Decision making for sustainable natural resource management under political constraints – the case of revising hydropower licenses in Norwegian watercourses

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Norway is the largest hydropower producer in Europe and provides currently 96% of domestic electricity supplies (MoPE 2018). Hydropower is a renewable and climate friendly source of energy, but causes an impairment on local environmental conditions, recreational use and aesthetics in and along impacted watercourses and lakes. Around 70% of the larger Norwegian watercourses and half of the country`s total water-covered areas are regulated for hydropower production. Before 2022, up to 430 hydropower licences will come up for revision of terms in Norway, potentially enabling change in flow requirements and reservoir regulations. These revisions are the central instrument to implement the European Water Framework Directive (WFD) in Norway. The outcome of these revisions has a large potential to increase environmental and aesthetic conditions in Norwegian watercourses (Ruud & Aas 2017). We examined the decision-making of five completed licence revisions by means of document analyses of all relevant written sources. This analysis aimed to show the content, methods and procedural qualities of the revision process. Despite case-specific differences, there are significant commonalities which are a basis for recommendations. Multi-criteria decision analysis (MCDA) could be used to improve the documentation of physical impacts and value judgements in decision-making processes in future hydropower revisions. The second aim of the study was, through structured qualitative interviews, to analyse the perception of main interest groups with regards to the use of MCDA in future revisions. The results show that there exists a rather strong resistance to using MCDA due to a variety of political and regulatory reasons.

Keywords: hydropower, integrated water resource management, environmental conditions of watercourses, recreational and aesthetic interests, qualitative social research, multi-criteria decision analysis (MCDA)

Introduction:

Hydropower (HP) is a renewable source of energy, without direct climate gas emission

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in Norway. But its production impairs often the environmental conditions for plants and animals, the recreational use and the general landscape aesthetics in and along regulated rivers and lakes. Production of hydropower that is environmentally sound implies finding a sustainable balance between the advantages of producing climate-friendly, renewable HP energy and mitigating the local detriments to environmental and aesthetic conditions of impacted watercourses. This relates to different UN sustainability development goals (SDGs) to be reached by 2030, such as to substantially increase the share of renewable energy in the global energy mix, to protect and restore water-related ecosystems, to implement a more integrated water resources management to ensure the conservation, restoration and sustainable use of inland freshwater ecosystems and their services (UN 2015). To assess the trade-offs between the single goals and to find a sustainable balance between them requires often complex environmental engineering decision-making. Applied methods should be able to take account of the diversity of interests in HP regulated watercourses related to the economic, environmental and social dimensions of sustainability, in a transparent, structured and informed way (WCED 1987; ICDPR 2013).

Worldwide, Norway is the 6th largest producer of HP (World Energy Council 2016), and the largest one in Europe (Norwegian Environment Agency 2017) with an estimated net generation of 143 TWh, corresponding to ~ 25% of the European market share (NVE 2018). HP delivers 96% of the Norwegian electricity consumption (MoPE 2018). Currently, around 70% of the large Norwegian rivers and half of the country`s larger water-covered areas are impacted by HP production (Norwegian Environment Agency 2017).

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HP became very important for electricity production in Norway from around year 1900. HP licences granted before 1980 did normally include very limited and insufficient environmental requirements, by no means matching the present-day, modern standards for licenses issued after 1990 (Lindström & Ruud 2017).

Before 2022, approximately 430 HP licences that are 50 years and older are due for revision of terms in Norway[1], potentially allowing for change in environmental flow requirements, reservoir regulations and other mitigating measures (Sørensen et al. 2013). These revisions provide a unique possibility to weigh the costs and benefits of HP production for the environment and society, and to specify modified conditions to better mitigate for environmental damage than previously. One advantage of licence revisions over new licences is that environmental effects are already evident, rather than anticipated and theoretical. They therefore have a significant potential to improve the existing environmental situation throughout basins in the whole country. These license revisions are also considered the most important instrument to reach the objectives set by the implementation of the European Water Framework Directive (WFD) in Norway (Ruud & Aas 2017).

The Norwegian Ministry for Petroleum & Energy (MoPE) as the licence issuing authority states the main objectives for revising hydropower licences (MoPE 2012):

1) to improve the environmental conditions of the regulated watercourses. This should be weighed against the main intention of the concessions – HP production.

[1] The revision interval was reduced to 30 years for licenses granted after a change in law in 1992 (Falkanger & Haagensen 2002).

2) to conduct a holistic assessment of the degree to which proposed measures and terms will lead to substantial improvements of environmental conditions. This requires an assessment of the existing values in the respective area, the effects of proposed measures and terms on all affected user interests as well as their costs, and a weighting against the objectives of reliable power supply and renewable energy production.
3) to coordinate the revisions with the objectives of the WFD.

MoPEs directive (2012) states explicitly that aspects such as environmental conditions for fish, birds and general biodiversity, landscape perception and outdoor recreation should be considered in the assessments, but this should be balanced against the main purpose of the granted licence to produce HP electricity.

In 2013 the Norwegian Water Resources and Energy Directorate (NVE) and the Norwegian Environment Authority have undertaken a joint screening of 395 of the hydropower licences nation-wide up for revision before 2022 in order to prioritise which licences to revise according to the aforementioned environmental and hydropower importance (Sørensen et al. 2013). Barton et. al (2016) structured the methodology that was used for this national licence screening using multi-criteria decision analysis theory implemented in Bayesian Network (BBN) software and found a bias towards hydropower loss in criteria determining the ranking of concession revision importance.

Our study on the completed HP licence revisions has two main aims: First, to analyse the completed licence revisions in terms of their content, outcome, procedural qualities, and applied methods for decision-making, with the intent to inform and support the future work on HP license revisions. Based on the results and earlier research on

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structured decision-making methods, we recommended application of multi-criteria decision analysis (MCDA) methodology to facilitate more optimised decision support for achieving the aforementioned objectives.

MCDA is an umbrella term to describe a collection of formal approaches which seek to take explicit account of multiple, potentially conflicting criteria in helping individuals or groups explore decisions that matter. The MCDA process can aid decision making i.a. by helping to structure the problem, providing a focus and a language for discussion, and a means for learning about the problem situation, values and judgements of all involved actors (Belton & Stewart 2003).

However, application of MCDA was dismissed by the relevant public decision makers and concerned stakeholders. The refusal of applying more sophisticated, structured and systematic decision-making methods, in general - and specifically of MCDA methods, is a common challenge in environmental engineering decision making (Marttunen 2015, Ishizaka & Siraj 2018, Kiker et al. 2005). Therefore, the second aim of this study was to analyse the reasons for rejecting the use of MCDA in licence revisions in Norway.

In integrated water resources management, multiple interests need to be balanced and trade-offs to be assessed, requiring suitable assessment methods. Empirical research has shown that decision-makers are ill equipped for making such complex decisions, but also skilled at simplifying the decision problem to the requirements of the existing regulatory framework. They have limited skills for processing information, can be inconsistent when making choices, and can be biased when considering uncertainty and multiple competing objectives (von Winterfeldt & Edwards 1986). There may also be tensions between existing practice and decision-support methods that shift decision-making roles across actors traditionally involved in impact assessments within different

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policy fields. This is paramount in environmental policy decisions and initiatives of promoting environmental policy integration into other policy fields (Jordan & Lenschow 2010). This is exemplified by efforts of integrating environmental concerns into the policy field of energy in general and HP production in particular (Lindström & Ruud 2017).

Application of MCDA in HP planning

MCDAs applications in the field of water resource planning and management (Hajkowicz & Collins 2007) and more specifically sustainable HP planning and management has been demonstrated by many studies worldwide (for a comprehensive review of all peer-reviewed studies in the years 2000-2015 see Vassonney et al. 2017). MCDA methods have also been used in assessments for HP licence revisions in Norway (Barton & Berge 2010, Barton et al. 2015, Barton et al. subm., Berge et al. 2008). Authors have discussed several advantages of MCDA. It offers a structuring decision-making framework for handling complex and multifaceted problems where many different stakeholders with different proprieties, objectives and values are involved (Marttunen 2011; Belton & Stewart 2002). As Marttunen (2011, p 11) states it: "MCDA aims at helping people to analyse complex decision situations. It includes procedures helping people to identify courses of actions in a manner that is analytically robust and consistent in light of the available information and people's preferences. The key characteristic of this paradigm is that the decision-maker does not optimise a single objective but aims at reaching a balance among several." MCDA can help to face the problem of conflicting objectives by adding structure, auditability, transparency and rigour to the decision-making process (Šantl & Steinman 2015).

A key feature of MCDA is that it is able to integrate very different kinds of knowledge, data and judgements related to the various stakeholder interests (such as qualitative and quantitative; from the fields of natural, social and engineering sciences; monetary and non-monetary; value and scientific judgements; modelling data and stakeholder preferences). Trade-offs among multiple conflicting criteria can be assessed in a structured way and be visualised (Kiker et al. 2005). It therefore has different potential benefits for multi-stakeholder planning processes, for example by providing a meaningful and logical framework for the decision-making, thereby supporting a systematic and transparent evaluation of alternatives. It can clarify areas of agreement and disagreement, increase the fairness of the process by giving every participant potentially an equal voice, promote stakeholder learning and comprehensive understanding of the planning situation, and in sum support finding balanced and widely acceptable solutions. It must also be recognised that increased participation of MCDA involves additional process costs which may not be supported by the existing resources for decision-making. Furthermore, the opening up of decision-making processes shifts established mandates and power relations away from public auditing authorities - MCDA must overcome a built-in bias against change in established institutions.

Methods:

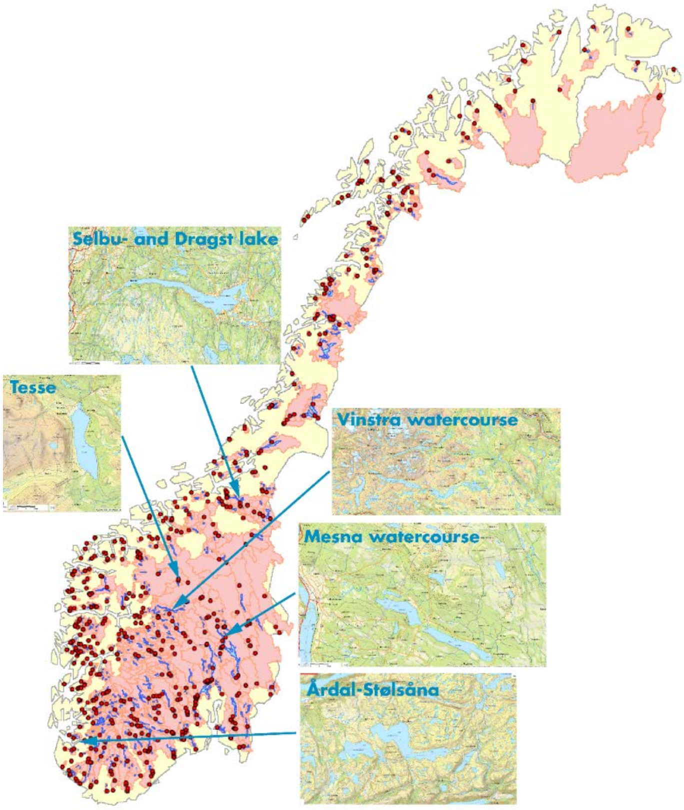
For our study of content, outcome, procedural qualities, and applied decision-making methods of the completed revisions of license terms (N=5; see figure 1), we analysed

1) the central legal documents, directives and white papers related to the revision of licence terms in Norway (such as MoPE 2012; Vannforskriften 2006; MoPE 2016; NVE 2013)
2) all documents related to the 5 licence term revisions issued, including those issued by the respective HP companies, all public hearing documents, the recommendations given by the Norwegian Water Resources and Energy Directorate (NVE) (NVE 2003 a,b,c,d,e; 2015), and the final evaluations/decisions[2] by MoPE (MoPE 2008; 2011; 2014; 2015; 2017).

All these documents were either directly publicly accessible or accessible from NVE`s archive on request.

Figure 1. Geographical overview of the five cases that were analysed in this study

[2] In Norway, the MoPE prepares a final evaluation for the government, based on the recommendation of NVE, the views of other ministries and local authorities. The government then makes a final decision in the form of a royal decree (Regjeringen 2008). In practice, MoPEs final evaluation represents the final decision.



We also used qualitative information gained in numerous project meetings, workshops, seminars and personal conversations during the years 2015-2018 with the reference group members of the CEDREN SusWater project (see acknowledgements), including representatives of various HP companies, NVE, the Norwegian Environment Agency, and Energy Norway, a non-profit organisation representing the Norwegian power companies.

In order to study the arguments for not applying MCDA, we conducted eight structured qualitative interviews with relevant representatives for stakeholder groups that were involved in the processes and two representatives from MoPE, a total of ten interviews. Integral to the ten interviews were the items adopted from a comprehensive review of international literature on valuation of the environment by Laurans et al. (2013). They included the following reasons for lack of use of diverse valuation methods, such as MCDA. In our interviews, these reasons referred specifically to MCDA. They included:

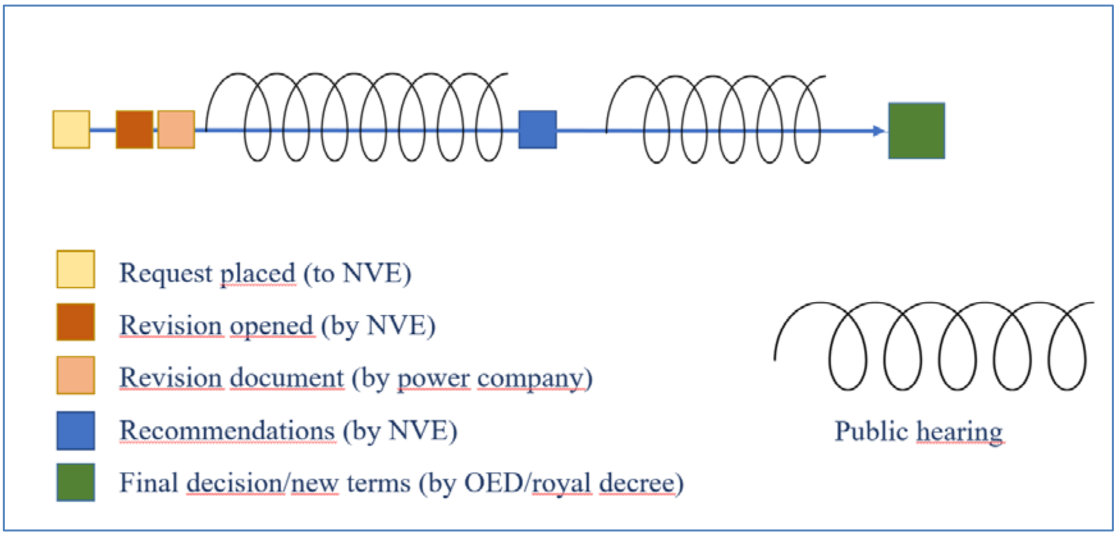
- MCDA may be too often inaccurate
- MCDA may contain fundamental inadequacies
- cost of MCDA may restrict its use
- decision-makers may not have sufficient training in MCDA
- regulatory frameworks may not be conducive to MCDA
- MCDA, by enhancing transparency, may hamper political strategies that require a certain opacity or ambiguity
- other reasons

Other reasons may include key stakeholders with decision mandates missing from the valuation consultation process (Barton et al. 2018).

Results: Document study on the completed HP licenses revisions

Our analyses of the five HP cases showed that they all followed the same formal appraisal procedure, as illustrated in figure 2.

Figure 2. Course of action of the decision-making process in the completed licence revisions.

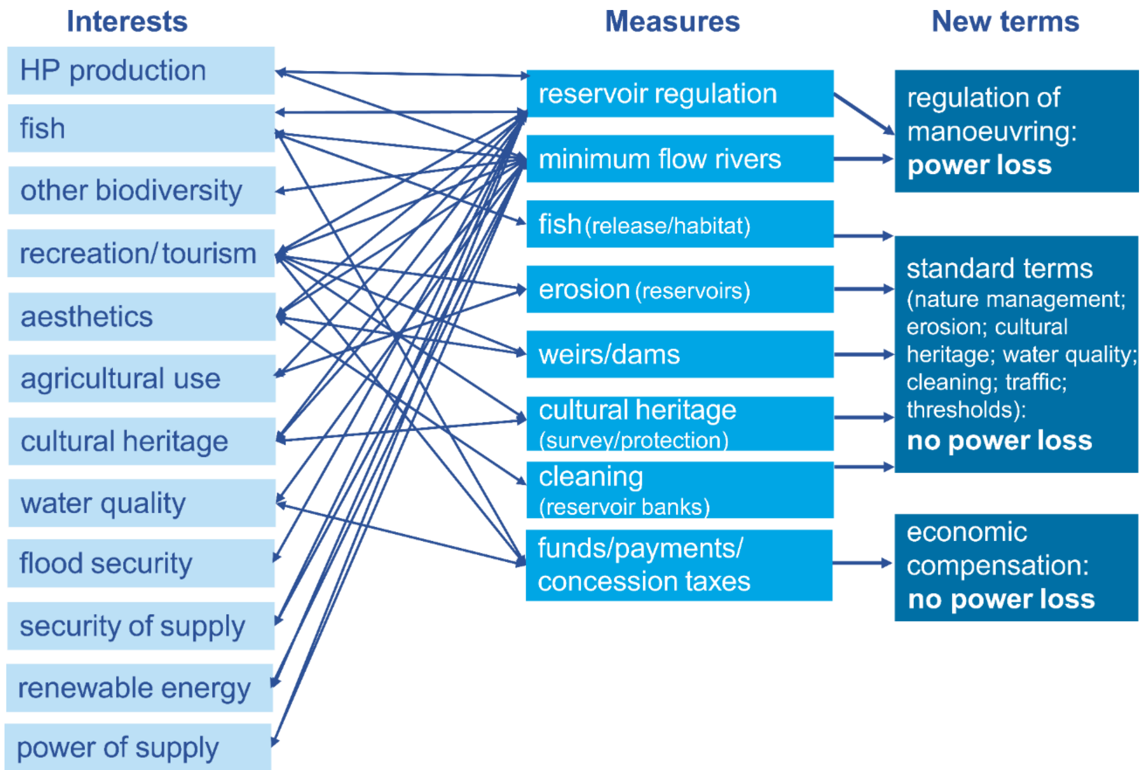


As required by MoPE (MoPE 2012), all revisions started with a written request by a representative of public interest (in many cases the local municipality) to open the revision process. This was sent to NVE. NVE made an assessment and in our cases opened an official revision and requested the respective HP companies to elaborate a revision document as basis for a public hearing with all affected interest groups. The interested parties had the possibility to send written statements with a description of their requests for certain measures and new concession terms. NVE then made a first written assessment and sent its recommendations for new terms to MoPE as well as to all involved interest groups for a 2nd public hearing round. The final assessment was then made by MoPE and the resulting new terms were eventually announced through a royal decree.

It needs to be pointed out that the state authorities on environmental issues, the Norwegian Environment Authority and the Ministry of Climate and Environment (KLD) have no formal decision-making power and in principle merely act as an interested party in this process. The decision-making mandate lies with those authorities having the responsibility to secure the national energy interests (NVE and MoPE). These first five licence revisions took substantial time with durations from 12 years (Vinstra watercourse), 15 years (Selbu and Dragst lakes), 17 years (Årdal-Stølsåna), 18 years (Tesse), to 25 years (Mesna watercourse).

Figure 3 shows a list of all interests that according to our analysis were represented in these revisions, the types of measures that were proposed and discussed in the decision-making, and the resulting types of new licence terms. Mitigation measures for fish were related to Atlantic salmon (*Salmo salar*) in two cases (Selbu/Dragst lakes and Årdal-Stølsåna), in all cases to inland brown trout (*Salmo trutta)*, except anadromous brown trout (same species migrating to the sea) at Årdal-Stølsåna) and only in the case of Vinstra also to European whitefish (*Coregnous lavaretus*) and minnow (*Phoxinus phoxinus*).

Figure 3. Interests, types of measures, relationships between interests and measures, and types of new terms of the analysed five HP revisions



As figure 3 shows, three types of new terms have resulted from the revisions. Only those terms related to the manoeuvring of the regulations - based on changes in minimal flow releases (MFR) or reservoir regulations (RR) - lead to potential loss in HP production. This is <u>not</u> the case for the second type terms, the so-called "standard (environmental) terms" and the third type of terms, economic compensation, although both of these types of terms imply costs for the respective HP company.[3] Figure 3

[3] Standard terms can be given for a range of subjects (e.g. nature management; weirs/ramps; accessibility/transport; cultural heritage; pollution; clearing and marking of ice). They are

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depicts also the highly complex network of interests and related measures that needed to be assessed.

Our analysis found that a multitude of economic, environmental and social interests were addressed and examined during the first completed licence revisions (see Figure 2). It confirmed our hypothesis that HP licence revisions take place on the interface between the three primary dimensions of sustainability (environment, society and economy). As shown, a complex nexus of effects of proposed measures/new terms on the respective affected interests need to be assessed and weighed against another. Therefore, we looked also at the existing knowledge and data input used for these assessments. We found that sufficient operational data and knowledge was available only for the effects of changes in MFR/RR regimes on HP production. These were also the only effects that were quantified in the decision-making process (as HP production loss in GW/h). The data and knowledge base for assessing other related effects were either insufficient (as in the case of fish versus MFR/RR), only partially existing (as for MFR/RR versus aesthetics, cultural heritage, flood security) or non-existent (as for all other relationships between MFR/RR and the remaining interests, as shown in figure 3). One exception was a series of photos depicting different concrete water flow release levels at the Hyttfossen waterfall in the river Nidelva for assessing aesthetic interests as

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not assessed as part of the actual licence revision assessment by NVE and MoPE but instead after the assignment of new terms by respective experts at the County Governor - the chief representative of the King and Government in the single Norwegian counties.

part of the Selbu and Dragst lake revision[4]. Anecdotical knowledge or qualitative assessments/estimations are else frequently used to consider the effects on the respective interests (except HP production loss) and potential trade-offs between them. In two of the five analysed cases (Vinstra and Selbu-/Dragst lake), trial regulations were introduced to improve the knowledge base of the effects of new MFR and the subsequent environmental conditions in the rivers.

However, our analysis shows that the decision-making for these completed licence revisions in general is characterised by limited data and knowledge, as partially unstructured and primarily based on qualitative expert judgement. The weighing of the various interests (e.g. biodiversity versus HP production, recreation versus HP production, or biodiversity versus recreation) lacks often clarity, justification and thus transparency. Existing uncertainties were partially mentioned in the analysed documents (e.g. in the Årdal-Stølsåna case), but in general they were not included in the assessment in an explicit and systematic way. Barton et al. (2016) conclude that hydropower loss criteria were considerably more import than environmental criteria in explaining which licences were given lower licence revision priority in the nation-wide screening.

In terms of the outcomes of these revisions, Table 1 gives an overview of the estimated quantified loss in HP production resulting from RR and MFR, as stated in the revision documents, and the percent of total production capacity of the respective power plants. The estimates for the average loss of production in GWh/year and the percent of the loss in total production resulting from the new licence terms are generally uncertain due to

[4] More detail on the knowledge base used in the revision assessments is given in Köhler et al. (2019)

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the difficulties to pinpoint precise production potential or unclear/changed inflow of water into the reservoirs (as for example in the case of the Årdal- Stølsåna revision). Notwithstanding, the calculation of the range of the total resulting production loss in relation to the production potential, indicates that it was substantially lower than 5% (the average loss estimated in the national screening by Sørensen et al. (2013) for the Selbu/Dragst lake, Årdal-Stølsåna and Mesna revisions) and as low as ~0,6% in the Mesna case. Barton et al. (2016) found that national-level estimates of significant adverse effect (cost) were relatively high in the screening project, due to the limited number of mitigation measures that were assessed.

Table 1. Estimated average HP production loss through revised terms related to minimal flow release and reservoir regulation, assumed production capacity and estimates of expected production loss by Sørensen et al. (2013).[5]

Revision	**Estimated average production loss due to new RR terms (in GWh/year)**	**Estimated average production loss due to new MFR terms (in GWh/year)**	**Production loss in % of total production capacity (assumed production capacity in GWh/year)**	**Expected production loss (NVE 2013)**
Vinstra	-	21,6	**1,7** (1306)	-
Tesse	<11	-	**<3,9-6** (182,3-280)	-
Selbu/Dragst lake	10-20	1,2	**1,1-2,9** (761-1010)	< 5%
Årdal-Stølsåna	-	20-30	**1,4-2,4** (1241-1422)	< 5%
Mesna	0	1	**0,6** (161-175,5)	< 5%

[5] More detail on claims and decisions related to revised RR and MFR terms for the cases of Vinstra, Tesse, Selbu and Dagst lake and Årdal-Stølsåna in Köhler et al.(acc.)

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Our study of the content, outcomes, procedural and decision-making qualities of the completed HP licence revisions in Norway substantiated our argument that the application of more sophisticated, structured decision-making methods still is needed.

Results: Reasons for objection of applying MCDA in decision making practice

In a first exploratory part of the interviews we asked whether MCDA methods would be suitable for multiple-use assessments in future revision of licence terms in Norway. None of our respondents considered that MCDA would likely be used in future decision-making processes in this area. This confirmed our earlier assessment of the situation that we had gained from several project meetings and seminars.

When asking first in an open, exploratory manner what the interviewees perceived to be the reasons for this, we received answers such as MCDA required a standardisation of criteria and indicators for all HP revisions that were not realistic and desired to obtain. Single revision cases were considered to be too different or too case-specific in order to standardize their assessment procedure. It was also stated that MCDA required a box thinking that was not suitable to this specific decision-making situation since it would unduly reduce the complexity of the situations. MCDA was considered to require too much data and amount of work. Several respondents expressed a wish that "revisions should be simpler", but they did not think that MCDA would make them more so, rather the opposite. MCDA was generally considered to be too complicated and unclear. Specifically, the respondents from the public decision-making institutions argued that they wanted to continue making revision assessments primarily based on expert judgement (estimation) and not on MCDA. In the case of MoPE this was justified with their mandate of leaving the final assessment to political priorities as given by the current government. NVE, on the other hand, stated that it was the mandate of public administration, i.e. their own mandate, to practice expert technical judgement to assess specifically subjective values, such as recreational interests, instead of using MCDA. However, one respondent stated clearly his conviction that it needed just one or very few key persons in responsible positions that were convinced of MCDAs benefits, to cause a shift in mind in terms of its uptake. According to him, these key persons were currently not present in the decision-making institutions. With the exception of the last point (missing key person/s), all of these reported reasons can be assigned to three of the statements adopted from Laurans et al. (2013) – 1) MCDA may contain fundamental inadequacies; 2) regulatory frameworks may not be conducive to MCDA; and 3) MCDA, by enhancing transparency, may hamper political strategies that require a certain opacity or ambiguity.

After this exploratory part of the interviews we asked the respondents (N=10) to state their opinions on each of all six items by Laurans et al. (2013), as listed in the methods section. After the interviews we assigned the respondents` respective answers a value on a 7-point scale reaching from 1: "strongly disagree" to 7: "strongly agree" in order to get a semi-quantitative overview over the distribution of the assessments for all respondents. The result of the mean values of this analysis is shown in figure 4.

The results of this part of the interviews with pre-stated items confirmed the findings of the exploratory interview part. The most important reasons for the lacking uptake were also here the perceived inadequacies of MCDA, little conducive regulatory frameworks, and the hampering of political strategies (items 2, 5 and 6).

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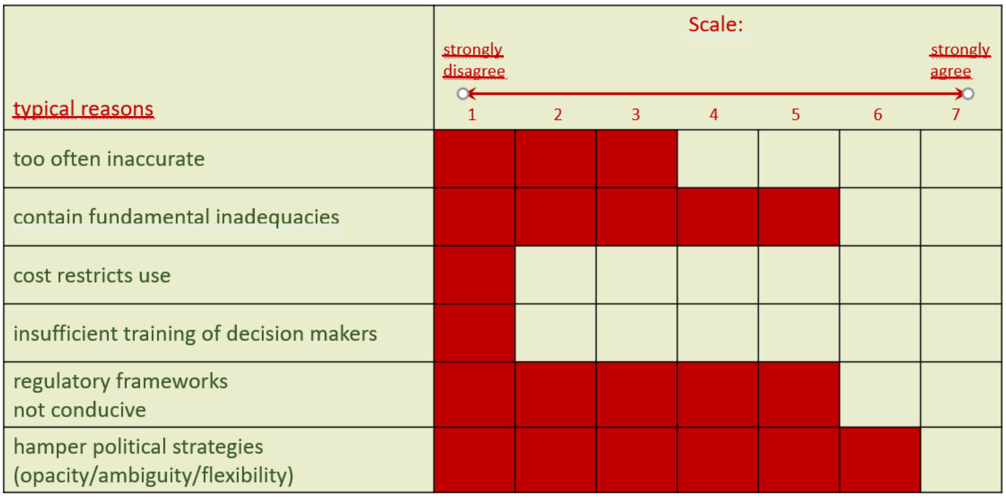
Figure 4. Typical reasons for lacking uptake into decision-making practice based on Laurans et al. (2013) and mean values of respondents` answers. (N=10)



Discussion

There are two types of environmental mitigation measures that are in direct conflict with HP production – minimal flow release requirements (MFR) and reservoir regulations (RR). Both play an important role for reaching the objectives of the European Water Framework Directive (Acreman & Ferguson 2010). MFR not only for new but also for existing HP concessions, are legally prescribed in many countries (e.g. in Austria and Switzerland (Kampa et al. 2017). In Norway, there is no general rule to adopt MFR for existing HP concessions. Therefore, they are assessed on a case by case-basis – by means of licence term revisions. Existing research as well as our study findings indicate clearly that also RR can have strong impacts on fish and other biodiversity, as well as on aesthetic and recreational user interests (Hirsch et al. 2017; Eloranta et al. 2017; Köhler et al. 2019). Therefore, a thorough case-by-case assessment of both MWF and RR is of high relevance. In our study we document that this is so far not done in a structured, transparent and systematic way in Norwegian cases. The assessments of the effects of several of the affected interests are instead conducted by means of qualitative expert assessments, normally based on limited knowledge and with a lack of transparency in terms of the related uncertainties (see also Köhler et al. 2019). Barton et al. (2016) found that uncertainty regarding data quality was significantly correlated with judgements about value, but not with judgement about impact, for all the environmental indicators in screening of concession revisions.

The assessments of these first five licence revisions have been criticised by stakeholders from affected communities and environmental organisations. This resulted for example in two official appeals to the European Surveillance Authority of the European Free Trade Agreement (ESA). One was sent by the Norwegian environmental umbrella organisation Norwegian Outdoor Recreation (FRIFO) and the Norwegian Biodiversity Network (SABIMA) as well as the Association of HP municipalities (LVK) after the completion of the Selbu- and Dragst lake revision (Ruud & Aas 2017). SABIMA issued another appeal after the Årdal-Stølsåni revision (Steel/SABIMA 2016). They criticised for instance that in their view the new terms did not serve to reach the objectives of the WFD and argued that revisions were actually used as a hindrance for implementing environmental measures in HP regulated watercourses. Recreational interests were perceived to be ignored, as well. The acquisition and usage of knowledge in the decision making was claimed to be irresponsible. In general, these appeals pointed out a lack of political will to implement “best practice” related to balancing HP production and the environmental conditions. ESA has not yet completed their assessment of the appeals.

Our analysis of the licence revision process shows that all interested stakeholders can feed in their arguments and claims for measures and new terms, normally at several stages. However, stakeholders that represent environmental and recreational interests, are frequently left with the burden of proof of validating their arguments. As a result, restrictions on MFR and RR are so far minimized, and in effect stay below the expected/pre-assessed thresholds of 5 per cent HP production loss (Sørensen et al. 2013). If we extrapolate the findings of theses first HP license revision cases to the large number of possible revisions in the next few years, it is likely that potential to mitigate existing negative environmental effects of HP production will be lost. On the other hand, it cannot be excluded that stakeholder claims result in higher production losses than necessary for mitigating environmental conditions.

Many of our interview partners emphasized that all revision cases will be very context-specific and different from one another. Nevertheless, we documented that the respective interests, relevant parameters, measures, and the needed assessments are sufficiently similar to benefit from using existing criteria indicators (e.g. Barton et al. 2010, 2015, 2016) or to develop them further. We argue that this holds potential to facilitate important systematic learning for the many HP licence revisions to come.

Our findings confirm the existence of technical, as well as institutional and political reasons why there may not be a MCDA uptake, as reflected in several text books (e.g. Munda 2008; Belton & Stewarts 2002; Beinat 1997). These are mainly reasons why decision-makers may feel that their preferences cannot be captured in an acceptable manner by MCDA value elicitation. Our results seem to be also in line with the technology acceptance model stating that “the intention of users to adopt new technology has two main extrinsic drivers: perceived usefulness and perceived ease-of-

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use (Davis 1989; Venkatesh & Bala 2008)" (Ishizaka & Siraj 2017). To our knowledge there is no substantial research on the relevance of the respective governance, political and regulatory contexts on the uptake of MCDA methods. However, our findings indicate that the most decisive factors for the lacking uptake of MCDA actually may lie in this political and regulatory realm in the case of HP licence revisions in Norway. The reasons for a lacking uptake of MCDA to improve the quality of decision-making indicate that it would be beneficial to develop this method further for application in the large number of licence revisions to come. The benefits of MCDA could be communicated better to avoid misconceptions.

However, our study also clearly shows that these efforts might not suffice as long as the political will and administrative interest to conduct structured and systematic assessments are missing. Clearer legal requirements could be given on the required knowledge and data base, the systematic treatment of uncertainties and the type of methodology used. This additional information would be costly. But our analysis shows that cost of MCDA is in fact a minor concern. More research is needed into the consequences of administrative impact assessment procedures that assign appraisal responsibility to a few selected experts, whose mandate confounds impact assessment with political value judgements in the concession revision process. More research is needed on the different assessment roles within institutions, on the resulting quality of decision-making and on the potential and limitations to the use of structured assessment methods, such as MCDA in revising hydropower licenses.

References:

Acreman, M.C., Ferguson, J.D. (2010). Environmental flows and the European Water Framework Directive. Freshwater Biology 55: 32-48.

Barton, D.N., Berge, D. (2010). Pressure-impact multi-criteria environmental flow analysis in the Glomma river. Striver technical brief. Strategy and methodology for improved IWRM - An integrated interdisciplinary assessment in four twinning river basins. TB No. 6

Barton, D.N., Sundt, H., Adeva Bustos, A., Fjeldstad, H.-P., Hedger, R., Forseth, T., Köhler, B., Aas, Ø., Alfredsen, K., Madsen, A.L. (subm.) Multi-criteria decision analysis in object-oriented Bayesian networks - diagnosing ecosystem service trade-offs in a hydropower regulated river. Environmental Modelling & Software.

Barton, D.N., Bustos, A.A., Köhler, B., Fjeldstad, H.-P., Alfredsen, K., Sundt, H. (2015). Multikriterievurdering av tiltak for habitatrestaurering i Mandalselva - en vurdering av interesse-forskjeller. Presentasjon for Rådgivningsgruppen i Miljødesignprosjektet Mandalselva Kristiansand 10-01-17.

Barton, D.N., Bakken, T.H., Madsen, A.L. (2016) Using a Bayesian belief network to diagnose significant adverse effect of the EU Water Framework Directive on hydropower production in Norway. Journal of Applied Water Engineering and Research 4(1): 11-24. doi.org/10.1080/23249676.2016.1178081

Barton, D.N., Kelemen, E., Dick, J., Martin-Lopez, B., Gómez-Baggethun, E., Jacobs, S., Hendriks, C.M.A., Termansen, M., García- Llorente, M., Primmer, E., Dunford, R., Harrison, P.A., Turkelboom, F., Saarikoski, H., van Dijk, J., Rusch, G.M., Palomo, I., Yli-Pelkonen, V.J. , Carvalho, L., Baró, F., Langemeyer, j., Tjalling van der Wal, J., Mederly, P., Priess, J.A., Luque, S., Berry, P., Santos, R., Odee, D., Martines Pastur, G., García Blanco, G., Saarela, S-R. , Silaghi, D., Pataki, G., Masi, F., Vădineanu, A., Mukhopadhyay, R., Lapola, D.M. (2018). (Dis) integrated valuation – Assessing the information gaps in ecosystem service appraisals for governance support. Ecosystem Services 29: 529-541. doi.org/10.1016/j.ecoser.2017.10.021

Beinat, E. (1997). Value functions for environmental management. Environment and Management book series (EMAN) Vol. 7.

Belton, V., Stewart, T.J. (2002). Multiple Criteria Decision Analysis. Kluwer Academics Publishers.

Berge, D., Dang, K.N., Phi Thi, T.H., Barton, D., Nesheim, I. (2008). The use of Environmental Flow in IWRM, with reference to the hydropower regulated Glomma River in Norway and Sesan River in Vietnam/Cambodia. STRIVER Report No. D 8.1

Cardoso, M.A., Santos Silva, M., Coelho, S.T., Almeida, M.C. and Covas, D.I.C. (2012). Urban water infrastructure asset management – a structured approach in four water utilities. Water Sci Technol 66(12): 2702-2711.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly 13: 319–340.

Eloranta, A.P., Finstad, A.G., Helland, I.P., Ugedal, O., Power, M. (2017). Hydropower impacts on reservoir fish populations are modified by environmental variation. Science of the Total Environment 618: 313-322.

Eurelectric (2011). Hydro in Europe: Powering Renewables.

Falkanger T., Haagensen K. (Eds.) (2002). Vassdrags og energirett. Oslo, Universitetsforslaget.

Grigg, N.S. (2016). Integrated Water Resource Management. An interdisciplinary approach. Palgrave Macmillan.

Hajkowicz, S., Collins, K. (2007). A review of multiple criteria analysis for water resource planning and management. Water Resour Manag 21(9): 1553–1566

Hirsch, P.E., Eloranta, A.P., Amundsen, P.-A., Braband, Å., Charmasson, J., Helland, I.P., Power, M., Sanchez-Hernandez, J., Sandlund, OT., Sauterleute, J.F., Skoglund, S., Ugedal, O., Hong Yang (2017). Effects of water level regulation in alpine hydropower reservoirs: an ecosystem perspective with a special emphasis on fish. Hydrobiologica 794: 287-301. DOI 10.1007/s10750-017-3105-7

ICDPR (2013). Sustainable Hydropower Development in the Danube Basin. Guiding principles. https://www.icpdr.org/main/resources/guiding-principles-sustainable-hydropower-development-drb.

Ishizaka, A. and Siraj, S. (2018). Are multi-criteria decision-making tools useful? An experimental comparative study of three methods. Journal of Operational Research 264 (2): 462-471.

Kampa, E., Tarpey, J., Rouillard, J., Bakken T.H., Stein, U., Nunes Godinho, F., Laitao, A.E., Portela, M.M., Courret, D., Sanz-Ronda, F.J., Boes, R., Odelberg, A. (2017). Fishfriendly Innovative Technologies for Hydropower (FIThydro). Deliverable 5.1. review of policy requirements and financing requirements.

Kangas J., Kangas A., Leskinen P., Pykalainen J. (2001). MCDM methods in strategic planning of forestry on state-owned lands in Finland: applications and experiences. J Multi Crit Decis Anal 10: 257–271

Kangas, A., Kurttila, M., Hujala, T., Eyvindson, K., Kangas J. (2008). Decision support for forest management. Managing Forest Ecosystems book series, Vol. 16. Springer Nature Switzerland.

Kiker, G. A., Bridges, T.S., Varghese, A., Seager, T.P., Linkov, I. (2015). Application of Multicriteria Decision Analysis in Environmental Decision Making. Integrated Environmental Assessment and Management 1(2): 95-108.

Köhler, B., Ruud, A., Aas, Ø. (2019). Hva kan vi lære fra gjennomførte vilkårsrevisjoner av vannkraftkonsesjoner i Norge? En dokumentanalyse av resultater, prosess og kunnskapsgrunnlag. Kart og Plan 2019/1.

Laurans, Y., Rankovic, A., Bille, R, Pirard, R. and Mermet, L. (2013). Use of ecosystem services economic valuation for decision making: Questioning a literature blindspot. Journal of Environmental Management 119: 208-219.

Lindström, A., Ruud, A. (2017). Whose Hydropower? From Conflictual Management into an Era of Reconciling Environmental Concerns; A Retake of Hydropower Governance towards Win-Win Solutions? Sustainability 9: 1262.

Marttunen, M. 2011. Interactive multi-criteria decision analysis in the collaborative management of watercourses. Doctoral Dissertation, Aalto University/Department of Mathematics and Systems Analysis, Finland.

Marttunen, M., Mustajoki, J., Dufva, M. and Karjalainen, T.P. (2015). How to design and realize participation of stakeholders in MCDA processes? A framework for selecting an appropriate approach EURO J Decis Process 3: 187. https://doi.org/10.1007/s40070-013-0016-3

Munda, G. (2008). Social-Multi-Criteria Evaluation for a Sustainable Economy. Springer.

Norwegian Environment Agency (2017). Vassdragsutbygging.

http://www.miljostatus.no/tema/ferskvann/vassdragsutbygging/

NVE (2003a). Trondheim Energiverk Draft AS - Revisjon av vilkår for konsesjon av 06.06.1919, regulering av Selbusjøen m.m., Selbu og Klæbu kommuner- NVEs innstilling.

NVE (2003b). Søknad om ny reguleringskonsesjon for Tesse. NVEs instilling.

NVE (2003c). Revisjon av konsesjonsvilkår i Vinstravassdraget NVEs innstilling

NVE (2003d). Revisjon av vilkår for konsesjonen gitt 19.11.1948 for regulering og overføring av Ardalsvassdraget til Stølsåna, samt regulering av Stølsåna mv. NVEs innstilling.

NVE (2018). Electricity disclosure 2017. https://www.nve.no/energy-market-and-regulation/retail-market/electricity-disclosure-2017/.

MoPE (2012). Retningslinjer for revisjon av konsesjonsvilkår for vassdragsreguleringer. http://www.nve.no/Global/Konsesjoner/Vannkraft/St%C3%B8rre%20kraftutbygging/Revisjoner/Retningslinjer%20for%20revisjon_25mai_siste.pdf , accessed 12. juni 2017.

MoPE (2016). Meld.St 25, 2016 presentet to Stortinget, https://www.regjeringen.no/no/dokumenter/meld.-st.-25-20152016/id2482952/

MoPE (2008). Revisjon av konsesjonsvilkår i Vinstravassdraget. Kongelig resolusjon.

MoPE (2011). Glommens og laagens Brukseierforening – Ny reguleringskonsesjon for Tesse i Lom og Vågå kommuner, Oppland fylke. Kongelig resolusjon.

MoPE (2014). Revisjon av konsesjonsvilkår for regulering av Selbusjøen m.m.

MoPE (2015). Revisjon av konsesjonsvilkår for regulering av Årdalsvassdraget,

This is an Accepted Manuscript of an article published by Taylor & Francis in Civil Engineering and Environmental Systems on 20.05.2020 available online: http://www.tandfonline.com/10.1080/10286608.2019.1615475

Stølsånaog Lysevassdraget samt overføring av Årdalsvassdraget til Stølsåna i Hjelmeland og Forsand kommuner.

MoPE (2018). Energi Fakta Norge. Kraftproduksjon. https://energifaktanorge.no/norsk-energiforsyning/kraftforsyningen/

Regjeringen (2008). Facts 2008: Energy and Water Resources in Norway. https://www.regjeringen.no/en/dokumenter/fact-2008---energy-and-water-resources-i/id536186/

Ruud, A., Aas, Ø. (2017). Vannforvaltningsplaner i Norge – opp som en løve, med som en skinnfell? En dokumentanalyse av prosessen i regulerte vassdrag med vannkraftproduksjon etter regjeringens første godkejnninger. NINA report 1351.

Šantl, S., Steinman, F. (2015). Hydropower suitability analysis on a large scale level: inclusion of a calibration phase to support determination of model parameters. Water Resour. Manag. 29(1): 109-123. http://dx.doi.org/10.1007/s11269-014-0830-9.

Sørensen, J., Halleraker J.H., Bjørnhaug, M., Langåker, R.M., Selboe, O.K., Brodtkorb, E., Haug, I., Fjellanger, J. 2013.Vannkraftkonsesjoner som kan revideres innen 2022. Nasjonal gjennomgang og forslag til prioritering. Rapport nr. 49/2013.

Steel, C./SABIMA (2016). Information update regarding Case 69544. SABIMA, Oslo.

UN (2015). Transforming our world: the 2030 Agenda for Sustainable Development. United Nations – Sustainable Development knowledge platform.

Vassoney, E., Mammoliti Mochet, A., Comoglio, C. (2017). Use of multicriteria analysis (MCA) for sustainable hydropower planning and management. Journal of Environmental Management 196:48-55.

This is an Accepted Manuscript of an article published by Taylor & Francis in Civil Engineering and Environmental Systems on 20.05.2020 available online: http://www.tandfonline.com/10.1080/10286608.2019.1615475

Venkatesh, V., Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. Decision Sciences, 39: 273–315.

Von Winterfeldt, D, Edwards, W. (1986). Decision analysis and behavioural research. Cambridge University Press.

WCED (1987). Brundtland Report. Our Common Future.

World Energy Council (2016). World Energy Resources Hydropower 2016.

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