se/sites/default/files/fondkarta_rapporter/ouloujoki_rapport.pdf

[32] More info in Norwegian: https://www.ae.no/konsernet/renewables/bra-miljoval/

[33] More info in Norwegian: https://www.bkk.no/vannkraft/nye-miljoetiltak-i-teigdalselva

[34] More info in Swedish: https://www.lansstyrelsen.se/download/18.6ae610001636c9c68e555bee/1531294561506/LIV_laxfisk_nedre_dalalven.pdf

The project will carry out an overall fish biological analysis of Lower Dalälven with its many power plants and ponds. It intends to investigate the water system's potential for fish reproduction with the current water content. The project area extends from Älvkarleby up to Näs power station.[35]

6.4 Naturemade – Swiss certification for energy from renewable and environmentally sound sources

The **Naturemade** certification is sponsored by the Swiss Association for Environmentally Sound Energy (VUE), established in 1999. Its members are environmental and consumer organizations, companies and organizations from the energy sector, small and large consumers of renewable energy[36]. Naturemade`s official partner is SwissEnergy, a program within the Swiss Federal Minstry of Energy for the promotion of renewable energy, founded by the Swiss Federal Council in 2001[37]. All member categories of VUE are represented on the VUE Board[38]. There is an executive office of VUE in Zurich that has been managed by Brandes Energie AG since 2001[39]. Currently, certification guidelines exist not only for hydroelectric power (pumped storage and run-of-river power plants, drinking water and waste water power plants, reserved-flow turbines) but also photovoltaic systems, wind energy and energy from biomass (green waste, wood, agricultural biogas, sewage gas, vegetable oils).

The VUE members have subscribed to a common goal - to promote new renewable energies and environmentally friendly energy products to help protect the climate and the environment. A relatively concrete objective is to see Switzerland supplied by 100% renewable eco-energy by 2050, applying to both energy production and the supply mix.

The Naturemade label is granted on to levels – "Naturemade basic" and "Naturemade star". Both are labels for energy from 100% renewable sources, but only Naturemade star is ecological (eco-) energy.

naturemade basic ! *Renewable*

The **Naturemade basic** quality label is awarded for electricity and heat from 100% renewable sources; under this label, mainly large hydroelectric power plants and waste incineration plants are certified. The purchase of Naturemade basic-certified energy helps fund the construction of new eco-energy plants.

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[35] More info in a Swedish summary: http://www.naturskyddsforeningen.se/sites/default/files/fondkarta_rap-porter/livNedreDalalven_rapport.pdf . The full report – also in English at: https://www.lansstyrelsen.se/down-load/18.7ab1493f1677d97be13200f/1544189077526/LIV_laxfisk_nedre_dalalven_ny.pdf

[36] Association membership categories:

- Electricity producers "Hydroelectric power plants" and their associations.
- Producers "New renewable energies" and their associations.
- Energy suppliers, energy traders and their associations.
- Environmental organizations.
- Small consumers' associations.
- Large commercial consumers and their associations.

[37] More info about the SwissEnergy program can be found at: www.bfe.admin.ch/energie/00458/index.html?lang=en

[38] https://www.naturemade.ch/en/vorstand.html

[39] https://www.naturemade.ch/en/geschaeftsstelle.html

naturemade star ! *Ecological energy*

The **Naturemade star** quality label is awarded for energy generated through particularly environmentally friendly processes. Naturemade star eco-energy comes from 100% renewable sources, and the label certifies that further stringent, comprehensive environmental conditions are met. Certification of energy generation under the Naturemade star label takes the natural environment, i.e. the plant and animal species living around power plants, into particular account. Environmental protection and upgrades are of particular importance when using hydroelectric power, which is why hydroelectric power plants to be certified under the Naturemade star scheme not only need to comply with the relevant criteria, but operators must also pay one centime per kilowatt-hour of electricity sold into an environmental improvement fund. (Naturemade website 2018, www.Naturemade.ch/de/unterschiede-star-und-basic.html)

For more detailed information on the certification modalities for both labels see the guidelines at: https://www.Naturemade.ch/en/Naturemade-zertifizieren.html (certification guidelines).

The Naturemade labels aim to generate added value for hydropower producers and suppliers by giving them the possibility to position themselves in the market as providing added qualitative, environmental and corporate value. For producers, added qualitative value comes from credibility through broad support from environmental and consumer organizations and the energy sector. Added environmental value comes from continual improvement of internal environmental performance through the implementation of the mandatory environmental management system, for guaranteed highest environmental standards regarding the protection of bodies of water and the species for which they provide habitats (Naturemade star), and environmental improvements around plants through dedicated power plant funds of Naturemade star-certified hydroelectric power plants. Corporate value is added through credible evidence of climate-friendly, green energy generation and quantifiable, added renewable and environmental value through energy balance reviews.

In addition to these value-adding aspects for producers, for suppliers a qualitative value is added through the delivery of guaranteed 100% energy from renewable energy sources and a separate certification of energy generation plant and energy product to ensure that only the energy actually being generated can be sold. In terms of corporate value, suppliers can also profit from sales arguments for end customers based on quality and credibility and a uniform product range and gain a stronger identity from a (Swiss) quality label with a clear origin (VUE website 2018). By becoming VUE members, Swiss or international companies and suppliers may certify energy generation plants and energy products under the Naturemade basic or Naturemade star labels.

VUE follows a clear vision that it intends to achieve through market instruments, close alignment with customers and the gradual greening of the energy system. The association pursues this vision by means of broad support of energy producers and suppliers, environmental and consumer organizations, large consumers, science, administrations at federal, cantonal and municipal level, and politicians. Working at market level it is committed to consumer involvement. It seeks to provide orientation through credible quality standards and relevant quality labels that are ahead of legal regulations. (VUE 2018)

Hydropower plants and products are certified separately. VUE claims that “independent certification ensures that the origin of every kWh of power sold is known, preventing double sales. The sale of certified products additionally supports the construction of new plants. Different certification criteria apply to production and supply.” Further, the audit and certification processes are independent of each other. Audits are carried out by accredited lead auditors employed by independent certification companies for quality and environmental management systems. The certification of Naturemade star hydroelectric power plants additionally involves accredited expert auditors that are also specialists in aquatic ecology. Certifications are awarded by the VUE Board. (Naturemade`s webpage: https://www.naturemade.ch/en/naturemade-zertifizieren.html)

While certain specific certification criteria exist for the Naturemade basic label (see VUE 2018 certification guidelines for more detail), we will here focus on the environmental criteria that are required for the Naturemade star eco-label:

- Compliance with life cycle assessments (LCA) threshold (for both Naturemade basic and star). LCA must be produced for all energy systems to be certified under the Naturemade scheme. To remain below a maximal environmental impact (LCA) threshold a Naturemade-certified production plant must not exceed half of the environmental impact of a modern combined-cycle gas-turbine power plant. This ensures that plants for the generation of electricity from renewable energies operate efficiently.
- Compliance with scientific criteria regarding residual flow management, hydropeaking management, reservoir management, bedload management, plant design
- For new or newly expanded plants: prohibition of deterioration. They can only certified if they do not impair additional natural or near-natural habitats, populations or landscapes.
  The criteria for aquatic ecology under the Naturemade star scheme have been defined to ensure that the environmental functions of bodies of water are preserved even with the use of hydroelectric power.

They are based on environmental criteria for hydroelectric power developed by the Swiss Federal Institute of Aquatic Science and Technology (EAWAG), the so-called *greenhydro* standard (Bratrich & Truffer 2001)[40]. “The requirements are structured along two dimensions, which are related to the potential environmental impact and the operation of a hydropower station. In both dimensions five domains are distinguished (see **figure 24**): the environmental domains include (1) hydrological character, (2) connectivity of river systems, (3) solids load and morphology of the river, (4) landscape and biotopes and (5) biological communities and protected species along and in the river. The management domains include: (1) regulations on residual flow, (2) regulations on hydropeaking regime, (3) regulations on reservoir management, (4) guidelines on bed load management and (5) guidelines on an environmentally compatible power plant design. For each field of the resulting matrix, specifications for ecological targets, assessment criteria and methods / literature references of how to verify these criteria are described.” (Markard & Vollenweider 2005)

[40] “In Switzerland, the standard for green hydropower was developed together with the *naturemade star* eco-label, which today applies the *greenhydro* standard in practice. Development started in 1997, when a research project “Green Electricity from Hydropower” was set up at Eawag. The project had the aim of developing criteria and a certification procedure for green hydropower, to support the set up of a national eco-label and to also exchange experiences internationally (Truffer *et al.* 2002). The research was based on literature reviews, expert workshops and on a case study on a storage power plant in Southern Switzerland. In the case study, a selection of criteria was tested in detailed biological, chemical and physical measurement programs. During the entire project the Eawag team collaborated with other research institutes, private consultants, electric utilities and hydropower operators.” (Markard & Vollenweider 2005)*)*

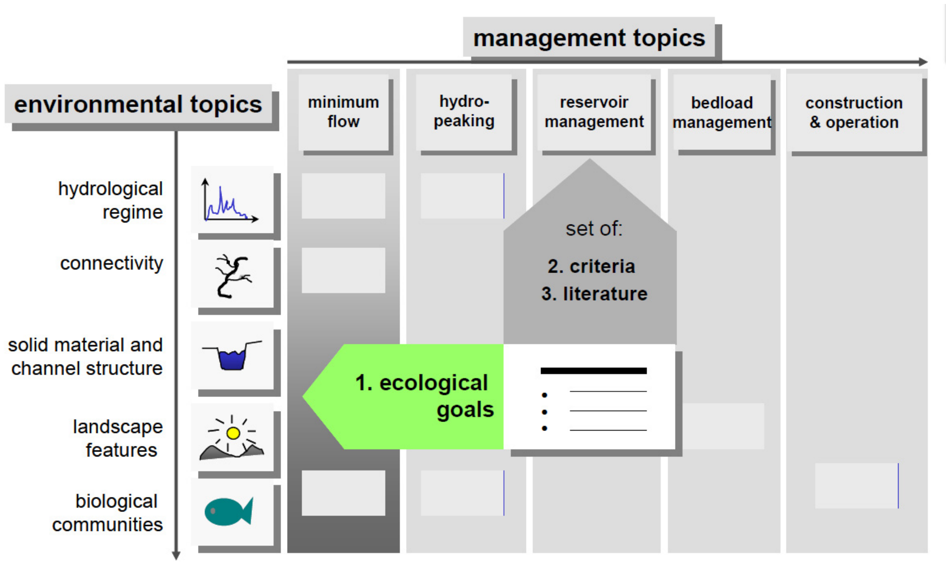

***Figure 24**. Environmental management matrix: The basic requirements are assigned to five so-called management fields and five environmental fields. In addition, individual restoration measures are foreseen, which will be carried out using eco-investments. Source: Markard & Vollenweider (2005), based on greenhydro standard as developed in Bratrich &Truffer (2001).*

Independent auditors from recognized institutes[41] verify on behalf of VUE whether all criteria are complied with and make recommendations for certification to VUE. These audits are repeated every five years (recertification). Auditors additionally verify the annual energy production and sale volumes and check that all requirements are complied with.

In a broad international comparative study by PricewaterhouseCoopers (Pwc), Naturemade star was assessed to have Europe-wide best performance standard for eco-labels (Pwc 2009) (see section 6.2. for more detail). This was to a large extend based on the fact that Naturemade star is the only quality label that comprises scientifically developed environmental criteria for hydroelectric power (Markard & Vollenweider 2005).

Receiving the Naturemade star quality label requires hydroelectric power plants not only to comply with the ecological criteria as listed above, but also to establish environmental improvement funds for plants with outputs of >100 kW. Since 2016, certification holders have been required to pay one centime per KW/h of Naturemade star electricity sold, whereas until the end of 2015 they had to pay 0,1 centime per kilowatt-hour of certified electricity generated and 0,9 centimes per kilowatt-hour of electricity sold. These funds are used for measures such as the revitalisation of bodies of water, the creation of new interconnections between bodies of water and the establishment of new aquatic and terrestrial habitats. Funds are primarily used for environmental improvements of the affected bodies of water (not only in stretches covered by licenses) and their hydrological catchment areas. If no first-priority measures can be identified, environmental improvements of other bodies of water or at-risk habitats of non-aquatic flora and fauna may also be funded. The allocation of funds is decided on by a local/regional body comprising representatives of the relevant power company, authorities and environmental organisations. (VUE 2017)

Costs for the certification of plants or energy products under the Naturemade scheme incur certification and licensing fees, audit charges and costs of developing the management strategy (for Naturemade star-certified hydroelectric power plants) plus the costs of meeting the certification requirements. More

[41] Associated with the ISO standards ISO 17020 and ISO7021.

detailed information on the arising costs can be found at: www.Naturemade.ch/en/kosten.html. The use of the quality labels is not subject to the payment of a fee.

6.4.1 Current status of activities and implemented environmental measures

In 2017, Swiss hydroelectric power plants generated a total of 32,5 TWh/a of electricity, about 5 % of which (1,5 TWh/a) was produced by Naturemade star-certified plants (VUE 2017). In 2018, there were 37 Naturemade star licenced supply licences for the production of 1.603 TWh hydropower, 16 Naturemade star certified energy products, and 26 mixed Naturemade star and basic energy products (with a share of Naturemade star between 5-15%) (VUE 2018b and c).

The environmental improvement funds associated to the Naturemade star quality label accrued a total of about CHF 88 million for environmental improvements between early 2000 and the end of 2016. The funds can be used for the ecological rehabilitation of terrestrial and aquatic ecosystems but also for networking, information and communication projects (campaigns, youth programmes, creation of educational nature trails etc.). Since 2000, projects worth a total of CHF 40.5 million have been fully or partially funded, meaning that about 46 % of the accrued funds have been spent (see **figure 25** for funds spent on concrete types of measures). Another CHF 23 million (26 %) have already been earmarked for specific projects. As projects relating to hydroelectric power plants are frequently very cost-intensive and require long-term planning, substantial funds are often accrued before they can be spent on appropriate measures. In 2017, another estimated CHF 11 million were paid into the funds (VUE 2017).

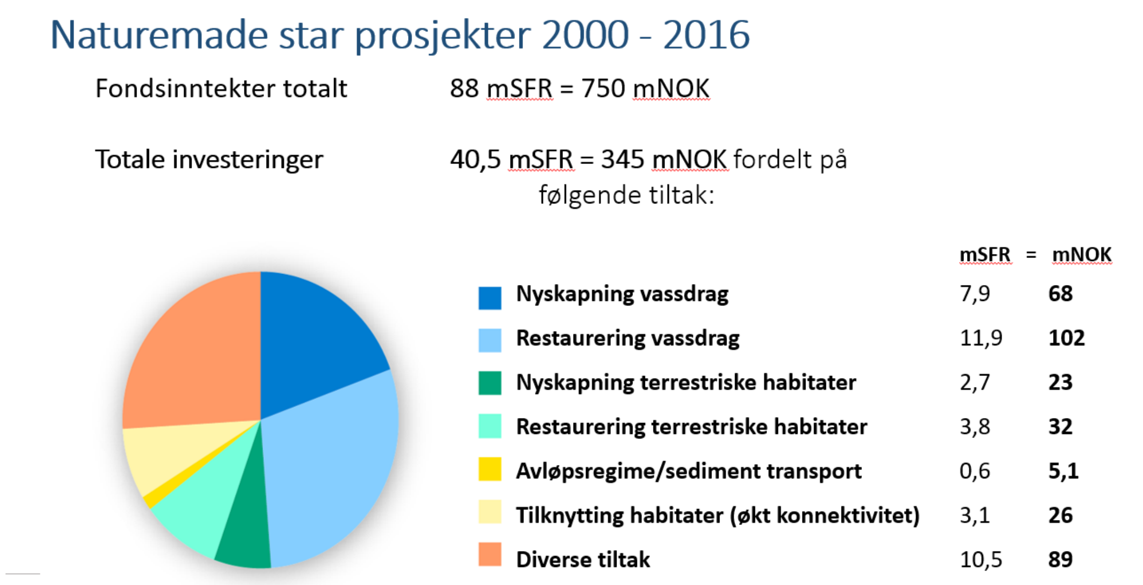

***Figure 25**. Overview over environmental improvement funds in the period 2000-2016 spent on concrete types of measures. Source: VUE/Steingruber (2018).*

6.4.2 Further examples of eco-labels for hydropower

We will below present a selection of other international eco-labels in a short overview.

OK-Power[42]

The ok-power[43] label is a German eco-label promoting energy from new power plants and is based on renewable energy documented by Guarantees of Origin. This eco-label is awarded to high-quality eco-electricity products that make a useful contribution to energy transition. In choosing an ok-power certified product, electricity customers thereby have the transparency and security of choosing an electricity product that leads to an actual environmental benefit.

ok-power is awarded by the non-profit association EnergieVision e.V., which is organized by Öko-Institut (Institute for Applied Ecology) and the Consumer Association of North Rhine-Westphalia (Verbraucherzentrale Nordrhein-Westfalen).

The criteria are developed by an advisory board established for this purpose, which is made up of experts on energy and climate protection. To meet the criteria of the ok-power label, the eco-electricity products must fulfil several conditions including the delivery of 100% electricity produced from renewable energy sources and further project promotion. Furthermore, the electricity providers applying to use of the label must meet select criteria such as having no stake in the operation of nuclear or lignite power plants.

Green-e Energy

Since 1997, Green-e Energy[44] has certified clean energy sold to consumers and businesses in North America – particularly Canada and the U.S., that want to reduce the environmental impact of their electricity use. Green-e Energy is a consumer protection program designed to provide purchasers of renewable energy good product information, assurance of product quality and verification of product ownership.

Green-e Energy certifies renewable energy that meets the highest standards: it must be generated from new facilities, marketed with complete transparency and accuracy, retired for the purchaser who has sole title.

The program is administered by the parent NGO, Center for Resource Solutions, a nonprofit based in San Francisco, CA. The independent Green-e Governance Board oversees frequent updates to the Green-e Energy Standards.

TÜV SÜD

TÜV SÜD[45] is a global technical services provider with long-standing international experience in the field of energy certification. The TÜV SÜD Generation EE label certifies electricity produced from renewable resources where generation can be attributed to a clearly identifiable source.

The TÜV SÜD Generation EE standard comprises ‘general requirements’ concerning the organization to be certified, ‘special requirements’ addressing the generation and the recording of the generation of the individual plants, and ‘optional requirements’ defined for electrical work and power guarantees.

The certification of the Generation EE+ module (work and power guarantees) can only be provided for a pool of plants. The certified pool of power stations enables the organization to be certified to guarantee the power purchaser that the pool of plants is able to produce the requested load profile at any time.

[42] The brief overview also draws on information found at: http://energyorigins.net/green-power-products/

[43] Further info in German at: https://www.ok-power.de/

[44] More info found at: https://www.green-e.org/programs/energy

[45] More info found at: https://www.tuv-sud.com/about-tuev-sued/about-us

Compliance with the Generation EE+ module is particularly suitable for green power products certified in accordance with the TÜV SÜD standard "product EE02" (certification of electricity products from renewable sources with simultaneous supply).

EKOenergy – also with an additional funding scheme
This eco-label was founded after the study of Pwc (2009). In 2010, Bellona Russia, the Estonian Fund for Nature, the Latvian Fund for Nature, the Finnish Association for Nature Conservation, Ecoserveis and AccioNatura from Spain, as well as 100% Energia Verde and REEF from Italy joined forces to develop an international eco-label for electricity named EKOenergy.[46] This is a non-profit organization based in Finland.

The electricity sold with the EKOenergy label fulfils strict environmental criteria, but also raises funds for new renewable energy projects. Consumers of EKOenergy receive information about the origin of their electricity and about the attributes of their purchase.

For each MWh of EKOenergy sold, the retailer contributes €0,10 to EKOenergy's Climate Fund. This money is used to finance renewable energy projects tackling energy poverty. EKOenergy comes from power plants that fulfil specified sustainability criteria, for example hydropower plants with a minimal negative impact on fish migration, or from wind turbines situated outside of important bird areas. The EKOenergy label has resulted from a pan-European consultation process and is recognized by stakeholders in all European countries.

Source: EKOenergy (www.ekoenergy.org/es/extras/logo/)

[46] More info found at: https://www.ekoenergy.org/

7 Summary of findings across the three case countries

In our study of how environmental measures are realized in European hydropower we mapped the current situation related to hydropower production, environmental status of the regulated water bodies and implemented measures, management practices, methods to assess trade-offs and funding mechanisms in the three case-studies Austria, Switzerland and Sweden. We also aimed to explore the question of which factors are decisive for the amount and variety of implemented environmental mitigation measures. We found similarities and differences in the opportunities and drivers, challenges and barriers that exist in the three case countries. An important and interesting factor amongst those are certainly public and private funding possibilities.

7.1 Key characteristics of hydropower production

The three case countries are all amongst the larger producers of hydropower in Europe in terms of installed capacity with ranks 6 (Switzerland: 16.657 MW), 7 (Sweden: 16.466 MW) and 8 (Austria: 14.116 MW)[47] (IHA 2018). They are comparable in terms of the large share of hydropower in the respective national electricity supply mix and have a strong degree of electricity interconnection with their neighboring countries. All three countries have a high number of hydropower plants, while only a relatively small share of them generates the main share of production (e.g. 14% of total number of plants generate 94% of production in Switzerland; 3.6% largest hydropower plants generate 79% of the yearly production in Austria).

Table 5. *Summary of key characteristics of hydropower production in the case study countries*

	Austria	**Switzerland**	**Sweden**
Yearly HP production in TWh	38,54 (2018)	36,56 (2018)	62 (2018)
HPs share of national electricity supply in %	56	57	40
Degree of electricity interconnection with neighbouring countries	strong	strong	very strong as part of the Nordic electricity market
Number of HP plants	2882 (total); 2722 (< 10 MW), 56 (10-20 MW), 104 (20 – 300 MW)	1365 (total) 715 (< 0,3 MW), 225 (0,3-1MW), 237 (1-10 MW) 188 (>10 MW)	2057 (total) 1615 (< 10 MW, 442 (> 10 MW)

[47] Norway holds the 1st rank in the IHA (2018) list with 31.837 MW installed capacity.

7.2 Types of environmental measures to be implemented related to existing hydropower concessions and status of accomplishment

In this study we have focused on the modernization of environmental standards for the large number of existing concessions. It was surprising to find relatively large differences in the spectrum of environmental measure types that are legally required when existing hydropower concessions are revised. These range from currently no legal requirements in Sweden, a rather limited range in Austria to a large range of measures in Switzerland. Of the large numbers of minimal flow measures estimated to be needed in the single countries, Switzerland has to date implemented by far the largest share. That is surprising given the fact that in this country there is no external policy driver for this process, as the EU WFD presents for the EU member states Austria and Sweden. Austria shows good progress in terms of installing river continuity measures, at least upstream. In Sweden only a very limited number of any type of environmental measures has been realized. The demand for measures that can ameliorate the effects of hydropeaking is generally recognized, but the scientific and practical basis for implementing them has been missing. There have been recent Swiss efforts to improve this situation (see e.g. the FOEN publication Tonolla et al. 2017), and a first measure has been tested (retention basin at Hasliaare).

In all of the countries, however, we could document efforts by single hydropower companies and NGOs, with support of local, regional and national administrations, to implement environmental mitigation measures on a voluntary basis. These include frequently also morphological measures. These efforts are frequently characterized by the attempt to improve the environmental status of the respective water course from a more encompassing perspective, taking into account the various sources of environmental degradation of which hydropower production is just one. Market-based, private funding solutions such as support schemes of the eco-labels Naturemade and Bra Miljöval (see sections 6.2., 6.3. and 7.6.) play here a substantial role, but also requirements of EU funding such as the EU LIFE-program (e.g. Traisen Project Austria). In Switzerland it is also the parallel realization of broader river restoration endeavours related to regional restoration plans that supports the implementation of a wider scope of measures at single sites.

Table 6. *Comparison of criteria related to implementation of environmental measures for the case study countries.*

	Austria	Switzerland	Sweden
Types of measures that are legally required in revision of existing HP concessions	minimum flow, river continuity/fish migration (upstream), habitat improvement (requirement defined in individual cases)	minimum flow, river continuity/fish migration (up- and downstream), sediment transport, hydropeaking, habitat enhancement[48]	none, requirement defined in individual cases: minimum flow, hydropeaking
Types of measures that are voluntarily implemented	habitat enhancement; lateral connectivity; ecological restoration;	habitat enhancement; lateral connectivity; ecological restoration	habitat enhancement, lateral connectivity, fauna passage, ecological restoration
Estimated demand for environmental measures	minimum flow: ca. 2.300 sites[49]; river continuity: ca. 3.310 sites[50]; hydropeaking: 69 river stretches[51]	minimum flow: 980 sites[52], river continuity/fish migration: 1.000; sediment transport: 500; hydropeaking: 100[53]	1.800 projects[54]
Share of measures (per type) that have been implemented (status Jan. 2019)	minimum flow: 200 river stretches; river continuity: 1.000; additional restoration measures (frequently incl. morphological measures) related to EU – LIFE projects	minimum flow: 732 (status 2016) → 75% of demand (94 % expected in 2030); river continuity/fish migration: 4 (upstream) and 2 (downstream) projects reported; sediment transport: 2 projects reported; hydropeaking: 1 [55]; measures implemented with support of Naturemade star funding	a very limited number since no measures imposed by regulatory authorities/requirement is only defined in individual cases; 166 projects realized through Bra Miljöval; 1 EU-LIFE project

[48] The WPA requires habitat enhancement (river restoration and improvement of the morphology) until 2090. These measures are a responsibility of the Cantons, not the power plants (Dworak 2011; Kampa et al. 2017)

[49] Residual flow stretches without minimal flow requirement (NGP 2015, table 21)

[50] Number of transverse structures hindering migration of fish or other water organisms due to hydropower production (NGP 2015)

[51] Acc. to BMLFUW (2015), p. 52/table 2.1-13.

[52] Baumgartner et al. (2016)

[53] FOEN 2015

[54] According to Kampa et al. (2017), FITHydro report, p. 95.

[55] FOEN is currently conducting a survey to get an overview over implemented measures from the cantons; data is not accessible yet but expected to be published by September 2019. Most measures are in planning status, and not yet implemented (pers. conv. FOEN and Pronatura).

7.3 Ways to assess and discuss the trade-offs between energy production and environmental objectives

As this report clearly shows, the challenge and need to balance the complex nexus of trade-offs between energy services and other environmental objectives and ecosystem services is quite similar in the analysed case countries. The framework for the discrepancy is defined by the overarching EU RES and WFD directives for the two EU member states Austria and Sweden. Here, these two regulatory frameworks related to the energy and environmental concerns appear to be in conflict, having created overlapping and conflicting national strategies, policies and laws. One reason for these unresolved conflicts could be that the EU WFD is essentially an attempt to unify, improve and expand the reach of fragmented European legislation on enhancing and safeguarding environmental quality of watercourses predating international concerns for renewable energy and climate change (Lindström & Ruud 2017). To address the issue of nevertheless finding a way to reach both overarching objectives, national prioritization strategies have been developed in Austria (BMLFUW 2009) and Sweden (SwAM 2014). In addition, national guidelines for assigning HMWBs and defining GEP (as a less stringent objective than GES) have been formulated (Austria: BMLFUW 2015; Sweden: SwAM 2016). These varying guidelines are based on and attempt to interpret the EU Common Implementation Strategy (CIS). They show, however, as also Halleraker et al. (2016) point out, that there is currently no common definition or method among EU member states on how to identify HMWBs.

In Switzerland, efforts to assess trade-offs are being made mostly on the cantonal level. By means of cantonal restoration plans and their prioritization strategy, the two main objectives river rehabilitation through space for the rivers and ecological improvement of hydropower installations are coordinated.

An inherent driver of improving the environmental condition of all Swiss watercourses, including those serving hydropower production, has been the political will as stated clearly in the 2004 public referendum „Living Waters“. As a result, Switzerland is following the trajectory to restore all regulated watercourses until 2030. Respective funding sources of ca. 1 billion Swiss Francs for compensating the hydropower companies for the required restoration costs were established through the Swiss Grid fond as well as the public tax-based restoration fond. However, mirroring the situation of the larger European context, the Swiss public agreed in another referendum in 2017 i.a. on the objectives of the Swiss Energy Strategy 2050 to aspire a rather substantial increase of hydropower production until 2050. The currently heated public debate around hydropower production losses due to planned minimal flow implementation indicates (based on production loss scenarios in Pfammatter & Semadeni Wicki (2018)) indicates the same difficulty with finding a societally acceptable balance between energy and environmental objectives, as in the EU member states. It might lead also in Switzerland to the definition of an upper threshold of tolerated energy production loss, as appears to be promising for accomplishing the implementation of environmental measures at Austrian and Swedish hydropower producing watercourses.

Table 7. *Comparison of criteria related to assess and discussing the trade-offs between energy production and environmental objectives*

	Austria	**Switzerland**	**Sweden**
Methods for finding a balance between HP production and ecological objectives	Master plans (by different sectors); national prioritization framework	Regional restoration plans (responsibility of cantons) incl. use of cost-benefit analysis; Round Tables (incl. joint field visits)	Water Activity Review (2014); national strategy, i.e. prioritization framework for HP regulated river basins (indicator-based; uses multikriteriaanalyse)
Defined threshold of upper production loss through environmental mitigation measures	expected loss 1,49 TWh, but to be compensated by increase in production efficiency (1,4 TWh)	no	yes (1,5 TWh)
Existing frameworks for assigning HMWBs	yes	not applicable	yes

In fact, the political compromise in a general identification of an upper threshold for production loss (in Sweden and Austria) can both be seen as a result of an assessment of trade-offs between renewable hydropower production and ecological objectives as well as a factor influencing future evaluations of implementing environmental measure with effect on hydropower production. This cap on production loss as defined in Sweden and Austria suggests to ease the future implementation of such measures and can thus be regarded as an opportunity or driver. The lack of such an upper threshold, on the other hand, can also be seen as a challenge or barrier to their implementation, as the current discussion in Switzerland indicates.

7.4 Opportunities and drivers, challenges and barriers

One working hypothesis was that being an EU member state would definitely present a driver for implementing environmental measures in regulated watercourses due to the requirements of the EU WFD. As the case of Switzerland showed, however, this was not a necessary condition for having environmental ambitions related to a wide range of measures types and a far-reaching implementation of residual flow measures has been realized regardless of not being committed to the EU WFD (see also table y, section 7.2.). One of the reasons that the EU WFD as a driver was not as protruding as assumed can be seen in the fact that at the same time the EU member states have to implement the EU RES, causing a clear conflict of objectives. On the other hand, the question whether Austria and Sweden would have aspired to implement as far-reaching mitigation measures as Switzerland does, without being committed to the EU WFD, cannot not be answered by this study.

All three countries have made legal revisions and set new environmental goals. There exist now legal references enabling the enforcement to realize environmental mitigating measures, but the types of mitigation measures and their actual implementation varies. One factor that seems to clearly be a driver is the possibility to legally impose mitigation measures on existing hydropower concessions, as is the case in Austria and Switzerland. The fact that there has been so far no opportunity for this in Sweden, in combination with a missing funding agreement until recently, seems to have contributed to the low number of implemented measures in that country. While there exists a requirement of financial compensation of hydropower companies for production loss or other costs due to environmental measures in Switzerland and Sweden, this supposed barrier to mitigation measure implementation has not been decisive in Switzerland due to a strong public vote in favour of such measures ("living waters" referendum) and a resulting political will to establish funding mechanisms (Swiss Grid Fond and public tax-based Restoration Fond). In Sweden, however, this seems to have been a hindering factor given the fact that there was no funding mechanism in place until now.

The possibility of assigning hydropower regulated watercourses the status of HMWBs, implying an adjustment of reaching the relatively clear objective GES to aiming instead for the currently rather undefined objective of GEP was used to a larger extent in Austria as in Sweden (while this assignment is not applicable for Switzerland). There seems to be no clear relationship, however, between the share of HMWB assignment and the share of environmental measures that have been realized until now.

Table 8. *Overview over relevant governance aspects with the potential to promote or hinder the realization of environmental measures*

	Austria	**Switzerland**	**Sweden**
Member of EU, i.e. implementing EU WFD and EU RES	yes	no	yes
Costs for HP companies for water use rights	no	yes	no
Requirement of financial compensation of HP companies for production loss or other costs due to environmental measures	no	yes	yes
Possibility to legally impose mitigation measures on existing concessions	yes (in relation to the RBMPs)	yes (but for minimal flow only to a limited degree)	no (but issue is currently under discussion)
Number of currently defined HMWBs / number of HMWBs with pivotal use to HP production	627/372	-	ca. 940 (ca. 4% of total number of 23418 water bodies)
Need for better sectoral integration	medium	medium - high	high
Fora for networking, communication and trust-building	long-standing network (with workshops) between Ministry, research and power companies	communication and networking platform Water Agenda 21, Round Tables	national dialogue (facilitated by SwAM); the national plan (pending); regional plans (e.g. Dalälven)

We found in the case countries different fora for networking, communication and trust-building that were established both top-down and bottom-up. Both Sweden and Switzerland have had a strong and focused public debate on the role of hydropower and realistic and feasible environmental measures. Such public discourses, often fueled by environmental NGOs such as WWF or ProNatura, can by themselves be regarded as factors promoting and driving the process of implementation of mitigation measures. In Switzerland and Austria, environmental NGOs have not only had this role but were also central driving actors for designing planning instruments for watercourse prioritisation and evaluation of trade-offs (e.g. Ökomasterplan by WWF Austria) or participatory evaluation instruments for residual flow requirements (e.g. roundtables as demanded and conducted by WWF Switzerland). In Austria, the public debate has centered more around the building of new hydropower in unregulated watercourses. Even though the debate is less heated in Austria, the same line of conflict as in Switzerland and Sweden exists related to weighing ecological improvement measures against potential losses in hydropower production. Authorities, power companies and other relevant stakeholder pursue a demanding balancing act of realizing more environmental sound solutions while promoting, securing and safeguarding supply of hydropower electricity. Within this trade-off context we found in all of our case countries an expressed lack of sectoral integration on the state and/or regional level, reaching from medium to high, to be a challenge to organized planning and action for environmental measure implementation with clear potential of future improvement. A common challenge for environmental measures are not surprisingly, sufficient funding opportunities.

7.5 Funding opportunities

Public funding has been insufficient in Sweden while the first planning cycle of the EU WFD in Austria was relatively well-funded, and both the grid tariff fund and the tax-based restoration fund have created ample opportunities of implementing environmental mitigation measures in Switzerland (Table 9). However, there are concerns raised that the Swiss Grid Fund might not be sufficient to implement all planned mitigation measures and a discussion has started concerning the need to increase the existing state funding sources. After a well-funded start of environmental measure implementation there has been a cut in public funding in Austria for the 2nd WFD planning cycle that remains an open challenge threatening the further progression of the so far successful course of action. In Sweden the "Vattenkraftens Miljøfond" is still pending, but it is a very promising initiative given the national trial is proceeding as planned and expected.

Private, voluntary schemes such as the Bra Miljöval and Naturemade star eco-labels provide additional funding for environmental measures by addressing the environmentally conscious customers willing to pay an additional fee for "greener" hydropower. Such eco-labels appear to be win-win solutions for hydropower companies that are also concerned with reputation management as an integral part of a more diversified market

Table 9. *Overview over aspects found to be relevant for funding of environmental measures*

	Austria	**Switzerland**	**Sweden**
Primary requirement of financing ecological mitigation measures	HP companies (polluter pays principle)	The public; HP companies need to be compensated by virtue of the rights acquired following the granting of a concession for HP use	HP companies, but in accordance with national planning target of max. 1,5 TWh energy loss
Consensus on public financing subsidies 1st RBMP/2nd RBMP	yes/no	yes	no/yes
Source and amount of public financing	140 Mill EUR (for 1st RBMP 2009-2015); Federal Environmental Aid Act (UFG); currently none for 2nd RBMP 2015-2021.	40 Mill CHF/year restoration fund (public tax-based); up to 50 Mill CHF/year (tax on the electricity bill for grid use)	no direct support, but indirectly through lowering of property tax for HP companies agreed upon in the energy accord in 2016
Eco-labels with financial support scheme for environmental improvement funds	no	yes (Naturemade)	yes (Bra Miljöval)

The funding solutions for environmental measures can also be summarized in regard to public and private sources as in **table 10.**

Table 10*. Types of funding solutions for environmental measures in hydropower regulated watercourses*

	public		**private**	
	national	international	legally imposed	voluntary
Switzerland	Yes	No	Yes	Yes
Austria	Yes	Yes	No	No
Sweden	No	Yes	Yes	Yes

8 Conclusions

All of our case study countries currently seem to be in an important period for determining how to address the conflicting ambitions of realizing on one hand environmental objectives and energy security concerns as well goals of renewable energy production, on the other hand. Hereby, it is interesting that the same conflict line is clearly visible also in Switzerland, even though the country is not required to implement the European WFD and RES, being not an EU-member state as Austria and Sweden.

For defining acceptable trade-offs between environmental ambitions, societal goods and renewable energy from hydropower, the identification of a threshold of 1,5 TWh total hydropower generation loss in Sweden seems to be an important accomplishment and compromise, given the complexity of such a process. Though there are still question marks over the methodology, and the figure remains somewhat controversial, it appears to have been broadly accepted (and thus, arguably, legitimized) in the multi-stakeholder dialogue process managed by the water and energy authorities (SwAM & SEA). It has also been instrumental for the regional work and proposed pilot mitigation plan for Dalälven (see section 5.4.). Nevertheless, Sweden has currently the lowest share of implemented environmental measures in regulated rivers compared to Austria and Switzerland. This is primarily due to the legal requirements on financial compensation which have not yet been taken into account in proposed revisions of hydropower licenses.

A sum of expected loss in hydropower production similar to that in Sweden has also been calculated in Austria (ca. 1,49 TWh). At the same time, however, an optimisation potential of future hydropower of similar size (1,4 TWh) was identified. Our impression is that these numbers have been less contested in Austria, and the question can be raised if all similar optimisation potential was taken into account in the definition of the production cap in Sweden. While there has been no upper production cap officially agreed upon in Switzerland, the current debate around the production loss (see scenarios in Pfammatter & Semadeni Wicki (2018)) show also here the need to define it more closely in the near future.

When it comes to scale, as elaborated by Lindström & Ruud (2017), there are two separate, but connected issues that pose specific challenges. One relates to how best to value the services and revenues coming from renewable electricity produced by hydropower vis-à-vis the environmental impacts and assessed environmental values. The other issue is related to the relevance of scale in assessing environmental impacts from hydropower as a whole (ibid). The two EU member states within our sample – Austria and Sweden – have both developed national prioritization plans in order to cope with these challenges. In their function as a planning framework, these plans serve also to legitimise a phased implementation of environmental measures in accordance with the EU commitments.

The political agreement on energy of 2016 and the legal changes in 2018 in Sweden highlight the fact that the pursuit of environmental mitigating measures must be balanced with energy concerns given the importance of safeguarding energy supplies in line with the commitments of the EU RES Directive and the balancing capacity in particular. Besides, observing the pending planning currently taking place related to identifying feasible mitigating projects and water courses, the need for national consolidation both politically and scientifically is crucial.

In two of our case studies - Switzerland and Sweden - we found eco-labels that reach beyond a guarantee of origin to be a promising financing solution to supplement public funding schemes, for promoting environmental measures in watercourses impacted by hydropower production. We gave therefore a detailed description and assessment of these labels and certification arrangements particularly aimed at financing schemes for local environmental mitigating efforts in the second part of this report. We think that this information can be especially beneficial for hydropower companies and exporters in Norway for developing and using new marketing and financing solutions for environmental measures in impacted watercourses.

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10 Appendix:

Focus and content of the 4.1.1 mapping:

1. Documentation of impacts related to hydropower production
    a) in river stretches and
    b) regulated lake and reservoirs

2. Overview of reported environmental objectives and planned program of measures concerning existing concessions. Could be in accordance with the requirements of the Water Framework Directive or something similar for the cases of Switzerland, Canada and Iceland:
    - WFD homepage: http://ec.europa.eu/environment/water/participation/map_mc/map.htm
    - WISE database (Audun contacts A. Lyche Solheim/NIVA) and Jo Halleraker (for first information see Appendix 1),
    - contact and ask informants in the different countries for information as part of the desk-top study (before interviews)
    - other sources (?),

3. Concrete Environmental measures:
    a. In river stretches and
    b. regulation reservoirs

For both a) and b):

i. Which specific environmental measures have actually been implemented/initiated in individual concessions/permits in the selected hydropower producing countries?
ii. Which types of environmental measures do these belong to?
iii. Which user interests do they relate to?
iv. Which regulatory agencies are involved?

We aim at capturing a possibly wide spectrum of measures and related interests following the extended environmental design approach on biodiversity and recreational interests. Possible types of measures could also be related to improved access to the watercourses and general welfare. Offsetting measures should also be documented – if relevant –see question 11.

We will likely find more data related to objectives and programs of measures (PoMs) related to WFD than on concrete environmental measures. But we aim at finding representative data on specific implemented measures in river basins impacted by hydropower production.

How can these environmental measures be categorised in relation to types of watercourses and hydropower regulation (see typology proposed by Bakken & Harby (2018)? Also look at "Tiltakshåndboka" by Pulg et.al: http://uni.no/nb/uni-miljo/lfi/tiltakshandbok-for-bedre-fysisk-vannmiljo/ [56]

[56] The connection to the tiltakshåndboka at: http://uni.no/nb/uni-miljo/lfi/tiltakshandbok-for-bedre-fysisk-vannmilj/

4. Which methods or tools are used for developing, planning and assessing specific environmental measures? (methods e.g. trial regulation; methods to define minimal flow release, see e.g. http://publikasjoner.nve.no/rapport/2013/rapport2013_73.pdf)

5. Green power labels[57]:
    1. What requirements related to implementing environmental measures do they have?
    2. How are the arrangements financed?
    3. What part of the incomes of the label are spent on concrete environmental measures?
    4. What kind of environmental measures are financed?
    5. What are documented effects?
    6. How is the choice of measures evaluated and how are measures revised?
    7. How are improvements secured?
    8. Who is involved in the implementation of the environmental measures?
    9. How is the interaction with other public or private initiatives?

6. To what extent are measures coordinated and potential trade-offs assessed?

7. Is there a difference between environmental measures that are implemented in new hydropower development versus existing concessions?

8. Which governance schemes effecting the implementation the documented environmental measures (both for new and existing concessions) are related to?
    a) Public requirements
        i. European policies
        ii. National legislation, strategic planning instruments, environmental requirements (duration of permits/concessions, revision of permits of existing hydropower plantsP, types of environmental measure requirements and documented user interests, monitoring requirements)
    b) Public-private arrangements
    c) Private initiatives
    d) More independent court-based measures (understand better courts` practice and influence on concrete environmental measures)
    e) Other voluntary efforts with non-governmental organizations

How do the schemes effect the implementation of measures?

9. Drivers[58]: What promotes the implementation of environmental measures?
   What kind of drivers, both national and supra-national?

[57] Such as: Bra Miljöval (https://www.naturskyddsforeningen.se/in-english), Naturemade (https://www.naturemade.ch/en/naturemade-zertifizieren.html) and Bullfrog (https://www.bullfrogpower.com/)

[58] "Drivers" are broader than governance schemes, reflecting concerns beyond political, regulatory schemes.

i. Political
ii. Economic
iii. Social
iv. Judicial
v. Voluntary

Please specify the drivers or motivations for implementing environmental measures?

9. What are the available funding mechanisms for implementing environmental measures?
    i. EU support instruments
    ii. Instruments across country borders
    iii. Instruments at country level
    iv. Feed-in tariffs
    v. Corporate funding and revenue restrictions
    vi. Other

10. How are these funding sources related to the drivers mentioned above?

11. Who implements these measures and how?
    - Who are the players/institutions implementing the environmental measures?
    - Do they do so as part of a requirement, or voluntarily?
    - Which planning and decision-making instruments/methods are used to choose the most effective measures?
    - How were the environmental measures that were implemented chosen?
    - To what degree are different measures in accord with another or in conflict?
    - Are there efforts of pursuing ecological off-setting?

12. Other specificities of the respective societal context of hydropower development and implementation of environmental measures: e.g.
    - What kind of history has hydropower development in the respective country (e.g. rationale for promotion)?
    - Did the inclusion and requirement of environmental measures in hydropower concessions change over time (when, why and how?)
    - Have there been conflicts related to the implementation (or missing implementation) of environmental measures in the (recent) past in the different countries?
    - Are there e.g. actors that demand different environmental measures to be implemented or that environmental measures are implemented more widely?
    - What could increase the acceptance of implementing environmental measures?

13. Barriers: What hinders the implementation of more environmental measures in existing or new projects?
    a. Specification of bottlenecks, limiting factors? (e.g. policy, knowledge, funding, other?)
    b. Are there other factors (persons/agents or institutions) that hinder a more extensive implementation (if so, why? how?

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HydroCen
v/ Vannkraftlaboratoriet, NTNU
Alfred Getz vei 4,
Gløshaugen, Trondheim

www.hydrocen.no
HydroCen
@FMEHydroCen