REPORT L. 7065-2016

Hydropower in Norway.

An overview of key tools for planning, licensing, environmental impacts and mitigation measures

Norwegian Institute for Water Research

REPORT

Main Office
Gaustadalléen 21
NO-0349 Oslo, Norway
Phone (47) 22 18 51 00
Telefax (47) 22 18 52 00
Internet: www.niva.no

NIVA Region South
Jon Lilletuns vei 3
NO-4879 Grimstad, Norway
Phone (47) 22 18 51 00
Telefax (47) 37 04 45 13

NIVA Region East
Sandvikaveien 59
NO-2312 Ottestad, Norway
Phone (47) 22 18 51 00
Telefax (47) 62 57 66 53

NIVA Region West
Thormøhlensgate 53 D
NO-5006 Bergen Norway
Phone (47) 22 18 51 00
Telefax (47) 55 31 22 14

Title	Serial number	Date
Hydropower in Norway. An overview of key tools for planning, licensing, environmental impacts and mitigation measures	7065-2016	29.6.2016
Author(s)	Topic group	Distribution
Haakon Thaulow, Ingrid Nesheim, Line Barkved	Water resources management	Open
	Geographical area	Printed
		NIVA

Client(s)	Client's reference
The Regional Environmental Center for Central and Eastern Europe (REC) – Branch Bulgaria In cooperation with: Eastern Aagean River Basin Directorate (EARBD) –Plovdiv Western Aagean River Basin Directorate (WARBD) - Blagoevgrand	Ventzislav Vassilev

Summary

The report deals with HP management issues in Norway to provide a basis for exchange of experiences. The focus and level of detail in the report is based on dialogue with the Bulgarian partners to ensure relevance. The applicability of the studied practices should be closely examined and adaptation must take the national specifics into consideration for adoption in Bulgaria. The HP developments in Norway is largely dependent on country-specific favorable natural conditions and the transferal of experience to countries with different natural, social and economic context must be handled carefully. However, certain approaches and principles of sustainable HP development in Norway are generally valid and could be useful as references. In particular we assume that the processes and the approaches of some framework plans, and the licensing systems are of particular relevance. Particularly the integration in time and place of the implementation of the Water Framework Directive and the extensive revision of licenses for older HP plants are relevant information. The environmental/ecological criteria related to HP development vary over time and with the type of management tool, and is to a great extent related to water management priorities. A national approach is recommended for Bulgaria, taking into account the environmental objectives for the rivers, set by WFD and other regulatory documents. Currently in Norway the most important mitigation measures include demand for environmental flow or minimum flow, restrictions on regulation heights of dams, release of fish, fish passes in Power station, construction of thresholds and habitat adjustments. The general approach of selection and implementation of the mitigation measures is applicable outside Norway, bu the design of measures must be adapted to the specific habitat and species needs

Four keywords	Fire emneord
1. Vannkraft	1. Hydropower
2. Vannforvaltning	2. Water management
3. Konsesjon	3. Licensing
4. Norge	4.

Ingrid Nesheim

Ingrid Nesheim
Project Manager

Sindre Langaas

Sindre Langaas
Research Manager

ISBN 978-82-577- 6800-3
NIVA-report ISSN 1894-7948

Hydropower in Norway

An overview of key tools for planning, licensing, environmental impacts and mitigation measures

Contribution to Energy and Water management authorities in Bulgaria

Водната енергия в Норвегия

Преглед на основните инструменти за планиране, лицензиране, въздействие върху околната среда и смекчаващи мерки

Принос за компетентните органи в областта на енергетиката и управлението на водите в България

Preface

The project *"Assessment of the combined effects on HPP on the ecosystems and the ecological status of rivers"* (ANCHOR) is a project funded by the EEA program *"BG02 Integrated Marine and Inland Water"* and its subprogram *"BG02.01 More integrated management of marine and inland water resources"*.

ANCHOR is co-ordinated by the Regional Environmental Center for Central and Eastern Europe (REC) – branch Bulgaria. In addition to REC, there are two other Bulgarian partners;
Eastern Aagean River Basin Directorate (EARBD) –Plovdiv, and Western Aagean River Basin Directorate (WARBD) - Blagoevgrand.

The Norwegian Institute for Water Research, NIVA, is the fourth partner in the project contributing with its knowledge, experience and network related to hydropower management in Norway.

According to the project description NIVA shall contribute with input to project activity 2: "*Analysis of EU and EEA best practices for assessment of the hydropower potential and methodologies for classification of river sections as eligibility for the construction of HPP"* through project activity 2.2: "*Analysis of existing publications, research and methodologies/criteria applied in Norway for the assessment of hydropower impacts and designation of river sections eligible/non-eligible for the HPP development"*. The output of the activity , "*an expert report on the Norwegian experience and knowledge transfer"*, is this report.

The report has been developed through an iterative process and in close dialogue with Bulgarian partners to ensure high relevancy in the Bulgarian context.

Key elements in the process since the kick-off-meeting in Sofia, Bulgaria May 28th 2015 was a two days visit to Norway by the Bulgarian delegation on the 19-20th October 2015 with participation from the Norwegian Water and Energy Directorate (NVE) and ECO-Energy, - one of Norway's largest hydropower companies and NIVA including a fieldtrip to ECOs Embretsfoss "run of the river" power plant at Drammenselva. Finally NIVA presented the report at the ANCHOR-project seminar in Sofia Bulgaria May 12th 2106.

This report should be considered as a key tool for the knowledge and experience transfer on how Norway assess, manage and regulate the effects of hydropower development. The focus for the knowledge transfer is on practical management experiences in their legal context and not on research activities.
In the writing of the report we have depended heavily on reports and presentations from the Ministry of Petroleum and Energy, the Norwegian Energy and Water Resources Directorate, the Ministry of Climate and Environment and the Norwegian Environment Agency.

Oslo, June 29th 2016

Ingrid Nesheim
Project Manager

Haakon Thaulow
Report Responsible

Въведение

Проектът *„Оценка на комбинираните въздействия от ВЕЦ върху екосистемите и екологичния статус на реките“* (ANCHOR) е проект, финансиран от Програма BG02 *„Интегрирано управление на морските и вътрешни води”* на Финансовия механизъм на Европейското икономическо пространство, по покана *BG02.01 „По-интегрирано управление на морските и вътрешните водни ресурси“*

ANCHOR се координира от Регионалния екологичен център за Централна и Източна Европа (РЕЦ) - клон България. Има още двама допълнителни български партньора:
Басейнова дирекция Източнобеломорски регион, (БД ИБР) - Пловдив, и басейнова дирекция Западнобеломорски регион (БДЗБР) - Благоевград.

Норвежкият институт за изследване на водите, NIVA, е четвъртият партньор в проекта, който допринася със своите познания, опит и мрежа, свързана с управлението на хидроенергетиката в Норвегия.

Според описанието на проекта NIVA ще допринесе за дейност 2 на проекта: „*Анализ на най-добрите практики на ЕС и ЕИП за оценка на потенциала на хидроенергетиката и методиките за класификация на речни участъци като допустими за изграждане на ВЕЦ“* чрез дейност 2.2: „Анализ на съществуващите публикации, изследвания и методики/критериите, прилагани в Норвегия за оценка на хидроенергийни въздействия и определяне на речни участъци като допустими/недопустими за развитието на ВЕЦ“. Резултатът от дейността „експертен доклад на норвежкия опит и трансфер на знания“ е настоящият доклад.

Докладът е разработен чрез един повтарящ се процес и в тесен диалог с българските партньори, за да се гарантира високо ниво на приложимост в българския контекст.

Ключови моменти в процеса са провеждането на срещата по откриването в София, България 28 май 2015 г., двудневното посещение в Норвегия на българската делегация в периода 19 - 20 октомври 2015 г. с участието на Норвежката дирекция по водите и енергетиката (NVE) и ECO-Energy - една от най-големите водноелектрически компании в Норвегия, и NIVA, което включваше посещение на място на руслова водноелектрическа централа Ембретсфос на ECO в поречието на р. Драменселва. В резултат NIVA представи доклада по време на семинара по проект ANCHOR, проведен в София, България, на 12 май 2116 г.

В изготвянето на доклада сме разчитали в голяма степен от доклади и презентации от Министерството на петрола и енергетиката, Норвежката дирекция за енергетика и водни ресурси, Министерството на климата и околната среда и Норвежката агенция по околна среда.

Осло, 29 юни 2016 г.

Ингрид Нешеим
Ръководител на проекта

Хаакон Таулоу
Докладчик

Contents

Abbreviations

CIS	Common Implementation Strategy
EIA	Environmental Impact Assessment
HMWB	Heavily Modified Water Bodies
HP	Hydropower
IA	Impact Assessment
ICS	Internal Control System
MCE	Ministry of Climate and Environment
MLGM	The Ministry of Local Government and Modernization
MPE	The Ministry of Petroleum and Energy
NEA	The Norwegian Environment Agency
NVE	Norwegian Water Resources and Energy Directorate (NVE)
PBA	Plan and Building Act
RBMP	River Basin Management Plans
WFD	Water Framework Directive
WPP	Watercourse Protection Plans

1. Summary

Natural conditions for the production of HP in Norway are very favourable with high yearly precipitation rather evenly distributed over the year, large mountainous areas/plateaus with high elevation with short distances down to the lowlands. High number of lakes provides ideal conditions for reservoirs. Norway in general and mountainous areas particularly, is very scarcely populated, hence only in a very few cases resettlements of people has been necessary. Yet, environmental issues have been very important for HP development.

The first large HP plants were built in Norway around 1910. The Norwegian government passed laws and regulations to regulate hydropower production and it invested heavily in HP as a key tool to industrialize the country. However, most of the plants were built after the Second World War when a period of extensive HP development started and lasted until the 1980-ties. The main grid system including international connections (Finland, Sweden, Denmark, and Germany) was developed simultaneously.

Due to environmental awareness emerging in the late 1960-ties/early 1970-ties, a number of large plans were heavily debated and plans were reduced for environmental reasons. Conflicts culminated during the planning and construction of the Alta HP plant in 1980/1981.

The pace of HP development leveled out in the 1980-ties; partly because of the work with a national co-ordinated plan for development halted licensing processes, partly because a new market- oriented energy legislation was introduced in 1990 which optimized and made the national HP- infrastructure more efficient.

As of today Norway's total electricity production is ca. 135 TWh of which 95 % is based on HP. Total installed capacity in Norway was 31 100 MW. There are a total of 1510 HPplants of which 80 with installation larger than 100 MW produce 80% of the total production.

The outlook for future HP depends on both drivers for increased production and environmental restrictions. The main driver for more HP is the need to replace fossil-based energy with renewable. Two key tools: the EU Renewable Energy Directive setting the goal for Norway to 67, 5 % of gross end consumption of energy to be renewable, and Norway/Sweden's common electric certificate scheme with the goal to produce 26,4 TWh new renewable energy by 2020. Climate change will result in more precipitation and changed run-off patterns and will increase the production and the value of HP. The need to upgrade older plants will also increase production. The key driver against further development, restrictions and even lower production are environmental considerations in general. As a high percentage of HP resources are already developed; untouched nature, biological diversity, recreation interests are highly valued. Two key management tools are particularly important; the Water Framework Directive with its River Basin Management Plans and the ongoing process for revision of older HP licenses.

Several ministries and directorates play key roles in energy and water management related to HP,- of which the most important are: the Norwegian Water Resources and Energy Directorate (NVE) reporting to the Ministry of Petroleum (MPE), and the Norwegian Environment Agency (NEA) reporting to the Ministry of Climate and Environment (MCE). The legal framework of laws and regulations is comprehensive with the Watercourse Regulation Act (1917), the Water Resources Act (2000), the Planning and Building Act (1965-2009) and the Water Framework Directive (Vannforskriften 2006) as the most important.

Licensing procedures for the production of renewable energy is "surrounded" by a number of framework plans; some focused on HP development and some on environmental protection and/or natural resources in general. The four most relevant are: The Watercourse Protection Plan, The Master Plan for Hydropower Development, The Water Framework Directive and the report/plan on Hydropower and

licenses subject to revision before 2022.

The Watercourse Protection Plan was developed in five stages from 1973 to 2009. A total of 388 river systems with a potential of approx. 45 TWh is permanently exempted from HP larger than 1 MW. The Master Plan for Hydropower Development was developed in three stages from 1986 till 1992 providing and order of priority of projects for later licensing based on project economy and environmental impacts. 350 projects in 540 alternative alternatives were evaluated in the first parliamentary report in 1986.

The Water Framework Directive was introduced in Norwegian legislation in 2006, and the first full planning cycle (2009-2015) is now under final evaluation by the MCE. The River Basin Management Plans will serve as guidance to the licencing processes. The report on Hydropower Licenses subject to revision before 2022 provides a national overview and proposed priorities for 430 old HP licences for which environmental related licence terms can be subject changes. The priorities in 4 classes are important for the formal revision license processes as well as for the River Basin Management Plans.

A HP license is a document which grants special permission to develop and run power stations and dams including conditions and rules of operation and on specific terms cause environmental impacts. Within the constraints of framework plans there are 3 types of licensing procedures: 1) Large hydropower projects > 10MW installation, 2) Small hydropower projects >10 MW installation, and 3) Revisions of conditions/terms in older hydropower licenses. For large HP projects the Government (King in Council) is the licensing authority, for Small Hydro NVE and for plants < 1 MW the County Council. NVE with its regional offices is the key management body for all HP licensing processes.

Key acts are the Watercourse Regulation Act, the Water Resources Act and the Planning and Building Act for issue of Environmental Impact Assessments (EIA). The 3 different processes are described in relative detailed including the special processes related to the EIA`s. There are different demands for EIA depending on the HP size and expected impacts. As to the EIA content and process, the report provides rather detailed information. The environmental authorities (MCE, NEA and their regional environmental bodies) have major influence on the EIA content and processes.

There is a general agreement that the licensing processes can be characterized as transparent with predefined procedures offering good and sufficient possibilities for public involvement. The process can, however, be quite time-consuming; from ½ year up to 5 years and sometimes even more for "difficult/complicated" projects.

Licensing has to be related to the Water Framework Directive as new HP projects under certain conditions can be implemented even if environmental goals in the directive cannot be reached. Today's licensing balances power production (benefits) and environmental impacts (costs) according to the directive. It is worth noticing that the environmental criteria in licensing have a wider focus than those of the directive which focus on biology and chemistry in the water string itself.

The WFD and the licensing provisions for revision of environmental terms in older licenses, -both processes working in parallel, aim at enhancing the water environment. Thus there are important and crucial links between the two processes, with two different ministries responsible. The required interaction so far is not well developed. Goals, required analyses and measures related to Heavily Modified Water Bodies (HMWB) were not adequately dealt with in the first full planning cycle of the WFD in Norway (2010-2015),. As in many other countries, HMWB issues will be very much in focus in Norway in the next planning cycle from 2016 to 2021.

Licenses contain conditions such as approval of plans, deadlines, transfer of funds to local municipalities, fishing/hunting outdoor recreation, environmental issues including environmental flows, rules of operation etc. NVE with its regional offices is the key body for surveillance, control and compliance with license conditions. However the core of the license control system is the Internal Control System for which the energy company/license holder is responsible. According to law, the ICS system contains detailed rules on how the energy companies should monitor and report on all issues required in laws and regulations. ICS has two main focuses; security and environment. As to the environment the key issue is to the environmental related license onditions.

NVE has the responsibility to control the content and functioning of the ICS system. NVE will also have control inspections through the different phases from planning to operation to control compliance with laws, regulation license conditions, detailed plants etc. The relevant Municipality and the County are invited to the inspections. The number of inspections varies with the size and complexity of the HP – plant. A rather detailed guidebook on environmental surveillance of watercourse infrastructure is issued by NVE. Also issued are practically oriented guidelines for release and documentation of minimum water flow for small watercourse infrastructure with license.

Mitigation measures aim to avoid or minimize the negative environmental effects of HP development and operation. Negative impacts of HP may typically include; loss of biological diversity, reservoir impoundment, reservoir sedimentation, reduced water quality, modifications of hydrological regimes, barriers for fish migration and river navigation. Mitigation measures have for decades been important elements in HP management and now increasingly focused through the implementation of the WFD and the revision of older licenses. Most measures in Norway have been directed at ecological conditions in the water course, while some have been implemented for the benefit of landscape and other important societal values.

Important measures for hydropower reservoirs and for rivers are listed and shortly commented in the report In reservoirs, measures address inundation of land area, water quality , fish releases, water level fluctuations, habitat revegetation and vegetation harvesting, sediment management and planning of measures related to expected impacts of climate change. In rivers, key measures are minimum flow/environmental flow/flow regimes, fish passes, thresholds and habitat adjustments.

Of particular interest are minimum flow/environmental flow issues. Minimum water flow is important for several reasons: preserving biological diversity including biological continuity for fish and other aquatic life, maintain landscape qualities, and provide sufficient water for other user interests. There is no standard method for assessing minimum water flow. It varies from case to case depending on the size of the river, the impact of the HP-plant, river morphology and ecology and public interests etc. Historically minimum flow has been determined by a balance between power production and environmental considerations, where minimum flow was usually set very low, similar to a historically normal low tide (Q95) and /or 5-10 % for annual average flow.

Environmental flow is seeking to simulate the natural or desirable water flow in water courses and it refers to rules governing the release of water so as to ensure water levels and flows well suited for the overall river ecology and human water use interests This is based on the recognition that variation of flow and extreme events is important for the watercourse ecosystem.

Possibilities for anadromous, such as salmon and/or catadromous fish, such as eel - to pass hindrances are important issues. Norway has a very long tradition and experience in building and operation of devices designed to provide biological continuity. Measures to ensure upstream movements include inter alia fis ways, bypass channels, fish elevators, with attraction flow or leaders to guide fish to fish ways, capture and transportation of fish upstream. Particularly fish ladders have been important in Norway and mmore than 500 fish ladders mostly designed for salmon, trout and grayling have been built in Norway. However many of the ladders do not function well; location of the ladder entrance and water flow in the ladder is important (Anon, 1990). There are no general technical requirements for the fish pass/fish ladders. There are guidelines and literature for the technical design, but the actual design at the site will have to be tailor-made based on local knowledge and studies of the ecosystem. The most effective techniques for downstream fish movement are improvement in turbine, spillway openings during downstream movement of migratory species or overflow design, management of flow regime and installation of avoidance systems upstream the power plant such as screens, strobe lights, acoustic cannons, electric fields, etc.

Thresholds are a mitigation measure to maintain a water surface under greatly reduced water flow. It is aimed at improving conditions for fish by creating spawning and nursing areas and for the water ecosystem in general. Another important objective has been to improve the aesthetics of the landscape.

As rivers that have been channelled often become uniform with small variation in flow patterns and depth conditions which creates unfavourable conditions for fish and other benthic species, habitat adjustments as measured should be considered. Various measures such as excavation ponds, changing river morphology may enhance habitat diversity.

Some conclusions and recommendations underline that the report entirely deals with HP management issues in Norway. Focus and and level of details in each chapter, however, have been discussed with our Bulgarian partners. As the HP developments in Norway is largely dependent on the country-specific favorable natural conditions, including abundant water resources, favorable landscape and moderate social conflicts due to low population density, the transferal of experience to countries with different natural, social and economic context must be handled carefully. The applicability of the studied practices should be closely examined and adaptation must take the national specifics into consideration.

1. Резюме

Природните условия за производство на ВЕ в Норвегия са много благоприятни, с високи нива на годишните валежи предимно равномерно разпределени в рамките на годината, големи планински райони/плата с висока надморска височина, с къси разстояния надолу към низините. Големият брой езера осигурява идеални условия за резервоарите. Норвегия като цяло и планинските райони в частност, са много слабо населени, следователно само в много редки случаи е било необходимо преселване на хора. Въпреки това, проблемите на околната среда са много важни за развитието на ВЕ.

Първите големи водноелектрически централи в Норвегия са построени около 1910 г. Норвежкото правителство прие закони и наредби за регулиране на производството на водноелектрическите централи и инвестира сериозно във ВЕ като ключов инструмент за индустриализацията на страната. Въпреки това, повечето от централите са построени след Втората световна война, когато започва екстензивно развитие на ВЕ и продължава до 80-те години. В същото време е разработена основната система на електрозахранващата мрежа, включително и международните връзки (Финландия, Швеция, Дания и Германия).

Благодарение на повишаването на осведомеността по екологичните проблеми в края на 60-те години/началото на 70-те години, редица големи планове бяха обстойно обсъдени и бяха съкратени поради екологични причини. Конфликтите ескалираха по време на планирането и изграждането на ВЕЦ Alta през 1980/1981 г.

Темпът на развитие на ВЕ се стабилизира през 80-те години; отчасти дължащо се на работата с национален координиран план за развитие, което спря лицензионните процеси, отчасти поради новото пазарно ориентирано енергийно законодателство, въведено през 1990 г., което оптимизира и направи националната ВЕ инфраструктура по-ефективна.

Към днешна дата общото производство на електроенергия в Норвегия е около 135 TWh, от които 95 % се основава на ВЕ. Общата инсталирана мощност в Норвегия е 31 100 MW. Има общо 1510 ВЕЦ, от които 80 с инсталация, по-голяма от 100 MW, произвеждат 80 % от общото производство.

Прогнозите за бъдещите ВЕЦ зависят както от мотивацията за увеличаване на производството, така и от и екологичните ограничения. Основният фактор за увеличаването на ВЕЦ е необходимостта да се замени енергията, базирана на изкопаемите горива с енергия от възобновяеми източници. Два са основните инструмента: Директивата на ЕС за възобновяема енергия за определяща целта на Норвегия за достигане на 67, 5 % от крайното брутно потребление на енергия да бъде от възобновяеми източници, както и общата електрическа схема Норвегия/Швеция за сертифициране с цел производство на 26,4 Twh нова енергия от възобновяеми източници до 2020 г. Изменението на климата ще доведе до повече валежи и променени модели на оттичане и ще увеличи производството и стойността на ВЕ. Необходимостта от подобряване на старите инсталации също ще увеличи производството. Основният фактор срещу по-нататъшното развитие, ограниченията и дори по-ниското

производство са екологичните съображения като цяло. Тъй като голям процент от водноелектрическите ресурси са вече разработени; девствената природа, биологичното разнообразие, интересите за отдих са високо ценени. Две основни инструмента за управление са особено важни; Рамковата директива за водите заедно с плановете за управление на речните басейни и продължаващият процес на преразглеждане на по-старите лицензи на за ВЕЦ.

Няколко министерства и дирекции играят ключови роли в управление на енергетиката и водите, свързано с ВЕЦ – най-важните от които са: Норвежката дирекция по водните ресурси и енергетиката (NVE), която докладва на Министерството на петрола (MPE), и Норвежката агенция по околната среда на (NEA), която докладва на Министерството на климата и околната среда (MCE). Правната рамка от закони и разпоредби е всеобхватна със Закона за регулиране на водните течения (1917 г.), Закона за водните ресурси (2000 г.), Закона за планиране и строителство (1965 - 2009 г.) и Рамковата директива за водите (Vannforskriften 2006 г.), като най-важна.

Лицензионните процедури за производство на енергия от възобновяеми източници са „заобиколени“ от редица рамкови планове; някои се фокусират върху развитието на ВЕЦ, а други върху опазването на околната среда и/или природните ресурси като цяло. Четирите най-значими са: Планът за опасване не водните течения, Генералният план за развитие на Хидроенергетиката, Рамковата директива за водите и докладът/планът за хидроенергийните и лицензи, който подлежи на редакция преди 2022 г.

Планът за опазване на водните течения е разработен в пет етапа от 1973 г. до 2009 г. Общо 388 речни системи с потенциал от около. 45 TWh са трайно изключени от ВЕЦ, по-големи от 1 MW. Генералният план за развитие на хидроенергетиката е разработен в три етапа от 1986 г. до 1992 г., осигурявайки ред за приоритизиране на проекти, които да бъдат лицензирани по-късно на базата на икономичността на проекта и въздействието върху околната среда.

В първия парламентарен доклад през 1986 г. са оценени 350 проекта в 540 алтернативни възможности.

Рамковата директива за водите е въведена в норвежкото законодателство през 2006 г., а първият пълен цикъл на планиране (2009 - 2015 г.) в момента е в процес на крайна оценка от MCE. Плановете за управление на речните басейни ще служат като насоки за процеса на лицензиране. Докладът относно хидроенергийните лицензи, който подлежи на редакция преди 2022 г. предвижда национален преглед и предложения за приоритети за 430 стари лицензи за ВЕЦ, чиито лицензионни условия, свързани с околната среда могат да бъдат предмет на промени. Приоритетите в 4-те класа са важни за формалните процеси на преразглеждане на лицензите, както и за Плановете за управление на речните басейни.

Лицензът за ВЕЦ е документ, който дава специално разрешение за разработване и управление на електроцентрали и язовири, включително условия и правила за работа и конкретните условия оказващи въздействия върху околната среда. В рамките на ограниченията на рамковите планове има 3 вида на лицензионни процедури: 1) Големи водноелектрически проекти за инсталации > 10MW, 2) Малки водноелектрически проекти за инсталации > 10 MW, и 3) преразглеждане на условията/правилата в по-старите водноелектрически лицензи. За проекти за големи ВЕЦ правителството

(Кралският съвет) е лицензиращият орган, за малки водноенергийни централи, а за централи <1 MW – Окръжният съвет NVE със своите регионални офиси е ключов ръководен орган за всички лицензионни процедури, свързани с ВЕЦ.

Ключови актове са Законът за регулиране на водните течения, Законът за водните ресурси и Законът за планирането и строителството за издаване на оценки на въздействието върху околната среда (ОВОС). Трите различни процеси са описани относителна подробно включително специфичните процеси, свързани с ОВОС. Има различни искания за ОВОС в зависимост от големината на ВЕЦ и очакваните въздействия. Що се отнася до съдържанието на ОВОС и процедурата в доклада се съдържа по- подробна информация. Компетентните органи по околна среда (MCE, NEA и техните регионални органи на околната среда) имат най-голямо влияние върху съдържанието на ОВОС и процедурите.

Налице е общо съгласие, че процесите на лицензиране могат да се характеризират като прозрачни с предварително определени процедури, които предлагат добри и достатъчно възможности за участие на обществеността. Процесът обаче може да бъде особено продължителен; от ½ година до 5 години, а понякога дори повече за „трудните/сложни“ проекти.

Лицензирането трябва да бъде свързано с Рамковата директива за водите, тъй като новите проекти за ВЕЦ при определени условия могат да се изпълняват дори ако не могат да бъдат постигнати екологичните цели в директивата. Действащият процес на лицензиране балансира произведената мощност (ползи) и въздействието върху околната среда (разходи) в съответствие с директивата. Заслужава да се отбележи, че критериите за околната среда в процеса на лицензирането имат по-широк фокус от тези на директивата, която се фокусира върху биологичния и химичния аспект на самата вода.

РДВ и разпоредбите за лицензиране за преразглеждане на екологичните изисквания в по-старите лицензи, двата процеса действат едновременно, са насочени към подобряване на водната среда. Следователно са налице важни и решаващи връзки между двата процеса, за които отговарят две различни министерства. Необходимото взаимодействие не е добре развито към момента. Целите, изискващи анализи и мерки свързани със силно модифицираните водни тела (СМВТ) не са адекватно разгледани в първия пълен цикъл на планиране на Рамковата директива за водите в Норвегия (2010 - 2015 г.). В Норвегия, както и в много други страни въпросите, свързани със СМВТ ще бъдат много актуални в следващия цикъл на планиране за периода2016 - 2021 г.

Лицензите съдържат условия, като например одобряване на планове, срокове, прехвърляне на средства към местните общини, риболов/лов, отдих на открито, проблемите на околната среда, включително екологичен отток, правила за работа и т.н. NVE с нейните регионални офиси е ключов орган за наблюдение, контрол и спазване на изискванията в лицензите. Все пак в основата на системата за контрол на лиценза е Системата за вътрешен контрол (ICS), за която е отговорен собственикът на енергийната компания/лиценза. Според закона, системата ICS съдържа подробни правила относно начина по който енергийните компании трябва да осъществяват мониторинг, както и да докладват по отношение на всички въпроси, залегнали в законите и наредбите. ICS има два основни акцента; сигурността и околната среда. По отношение на околната среда ключовият въпрос е свързан с лицензионните условия отнасящи се до околната среда.

NVE има задължението да контролира съдържанието и функционирането на системата за вътрешен контрол. NVE също ще извършва контролни проверки през различните фази от планирането до експлоатацията, за да контролира спазването на законите, условията на лиценза, подробните планове и др. Съответната община и окръг са поканени на проверките. Броят на проверките варира в зависимост от големината и сложността на ВЕЦ. NVE издава подробен наръчник за наблюдение на околната среда на инфраструктурата на речното корито. Също така са издадени практически ориентирани насоки за освобождаване и документиране на минимален воден отток за малки речни инфраструктури с лиценз.

Смекчаващите мерки имат за цел да се избегнат или минимизират негативните ефекти за околната среда от развитието и функционирането на ВЕЦ. Отрицателното въздействие на ВЕЦ може обикновено да включва: загуба на биологично разнообразие, изграждане на резервоари, седиментация на резервоари, влошаване на качеството на водата, модификации на хидроложки режими, създаване на бариери за миграцията на рибите и речното корабоплаване. В продължение на десетилетия смекчаващите мерки са важни елементи в управлението на ВЕЦ и са все по-целенасочени чрез прилагането на Рамковата директива за водите и преразглеждането на по-старите лицензи. Повечето мерки в Норвегия са насочени към екологичните условия във водните течения, а някои от тях са прилагани за опазване на ландшафта и други важни обществени ценности.

По-важните мерки за водноелектрическите язовири, както и за реките са изброени и накратко анализирани в доклада. По отношение на резервоарите мерките са насочени към наводнения на сухоземните площи, качеството на водите, освобождаване на риба, колебанията в нивото на водите, рекултивация на местообитанията и събирането на растителност, управление на утайките и планиране на мерките, свързани с очакваните въздействия на изменението на климата. По отношение на реките, ключовите мерки са минимален отток/екологичен отток/ режими на оттока, рибни проходи, прагове и корекции на местообитания.

От особен интерес са минималният отток/проблеми, свързани с екологичния отток. Минималният воден отток е важен по няколко причини: запазване на биологичното разнообразие, включително биологичната приемственост за рибите и други водни организми, поддържане на качествата на ландшафта и осигуряване на достатъчно количество вода за други потребителски интереси. Няма стандартен метод за оценка на минималния воден отток. Той варира от за всеки конкретен случай, в зависимост от големината на реката, от въздействието на ВЕЦ, речната морфологията и екология, обществените интереси и т.н. В исторически план минималният поток е определян от баланса между производството на енергия и опазването на околната среда, където минималният поток обикновено е бил нисък, подобно на нормалния в исторически план отлив (Q95) и/или 5 - 10 % за средния годишен поток.

Възможности за анадромните видове риби, като сьомга и/или катадромните риби, като змиорка, да преминават препятствията са важни въпроси. Норвегия има много дълга традиция и опит в изграждането и експлоатацията на устройства, предназначени да осигурят биологичната непрекъснатост. Мерките за осигуряване на движението нагоре по течението включват, наред с другото рибни проходи, обходни канали, рибни асансьори, с притеглящи потоци на потока или водачи, които да насочват риба към рибните проходи, улавяне и транспортиране на рибата нагоре по течението. Рибните проходи са особено важни в Норвегия, повече от 500 рибни проходи, предназначени предимно за сьомга, пъстърва и липан. Въпреки това много от стълбите не функционират добре; местоположението на входа на стълбата и водния поток в стълбата са важни (Anon, 1990). Няма общи технически изисквания за рибните проходи/рибни стълби. Има насоки и литература за технически проекти, но същинското проектиране на обекта ще трябва да бъде направено специално въз основа на местните знания и изследвания на екосистемата. Най-ефективните техники за движение на рибата надолу по течението са подобрение в турбините, отваряне на преливниците по време на движение по течението на мигриращите видове или проектиране на преливниците, управление на режима на потока и монтаж на системи за отклоняване нагоре по течението, като например решетки, стробоскопни светлини, акустични оръдия, електрически полета и т.н.

Праговете са смекчаваща мярка за поддържане на водната повърхност при значително намален воден поток. Тя е насочена към подобряване на условията за рибите чрез създаване на места за размножаване и райони за захранване, както и за водната екосистема като цяло. Друга важна цел е да се подобри естетиката на ландшафта.

Тъй като реки, които са били насочвани често стават непроменливи с малки различия в моделите на потока и условията на дълбочината, което създава неблагоприятни условия за рибите и други бентосни видове, като мярка трябва да се разглеждат и корекции на местообитанията. Различни мерки, като например изкопни езера, промяна в речната морфология, могат да увеличат многообразието от местообитания.

Някои изводи и препоръки подчертават, че докладът изцяло обхваща въпросите за управление на ВЕЦ в Норвегия. Основните въпроси, както и нивото на детайлност във всяка глава все пак бяха обсъдени с нашите български партньори. Тъй като развитието на ВЕЦ в Норвегия до голяма степен зависи от специфичните за всяка държава благоприятни природни условия, в това число изобилие на водните ресурси, благоприятен ландшафт и умерени социални конфликти, дължащи се на ниската гъстота на населението, обмяната на опит със страни с различен природен, социален и икономически контекст трябва да се извършва внимателно. Приложимостта на изследваните практики трябва да бъде внимателно разгледана, а при адаптацията да се вземат под внимание националните специфики.

2. Hydropower (HP) in Norway

2.1 Natural conditions – very favourable for HP- production

Natural conditions for the production of HP in Norway are very favourable. Yearly precipitation in most of the country varies from 300/500 up to more than 2000 mm, and precipitation is rather evenly distributed over the year. There are large mountainous areas and mountain plateaus with high elevation and steep falls/short distances down to the lowlands/coastal areas. The high number of lakes provides ideal conditions for establishing reservoirs. They are key elements in the hydropower infrastructure as precipitation falls as snow 3-5 months during the winter season when runoff is at its lowest and electricity demand at its highest.

The Hydropower infrastructure is the sector with the most comprehensive impact on water resources in Norway. Environmental issues have been and are of paramount importance for HP development. However as Norway in general and mountainous areas particularly, is very scarcely populated, only in a very few cases resettlements of people has been necessary.

2.2 History of HP-development

The history behind HP- development is an important background to understand today's system and particularly the comprehensive licensing and revision systems. Both HP development history, the history of environmental issues and development of laws and regulations constitute a necessary background for today's understanding of Norway's HP management regime and our future challenges.

2.2.1 Production and transmission

We were able to start building the Norwegian society of today when we learnt how to use rivers and waterfalls to produce electricity. Hydropower has provided the basis for Norwegian industry and the development of a welfare society ever since the late 1800s.

The years from 1890 till 1910 were characterized by water fall investors who bought the rights to develop waterfalls for HP – production. The first very large HP plant was Vemork Power Plant, finished in 1911; build to supply electricity to produce fertilizer fixing nitrogen from the air through electrolysis. This was the start of the company Norsk Hydro, Norway's industrial flagship for many decades.

Figure 1. Vemork Power Plant. Norway's first large HP- plant was finished in1911. *Source:* reiseliva.wikispaces.com

The Government passed laws and regulations to ensure national control of the development of water resources for HP–production. It was an ambition that "the white coal" should form the backbone for the industrialization and buildup of the modern Norway, and the Government from 1907 to 1920 invested heavily in waterfall rights to ensure national control.

A period of heavy investments in HP ceased in the mid1920-ties, and due to the weak economic situation few plants were built in the 1930-ties. During the Second World War the German occupants started to construct some very large HP-plants with the aim to produce aluminum (electrolysis) for the war industry. However, they were not finished before the war ended.

The postwar years up to 1980-1985/1990 was the "golden age" for the construction of HP –plants. Figure 2. Illustrates the development from 1950 till 2014.

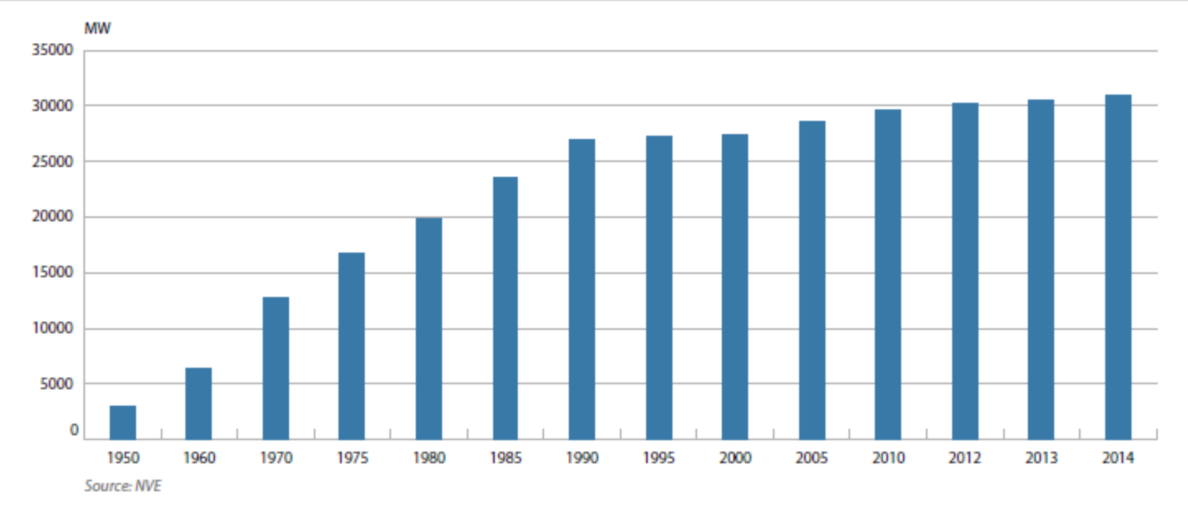

Figure 2. Installed capacity in HP-Plants as of 01.01.2014. *Source*: Norwegian Ministry of Petroleum and Energy, 2015.

The transmission and distribution systems, the electricity grid, were developed continuously during the build-up of the production capacity; -including international connections. A 700 MW interconnector between Norway and Denmark (SK4) has recently been completed (2015). This has increased the exchange capacity between Norway and Denmark to 1700 MW (Norwegian Ministry of Petroleum and Energy, 2015). Figure 3 shows today's transmission capacity within regions in Norway and in the nordic region.

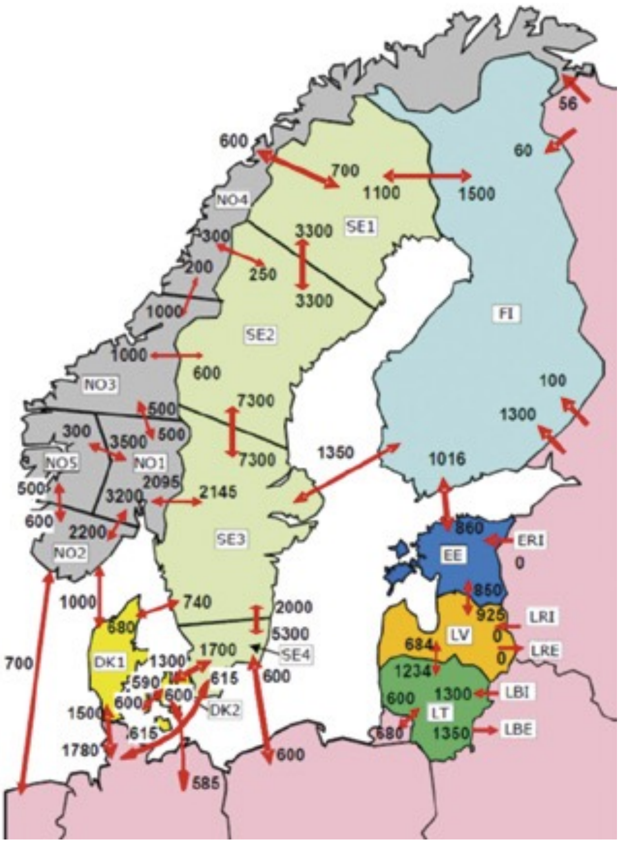

Figure 3. Transmission capacity between regions in Nordic countries. *Source*: Regional Investment Plan 2014 Baltic Sea, ENTSO-E

2.2.2 Environmental conflicts emerging in the 1960-ties - peaking in late 1970- ties/early 1980-ties.

Environmental awareness in general in the western world emerged in the late 1960-ties with the UN Natural Protection year in 1970 as an important milestone. And with the first UN high-level environmental conference in Stockholm in 1972 environmental issues really came at the global agenda.

In Norway environmental impacts of HP development was the first major environmental issue raised on the national level in Norway. Already before the Second World War, some waterfalls were protected from hydropower development; however, it was from the late 1960 ties the environmental impacts of some large HP-plans drew national attention. Focus was on impacts on, biological diversity, landscapes and outdoor recreation, fishing, tourism, cultural heritage, local communities and reindeer husbandry, but also on nature in general. .

In the 1970-ties and early in the 1980-ties a number of large plans were heavily debated and as a result altered/reduced for environmental reasons. (Aurland, Mardøla, Orkla-Grana and Alta.) Conflicts culminated during the planning and construction for the Alta HP in 1980/1981. Demonstrators tried to stop the construction work physically and 400 policemen were brought in to remove demonstrators who tried to stop construction work. There was a hunger strike in front of the Parliament (Storting) by activist representing inter alia the Sami people; Norway's ethnic minority in the north. They argued that the construction of the Alta HP-plant would have a very negative impact on Sami people livelihood and interests. The Alta plant was built, however delayed, but not according to the original scheme.

2.2.3 From 1990- ties fewer new HP- plants

As figure 2 clearly illustrates, the rate of construction of new HP decreased dramatically from the 1990-ties. In addition to low economic activity around 1990, there were other equally important reasons for this halt in HP development:

- Un until the 1980-ties the development of HP was based on the separate licensing of each project without a coordinated plan for the whole country. Each submitted application to build a hydropower plant was licensed separately and environmental impacts were evaluated and mitigation measures decided from case to case. The need to consider each application according to an overall plan had been discussed for years. The heavy conflicts became a burden to the government and the political system, and it became more and more pressing to consider the remaining HP resources in a broader national perspective. To comply with this the Government in 1980 decided to develop a national plan for the not-developed HP resources in Norway, entitled the Master Plan for Water Resources- se chapter 3.2.2. It was decided to halt all licensing of HP with the exception of HP-project considered necessary to cover expected electricity projected demand.

-A new energy legislation was introduced in 1990 covering production, transmission, trade, distribution and use of energy. The new act (Energy Act 1990) opened for a free market for buying and selling of electric energy and thereby an energy development more marked-oriented and less dependent of forecasts, planning and political decisions. It was a major step from planning free-market economy in the energy sector. With the new legislation Norway became a pioneer in liberation the energy sector. The act states that the duty for the energy companies is to produce and deliver to the national grid system, but the end users can themselves choose the energy provider. Thus the consumer can choose the cheapest and best energy product even if the energy company is located far away. This new market-oriented regime made the production and the distribution systems more efficient and effective and lowered the need and incentive to develop more HP for several years.

As "large hydro" had become "unpopular" and vast oil and gas resources were available in the North also through pipelines to the coast, the authorities for both economic and environmental reasons wanted to protect watercourses from HP development. It was decided to build gas fired power plants as an alternative to large HP plants for supplying electricity during high peak demand. Even if such power plants also were controversial due to emission of CO_2 (climate gas), two plants were built (Kårstø, 2007 and Melkøya, 2009). (It should be mentioned that the Kårstø power plant has not been in regular operation due to low electricity prices).

Figure 4. The Alta Conflict. Police removes demonstrators from construction site. *Photo*: Per R. Løchen / NTB / SCANPIX. Hunger strike in front of the Norwegian parliament. *Photo*:. Jan Erik Karlsen / Scanpix.

2.3 Hydropower resources in Norway today- outlook for the future

Norwegian electricity production totaled 134 TWh in 2014. Of this, approximately 129 TWh was produced in HP- plants, 1.9 TWh in wind power plants and 3.3 TWh in gas-fired power plants and other thermal power plants. The average electricity production has been approximately 135 TWh/year over the last 15 years. Thus 95 % of Norway electricity production is based on HP.

At the start of 2015, the total installed HP capacity in Norway was 31 100 MW. Figure 4 gives an overview for the HP potential as of 01.01.2014 in TWh/year. Out of the estimated 214 TWH total resources available (economy and environment), 62 % are developed.

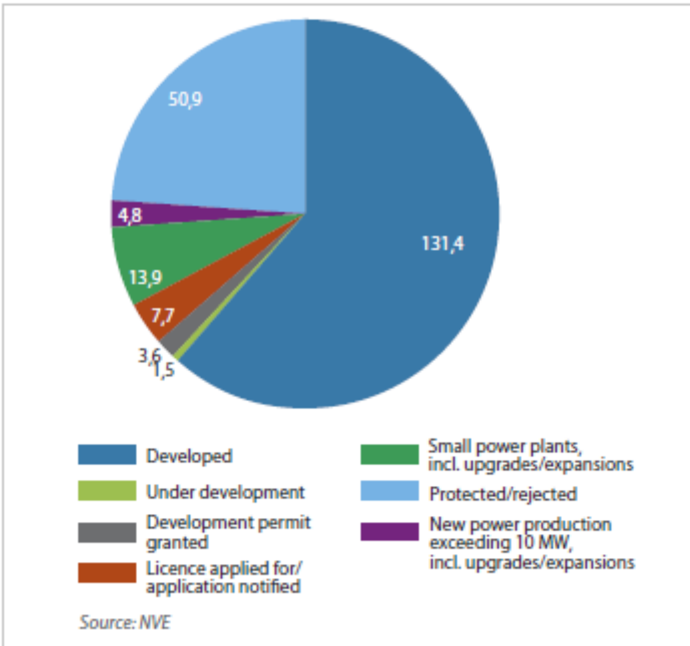

Figure 5. Hydropower potential and its status as of 1.1.2014. *Source*: Norwegian Ministry of Petroleum and Energy, 2015.

The distribution of size is shown in Table 1. We use the most common definition of small hydro that is plants with installation smaller than 10 MW.

Table 1. Hydropower plants in Norway 2015. *Source*: The Norwegian Water Resources and Energy Directorate, updated 2015.

Size in MW- Megawatt	Number of plants	Capacity in MW	Yearly production in MW
Under 1 MW	561	176	0,76
1-10 MW	614	2067	8,50
10-100 MW	255	9553	43,16
Over 100 MW	80	19299	79,66
Pumps	26	--	-0,16
Total	**Power plants 1510** **Pumps 26**		**131,91**

Small hydro (< 10MW) accounts for 78 % of number of plants but contribute to less than 1 % of the annual production. Plants with installation > 100 MW accounts for 62% of annual production. Several publications have argued for the heavy environmental impact of many small HP plants versus a few large HP plants (Bakken et al., 2014; Killer and Tullos, 2012).

The future for HP in Norway depends on drivers for more HP, as well as drivers for restrictions and even for less production. The overall driver for more HP is the need for more renewable energy to replace fossil-based energy.

Two important policy measures designed to increase the production of renewable energy should particularly be mentioned:

The EU Renewable Energy Sources (RES) Directive establishes a common framework for the promotion of energy from renewable energy sources, and was incorporated into the EEA Agreement on 19th December 2011. Each member state is required to ensure that it achieves its target for the share of energy from renewable sources in its consumption by 2020. Each member state and EEA states[1] will thus contribute to the achievement of the overall EU target. Norway's target is that the share of energy from renewable sources in Norway is to amount to 67.5 per cent of its gross end consumption of energy.

A national renewable energy action plan to achieve this is developed and submitted to ESA. (ESA is the surveillance authority for the comprehensive agreements between EU and Iceland, Lichtenstein and Norway; countries not members of EU.)

The electricity certificate scheme: Norway and Sweden have since January 2012 had a common electricity certificate market. This scheme is the most important single measure for achieving Norways national energy target in accordance with the renewables directive. Over the period until 2020, the two countries aim to increase their production of electricity from renewable energy sources by 26,4 TWh. Producers of electricity based on renewable energy sources receive an income from the sale of electricity certificates, in addition to income from the sale of electric energy. The joint market will permit trading in both Swedish and Norwegian certificates. Norway will be credited for half of the overall target for the joint certificate market between Norway and Sweden, regardless of where the production takes place, i.e. 13.2 TWh (26.4 TWh in total). The Norwegian-Swedish electricity certificate scheme is the first example of a joint support scheme between member states under the Renewables Directive.

Also to be mentioned is the need to upgrade older plants, which involve replacement of turbines and generators. This will increase yearly production and often result in increased installed capacity.

There are also direct international drivers favoring production of hydropower in Norway. Almost 50% of Europe's reservoir capacity is located in Norway (Heineman, 2011) and this enables Norway to supply power when wind/solar production is low in continental Europe. The international grid enables exchange of electricity and there is ongoing planning of more interconnections between Norway and continental Europe. In the autumn of 2014, licenses were granted to build interconnectors to Germany (under constructions) and the UK. Each of the interconnectors will have a capacity of 1400 MW. Completion is scheduled for 2018 and 2020 respectively.

The impact of predicted climate changes in Norway has already and will have profound effects for HP production. Recently the report "Climate in Norway 2100" (Hanssen-Bauer et al., 2015) was published as a collaborative effort between NVE and seven other institutions as part of the Norwegian Climate Service Centre (Norsk klimaservicesenter). The report analyzes the climate trends towards the end of the century and the consequences of climate change for Norway. Climate projections suggest that there will be more rainfall and also more runoff in most regions in the future. However, regional and seasonal differences are

[1] The European Economic Area (EEA) unites the EU Member States and the three EEA EFTA States (Iceland, Liechtenstein, and Norway) into an Internal Market governed by the same basic rules.

projected. As an extension of "Climate in Norway 2100", NVE has taken some of the data as input into their power market model to analyze potential effects of climate change for the Norwegian power system. In a recent report (NVE, 2015) they give some of the main potential trends that could be expected in the power system as a result of a warmer and wetter climate. Key points in the NVE-report (NVE, 2015) regarding potential consequences are (p. 3):

- Increased runoff as more precipitation expands the hydropower potential.
- More evenly distributed runoff over the year; as temperatures increase precipitation will come as rain instead snow in a greater part of the year. This will contribute to more autumn and winter runoff. Whereas today much of the peak flow comes from snowmelt, it will in the future come earlier and decrease.
- Increased hydropower generation as a result of higher runoff. The greatest increase will be in areas with much regulated power generation as the runoff also increases most in these regions.
- Increased flood loss, as the HP infrastructure cannot handle the large increases in runoff during autumn. This will lead to significant increase in the flood loss during autumn mainly in smaller and medium-sized magazines. The flood loss during spring will be reduced, but the total flood losses increase towards the century.
- Increased production and reduced flood loss in the more unregulated watercourses. When the inflow is distributed more evenly over the year, the major flood losses associated with snowmelt is avoided, while autumn and winter production increases. Smoother inflows over the year contribute to a higher utilization of production facilities throughout the year in areas with much unregulated production.
- Climate change makes the need to move water between seasons less. As the temperature increases, the discrepancy between resource availability and resource needs becomes smaller.
- The profitability by moving water between years increases as the seasonal variations become smaller. There will be a greater variation in reservoir optimization from year to year because the largest reservoirs to a greater extent are allocated as multi-year reservoirs.
- There will be less seasonal variation in energy prices as smoother inflow contributes to the seasonal price fluctuations reduced. This changes the competitive relationship between different types power generation.
- Reduced winter consumption due to temperature increase, increasing relatively more in the winter, which can lower power demand in the cold season.

As of 2013 all Environmental Impact Assessments (EIA) in connection to hydropower development projects are to describe and take into account how climate change is expected to influence relevant aspects and furthermore how climate change adaptation is taken into account. This is now part of the standard requirements set by the NVE for EIAs in HP project applications. As this is a relatively new "demand"; the exact practice of how this is done is still being developed and evaluated.

The HP companies themselves are now in the process of establishing how to work with and take into account climate change aspects in practical terms as part of their planning and operations (E-CO Energi, 2015). Furthermore, connected to water resources management following the Water Framework Directive (WFD) the Norwegian Environment Agency being responsible for the implementation in Norway, has now initiated activities for developing new national guidance material on how to include aspects of climate change in the implementation of the WDF. This will then be particularly relevant related to environmental measures concerning hydropower development and operation.

The key driver against further development, restrictions and even lower production are environmental considerations in the broad sense. Key issues are; the high percentage of resources already developed, the need to preserve nature untouched, biological diversity and in general all the well-known impacts of HP: landscape esthetics, outdoor recreation, fishing, tourism, cultural heritage, local communities etc. There is a number of management tools designed to balance HP development with environmental impacts (see Chapter 5 on mitigation measures).

In this context the WFD and the system for revision of older HP licenses system should particularly be mentioned:.

The WFD`s River Basin Management Plans (RBMP`s)for the planning cycle 2009-2015 now under consideration in the ministries, contain proposals for improving the water environment in regulated rivers and lakes (in water bodies classified as Heavily Modified Waters). The implementation of proposed measures like minimum/environmental water flow and or reservoir restrictions will result in a certain loss of production capacity. It is accepted that the implementation of the WFD in watercourses developed for HP will result in a certain loss of electricity production. The final evaluation of the RBMP will inter alia consider the plans consistence with national goals for production of renewable energy.

Likewise, the ongoing revision of conditions in older licenses, also with the aim to improve the water environment, will often result in less energy production.

3. Licensing and planning frameworks for HP

3.1 Introduction – key players and roles in Energy- and Water management

In order to present and understand licencing and planning processes relevant for HP, it is necessary to have some basic knowledge of the "players"; who are they, what are their responsibilities and tasks.

- The Parliament (Stortinget) determines laws and the political framework for energy and water management.

- The Government has the executive authority, and exercises this through various ministries. The three most important ministries are:

- The Ministry of Petroleum and Energy (MPE) has the overall administrative responsibility for energy and management of water as a resource
- The Ministry of Climate and Environment (MCE) is responsible for environmental legislation, and management of water quality issues (pollution). It is the responsible ministry for the implementation of the Water Framework Directive in Norway.
- The Ministry of Local Government and Modernization (MLGM) is responsible for the planning legislation.

Two key governmental bodies under MPE and MCE have very important task:

Norwegian Water Resources and Energy Directorate (NVE) reports to the Ministry of Petroleum and Energy, and is responsible for managing domestic energy resources. It is also the national regulatory authority for the electricity sector. NVE is responsible for managing Norway's water resources (quantity) and for central government functions as regards flood and avalanche/landslide risk reduction. NVE is involved in research and development and international development cooperation, and is the national hydrology expert body. NVE is the key institution for licensing and license compliance control for HP. NVE has five regional offices with defined responsibilities.

Anyone who wants to undertake a project related to the energy sector (that requires a licence) needs to apply for a license with the NVE. The NVE evaluates the impacts on the environment and society against the use and necessity of the construction of the hydropower plant. The details concerning the licencing process will be described in the next chapter.

The Norwegian Environment Agency (NEA) reports to the Ministry of Climate and Environment and it is the key governmental player for execution environmental legislation on the environment, including impacts of HP. At the national level, the NEA has the overall responsibility for the management of pollution, climate mitigation and adaptation. NEA is responsible for the implementation of the Water Framework Directive in Norway.

The key state organizations of energy and water resources management are illustrated in Figure 6 below.

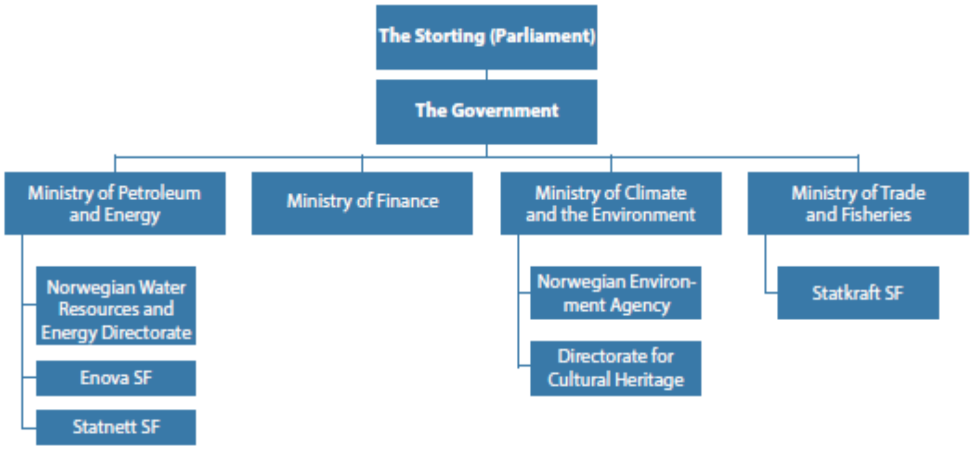

Figure 6. Key State Organizations in Energy and Water Resources Management.[2] *Source*: Norwegian Ministry of Petroleum and Energy, 2015.

At the regional level, the counties (19 in Norway), and the water regions (according to the WFD, 11 in number) have important roles. At the local level, municipalities (over 400 in Norway) have key roles and major influence. The municipalities are heavily involved in the HP licensing process and also surveillance activities after the plant has been constructed. The "hydropower municipalities" are among themselves organized in the organization: "The Norwegian Association of Municipalities hosting Hydropower Plants" (LVK). Althogether 172 municipalities as members here.

Environmental NGOs are important players in HP-issues. Particularly should Norges Naturvernforbund (Friends of the Earth Norway) be mentioned, already founded in 1914. It has been and is the most important NGO related to HP.

3.2 Framework for licensing

3.2.1 Introduction

The licensing system is the management tool which frames a license application and defines a future HP project. A license is necessary for all forms of HP development; be it large or small, new or related to extending/upgrading of an old plant.

The HP licensing system operates within a framework of governing laws and regulations. We can distinguish between a legal framework consisting of laws and regulations, and different framework plans. It is however, often difficult to separate between a legal framework and a planning framework as these can be overlapping. The Water Framework Directive (WFD) is an example of such an overlapping regulation

[2] Comments on bodies not mentioned in the text: Statnett is the state-owned enterprise for building and operating the central grid. Enova is a state-owned enterprise that manages the assets in the Energy Fund. Enova's objective is to promote a shift to more environmentally friendly consumption and production. Statkraft is the independent state-owned energy company. Directorate for Cultural Heritage is inter alia responsible for evaluating relevant impacts of HP.

as it forms part of the of national legislation (the Water Regulation /Vannforskriften), and as it provides detailed guidelines for water resources planning through the River Basin Management Plans.

3.2.2 Legal framework, laws and regulations

The legal framework for licensing has developed in parallel with the increasing weight on environmental issues. As environmental issues related to HP emerged and got stronger , the government established a comprehensive set of laws, regulations, licensing procedures and framework plans to improve the balance between the need for more energy from HP and environmental requirements.

The most important management tools relevant for HP development and the year of their introduction are shortly described below. It should be mentioned that in the two laws from 1917, the environment was not an important issue.

Industrial Licensing Act (1917)

The purpose of the Act relating to acquisition of waterfalls is to ensure that hydropower resources are managed in the best interests of the general public. This is to be ensured through public ownership of the hydropower resources at national, county and municipal levels.

Watercourse Regulation Act (1917)

A permit according to this Act relates to the regulation of watercourses to make use of the water in a regulation reservoir for power generation[3]. Transferring water in a watercourse also requires a license. The Act also gives the licensee the authority to expropriate necessary property and rights in order to carry out the regulation measures. Even if someone has the right of ownership of a waterfall, a separate permit is required under this Act.

Water Resources Act (2000)

Power plants that do not involve regulation of a river will most often require a license under this Act. The permission then refers to the potentional impact on river systems and groundwater. Environmental concerns, maintenance of natural processes in river systems, and their intrinsic value as landscape elements are some of the important factors of focus for this Act.

Planning and Building Act (1965-2009)

The Planning and Building Act (PBA) is the key legislation for Environmental Impact Analyses (EIA) (see Chapter 4). Furthermore, the decree for the implementation of the Water Framework Directive (WFD) – the Water Regulation - and its legal authority is partly provided by the Planning and Building Act, and inter alia for the preparation of the River Basin Management plans.

The Act relating to planning and processing of building applications applies in parallel with the energy and water resources legislation, but important exemptions have been made for the energy sector. As a general rule, the provisions of the Planning and Building Act relating to building applications do not apply to projects under the energy and water resources legislation.

Other national laws and regulations

There are several other national relevant laws statutes that are significant for energy and water resources:

• Nature Diversity Act (Ministry of Climate and Environment)
• Expropriation Act (Ministry of Justice and Public Security)
• Competition Act (Ministry of Government Administration

[3] TheWatercourse Act of 1887 codified and clarified the legal rights that had developed along the extensive use of water power for local grain-mills etc. over centuries. The right to utilise the water fall could be sold off separately by the owner of the adjacent land. But the owner of the utilisation right could not alter the flow or the course of the water to the detriment of others without permission (Wold et al. 2007).

Reform and Church Affairs)
• Natural Gas Act (Ministry of Petroleum and Energy)
• Consumer Purchases Act (Ministry of Justice and Public Security)
• Pollution Control Act (Ministry of Climate and Environment)
• Neighboring Properties Act (Ministry of Justice and Public Security)
• Cultural Heritage Act (Ministry of Climate and Environment)
• Outdoor Recreation Act (Ministry of Climate and Environment)
• Reindeer Husbandry Act (Ministry of Agriculture and Food)
• Public Administration Act (Ministry of Justice and Public)

The Water Framework Directive (WFD) and other relevant EU legislation
The WFD is the EU directive most important for current HP management. The directive itself is assumed to be well known for the target group; thus only a very short introduction is included in the following section on Framework plans. In Norway, the The WFD has been implemented through the decree, "The Water Regulation" (in Norwegian: "Vannforskriften").

In addition to the WFD, a number of directives and regulations in the energy field have also been integrated in the EEA agreement. (Inter alia EUs 3 Energy marked Packages, The Renewable Energy Directive (RES), the Energy Performance Buildings Directive, the Eco-design Directive and the Energy Labelling Directive).

3.2.3 Framework plans

In this section we cover the thematic framework plans and policies; the national management tools that set the framework for licensing procedures for the production of renewable energy in Norway. The different types of plans and policies mentioned are very different.

Framework plans important for HP licencing can be said to be of three types according to their relation to HP: 1) "HP focused" (sector specific, dark blue), 2) "Environmental protection-oriented Plans" (light blue) and 3) "HP- neutral" (sector neutral, light green). Figure 7 illustrates the most important plans which should be considered for licencing of renewable energy, including HP.

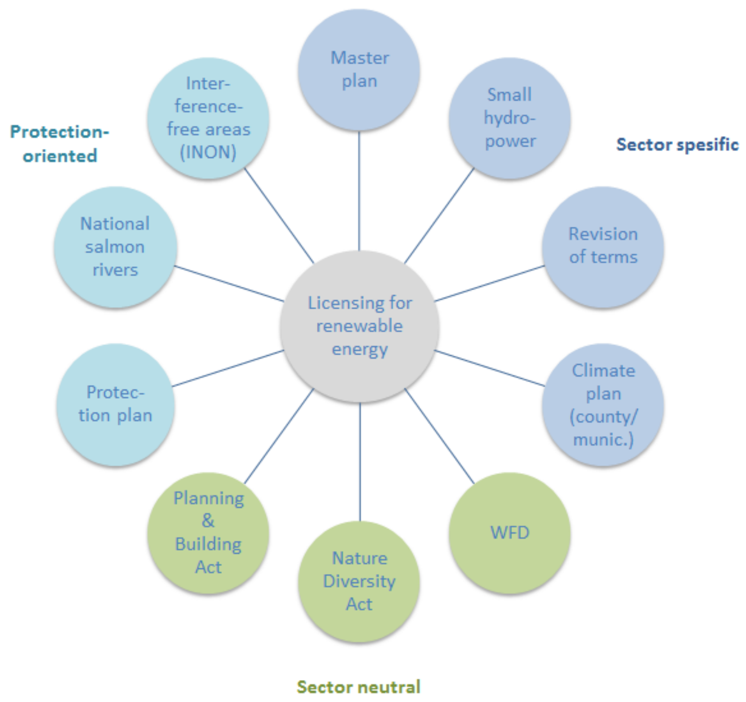

Figure 7. Licensing for renewable energy and surrounding framework plans. *Source*: modified from NIVA, 2011.

Five important framework plans are described in some detail in the continuing pages:

- The Watercourse Protection Plan (1973)- (Environmental Protection Plan)
- The Master Plan for Hydropower development (1986)- (HP-focused Plan)
- The Water Framework Directive (2006)- (Natural Resource Plan)
- Hydropower Licenses subject to revision before 2022. National overview and proposed priorities (Revision Survey, 2013)

Other relevant framework plans are described only shortly below in the paragraph "Other Framework Plans/Planning Activities" at the end.

The Watercourse Protection Plan

The first major effort to protect watercourses from HP development was the Watercourse Protection Plan (WPP) (The Watercourse Protection Plan, 1983). The plan aims to secure whole watersheds with its diversities from "mountains to fjords". The protection is focused on HP development, but also other impacts shall be considered. The river systems listed in the WPP are permanently protected against hydropower developments larger than 1 MW. The first plan was adopted by the Parliament as early as in 1973 and six supplementing plans; the last in 2009 has followed.

The plan constitutes binding instructions for the public administration not to grant licenses for regulation or development of specific river systems for power production purposes. In evaluating which river systems should be protected, it was considered important to ensure that a representative selection of Norwegian river systems was protected. Any distinctive features and opportunities for outdoor recreation in the respective areas were also considered important. A total of 388 river systems or parts of river systems with a hydropower potential of approximately 45 TWh/year are protected against hydropower development following the WPP[4]. Figure 8 shows that the WPP cover a considerable part of Norway.

In the Parliamentary report on energy ((White Paper 25 (2015-2016) "Kraft til endring – energipolitikken mot 2030*"*) proposed by the government April 15th 2016, it is opened for HP development in some of these protected watercourses if societal benefits of the HP-project are large and the environmental impacts are acceptable. It is expected that this proposal to "open" the Watercourse Protection Plan will be heavily debated in the Parliament.

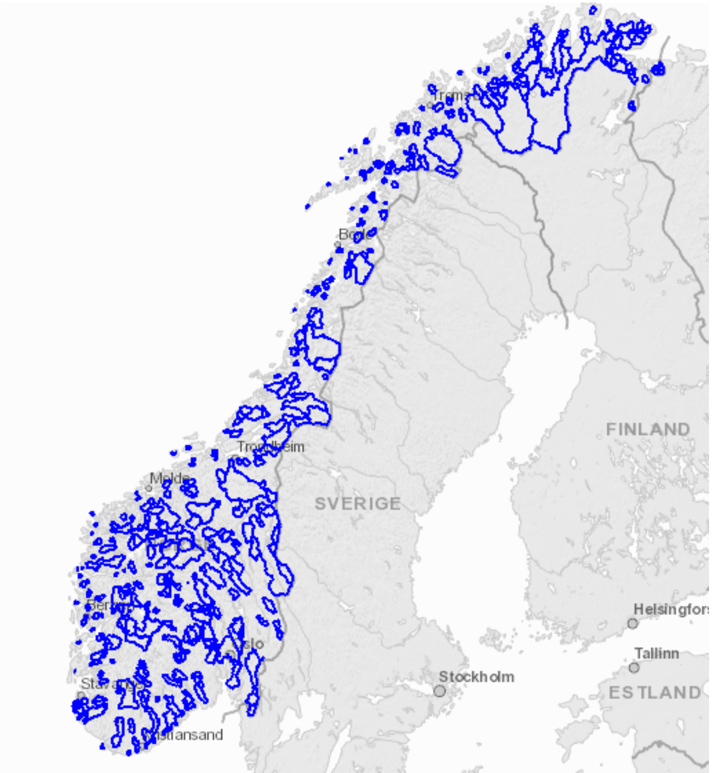

Figure 8. Protected watercourses in the Watercourse Protection Plan. *Source*: The Norwegian Water Resources and Energy Directorate (NVE)

The Master Plan for Hydropower development

As a result of the environmental conflicts related to HP- projects in Norway, and in particular the Alta project in the 1970-ties, the Parliament decided in 1980 to provide resources for the development of a national framework priority plan regarding future HP development. The first master plan was presented to the Parliament in 1985.

The Master Plan for Hydropower Development was a recommendation in the form of a white paper (most recently Report No. 60 (1991-92) to the Parliament). The plan sets out an order of priority for projects that can be considered for licensing, and divides them into two categories. *Category I* include projects where licensing procedures may be started immediately. Projects in *Category II* includes projects which may not be submitted for licensing at the present. Projects are classified as *Category I* or *Category II* projects depending on two aspects; their economic impact consideration and their degree of conflict with other interests. Figure 9 below illustrates how the economic impact considerations and the different

[4] The Water Resource Act defines protected river systems, and lays down rules for their protection both against hydropower developments and against other types of disturbance

conflict classes in combination places a project in either *Category I* or *Category II*.

The Parliament discussed the framework for the Master Plan in 1983. The basic principle was that all HP resources, from well planned projects in the licensing process to HP projects subject to prefeasibility studies and HP resources with only sketchy plans existed, should be included in the plan. All licensing procedures were in principle ceased till the Master plan was finished. However, due to the need to ensure adequate power coverage, it was decided that some watercourses/projects had to be exempted from the planning. Thus some large projects, mostly in the licensing process, were not included in the plan representing approx. 11 TWh. Also projects with installation < 1 MW were not included.

The following basic impact areas/criteria were used to develop this master plan: Nature Conservation, Outdoor recreation, Fish and Wildlife, Water Supply and Water Quality, Cultural Heritage, Agriculture and Forestry Reindeer Husbandry, Flood Protection and Erosion Control, Transportation, Ice and Water Temperature, Local Climate and Regional Economy. All impacts were classified on a scale from -4 (negative impacts) to + 4 (positive impacts), weighed and then aggregated to an impact class C1-C8 and then further balanced with six economic hydropower classes (E for economy class in Figure 9) .

Conflict class

	C1	C2	C3	C4	C5	C6	C7	C8
E1	1	1	2	3	5	7	9	12
E2	1	1	2	3	5	7	9	12
E3	2	2	3	4	6	8	10	13
E4	3	3	4	5	7	9	11	14
E5	4	4	5	6	8	10	12	15
E6	5	5	6	7	9	11	13	16

Economy Class

Category I

Category II

Figure 9. Balancing economy and environment in the Master Plan for Hydropower development. The shaded squares / red numbers refers to Category II type of projects i.e. projects which not be submitted for licensing at the present . *Source*: The Master Plan for Hydropower Development, 1984.

Appendix B. provides more detailed information about the methodology in the Master Plan including the approach in weighing economy and impacts and the rationale behind the 16 groups and the 2 final categories.

The intention was to ensure that the river systems that will provide the cheapest power and where development will have the smallest environmental impact are developed first. However, the fact that a project has been approved in the Master Plan, does not entail a binding advance commitment to grant a license, only that the application may be processed. The licensing authorities (NVE) have turned down applications for projects in Category I. They have the legal authority to reject applications that are in conflict with the plan.

When the Parliament considered the 2005 supplement to the Protection Plan, it was decided that hydropower projects up to 10 MW or projects with an annual production of up to 50 GWh would be exempted from processing in the Master Plan. Many of the relevant developments will fall into this category. Since the Parliament considered the Master Plan in 1993, the framework for HP development has altered in a number of ways. Most of the projects that are notified today are different in technical, environmental and economic terms from those described in the Master Plan.

In the Parliamentary report on energy (White paper 25 (2015-2016)*Kraft til endring – energipolitikken mot 2030*") proposed by the government April 15th 2016, is proposed to delete the evaluation of proposed HP – plans position according to the Master Plan. The reasons for this is partly that projects in the Master Plan are outdated, and partly that the WFD planning system with the RBMP`s now act as a necessary framework planning tool for HP- licenses.

The Water Framework Directive (WFD)

The basics of the WFD in general are well-known to the project group of Bulgaria, and are hence not elaborated in detail in this report.

The WFD has been implemented in Norwegian law through the decree "The Water Regulation". (In Norwegian: "Vannforskriften"). The standard environmental objectives are the achievement of «good ecological status" no later than 15 years after the entry into force of the WFD. The directive was formally adopted by Norway in 2006; thus 2021 is the target year to achieve the environmental goals.

The WFD allows for the definition of certain water bodies as; "heavily modified" (HMWB). The environmental objectives for these are less ambitious. They include water bodies where extensive physical alterations have been made for the benefit of society, so that they will not be able to achieve the standard environmental objectives.

Member states may also set, "less stringent environmental objectives*"*. This refers to water bodies which are so affected by human activity or natural conditions that the objective of good quality cannot be met, and the environmental and socio-economic needs served cannot be achieved by other means including a significantly better environmental option. The set of criteria to be fulfilled for allowing less stringent environmental objectives is strict. These criteria refer to:

(i) New sustainable human development activities;
(ii) Actions or policies aiming to protect fundamental value for citizen's lives (health, safety, environment);
(iii) Artificial or heavily modified water bodies being described.

In Norway the selected HMWB`s, and the water bodies where less environmental objectives have been set, are dominated by water bodies that have been regulated for hydropower production.

Norway is divided into 11 water regions (see Figure 10).

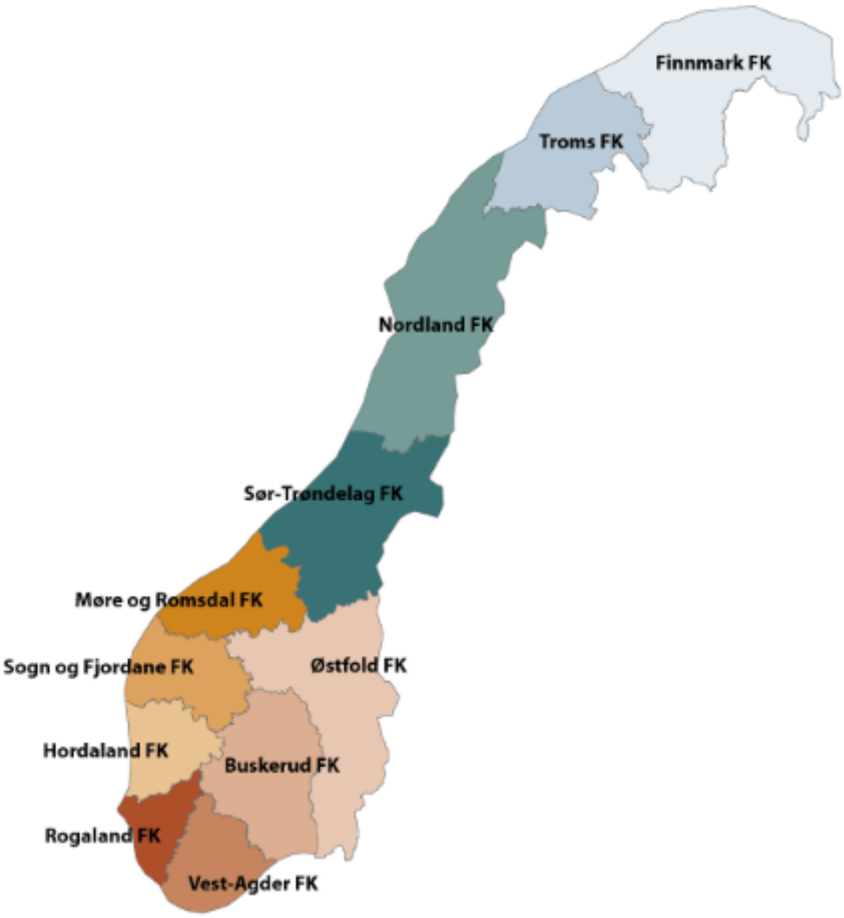

Figure 10. Water Regions in Norway according to the WFD. *Source*: Vann-nett, 2010; www.miljøstatus.no

After a voluntary pilot period (covering 29 watersheds) parallel to the first planning cycle of the WDF in the rest of Europe, Norway`s first full planning six year cycle (2009-2015) is now finished and the first set of River Basin Management plans (RBMPs) was during autumn 2015 approved by the 11 water regions and the 19 county councils (fylkeskommuner). While this report is written, key organizations in the central government; the two key ministries and their subsidiaries (MPE, MCE, NVE and NEA) are evaluating the plans, their consistencies with national policy and goals, points for improvements etc. The RBMP`s are expected to be adopted by the Ministry of Climate and Environment, -the ministry responsible for the WFD-, during the second half of 2016.

The licensing of HP has to relate to the framework of laws and plans (Chapter 2.1 and 2.2.). The licensing authorities, however, are not formally obliged to follow the RBMPs and its proposed measures; the RBMPs are supposed to guide the HP licensing. Yet, according to the WFD, this guidance should have real influence if the necessary requirements for proposed measures in the RBMP are fulfilled.

The implications of the WFD for HP management are further discussed in section 4.5.

Hydropower Licenses subject to revision before 2022. National overview and proposed priorities

An ongoing important and dominating HP licensing activity in the coming years is related to regulations which may can be revised, - if demanded.50 years after a licence was granted (30 years for all licenses granted after 1992), the licensing conditions may be revised. The current situation is that approximately 430 licenses can be revised before 2020. The purpose of the revision is to enable an updating of licensing condition to improve environmental conditions. Reservoir levels (HRLW/LRWL), economic compensations and private law issues are normally *not* subject to revision.

The survey of projects subject to revisions was presented in 2013 (NVE, 2013), (hereafter named the Revision Survey) with the goal to provide an overview of the watercourses where societal benefits of environmental improvements most likely would outweigh the cost in form of reduced renewable or regulated hydropower production.

Based on mapping of environmental values and user interests, it was in the Revision Survey considered if environmental flows and/or reservoir registrations were necessary to improve the water environment. Corresponding impacts for power production, flood protection, supply security and potential for upgrading and extension of existing plants for additional production were evaluated.

Key environmental aspects/criteria were: 1) Fish and fishing 2) Biodiversity and 3) Landscape and recreation /tourism. For each river/water body for these three topics the following evaluations were performed:

- The value and the impact of the HP-plant
- Possibilities for environmental improvements and actual measures
- Production limits and lost power if the environmental measures were implemented
- Aggregated evaluation

Table 2. The criteria for the 4 priority classes of rivers/water bodies in the Revision Survey. *Source*: Revision Survey, 2013.

Category	Priority	Explanation
1.1.	High 50 rivers/water bodies	Watercourses with high potential for improvement of important environmental values and small or moderate loss of power vs environmental improvement
1.2.	Lower 53 rivers/water bodies	Watercourses with moderate potential for improvement of important environmental values and larger (ref 1.1) loss of power vs. environmental improvement
2.1.	No priority 84 rivers/water bodies including 2.2.	Watercourses with less environmental values
2.2.	No priority 84 rivers/water bodies including 1.1.	Watercourses with important environmental values, but limited possibilities for further improvements or special conditions hinders measures

In the Revision Survey 187 rivers/water bodies were evaluated. Total loss of hydropower prodcution was estimated to 2, 3 - 3, 6 TWh/year (1, 8-2, 8% of annual production) and production loss was less than 5 GWh in 40% of the priority rivers. (Category 1.1. and 1.2.).

The Revision Survey with its priorities constitutes a very important framework both for the formal licensing procedures related to the revision of existing licenses as well as for River Basin Management Plans (RBMP) in the Water Framework Directive. It is an important input to the goalsetting and measures related to HP, and particularly in setting the good ecological potential in heavily modified water bodies in the RBMPs.

Other Framework Plans/Planning Activities
There are restrictions on HP development also in national parks, areas subjected to special protection due to landscape, biodiversity etc. Particularity it should be mentioned that a number of watercourses and fjords have been selected for the protection of wild salmon.

52 national "Salmon Rivers" and 29 "Salmon Fjords" have been selected from Norway's 600 salmon watercourses. The «Salmon Rivers" and "Salmon Fjords" represent about 75 % of Norway's wild salmon resources. The Government has stated that new HP developments must not harm salmon production considerably. For new HP schemes in Norway, mitigation measures to avoid damage to the salmon population has to be an important condition in the license for HP development.

Mapping of wilderness areas (INON: areas without major infrastructure development in Norway) should be mentioned. Both the Parliament and the Governments have expressed the value of maintaining areas untouched by major technical infrastructure such as larger power lines, roads and HP- infrastructure. Three classes of Wilderness have been defined: Class I: more than 5 km from major infrastructure, Class II: 3-5 km distance and Class III: 1-3 km distance. The so called "INON areas" have no formal position in laws or regulation, but can be considered an important policy.

Counties and municipalities, (regional and local level) have developed plans for hydropower development, which are considered during licencing activities. Several county and municipal small hydro overviews and priority plans have been developed. One such county plan is the Hordaland County Plan for Small Hydro (2009). Hordaland is among the Counties in Norway with the most HP. In this plan eight impact aspects/criteria are assessed: 1)Landscape/Vulnerable high mountain areas, 2) Fjord landscape, 3) Biological Diversity, 4) Wilderness, 5) Fish, 6) Cultural Heritage, 7) Outdoor recreation and 8) Tourism impact classes. Such plans are of particular importance in the hearing processes for the licensing and revisions of hydropower projects and/or plants. The Regional and Local Energy and Climate Plans will, however, have only more indirect implications for HP licensing.

4. The HP licensing process step by step

A license is a document which grants special permission to a specified company to develop and run power stations and dams specified in the license, including conditions and rules of operation. A license can also be defined as a permission granted by the authorities to cause disturbance or damage to the environment. However, the damage should be less important compared to the advantages of the project. The damage should not be larger than necessary, and may be mitigated at acceptable costs.

Before someone is allowed to build a new HP plant, they have to apply for a licence with the licensing authorities. These licensing authorities are the NVE, and on the higher levels the Ministry of Petroleum and Energy (MPE), the Government and the Norwegian Parliament[5]. It is their task to examine possible conflicts between the environment and the different interests groups involved.The public hearings[6] before a licence can be granted and the parliamentary debate on major development projects serve as the main tests of acceptability of the project amongst the public (Wold et al., 2007). Underlying this examination process is a framework of laws and regulations (see the previous chapter).

[5] For hydropower plants of less than 1 MG, and and not subject to licensing i.e. it will not be of significant damage or inconvenience to public interests , then it is the municipality that will deal with the case according to the Planning and Building Act. If the plant is less than 1MW but licensable, then an application will have to be submitted to NVE, NVE will write a recommendation and the County Governor will decide.
[6] When new hydropower projects are planned, public participation is normally financed by the municipality or in some cases by the counties.

The following sections present the different parts of the licensing system: Section 4.1 describes the three different licensing procedures; Section 4.2 specifies the EIA procedure; then Section 4.3 describes the conditions on which a license is given; and in Section 4.4 we describe how the licensing procedure relate to the WFD; then the last section, Section 4.5 the surveillance and control with compliance of the licensing system is described.

4.1 The licensing procedure

The steps of the HP licensing process depend on the size of the project, which also have associated different demands for an Impact Assessment (IA)/Environmental Impact Assessment (EIA).

The IA/EIA report shall provide details on potential impacts of the HP plant/project (see Section 4.2 on the EIA). It is a pathway to address potential impacts and how these may be addressed. It is a tool to integrate environmental concerns and considerations into the decision-making processes of governments. The assessments will help to arrive at informed decisions, set conditions for development and serve as a basis for the follow-up and monitoring of the implementation of decisions.

Below follows a description of the three different licensing procedures distinguished under the Watercourse Regulation Act and the Water Resources Act:

- Large hydropower projects > 10MW installation dealt with under the Water Resources Act and the Watercourse Regulation Act
- Small hydropower projects < 10 MW installation dealt with under the Water Resources Act that do not involve regulatory measures exceeding the limit that triggers licensing requirements under the Watercourse Regulation Act
- Revisions of conditions/terms in older hydropower licenses

Figure 11 shows a simplified illustration of the two dominating laws for HP licensing; the Watercourse Regulation Act and the Water Resources Act. The Acquisition Act is not important in this context; it applies when there are no/insignificant environmental impacts (renewal of machinery only etc.). The Planning and Building Act is the key legislation for the IA/EIA (see Section 4.2).

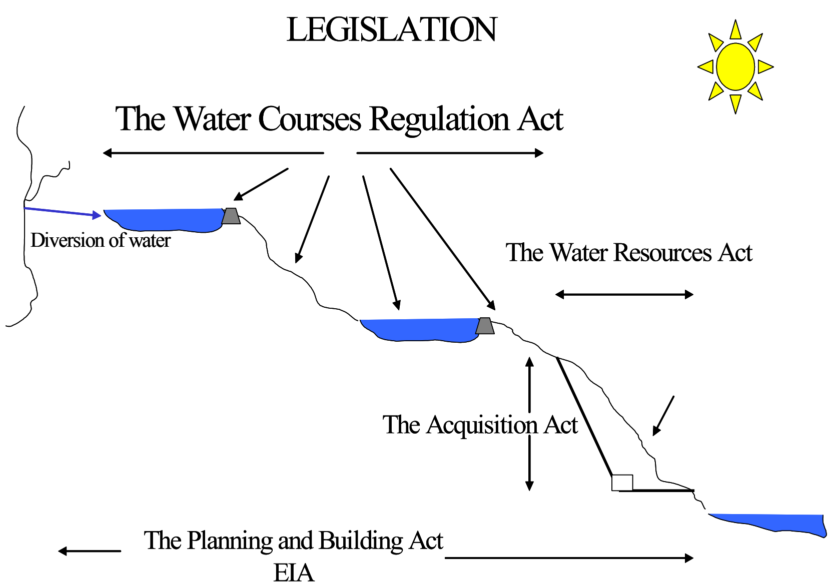

Figure 11. HP licensing in Norway and important laws. *Source:* NVE, 2015.

For all the three project types described below there is a general agreement that the processes can be described as democratic, with predefined procedures, sufficient possibilities for public involvement, and transparent (Wold et al. 2007). The process is however quite time-consuming, from half a year up to five years and sometimes even more for "difficult/complicated" projects.

4.1.1 Large Hydropower projects

The Government (King in Council) is the licensing authority for projects dealt with under the Watercourse Regulation Act and developments with an installed capacity exceeding 10 MW pursuant to the Water Resources Act. NVE is responsible for procedures during the application phase.

Proposals for hydropower plants larger than 10 MW or with an annual production exceeding 50 GWh must always first be assessed vis-à-vis the criteria of the Master Plan for Hydropower Development, unless they have already been placed in Category I (See Chapter 3). For projects listed in Category II, an application for an exemption must be submitted to the NVE. The NVE then consults the Norwegian Environment Agency (NEA) which makes a decision on this application.

If a project is approved under the Master Plan for Hydropower Development, the actual application process can start.

Step 1: The notification
As a first step towards a licence for the development of a large HP plant, the developer / the applicant sends a notification which includes a technical presentation of the project, alternatives, environmental impacts and the developer's proposed program for impact assessment studies to be carried out to is sent to the central and local authorities and also to the public for consultation. Local people may study the plans at the local post office, library or town hall. When and where the plans could be studied is advertised in the local newspaper. One or more public meetings are arranged in the project area to give information about the licensing process and the project plans. At the meetings, different opinions are expressed (including alternative plans) and the possible conflicts related to these plans or parts of the project are also discussed. Separate meetings to inform local administrations and politicians may also take place.

Step **2: The IA / EIA**
Stakeholders and the public are invited to comment on the notification within 6 weeks and particular emphasis is made on issues that should be subject to more detailed studies in an impact assessment study (IA). An EIA is mandatory for HP plants with an annual production exceeding 40 GWh. For other installations below 40 GWh, an EIA is required if the project may have significant effects on the environment and society. Opinions concerning the application and IA-reports are sent to NVE within a fixed time period (not shorter that three months). If the IA-reports uncover new aspects, additional IA-assessments may have to take place.

Step 3: The license application and the hearing
The NVE decides whether the impact assessments conducted, meet with the requirements as given in the IA program, and if the fact-basis for a decision is sufficient. If not, the applicant is requested to carry out additional studies. After completion of the impact assessment, a formal application and the full impact study are sent to the NVE. All this material is made available to the public, and stakeholders, and public meetings are organized to present the new technical plans, conclusions of the impact assessments and the further handling procedures. Another 12 weeks are available for comments and opinions on the project, opinions that the applicant gets the opportunity to comment on.

Step 4: NVE decision making
The NVE then make its final assessment of the project based on information presented in the application, the impact assessment studies and all written comments or opinions received. The assessment includes all the elements related to costs and benefits of the project, environmental and social issues and costs related to potential mitigation measures of any negative impact. A license is recommended only if the total

benefits exceed the costs and the negative social and environmental impacts of the project. The recommendation for or against the construction of the HP plan is then presented by NVE to MPE.

Step 5: Hearing at ministry level and final decision making on the construction of the HP plant
Before the case is concluded it is sent for another hearing to all affected ministries and local authorities for final comments. Based on all available information about the project, the MPE prepares a separate recommendation which goes to the Government for preparing the final decision in form of a royal decree. The recommendation is based on the application, the NVE's recommendation, the views of affected ministries and local authorities and the Ministry's own assessments. In case of a major or controversial project, the Parliament (Storting) is involved in the process, too, "so that it has an opportunity to debate the matter before a license is formally granted by the King in Council".

The figure below illustrates the procedures for large HP projects.

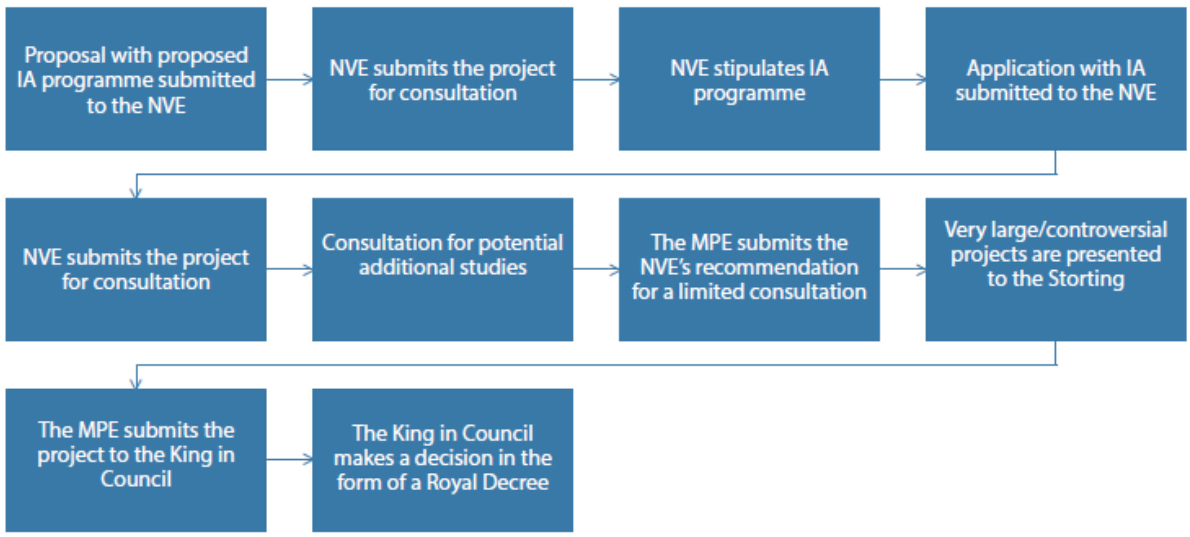

Figure 12. Procedure for larger HP projects subject to EIA regulations appendix 1. Small HP projects. *Source:* Norwegian Ministry of Petroleum and Energy, 2015.

4.1.2 Small-scale Hydropower Projects

The licensing authority pursuant to the Water Resources Act has been delegated to the NVE for power plants with an installed capacity below 10 MW, and for power plants that do not involve regulatory measures necessitaites that triggers licensing requirements under the Watercourse Regulation Act.

The procedures for small-scale hydropower plants are somewhat simpler than those for large-scale projects, so these can be processed more quickly. From 2010, the licensing authority for power plants below 1 MW (mini and micro power plants) has furthermore been delegated to the County Governor, except in cases involving the development of such plants in protected river systems. If the plant is less than 1MW but licensable, then an application will be submitted to NVE, NVE will write a recommendation and the County Council will decide. For hydropower plants with installation less than 1 MW, not subject to licensing and not causing significant damage or inconvenience to public interests, the the municipality can decide according to the Planning and Building Act.

In June 2007, the Ministry of Petroleum and Energy (MPE) published guidelines for small hydropower plants with the aim of facilitating regional planning of such power plants and strengthening the basis for comprehensive, efficient and predictable licensing procedures. For power plants of between 1 and 10 MW, a study of biodiversity that may be affected by the development is required.

The different licensing steps for small hydropower plants are as follows:

Step 1: The Application
Before writing the application the applicant should find out what type of application is needed, and who appropriate licensing authority (see is above). All HP plants above 10MW need a license from NVE. The application needs to include a short summary of the main technical interventions; specified hydrological information and a simplified environmental impact assessment i.e. how different public interests are affected, for example: landscape and outdoor recreation, cultural, valuable habitats, red-listed species, fish, user interests, reindeer. It should be stated whether it's planned release of minimum flow.

Step 2: The NVE license processing
Firstly a NVE officer checks that the submitted application follows the necessary requirements. Then pursuant to the rules of the Planning and Building Act, public notice of the application is given in the local media, it is distributed for public inspection and circulated to affected authorities, organizations and landowners for comments. Following the consultation process, the area will be inspected by NVE before a decision is made.

Step 3: The decision
NVE can make a final decision on licensing issues for small power plants. The decision is made based on the interests and values of stakeholders, the general public and private interests. and evaluated against each other. NVE's judgements are presented in a separate document. All assessments made are based on guidelines from the MPE.

The Ministry (MPE) is the appeal body for the NVE's decisions The MPE's decision is final and cannot be appealed to a higher authority. Figure 13. below illustrates the procedure for small HP- projects.

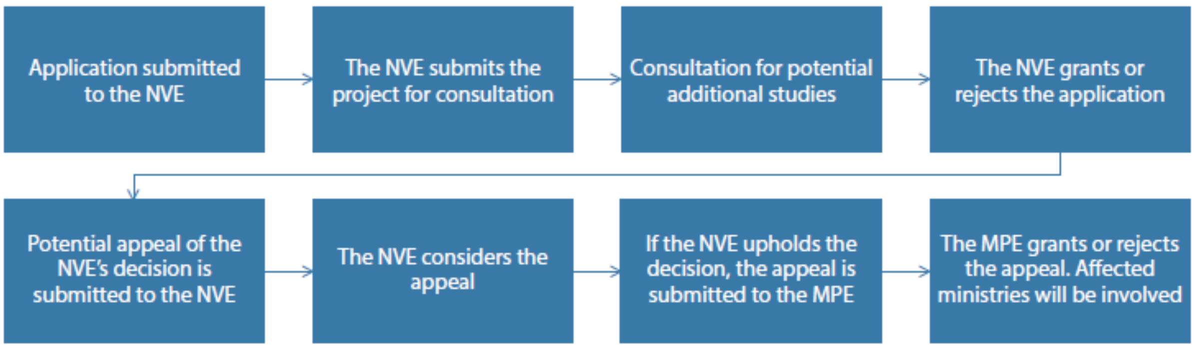

Figure 13. Licensing procedures pursuant to the Water Resources Act for small HP-projects. *Source:* Norwegian Ministry of Petroleum and Energy, 2015.

4.1.3 Revision of conditions in older licenses

For licenses with conditions related to reservoirs, dams, water tunnels and change of water flow, after 30 or 50 years after license is granted, local authorities or important stakeholders can demand revision of environmental conditions with the aim to improve the environment. The current guidelines for the revision process is set in a guiding document by the Ministry of Petroleum and Energy (MPE) of May 2012 (MPE 2012).

A simplified description of the revision procedure below:

Step 1: Demand for revision – opening of a revision case
Local authorities (Municipality), the River Basin Authority or public interests like NGO`s can forward

demand for revision to NVE, Public consultation and/or a public meeting takes place and a study program is determined. NVE discusses the demands for revision of the license conditions with the license holder and ask the license holder to consider possibilities to coordinate the revision process with upgrading/refurbishing of the current HP infrastructure. NVE decides whether to open the revision case.

Step 2: Revision document – investigation program
The license holder produces a revision document including an investigation program. Quality control of the program is undertaken by NVE. The program is executed by an objective consultant/scientist(s).

Step 3: Hearings and public consultations
The report based on the investigation program, is sent to relevant stakeholders by NVE, followed by public consultation/public meeting. Comments are then sent to the license owner for comments. Additional information/investigations can be demanded. NVE's recommendation with a set of conditions is sent to the Ministry of Climate and Environment (MCE)/National Environment Agency (NEA), and if necessary followed by consultation with other ministries and municipalities.

Step 4: Preparation of final decision – revision document
NVE proposal sent to the MPE and final decision is taken by the Government.

4.2 The Impact Assessment (EIA/IA)

All hydropower plants with planned installation of more than 40 MW and also projects which may be of significant damage or inconvenience to public interests shall undergo an Environmental Impact Assessment (EIA).

EIA is now a formally required decision-support instrument in nearly all jurisdictions, yet the EIA process can vary depending on the specific requirements of a governance system (Fischer and Noble, 2015). The common aim still, is to inform decision-makers and the public of potential environmental consequences of implementing a proposed project.

Requirements for an Impact Assessment (IA) in the energy sector are in Norway defined under the Planning and Building Act. The contents of an IA shall be in accordance with requirements stated in the regulations on impact studies by the Planning and Building Act , as well as more specific requirements in an assessment program established by NVE. The basic structure (Table 3) frames an IA, but consultation with local authorities and the public helps to specify the specific IA related to the particular project (see the *notification* in 4.4.1). As seen above there are different demands for an IA depending on the proposed HP development[7]. The Impact assessment (IA) in the licensing processes covers 3 main areas: Environment, Natural resources and Community. The Basic structure is shown in the table blow.

[7] The environmental/ecological criteria related to HP development has varied over time and with the type of management tool. Criteria used in the first Watercourse Protection Plan (1973) and in the Master Plan for Hydropower Development (1986-1993) differ from the criteria use in to-days licensing procedures and/or in the Revision Survey and in the WFD.

Table 3. Basic structure for the Impact Assessment *Source:* Norwegian Ministry of Petroleum and Energy, 2015.

Impact assessment (IA)		
Environment	Natural resources	Community
* Hydrology	* Agriculture	* Industries
* Geology	* Forestry	* Population
* Landscape	* Fresh water resources	* Service
* Local climate	* Marine resources	* Local finances
* Water quality	* Minerals & gravel	* Infrastructure
* Fresh water biology		* Social conditions
* Terrestrial biology		* Health
* Cultural monuments		* Outdoor life

The Impact assessments (IA) must be completed and be available concurrently with the license application. The IA is to be presented as a compiled report; in practice it is usually a compilation of several different technical reports. NVE may at any time in the process ask for additional assessments if necessary, but the most common is that this happens after the hearing of the application and impact assessment. The HP-developer will generally cover the costs of the impact assessment process.

The final decision by NVE shall explain how the assessment, with comments, has been evaluated and how the environmental impacts have been reflected in the decision, especially with regard to alternatives and requirements concerning mitigation measures. The responsible authority, NVE, cannot legally grant permits or take planning decisions in respect to a project until the requirements for an IA/EIA have been met.

Sometimes the cumulative effect of multiple interventions can be estimated by summarizing the effects of several measures. Other times, the cumulative effect is greater than the sum of each effect. The handling of cumulative impacts is, in Norway as in most countries, a great professional challenge. The Norwegian energy authorities are approaching this by striving for a coordinated processing of projects in the same area.

After a project has been granted a license, it is followed up by NVE. This department /authority shall verify that the construction, maintenance and operations are carried out according to established requirements. More about surveillance and control in the final section of this section 4.5.

4.3 The licence conditions

A recommendation for a licence will contain a set of conditions regulating the whole 'life' of a licence: from approval of detailed construction plans regarding landscape to environmental and safety aspects, plant maintenance and even the ultimate, closing the plant. This could involve constructing weirs, building fish ladders, correcting river courses and removing vegetation from regulated zones. The conditions can be revised 30 to 50 years after the licence has been granted (see Section 4.1.3).

The owners of the power stations are also obliged by these conditions to pay annual fees to the municipalities and the state based on the potential mean annual production. 25% of the total fee is paid to the central government and 75% of the fee is divided between all the affected municipalities in the reservoir area[8]. In addition addition the local municipality is entitled to a certain part of the electricity

[8] During the early development period of the country many licenses also had conditions related to health and education, and other special services related to the local community. The licensee would e.g. have to provide the necessary medical aid and hospital facilities, housing facilities, social benefits etc. to its employees and these would normally be taken over by the local authorities after the completion of the construction works (Wold et al. 2007).

production ("Royalty power") payable at cost only[9]. The licensee is also be obliged to establish special funds to encourage local industry.

Failure to adhere to the agreed conditions can result in a fine, and repeated violations may result in withdrawal of the licence itself. According to the Norwegian legislation, affected land owners and farmers will be compensated either by mitigation measures or by money.

All licenses have a set of conditions that define the terms under which the licensed operation must be carried out. These terms include both general and project specific rights and obligations such as highest and lowest water level, seasonal restrictions on water level and compulsory water release to affected rivers. Special rules for operation during floods or other hazard events might also be included. The conditions also include rules for punishment if the future operation is in conflict with the given terms or rules for operation.

The key conditions addressed in a HP licence are:

- Duration
- Approval of plans, inspection, etc.
- Construction deadlines
- Annual fees and industrial fund (state and the municipalities)
- Compulsory power to the municipalities (10 %)
- Natural features and cultural monuments
- Fishing, hunting and outdoor recreation
- Erosion, clearing up of regulation zones etc.
- Preventing pollution
- Roads, passages, foot paths (maintain/compensate)
- Hydrological observations
- Rules of operation, compensation water / environmental flow
- Irregularities/violations, penalty
- Revision of conditions

4.4 Licensing and the Water Framework Directive

4.4.1 New HP and the WFD

For new HP projects (large and small hydro) the licensing will particularly also have to relate to the Water Framework Directive through the Water Regulation[10] (Vannforskriften) §12 which states that HP new projects under certain conditions can be implemented even if environmental goals cannot be reached, and/or the water environment is worsened. It is assumed that today's licensing of HP balances power production (benefits) and environmental impacts (costs) according to § 12 in the Water Regulation.

In general it can be said that environmental criteria in licensing and in the framework plans have a somewhat wider focus than that of the WFD which concentrates on biology and chemistry, and hydro-morphology in the water string itself.

9 The intention behind this was originally to secure power for local electrification of households and small scale industry. Today, with a fully integrated transmission grid and a deregulated electricity market, the municipalities may trade their part of the generation in the market and some earn money from this. Others however prefer to supply their own inhabitants with cheap electricity (Wold et al., 2007).

10 As noted earlier Norway implements the WFD through the decree the Water Regulation (Vannforskriften)

4.4.2 Revision of licenses and WDF

As the goal of the WFD is to enhance the water environment to defined goals, we here find the important, concrete and crucial links between licensing and the WFD. In fact we have two different "systems" with the same goal with two different ministries responsible, with the Ministry of Energy and Petrolium (MPE) responsible for hydropower licencing and Ministry of Climate and Environment (MCE) for the WFD.

Even if more than approximately 430 HP projects can be subject for revision before 2020, only 3-4 revision documents so far have been finally approved by the MPE. The RBMPs have not influenced the content of these few revisions. However, this is about to change primarily due to the existence of the 2013 national overview with priorities of hydropower licenses subject to revision before 2022 (Revision Survey, 2013). The overview is already having influence on the work with the licensing of revision, as well as on the content of the RBMPs.

The very high number of licenses subject to revision necessitates a prioritization. And NVE in its work with revision licenses gives priority to the river/waterbodies in the Category 1.1 in the national overview of licenses subject to revision before 2020. The survey seems to function very well as a prefeasibility study (as the Master Plan for Hydropower Development for new projects) for the licensing guiding the resources of NVE and other players to the "right" projects.

4.4.3 Heavily Modified Water Bodies and River Basin Management Plans

In the existing RBMP it can be said that there are major deficiencies compared to the requirements in the Water Regulation («Vannforskriften») and edited guidelines. It must be said that such deficiencies are not specific for Norway; goals, analyses and measures related to Heavily Modified Water Bodies (HMWB) are a problem complex for the whole of Europe.

Issues related to HMWB have been discussed in many seminars for a long time in the CIS – system (CIS: Common Implementation Strategy). Thus guidelines from CIS have come late, which has influenced national guidelines in Norway. And internal discussions and disagreements in Norway are partly responsible for the late release (February 2014) of the national guidelines on HMWB "Heavily Modified Water Bodies. Selection, environmental goals and exemptions". According to the timetable, February 2014 was only a few months before the hearing of the RBMP was scheduled.

It is a fact that the required cost/benefit analyses and economic analyses regarding the proposed measures, for example demand for increased environmental flows or adjustments or operation of reservoirs are, with a very few exceptions not satisfactorily dealt with. (*Source*: NEA 2015. Anders Iversen)

About the HMWB in the RBMPs it can be concluded that goals, required analyses and measures in this first full planning cycle of the WFD, are not adequately dealt with in the 1st complete set of RBMPs. As in most other countries, there will be a much effort on the HMWB- issues in Norway in the next planning cycle from 2016 -2021 (NEA, 2015).

4.5 Surveillance and controlling compliance with licensing conditions

NVE is the key state directorate responsible for surveillance of water resources and water use in general and related to HP in particular. NVE is not responsible for surveillance of water quality and water pollution issues or drinking water control. Monitoring according to WFD is the responsibility of Ministry of Climate and Environment (MCE) and Norwegian Environment Agency (NEA) and the Water Regions. NVE, however, has an important role as the supplier of all hydrological input to the WFD work.

For all the three licensing types (small-scale and large-scaled hydropower plants and older hydropower plants for subject for revision), NVE with its five regional offices it the key state body for surveillance/control.

Regarding responsibility of the safety it is the owner of the dam who has to satisfy certain formal requirements[11] (Wold et al 2007). NVE has been given the authority of public supervision of all Norwegian dams that might represent a potential hazard to life, property or the environment.

These license conditions are surveyed and controlled through different management tools, as presented below.

4.5.1 Internal Control System – ICS

The prime responsibility to comply with laws and regulations, including conditions in a license, lies with the energy company who has been granted the license. The regulation (decree) for the Internal Control System (ICS) based in the Water Resources Act came into force in 2003. The regulation provides detailed rules on how the energy companies should monitor and report on all issues required in laws and regulations. The ICS system has two main focuses: Security and environment. As to the environment a key issue for the reporting from the ICS is related to license conditions.

NVE has the responsibility to control that the ICS is satisfactory and functions according to the regulation. Key elements in the ICS reporting are: overview of laws and regulations, organization and responsibilities in the company documented, maps and drawings of infrastructure, knowledge and skills are adequate mandatory courses followed, establish quantitative criteria (compliance with license conditions such as ; water levels in thresholds, tidy infrastructure, documentation of minimum flow measurements , internal control of water levels). Required monitoring must be documented for example: reservoir levels, release of minimum flow, thresholds stability and function.

The ICS system should be revised regularly. The ICS is the key tool for surveillance and control activities both for the Energy Company and NVE.

4.5.2 Site inspections

NVE will have inspections through the different phases from planning to operation to control compliance with laws, regulation license conditions, detailed plants etc. And related to the environment. NVE controls if the ICS system is updated and operational. Non-compliance will be reported and followed up.

If the HP has a license, the conditions in this are the main focus in the inspections. Licenses have conditions related water levels and flow, landscape, cultural heritage. A standard condition in a license is the requirement for a detailed plan. The control of this plan is a key element in the site inspections. The relevant municipality and the county are invited to the inspections. The number of inspections varies with the size and complexity of the HP plant,

NVE has issued a rather comprehensive guidebook “Miljøtilsyn ved vassdragsanlegg” – Environmental Surveillance of Watercourse Infrastructure (NVE, 2005). In addition to laws regulations and procedures the guidelines provide advice and guidance for a number of infrastructure elements. (HP plant, intake, discharge, construction roads, mass outtake and deposits, dams and reservoirs, river intakes, measures in rivers with reduced flow etc.).

ICS and site inspections are for practical reasons often combined.

[11] The dam owner’s internal quality control system must have a clear reference to the relevant dam safety regulations and shall include the following: - description of the organization, defining clear responsibilities and reporting routines, -minimum qualification requirements for dam safety personnel, documentation of the structures and safety procedures, -inspection program, including a detailed description on who, when and how, - contingency planning, including emergency action plan. In addition all dam owners are obliged to have an Emergency Action Plan in order to deal with major accidents in river basins and to reduce potential damage.

4.5.3 Guidelines for release and documentation of minimum water flow for small watercourse infrastructure with license

NVE has recently (2012) published guidelines for documentation of water flow for small watercourse infrastructures with license (NVE, 2012) The reason for this is the construction of a large number of small hydro with a license with requirement to release minimum flow. The guidelines (only in Norwegian) contain the requirements for control, recommendations for practical release solutions, and technical guidelines for monitoring.

5. Mitigation measures of HP

5.1 Introduction

The purpose of mitigation measures of hydropower projects is to avoid or minimize the negative environmental effects of HP development and operation. Negative impacts of HP may typically include; loss of biological diversity, reservoir impoundment, reservoir sedimentation, reduced water quality, modifications of hydrological regimes, barriers for fish migration and river navigation and modification of landscape. As part of planning and defining the management regime in regulated rivers, it should be explored if environmental/ecological benefits can be achieved by adjusting operations and operation of power plants. A number of measures can be identified to reduce the negative impacts of hydropower regulation and several of these may not reduce energy production.

Norway has a long tradition and experience in building and operating devices designed to reduce the negative effects of HP development. Most mitigation measures have been directed at ecological conditions in the water course, while some have been implemented for the benefit of landscape and other important societal values[12]. Currently in Norway the most important mitigation measures include demand for environmental flow or minimum flow, restrictions on regulation heights of dams, release of fish, construction of thresholds and habitat adjustments. A concept which has received much interest in Norway since it publication in 2013, is the concept of "environmental design" referring to combining the interests of salmon production and power production[13]. Demand for mitigation measures however, will vary among and within watercourses. There are various ways of compensating for impacts that are not possible to mitigate, or impacts that can be mitigated only to a limited degree, however, we emphasize in this report on mitigation measures not on compensatory measures.

For identifying successful mitigation measures (Glover et al., 2012) , the following issues should be considered:

i) What is the main objective of the measures?
ii) What are limiting factors, i.e. what are factors having negative impact on the identified objective?
iii) Will the measure impact the limiting factor(s) in wanted directions?

Implementing the Water Framework Directive (WFD) in Norway has resulted in an increased focus on the ecosystem approach in the watercourse. In order to arrive at a suitable program of mitigation measures the WFD requires that all known measures to restore the natural state should be considered. It is therefore

---

[12] Focus has mostly been on wild salmon; without comparison the most valuable and "politically "the most important freshwater fish.

[13] Norway`s knowledge of in the field "hydropower and salmon" has recently been published as a handbook: "Handbook for environmental design in regulated salmon rivers" (Forseth et al., 2013). http://www.nina.no/archive/nina/PppBasePdf/temahefte/053.pdf) The handbook describes how to evaluate, develop and implement measures to improve living conditions for salmon populations in regulated rivers, while taking hydropower production into account.

important that environmental considerations are incorporated from the beginning of the planning phase. We have below listed the main important measures; for hydropower reservoirs, and for rivers.

5.2 Mitigation measures in magazines / hydropower reservoirs

Inundation of land area
In cases where creating hydropower reservoirs involves inundation of land area there is a need to carefully consider the siting of reservoirs. The following factors should be considered; human population density, water quality, wildlife or wilderness reserves, national parks, valuable agriculture, valuable forestry, and seismic activity. "Mitigation measures" refers to impact avoidance actions by limiting the extent of flooding, localized vegetation clearing prior to impoundment, and by compensation measures (see Trussart et al., 2002). Inundation by hydropower reservoirs has only occurred to a limited extent in Norway.

Water quality
Main mitigation efforts involve keeping contaminants away from watercourses, considering reservoir intake position and depth, and implementation of an effective sewage treatment to avoid eutrophication and aggressive aquatic plant growth.

Fish releases
Regulating a lake or part of the water course to create a reservoir, will limit or prevent spawning and potentially reduce recruitment. The objective is to ensure recruitment and production of catchable fish. Release of fish fry however, is only effective if spawning and nursery areas are the limiting factors. If other factors such as for example food availability is the limiting factor, then the measure has no effect and can in some cases be counterproductive (Glover et al., 2012). Ecologically based restoration projects should focus on better conditions for natural recruitment by means of spawning and rearing habitats.

Water level fluctuations
Large water level fluctuations in reservoirs are in conflict with interests related to landscape, outdoors, tourism and the use of boats, as well as having ecological impacts (Bakken et al., 2016, Harby and Noack 2013). The obvious mitigation measure is to impose restrictions on the level of fluctuations, however, the ability to vary the water level is highly appreciated by hydropower companies and restrictions may be very costly. A compromise is to impose restrictions on the draining of reservoirs during certain periods of the year.

Habitat Revegetation and unwanted vegetation in magazines
Revegetation of the littoral zone of magazines has been tried, but attempts have rarely been successful. Even after providing fertilizers, plant growth has been low and survival poor. The problem is that few plants can grow in the context of large water levels fluctuations (Glover et al., 2012). In magazines with small water level variations of magazines or along rivers with stable water flow this can be possible, but only under certain assumptions.

Unwanted vegetation are often found in several regulated rivers and river reservoirs. The most relevant measures are physically removing vegetation with machines

Sedimentation related mitigation measures
Common mitigation measures include flood management programmes, sand traps and silt fences, flushing programmes, upstream reservoirs and cofferdams, intake design to enable sediment bypass, controlled dredging, physical bank stabilisation, revegetation of erosive slopes, watershed land use programmes to prevent reservoir sedimentation.

Climate related mitigation measures
Some modification in local climate may be caused by changes in the hydrological regime related to HP development. This may involve such as changes in water temperatures (in Norway cooler water may be

released in downstream areas). Generally, the most effective mitigation measures in relation to climatic changes involves a careful evaluation of the relevant parameters before site selection and technical solutions are decided upon.

5.3 Mitigation measures in rivers

For rivers, mitigation measures may be implemented far from those water bodies directly impacted by the regulations. Fish release and climate mitigation measures are refered to under "mitigation measures in magazines, Section 5.2.

5.3.1 Minimum flow and environmental flow

Minimum flow, water quantity and quality
Minimum water flow is important for several reasons: preserving biological diversity including biological continuity for fish and other aquatic life, maintain landscape qualities, provide sufficient water for other user interests, the water course as a source of water supply, irrigation, water-based recreation, and resipient, maintaining receiving water capacity for pollutants and preserve the groundwater level.

There is no standard method for assessing minimum water flow. It varies from case to case depending on the size of the river, the impact of the HP-plant, river morphology and ecology and public interests. Historically minimum flow has been determined by a balance between power revenue and environmental considerations, where minimum flow was usually set very low, similar to a historically normal low tide (Q95) and /or 5-10 % for annual average flow. It was reasoned that when fish stocks in the river had survived this low tide that this was enough to maintain the same fish stocks. Recent research however, has shown that long periods of several months at a constant low rates of flow leads to greater problems than they shorter periods with the same water flow before the river system was developed. The continuous release of minimum flow over the year is also very costly with reference to lost energy production.

Environmental flow
Environmental flow seeks to simulate the natural or desirable water flow in water courses and the concept refers to rules governing the release of water so as to ensure water levels and flows well suited for the overall river ecology and human water use interests (Tharme, 2003; Richter et al., 2006). This is based on the recognition that variation of flow and extreme events is important for the watercourse ecosystem.

Larger floods initiates in many cases fish migration in several species, both up stream and down stream (Jonsson, 1991; Kraabøl, et al., 2008). Floods can also help cleanup of plants and mosses which otherwise can form dense stands of low diversity. Lack of floods can lead to increased sedimentation and reduced water flow in the sediments with minor oxygen supply to the fish eggs located in the gravel. A widely used measure is the release of "artificial flushing flows" to provide for "cleanups" (Ward and Wiens, 2001). However, if there is too long between such artificial flush floods, flushing out fine sediments will be harder.

Performance criteria for environmental flow refers to the carrying capacity for the production of catchable fish, and that the natural processes (natural condition or good ecological potential) in the watercourse is maintained. There are numerous scientific methods that establishes a quantitative, scientific connection between flow and environment / biology (Tharme, 2003)

For *large HPP,* the approach to environmental flow/lowflow naturally has to be sophisticated. A combination of different methods for assessing minimum flow is used; often the "Q 95" approach for various seasons, mostly summer and winter. The figure below illustrates a low -flow regime in Suldalslågen primarily adjusted to the life cycle and needs of the salmon in the river.

S*mall* HPP often have the following characteristics; short stretches being affected, steep gradients and relatively "simple" ecosystems. Since the variation in seasonal flow often are very large, it is normally not recommended to use annual water flows or "common low flow" as a basis for assessment. In such rivers

Q 95 for the different seasons is used as basis for the evaluation of low flow before taking ecological values, landscape, public interests etc. into consideration.

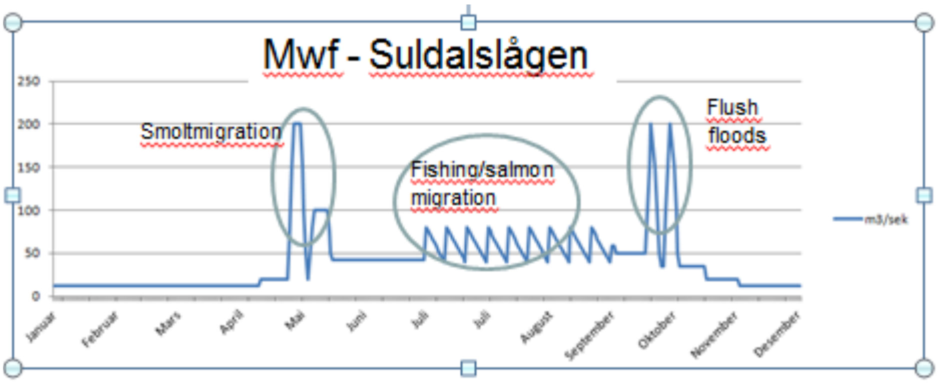

Figure 14. Low flow regime in Suldalslågen adapted to salmon in the river. Assessment of this flow-regime is a result of several years experimental period to optimize the operating rules for this river. Even after several years with experiments and site surveys some uncertainty regarding the optimum flow still remains. *Source*: NVE, 2015.

Figure 15. Evaluation of impact on landscape through photo documentation with various flows. *Source*: NVE, 2015.

To evaluate the impact on landscape often photo documentation with various flows is a good and simple tool (NVE, 2011).

5.3.2 Fish passes

Possibilities for anadromous, such as salmon and/or catadromous fish, such as eel - to pass hindrances are important issues for HP development. There is a need for biological continuity in water courses (Kraabøl, 2009; WFD 2000). The anadromous and catadromous species are characterized by a lifecycle that involves migrating up the watercourse for spawning, and returning to the sea for adolescence. Construction of passways hence ensures production of fish, recruitment and adolescence, genetic exchange, and possibilities for angling. Limiting factors for migration refers to; dams, river stretches with low water flow, and hydropower plants. Success criteria for fish passes refers to successful upstream and downstream movement of fish. Most fish injuries or mortalities (adults and juveniles) during downstream movement are due to their passage through the turbines and spillways (Kraabøl et al., 2008). The effectiveness of fish passes vary for each species, the size of the river, and the design of fish passes.

Norway has a very long tradition and experience in building and operation of devices designed to provide biological continuity. Traditionally *fish ladders* have been the built as a compensation measure connected to HP development. More than 500 fish ladders mostly designed for salmon, trout and greylin have been

built in Norway. However many of the ladders do not function well; location of the ladder entrance and water flow in the ladder is important (Anon, 1990). The Norwegian Environment Agency (NEA) has the authority to demand fish ladders to be built, and the design has to be approved by NEA. There are no general technical requirements for the fish pass/fish ladders. However, the actual design at the site will have to be tailor-made based on local knowledge and studies of the ecosystem.
The most effective techniques to ensure upstream movement (Glover et al., 2012):

- Locks, lifts and elevators for watercraft.
- Fishways, bypass channels, fish elevators, with attraction flow or leaders to guide fish to fishway.
- Capture and transportation of fish upstream

The most effective techniques for downstream fish movement:

- Improvement in turbine, spillway openings during downstream movement of migratory species or overflow design.
- Management of flow regime or spillway during downstream movement of migratory fish.
- Installation of avoidance systems upstream the power plant such as screens, strobe lights, acoustic cannons, electric fields, etc.).
- Capture and transportation of fish downstream.

5.3.3 Thresholds

Thresholds were originally planned as a mitigation measure related to low water flow after divertion as part of river regulation. The purpose of thresholds is for it to maintain a water surface under greatly reduced water flow. It has been a common measure to improve the conditions for fish by creating spawning and nursing areas, varied micro habitats, and in colder region to prevent freezing of eggs and benthic animals during the winter. Another important objective has been to improve the aesthetics of the landscape by avoiding desertlike conditions in the river basin. A threshold can be constructed as a concrete "fence" on the river bed, constructions made by wood, or in the form of different types of bedrocks. However, there have been unwanted effects of thresholds; thresholds as new migration barriers for fish, induced overgrowing vegetation behind thresholds, deposition and possible fouling in threshold pools (WFD 2012; Rudberg et al., 2015; Tockner et al., 2009). Constructed thresholds have also been reported to destroy spawning areas, to favors minnows and other smaller swim strong species (Glover et al., 2012).

Prerequisites for success are; adequate minimum water, stable construction during flood, possibility of crossing upwards (cf. water regulation on migration obstacle). Constructing thresholds requires a multidisciplinary approach; knowledge on technical expertice, hydromorfologi, landscape and outdoor recreation (fishing, swimming, hiking) is needed.

5.3.4 Habitat adjustments

In rivers that have been channelled the substrate is often uniform with small variation in flow patterns and depth conditions, creating unfavouring conditions for fish and other benthic species. Various measures such as excavation ponds and or thresholds, and intentionally regulated water flow may increase habitat diversity; substrate, flow and depth. A special form of substrate improvement is laying spawning gravel in magazines and or in regulated rivers. Adding spawning gravel however, should not be implemented in rivers with large material transport as the substrate then quickly will become silted. The problem can be mitigated by providing flush floods regularly. Habitat adjustments or habitat improvements are made both in reservoirs and regulated rivers (Brittain et al., 2006; Julien et al., 2005).

6. Some conclusions and recommendations

This report entirely deals with HP management issues in Norway to provide basis for exchange of experiences. The focus and level of details in each chapter are based on discussions with the Bulgarian partners. The preliminary recommendations below are likewise based on some input from our partners, but it should be emphasized that NIVA has limited knowledge of the situation for HP management in Bulgaria.

- As the HP developments in Norway is largely dependent on country-specific favorable natural conditions, including abundant water resources, favorable landscape and moderate social conflicts due to low population density, the transferal of experience to countries with different natural, social and economic context must be handled carefully. The applicability of the studied practices should be closely examined and adaptation must take the national specifics into consideration.

- Certain approaches and principles of sustainable HP development in Norway are generally valid and could be useful as references. In particular we assume that the processes and the approaches of some framework plans, and the licensing systems are of particular relevance.

- The integration in time and place of the implementation of the Water Framework Directive and the extensive revision of licenses for older HP plants is worth looking at. The large number of older plants in Norway imposes the need of technical upgrade, replacement of turbines and generators which will increase yearly production and often result in increased installed capacity. This process is combined with the need to comply with newer ecological standards in the Water Framework Directive and demand for improvement of the environment in the revision processes. Measures to facilitate for biological continuity to enable fish migration upstream and downstream the river are among the important measures in this context.

- The process in Norway of Hydropower Licenses subject to revision before 2022 includes a Revision Survey, with the goal to identify the watercourses/project areas where societal benefits of environmental improvements most likely will outweigh the cost in form of reduced renewable or regulated hydropower production. Key environmental criteria used in this process (1-Fish and fishing 2-Biodiversity and 3-Landscape and recreation /tourism) are generally applicable for similar processes in Bulgaria.

- The Watercourse Protection Plan developed from 1973 to 2009 provides permanent protection of certain river systems against hydropower developments larger than 1 MW. A similar approach might be considered introduced in Bulgaria. Also the approach in the Master Plan for Hydropower Development (1986-1993) is worthwhile considering in Bulgaria. The plan categorizes and prioritize HPP projects according to energy production economics and environmental conflicts. The methodology in general and the approach for balancing economy and environment in HPP licensing was adopted by the Norwegian Parliament and thus has certain formal status. Similar approaches have been lately introduced in many European countries, with variations of assessment criteria, depending on national features and legislation. After proper and careful adaptation, the approach could be introduced in Bulgaria. The ANCHOR Project is an effort in this direction.

- The environmental/ecological criteria related to HP development vary over time and with the type management tool, and to great extent are related to the water management priorities. A national approach is recommended for Bulgaria, taking into account the environmental objectives for the rivers, set by WFD and other regulatory documents.

- Environmental mitigation measures include inter alia the following main categories: Minimum flow or Environmental flow, Detour channel/fish passes in Power station, Restrictions on regulation heights of dams, Strengthening fish population, and construction of thresholds and habitat adjustments. The general approach of selection and implementation of the mitigation measures is applicable outside Norway. However, the design of measures has to be adapted to the specific habitat and species needs.

Заключения и препоръки

- Този доклад изцяло обхваща въпросите за управление на ВЕ в Норвегия. Въпреки това, основните теми и нивото на детайлност във всяка глава се основават на дискусии с нашите български партньори. Предварителните препоръки по-долу по същия начин се основават на принос от нашите партньори, но трябва да се подчертае, че NIVA има много ограничена информираност относно ситуацията за управление на ВЕ в България. Препоръките могат да бъдат разширени и по-подробни след семинара, който ще се проведе на 12 май в София.

- Тъй като развитието н ВЕЦ в Норвегия до голяма степен зависи от специфичните за всяка държава благоприятни природни условия, в това число изобилие на водните ресурси, благоприятен ландшафт и умерени социални конфликти, дължащи се на ниската гъстота на населението, обмяната на опит със страни с различен природен, социален и икономически контекст трябва да се извършва внимателно. Приложимостта на изследваните практики трябва да бъде внимателно разгледана, а при адаптацията да се вземат под внимание националните специфики.

- Въпреки това е ясно, че някои подходи и принципи на устойчивото развитие на ВЕ в Норвегия са общовалидни и биха могли да бъдат полезни за референции. По-специално, предполагаме, че процесите и подходите на някои рамкови планове, както и на системите за лицензиране са от особено значение.

- Полезно е да се обърне внимание на навременната интеграция на изпълнението на Рамковата директива за водите и обширното преразглеждане на лицензите за по-старите ВЕЦ. Големият брой на стари централи в Норвегия налага необходимостта от техническо обновяване, подмяна на турбини и генератори, които увеличават годишното производство и често водят до повишаване на инсталираната мощност. Този процес се съчетава с необходимостта да се изпълнят новите екологични стандарти в Рамковата директива за водите и изисква подобряване на околната среда в процеса на преразглеждане. Мерките за улесняване на биологичната непрекъснатост с цел да се позволи миграцията на рибите нагоре и надолу по реката са сред най-важните мерки в тази връзка.

- Процесът по издаване на хидроенергиен лиценз, който подлежи на преразглеждане преди 2022 г. в Норвегия, включва проучване, с цел да се идентифицират водните течения/проектни области, при които ползите за обществото от подобренията на околната среда най-вероятно ще надхвърлят разходите под формата на намаляване на производството на възобновяема или регулирана хидроенергия. Обикновено за подобни процеси се прилагат ключови екологични критерии, използвани в този конкретен процес (1- Риби и риболов 2- Биоразнообразие и 3- Ландшафт отдих/туризъм).

- Планът за опазване на водните течения, разработен в периода 1973 – 2009 г. осигурява постоянна защита на някои речни системи срещу развитието на хидроенергийни проекти по-големи от 1 MW. Подобен подход може да се счита за въведен в България. Също така в България ще бъде полезно да се разгледа подходът в Генералния план за развитие на хидроенергетиката (1986 - 1993 г.). Планът категоризира и приоритизира проекти за ВЕЦ според икономиката на енергийното производство и конфликтите, свързани с околната среда. Методологията като цяло, както и подходът за балансиране на икономиката и околната среда в лицензирането на ВЕЦ е приет от норвежкия парламент и по този начин има определен официален статут. Подобни подходи напоследък са въведени в много европейски страни с различни варианти на критерии за оценка, в зависимост от националните особености и законодателство. След правилна и точна адаптация подходът може да бъде въведен в България. Проектът ANCHOR е усилие в тази посока.

- Критериите за околната среда/екологичните критерии, свързани с развитието на ВЕЦ варират с течение на времето и с типа инструмент за управление и до голяма степен са свързани с приоритетите в управлението на водите. За България се препоръчва национален подход като се вземат предвид екологичните цели за реките, определени от РДВ и други нормативни документи.

- Екологичните смекчаващи мерки включват, наред с другото следните основни категории: Минимален отток /екологичен отток, обходен канал в енергийната централа, смяна на температурата, управление на резервоарите, укрепване на рибните популации и въвеждане в експлоатация на рибните местообитания. Общият подход на подбор и прилагане на мерките за смекчаване е приложим извън Норвегия. Въпреки това, определянето на мерки трябва да се адаптира към специфичните нужди на местообитанията и видовете.

7. References

Anon. 1990. Fisketrapper. Funksjoner og virkemåter. Innstilling fra fisketrapputvalget. Rapport Direktoratet for naturforvaltning og Vassdragsregulantenes Forening, 71 p.

Bakken, T.H., Aase, A.G., Hagen, D., Sundt, H., Barton, D.N. and Lujala, P. 2014. Demonstrating a new framework for the comparison of environmental impacts from small- and large-scale hydropower and wind power projects. Journal of Environmental Management 140, 93-101.

Bakken, T.H., Forseth, T. and Harby, A. (red). 2016. Miljøvirkninger av effektkjøring: Kunnskapsstatus og råd til forvaltningen og industri – NINA Temahefte 62, 205 p.

Bradely, D. C, Cadman, D. and Milner N.J. 2012., Ecological indicators of the effects of abstraction and flow regulation; and optimization of flow releases from water storage reservoirs. Sniffer 2012. http://www.wfduk.org/sites/default/files/Media/Assessing%20the%20status%20of%20the%20water%20environment/WFD21D%20Final%20Report_30%2008%2012.pdf

Brittain, E.J., Eie, J.A., Brabrand, A., Saltveit, S.J. and Heggenes, J. 2006. Improvement of fishe habitat in a Norwegian river channelization scheme. Regulated Rivers: Research and Management vol. 8, issue 1-2.

E-CO Energy, 2015. A view from an energy company. Hydropower , licensing and WDF. Presentation by Halvorsen, H.K. October 15th 2015 at NIVA, Oslo.

ENTSOE-E 2015. Regional Investment Plan 2015 Baltic Sea region - Final version after public consultation 2015. European Network of Transmission System Operators for Electricty (ENTSO-E). https://www.entsoe.eu/Documents/TYNDP%20documents/TYNDP%202016/rgips/Regional%20Investment%20Plan%202015%20-%20RG%20BS%20-%20Final.pdf

Fischer, T. and Noble, B. 2015. Impact Assessment Research: Achivements, Gaps and Future Directions. Introduction to the March 2015 Special Issue of the Journal of Environmental Assessment Policy and Management. Env. Assmt. Pol. Mgmt. Vol 17:01, 1-12

Forseth, T. and Harby, A. (eds) 2013. Handbook for environmental design in regulated salmon rivers. NINA Special Report 53, 91 p. http://www.nina.no/archive/nina/PppBasePdf/temahefte/053.pdf

Glover, B., Brabrand, Å., Brittain, J., Gregersen, F., Holmen, J. and Saltveit, S.J. 2012. Avbøtende tiltak i regulerte vassdrag Målsettinger og suksesskriterier. NVE Rapport nr. 10 – 2012.

Hanssen-Bauer, E.J., Førland, I., Haddeland, H., Hisdal, S., Mayerm A., Nesje, J.E.Ø., Nilsen, S., Sandven, A.B., Sandø, A., Sorteberg and Ådlandsvik, B. 2015. Klima i Norge 2100. Kunnskapsgrunnlag for klimatilpasning oppdatert 2015. Miljødirektoratet rapport 2/2015. ISSN nr. 2387-3027.

Harby, A. and Noack, M. (2013) Rapid Flow Fluctuations and Impacts on Fish and the Aquatic Ecosystem, in Ecohydraulics: An Integrated Approach (eds I. Maddock, A. Harby, P. Kemp and P. Wood), John Wiley & Sons, Ltd, Chichester, UK.

Heineman, B. 2011. The Green Battery of Europe Balancing renewable energy with Norwegian hydro power. ETH, Zurich.

Hordaland Fylkeskommune 2013. Fylkesdelplan for små vasskraftverk i Hordaland 2009-2021 Justert 2013 etter handsaming i Miljøverndepartementet. http://www.hordaland.no/globalassets/for-hfk/plan-og-planarbeid/regionale-planar/smakraftplan-etter-vedtak-i-md-webutgave.pdf

Jonsson, N. 1991. Influence of water flow, water temperature and light on fish migration in rivers. Nordic Journal of Freshwater Research, vol. 66, 20-35.

Julien, P., Richard, G. and Albert, J. 2005. Stream restoration and environmental river mechanisms. International Journal of River Basin Management, vol. 3, no 3 pp 191-202.

Killer, K.M. and Tullos, D.D. 2013 Cumulative biophysical impact of small and large hydropower development in Nu River, China Water Resources Research, vol. 49, 3104–3118.

Kraabøl, M., Arnekleiv, J.V. and Museth, J. 2008. Emigration patterns among trout, Salmo trutta (L.), kelts and smolts through spillways in a hydroelectric dam. Fisheries Management and Ecology 15, 417-423.

Kraabøl, M., Johnsen, S.I., Museth, J. and Sandlund, O.T. 2009. Conserving iteroparous fish stocks in regulated rivers; the need for a broader perspective! Fisheries Management and Ecology 16, 337-340.

Kårstø, 2007. http://www.statkraft.no/Energikilder/vaare-kraftverk/norge/Karsto/

Master Plan for Hydropower 1991-92. "Samlet plan for vassdrag" White paper No 60, 1991-92. http://miljodirektoratet.no/old/uversjonert/Vassdragsrapporter/Samla%20Plan/_Hovedrapport/The%20Master%20Plan%20for%20Water%20Resources.pdf

Melkøya, 2009. http://barentsobserver.com/en/energy/statoil-puts-melkoya-lng-back-production-03-08

Norwegian Ministry of Petroleum and Energy (MPE), 2012. Retningslinjer for revisjon av konsesjonsvilkår for vassdragsreguleringer, 25.mai 2012, 59 p.

Norwegian Ministry of Petroleum and Energy (MPE), 2015. Facts 2015. Energy and Water Resources in Norway. Publication code: Y-0102/9E. https://www.regjeringen.no/contentassets/fd89d9e2c39a4ac2b9c9a95bf156089a/facts_2015_energy_and_water_web.pdf

Norwegian Environment Agency (NEA), 1984. Samlet plan for Vassdrag (in Norwegian). The Master Plan For Hydropower Development http://miljodirektoratet.no/old/uversjonert/Vassdragsrapporter/Samla%20Plan/_Hovedrapport/Samlet%20Plan%20for%20vassdrag%20-%20Hovedrapport.pdf

Norwegian Environment Agency (NEA), 2015. Vanndirektivet hjemme og ute. Miljøkrav til den regulerbare vannkraften. Presentation by Iversen, A. at Norges Energidager Conference.

NIVA, 2011. Miljørammer for fornybar energi. NIVA rapport L:NR 6274-2011.

Hamarsland, A. (ed) 2005. Miljøtilsyn ved vassdragsanlegg. NVE, Veileder nr. 2 -05

The Norwegian Water Resources and Energy Directorate (NVE). Protected watercourses in the Watercourse Protection Plan. NOU 1998:11.

NVE, 2011. Miljøbasert vannføring http://webby.nve.no/publikasjoner/rapport/2013/rapport2013_73.pdf

NVE, 2012. Slipp og dokumentasjon av minstevassføring for små vassdragsanlegg med konsesjon, gjennomgang og forslag til prioritering. NVE Report 489; 2013.

NVE, 2013. Revision Survey Vannkraftkonsesjoner som kan revideres innen 2022. Rapport nr. 49/2013, p. 316.

NVE, 2015. Hydropower licensing in Norway. Presentation by Brodtkorb, E., at NIVA, Oslo October15th.

NVE, updated April 2016. https://www.nve.no/energiforsyning-og-konsesjon/vannkraft/vannkraftpotensialet/

Richter, B. D., Warner, A. T., Meyer, J. L., and Lutz, K. 2006. A collaborative and adaptive process for developing environmental flow recommendations. River Research and Applications 22:297-318.

Rudberg, P.M., Escobar, M., Gantenbein, J. and Niros, N. Mitigating the Adverse Effects of Hydropower Projects: A Comparative Review of River Restoration and Hydropower Regulation in Sweden and the United States. The Georgetown Int'l Env. Law Review, Vol. 27:251
Tockner, K., Uehlinger, U. and Robinson, C.T. 2009. Rivers of Europe. Academic Press, p. 728

Tharme, R. E. 2003. A global perspective on environmental flow assessment: emerging trends in the development and application of environmental flow methodologies for rivers. River Research and Applications 19:397-441.

Trussart, S., Messier, D., Roquet, V. and Aki, S. 2002. Hydropower projects: A review of most effective mitigation measures. Energy Policy, vol. 30, 1251-1259.

Water Resource Act https://lovdata.no/dokument/NL/lov/2000-11-24-82; http://app.uio.no/ub/ujur/oversatte-lover/cgi-bin/sok.cgi?dato=&nummer=&tittel=water+resources&type=LOV&S%F8k=Search

Vann-nett, 2010; www.miljøstatus.no http://vannportalen.no/organisering/vannregioner

Ward, W. W. and Wiens, J.A. 2001. Ecotones of riverine ecosystems: Role and typology, spatio-temporal dynamics, and river regulation. Ecohydrology and Hydrology, vol. 1 no 1-2 25-36.

White Paper 2016. Parliamentary report on energy. (Meld. St. 25 (2015-2016) "Kraft til endring – energipolitikken mot 2030"). Norwegian Ministry of Petroleum and Energy.

Wold, B., Flatby, R., Konow, T., Løkke, K. 2007. Licensing for dam construction and operation - Practical decision support developed over 100 years. International Journal of River Basin Management, 5:3, 245-250.

Appendix A.

ANCHOR
Project meeting in Oslo

The purpose of this meeting is to learn about the Norwegian experience regarding management of rivers for sustainable hydropower production

Participants

Ventzislav Vassilev	Reg. Env. Center – Bulgaria	Eilif Brodtkorb	NVE
Vangeliya Ivanova	West Aegean River Basin Dir. – Blagoevgrad	Halvor Kr. Halvorsen	E-CO Energi
Ralitsa Kukova	West Aegean River Basin Dir. – Blagoevgrad	Haakon Thaulow	NIVA
Vasil Uzunov	East Aegean River Basin Dir. – Plovdiv	Line Barkved	NIVA
Mladen Angelov	East Aegean River Basin Dir. – Plovdiv	Ingrid Nesheim	NIVA

October 19th Venue: Room VIA - CIENS Building - Oslo Science Park, Oslo.

0845	Arrival at NIVA – Coffee	
0900 - 0915	*Ingrid Nesheim - NIVA*	Welcome and introduction
0915 - 0945	*Haakon Thaulow – NIVA*	The Management of Hydropower development in Norway, The history leading up to -days management regime: Environmental Constraints.
0945 - 1000	*Coffee*	
1000 - 1030	*Eilif Brodtkorb. NVE - Norwegian Water Resources and Energy Directorate*	Licensing of Hydropower in Norway The Water Framework Directive and Hydropower (Including discussion)
1030 - 1130	*Halvor Kr. Halvorsen, E-CO Energi AS*	A view from an energy company. Experiences (Including discussion of prepared questions)
1130 - 1230	*Lunch*	
1230 - 1400	Workshop: Introductions from *REC and EARBD/WARBD* on issues focused in our discussions. What can be learned from Norway relevant for HP development in Bulgaria?	
1430-1500/1530	*Venue: Room Skagerak at NIVA*	Discussion of "Expert report"- based on draft framework.

Tuesday Oct. 20th Field trip and wrap-up discussions

Venue: Embretsfoss Hydro Power Plant (75 minutes from Oslo by bus)

0900	Leave from hotel by bus.
1015	Arrival at Embretsfoss.
1015 - 1215	Embretsfoss. Hydropower and the Water Environment. Impacts and environmental measures. *Birger Holt, E-CO Energy*
1215- 1300	Lunch
1300-1330	Wrap - up discussion - lessons learned etc. (At Embretsfoss)
1345	Return to Oslo

About E-CO Energy and Embretsfoss hydropower plant:

Embretsfoss power plant is a hydroelectric power plant at Åmot in Modum in Buskerud County. The power plant was put into operation in 1916, and utilizes a drop of 16 meters at Embretsfoss in the Drammen River. It is a run-of- the-river type of power plant without a regulation magazine. The power plant uses water from Begna and Randsfjorden / Rand river via Tyrifjord and from Hallingdalselva via Krøderfjorden and Snarumselva. Annual streamflow during the waterfall is 285 cubic meters per second.

Embretsfoss 1 was the original power plant from 1916. This power plant was demolished in 1954. Embretsfoss 2 was put into operation in 1921. It had three turbines totaling 9 MW. The building will be demolished. Embretsfoss 3 was put into operation in 1954. It has a Kaplan turbine of 18MW, which now operates only for exploiting flood peaks. Embretsfoss 4 was put into operation in 2013. It has one of the largest Kaplan turbines of nearly 7 meters in diameter. Flood level can reach 1000 to 1400 cubic meters per second. The effect is 51.3 MW with a production of 120 GWh. Total annual production is now 335 GWh.

Embretsfoss power plant is owned by EB Power and E-CO Energi with 50% each.

Appendix B.

Masters Plan for Hydropower Development. Methodology for balancing and weighing user interests and environment vs. economy

The Master Plan for Hydropower Development (Master plan) is briefly presented in chapter 3.2.

In this appendix we describe the approach/ method leading from each project with its impacts to recommendation for licensing/not licensing in a national context. The methodology described is based on the initial project which was the basis for the first parliamentary report in 1985.

Basic evaluations

The basis was 310 new HP-projects presented in 542 project alternatives with a total HP potential of approx. 40 TWh.

All 542 alternatives in 310 watercourses were technically an economically planned, environmental consequences analyzed and finally each alternative was placed into a group to satisfy the goal of the Master Plan: A sequencing of projects into priority groups where highest priority was given to projects with the least cost and least environmental impacts.

The Master plan was neither a protection plan nor a development plan. It provided an administrative guiding framework for later licensing.

A total evaluation for the impacts of the 540 HP alternatives implies the weighing against each other of a number of dimensions which are impossible/difficult to compare. Each interest has its own view of what is important. Some impacts can be compared by expressing loss or profit in terms om money or other measurable units, Most impacts, however , con only be expressed by using qualitative terms such as small , large, very large etc. . Weighing various elements/impacts against each other had to be done for each project, and the projects had to be weighed against each other.

The following themes were analyzed: Hydropower and the impacts on: Nature conservation , Outdoor recreation , Fish and Wildlife, Water supply and Water Pollution, Cultural Heritage, Agriculture and Forestry, Reindeer Husbandry , Flood protection/Erosion, Transport, Ice /Water temperature, Climate and Regional Economy .

From single project evaluation to group priority – weighing of different interests

The steps from each project/alternative to the final group priority are illustrated in figure 16 at the next page. There are six major steps I – VI in the evaluation process.

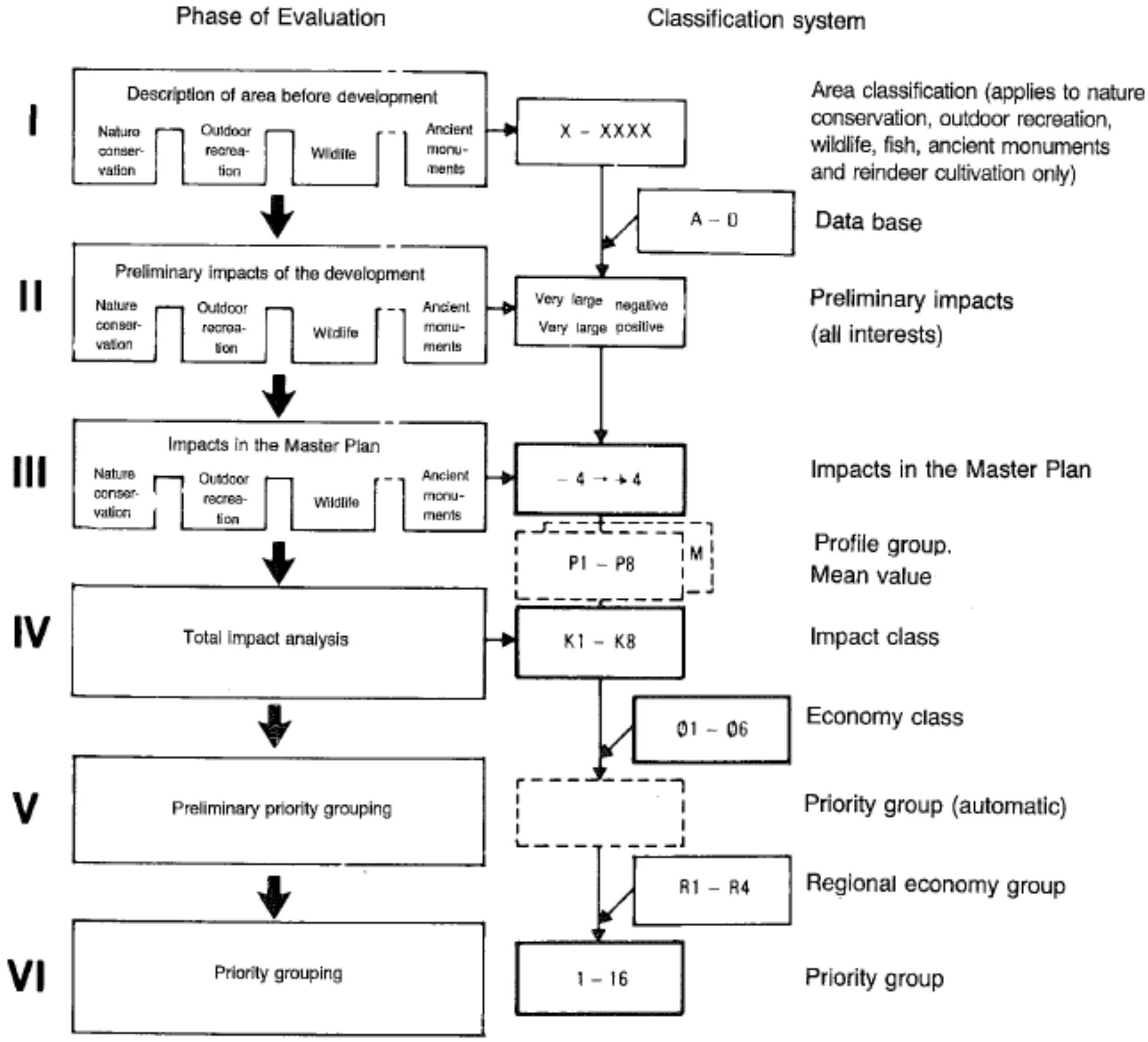

Figure 16. Classifications system in the Master plan in relation to the phase of evaluation of the different projects.

I. Mapping of area influenced by the planned project

The value of project area was classified in 4 classes for Nature conservation, Outdoor recreation, Wildlife and Fish, Cultural heritage and Reindeer husbandry.
The data quality was classified in 4 classes: A-D.

II. The impact of the HP- project on each of the impact themes (except regional economy) was evaluated on a scale from -4 to + 4; - 4 very negative impacts, -3 negative impacts etc. + 4. Very positive impacts. Naturally the negative impacts dominated; + classifications were related to Flood control and in some cases Agriculture and Forestry.
Each of the impact themes had sub- criteria and guidelines for classification.

III. All project information including the HP project and the impacts were presented in Project reports (Vassdragsrapporter) of which 285 were produced. The reports were subject to remittance to relevant stakeholders including counties, municipalities, NGO`s etc. Some classifications were changed/adjusted.

IV. The impact themes were weighed together and according to a weighing algorithm. All the -4 to + 4 classifications for all the impact themes were integrated to on impact value; firstly through an automatic algorithm, (profile groups) and then corrected/evaluated by an expert panel in the project administration. The final scale for the integrated impact value was C1- C8. (C: Consequence class in Norwegian K).

To reach one single environmental classification for each project alternative all the classifications had to be integrated into one single value. This process included weighing of incommensurable units. This was done through a two- stage process; First a technical classification without weighing of interests. Decisive for these technical classification were the number of extreme classifications (number of – 4), secondly a representative panel in the project administration weighed and discussed taking comments received into consideration.

Separately an economic classification of the value of the HP – project – was performed in 6 economy classes, E1- E 6 (E: economy class, in Norwegian Ø). This task was relatively easy (Engineering economics): Cost/produced electric current (GWh) - adjustments for higher percentage of “winter power”. The line between economically feasible and not economically feasible projects was drawn between E5 and E6.

Based on the comments the classification was adjusted and formed the input for the final evaluations in proposal for the national Master Plan.

V. The Weighing of Environmental Impacts and Project Economy was another crucial and difficult step. As was necessary in the other classifications of incommensurable values (C1-C8 – integrated environmental classifications) transparency was of paramount importance

With 8 C –classes and 6 E – classes each project /project alternative had 48 possibilities in an 8x6 Environmental/Economy matrix.

The result of the weighing between economy and environment is show in Figure 17. where we have numbers from 1 to 16 in the 48 square matrix. Projects in the matrix with the same number are given the same group priority.

Conflict class

	C1	C2	C3	C4	C5	C6	C7	C8
E1	1	1	2	3	5	7	9	12
E2	1	1	2	3	5	7	9	12
E3	2	2	3	4	6	8	10	13
E4	3	3	4	5	7	9	11	14
E5	4	4	5	6	8	10	12	15
E6	5	5	6	7	9	11	13	16

Economy Class

Category I

Category II

Figure 17. Economy/Conflict matrix. Result of weighing.

VI. Economy is the main priority criteria for projects in the lower environmental classes (C1-C2) Environmental impacts are most important for the grouping of project in the highest environmental classes (C7-C8)- This is illustrated by the bowed arrow (middle section) in Figure 18.

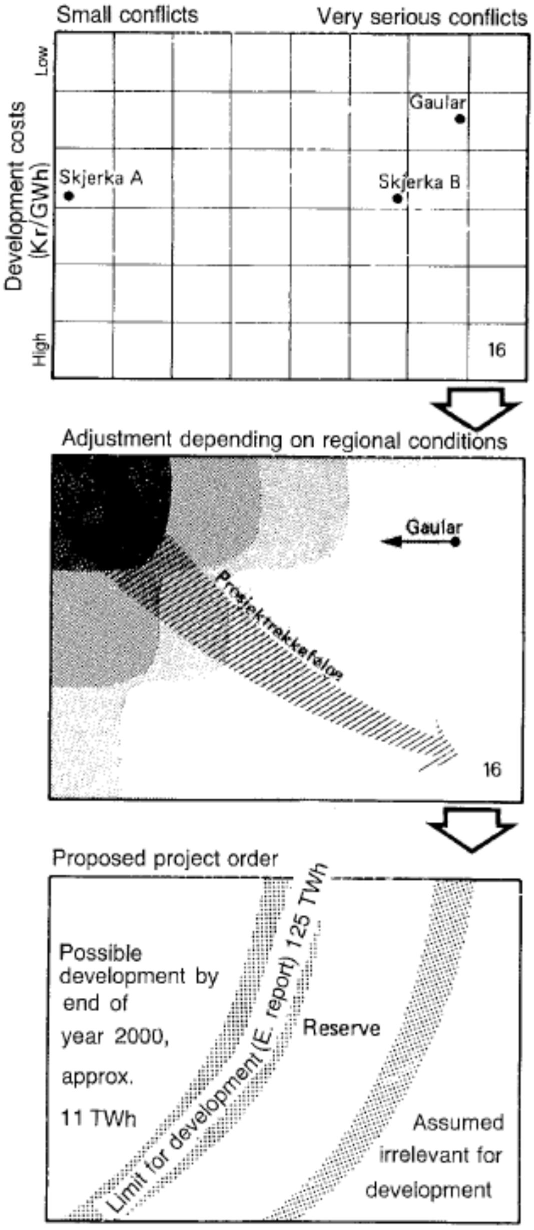

Figure 18. Illustration of weighing HP- economy/impacts and the Categories I –III.

It was no scientific algorithm involved in this step, jest "common sense" coupled with transparency and general knowledge on the experiences of balancing interest in the licensing processes.

Finally some projects group placements were adjusted according to regional economic impact. All projects were classified into 4 classes for "Regional Economic Impact".

Adjustments were also made for project Size. The classifications did not give consideration to the amount electricity that could be produced. The adjustment was necessary because large projects could be underestimated and given a too low priority in the Master Plan. (This "non-size" approach was heavily criticized but after hearings and reclassifications the same method approach was maintained in the revisions of the plan

542 alternatives in 310 projects were now sorted into 16 groups. However, as basis for political decisions in the government and the Parliament; projects in 16 groups were far too many. Thus the groups in the first planning round (Parliamentary report 1986) were divided into 3 categories:

Category I: **Projects all of which can be considered for licensing immediately in order to secure the supply of electricity. Group 1-5, in the Master Plan- 11 TWh).**
Category II: **Projects in watercourses that could be used for HP or for other purposes. Group 6-8 in the Master Plan.**
Category III: **Projects not considered relevant for licensing due to high degree of conflict with other user interests and/or high development costs.**

Relative to a traffic light analogy in relation to licensing: Category I: Green; Category II: Yellow, Category III: Red.

In the 2nd and 3rd planning round the number of categories was reduced from three to two as shown in figure, the new Category I consisted of the previous I and II, and the new Category II became the previous Category III. In figure 17. only 2 categories are illustrated.

NIVA: Norway's leading centre of competence in aquatic environments

NIVA provides government, business and the public with a basis for preferred water management through its contracted research, reports and development work. A characteristic of NIVA is its broad scope of professional disciplines and extensive contact network in Norway and abroad. Our solid professionalism, interdisciplinary working methods and holistic approach are key elements that make us an excellent advisor for government and society.

Norwegian Institute for Water Research

Gaustadalléen 21 • NO-0349 Oslo, Norway
Telephone: +47 22 18 51 00 • Fax: 22 18 52 00
www.niva.no • post@niva.no