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Ensuring sustainable hydropower development in the Nordic Region: balancing the promotion of renewable energy production and the "non-deterioration" principle.

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Abstract

The world's aquatic environment is at risk of irreversible environmental damage and most of Europe's lakes and rivers have shown signs of degradation from pollution and the changing climate. Water sources are not only essential for human life but crucial for the earth's biodiversity. The introduction of the Water Framework Directive (WFD) in the EU has been essential in providing its member states with a tool to protect and improve their water bodies. Similarly, the Renewable Energy Directive (RED) has encouraged and increased the development of renewable energy across all sectors within the EU. Hydropower in this context presents itself as a solution and problem since its negative environmental impacts conflict with its renewable and sustainable nature of energy production. Because hydropower is an important source of renewable energy it is important to assess its ability to be produced while conserving the impacted water bodies. Currently, the urge for expanding hydropower generation in the EU has an increasingly negative impact on freshwater ecosystems. This thesis will explore why the regulation around hydropower production has become a conflicting environmental matter in the present day and how can it be resolved. There is a potential to ensure sustainable hydropower production within the EU and more specifically the Nordic region. However, this must be done by implementing adequate integration of the conflicting policies and dealing with the current uncertainty within the energy-water nexus. By achieving this, it is possible that the promotion of hydropower as a renewable electricity source would not only align with the targets set by the RED, but it will do so while respecting the objectives of the WFD.

Keywords: Hydropower, Water Framework Directive, Renewable Energy Directive, Sustainable development, Environmental policy integration

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Foreword

I would like to express my deepest gratitude to my supervisor Ignacio Herrera-Anchustegui who has provided me with valuable insight and support during the writing of my thesis.

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Abbreviations

AA appropriate assessment

WFD water framework directive

RED renewable energy directive

EIA Environmental impact assessment

EU European Union

NGO non-governmental organization

MVP minimum viable population

RBMP river basin management plan

EPA environmental protection agency

ESHA European small hydro association

IEA international energy agency

HMWB heavily modified water bodies

ECJ European Court of Justice

SYKE The Finnish Environment Institute

1 Introduction

1.1 Background and context

Hydropower, deriving from the movement and flow of water to generate energy, is one of the key renewable energy sources aiding in the ambitious climate change transition goals of the 21st century. Even though hydropower has negative environmental impacts, it also provides the EU with 33% of its renewable energy and is the second most-produced renewable energy source.[1] While hydropower production is an attractive solution to eliminating non-renewable energy source use, it also presents conflicts when it is considered alongside EU legislation focusing on nature protection and water law. The objective of this thesis is to present the way hydropower and its environmental impacts are discussed and balanced in Finland and Sweden.

The 2018 Renewable Energy Directive (RED II) has provided the Member States of the EU with the set requirements to meet renewable energy targets which have been revised to reflect updated energy targets.[2] The energy sector is currently responsible for more than 75% of the EU's greenhouse gas (GHG) emissions.[3] Energy is termed as a "derived demand" due to all basic needs in society requiring the consumption of energy.[4] Thus, the drive for ensuring sustainable and efficient renewable energy production has become paramount. However, the need for efficient energy production highlights the fact that any industrial endeavours have the risk of bringing along undesirable environmental and social impacts.

Hydropower is one of the forms of clean renewable energy sources highlighted in the RED II; it has an important role in providing energy security for EU member states while in a broader sense supporting the EU's objective of becoming the first climate-neutral continent by 2050.[5] However, the use of hydropower does not come without detriments.

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[1] Eurostat 2020, "Renewable energy on the rise: 37% of EU's electricity" https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220126-1

[2] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources [2018] OJ L 328/82. (RED II)

[3] European Commission (2020) https://ec.europa.eu/commission/presscorner/detail/en/IP_20_1599

[4] Makuch and Perreira (2012) p.120 6.1.1

[5] Communication From the Commission to The European Parliament, The European Council, The Council, The European Economic and Social Committee and The Committee of The Regions The European Green Deal (Com/2019/640) – use 3 COM(2019) 640 final, p.1

Hydropower dams' environmental and social issues often become prevalent when considering their historical use and the legislation that has been put in place since to restrict its negative impacts. Hydropower production can cause adverse environmental degradation, specifically impacting key water sources such as rivers and their aquatic biodiversity. For example, hydropower dams cause significant changes in the water body they are developed at and cause changes to their hydrological regime.[6] Hydropower production also affects the water quality of water environments in the present and long run. With the Member States committing to the 'non-deterioration principle' [7] of surface waters, it becomes challenging to advance the promotion of hydropower under the objectives of renewable energy production. Additionally, the process of executing Environmental Impact Assessments (EIA) at the pre-production stage raises issues of balancing different interests. During the construction stage, social problems present themselves as conflicts arise between stakeholders such as regulators, citizens in the area, investors, and nature and wildlife advocates. Overall, these environmental costs can lead to the failure of meeting set requirements in the EU Water Framework Directive (WFD)[8], specifically on achieving and maintaining the 'good' water quality status of rivers and other water bodies.

The EU WFD was adopted in 2000 and it has transformed the regional water management objectives from only controlling pollution to promoting a more united and participatory water management approach.[9] The relationship between the environmental objectives of the WFD and the renewable energy production objectives of the RED becomes conflicted in the case of hydropower production. This is especially evident when the non-deterioration principle is put into practice on the national level. The increasing pressure to produce more renewable energy can also be seen with the increasing capacity for hydropower project plans, especially in the European region.[10] To address the negative environmental impacts the EIA is placed in between the hydro project plan and its initiation where a potential project plan must meet specific sustainability criteria. However, the practice of EIAs also differs between nations and their outcome raises debate over its efficacy. The case of hydropower production is today at a

[6] Tomczyk, P.; Wiatkowski, M. Challenges in the Development of Hydropower in Selected European Countries. Water 2020, 12, 3542.

[7] 2000/60/EC (WFD) Article 4

[8] Directive 2000/60/EC

[9] Dieudone-guy and Collins A. Water management and regulation, p.348

[10] 2021 Hydropower Status Report Sector trends and insights, International Hydropower association

crossroads between being an efficient renewable electricity source that is an answer to energy security concerns, and a local environmental challenge in the light of the degradation of river ecosystems and local biodiversity.

This thesis will present the legal challenges in balancing the production of hydropower in the Nordic EU region. It will include a critical assessment of hydropower production with a focus on its environmental impacts and sustainable energy production objectives. In order to incorporate a Nordic perspective, I will include case studies from Finland and Sweden. These countries are chosen to be examined due to their EU membership status which further motivates their increased development of renewable energy, and the relevant environmental issues and conflicts present when examining their hydropower use. Additionally, from a hydrological perspective, the mountain ecosystem of Sweden and the aquatic abundance of Finland offer a good insight into the environmental impacts of this region and why increased protection from hydropower generation is necessary within the Nordic region.

The thesis analyses hydropower production and why it presents challenges for the environment (chapter 2), after which the EU regulatory landscape relevant to hydropower production is addressed (chapter 3). The following chapter presents and discusses hydropower production in the Nordic region with case-studies from Finland and Sweden (chapter 4). After, the promotion of hydropower as a renewable energy source and the mitigation against its environmental challenges are critically analysed (chapter 5). This chapter includes the assessment of the current landscape and identifies future recommendations. The thesis will end with conclusions regarding the balancing of hydropower production and avoiding environmental degradation (chapter 6).

1.2 Research objectives

This thesis intends to identify and assess the environmental issues involved with hydropower production from a European perspective and use the Nordic region states as case examples in this assessment. As the world continues to advocate for and work towards increasing renewable energy production, the need for safeguarding environmental landscapes, biological diversity, and natural and cultural heritage sites is essential. This research aims to assess whether there are shortcomings in the current legal framework for hydropower developments when applied in the EU and Nordic contexts. The thesis will focus on the selected Nordic states and provide an insight into the regional and national applications to consider how it is possible to ensure the sustainable future implementation of hydropower developments through their regulatory landscape.

This thesis aims to answer the following research question: why has the regulation around hydropower production become a conflicting environmental matter in the present day and how can it be resolved? To answer this broad research question, I will look at three specific matters:

1. To what extent does the current regulatory landscape balance the promotion of hydropower as a renewable source of energy against the "non-deterioration" principle of the Water Framework Directive?
2. What further implications does the regulatory landscape of hydropower production present in the national context of Finland and Sweden?
3. How can the identified legal challenges between renewable energy promotion and the Water Framework Directive be better addressed?

1.3 Methodology

This thesis uses legal doctrinal research with the intention to "give a systematic exposition of the principles, rules and concepts governing a particular legal field and analyses the relationship between these principles, rules and concepts with a view to solving unclarities and gaps in the existing law." [11] Legal sources of international treaties and EU legislation will be used in the context of addressing hydropower development. Both "hard law"[12] and "soft law"[13] will be used for this paper. In regard to EU-level environmental regulations, the Water Framework Directive[14] and the Renewable Energy Directive[15] will be of focus.

The conflict between climate change mitigation using hydropower and the protection of the aquatic environment using the 'non-deterioration' principle of the Water Framework Directive will be assessed. In doing so, I will be looking at the law from the inside using the internal

[11] Smits, J. (2017) P.210
[12] Binding source of law
[13] Guiding sources
[14] Directive 2000/60/EC
[15] Directive (EU) 2018/2001 (RED II)

standard of environmental and water law to analyze the extent that which the frameworks balance contrasting concepts of environmental law. As well as considering the opportunities for policy integration through the energy-water nexus. While this thesis will require considering and using natural science and environmental policy research, it does not aim to do findings in these fields. Instead, it will use the research in these disciplines to support the legal arguments presented in this paper. The natural science and policy findings used in this paper will provide background context for identifying the relevant legal challenges The thesis will have focus on the science-policy interface relevant to hydropower production and its importance for legislative improvement.

It will start by introducing hydropower and the relevant EU directives for its regulation using scientific articles as well as various stakeholder documents. The analysis of the benefits and negative consequences of hydropower production will require the use of documents from governmental institutions, non-governmental organizations and public opinions from an EU and Nordic level. This thesis will present and analyze existing EU environmental law as it applies to the development and use of hydropower plants. A more critical approach will be taken to assess the relationship between the legal environmental principles of "non-deterioration" and directives and incentives promoting the exclusive production of renewable energy.

The relevant principles and policies will be introduced using a description of the official international legal sources using both legislation and case law, focusing on hydropower as a renewable energy source. The case studies on Sweden and Finland will provide an insight into the way hydropower and its mitigation is dealt with within the Nordic area. This will be researched through the countries' national River basin management plans (RBMP) and documents on different stakeholder views. The case studies will require reviewing three hydropower plant projects and their impacts on the respective rivers. The case studies will be on the Kemijoki River in Finland and Dalälven River and the Lule River in Sweden. This will require the use of national environmental legislation from Finland and Sweden.

1.4 Delimitation of the scope

The aims of balancing hydropower production and the objectives of the WFD will be taken into consideration by limiting the assessment geographically to the EU level, and more specifically to the Nordic region of the EU. While this thesis will present an overview of the present reality of hydropower production and its effects; it will do so by limiting the assessment to the EU member states of Sweden and Finland. These two countries are not entirely representative of the whole Nordic region. While being part of the Nordic region and being a prominent hydropower user, Norway is not an EU member state and will be thus out of the scope of this assessment. However, the discussion and findings from this thesis can be used to expand the discussion in other countries and regions as well.

2 Hydropower at the crossroads of being a vital renewable energy source and a local environmental challenge

It is important to understand the renewable functionality behind hydropower production which explains the continuing promotion of hydropower generation in the EU. However, different types of hydropower installations also have different impacts on the environment which brings forth further nuance to the use of hydropower. The distinction between hydropower plants with and without storage reservoirs and the different hydropower sizes present distinctive environmental deterioration elements which will be analysed in this chapter. The role of scientific input in policy making is important to ensure all risks and benefits are assessed adequately before promoting a widescale energy production mechanism for the EU region.

2.1 Hydropower as an energy provider

Hydropower produces electricity driven by the force of falling or flowing water. In the 21st century, hydroelectric power has become a prominent renewable energy source. Hydropower production involves the conversion of the potential energy of water into mechanical energy first by the flow of water turning a turbine.[16] The turbine is connected to a generator and this process will then secondly turn the mechanical energy into electrical energy. The end product is then

[16] Corà, E. et al. (2020). Hydropower Technologies: The State of the Art p.11

distributed as electricity to the power grid or users. Hydropower is currently projected to be globally the largest low emissions source of electricity.[17] According to the IEA, in 2020 hydropower contributed 13% to the total electricity generated in Europe.[18] This was an increase of 4% from the year before. However, there is also capacity and potential for increased hydropower installation and use globally which attracts investors to take on these projects.

2.1.1 Types of hydropower installations

There are many variables to hydropower plants as it is a site-specific technology. Factors such as location, water cycle, water flow, vegetation features, and nearby habitation all influence the types of hydropower plants that are installed in the area. It is also common to differentiate between small-scale and large-scale hydropower installations since their environmental effects on their surroundings vary. The way the water source is used presents a technical difference between hydropower installations. Water can be collected and stored in a reservoir, run through the turbines or it can be pumped from a lower level to a higher reservoir for storage purposes. By way of operation, hydropower plants can be classified into two main groups of plants. 1. Installations that don't use a reservoir: run-of-the-river power plants. 2. Installations equipped with a reservoir; storage power plants and pumped-storage power plants. Additionally, there are offshore hydropower plants which are a less established but developing technology using the power of waves and tidal currents to generate electricity from seawater.[19]

Run-of-the-river hydropower installations

The run-of-the-river installations use the natural water flow to produce electricity. The types of installations will be built within the watercourse where the water will be led through the installed turbines. These installations will lack water storage capabilities and the hydropower will be continuously generating electricity depending on the natural movements of the watercourse. This also means that this type of installation is sensitive to seasonal water flow variations.[20] Since the natural flow water regime is not majorly altered, and it does not feature

[17] IEA (2020), World Energy Outlook 2020, IEA, Paris https://www.iea.org/reports/world-energy-outlook-2020 p.222
[18] Ibid.
[19] IHA, Types of Hydropower, https://www.hydropower.org/iha/discover-types-of-hydropower
[20] Source for seasonal water variations

a reservoir the power plant's environmental impacts are considered smaller. The output of electricity from run-of-the-river installations depends on the availability of water in the river at any current time, and thus, can vary a lot throughout the year.[21]

Hydropower installations with a storage reservoir

A hydropower installation that includes a storage reservoir differs in its construction by the way it blocks the flow of water to create a dam. Here the upstream and downstream points of the watercourse will be impacted. Due to the blockage of water flow the downstream area will be dryer and reduced from its natural water flow while the upstream area where the reservoir is located will store a large quantity of water.[22] From this storage, reservoir water can be directed into turbines to produce electricity. Storage power plants produce electricity by releasing the water from the reservoir to pass through the turbine. They have the advantage of flexible use since they do not rely on the natural flow of the river stream. It operates independently by storing water, the potential energy, and releasing it to the turbines when the electricity is needed. While both run-of-the-river and storage reservoir installations can produce electricity, a storage reservoir has the additional benefit of storing energy. This is especially important for times when climate change and rainfall inconsistencies can fluctuate energy production from hydropower plants. The storage reservoir allows for use when there is an energy demand and especially aids during times of drought.

Pumped-storage hydropower installations

Pumped-storage installations are similar to hydropower installations with a storage reservoir, but they operate by having two water reservoirs, each situated at different elevations. These two reservoirs will be linked through tunnels or penstocks. The plant operates by moving stored water between the two reservoirs. Its operation can be divided into two modes; the production mode and the pumping mode.[23] In the production mode, the plant will release the water from the upper reservoir into the turbines to generate electricity, much like the standard hydropower plant. However, in the pumping mode, electric energy is used to pump the water back from the lower reservoir to the upper reservoir. The pumping is done using surplus electricity usually

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[21] Corà, E. et al. (2020). Hydropower Technologies: The State of the Art p.11
[22] SET Implementation Plan on Ocean Energy, 2021
[23] Corà, E. et al. (2020). Hydropower Technologies: The State of the Art p.11

during off-peak periods[24] While providing electricity, the plant also consumes energy during its pumping mode. The technology allows water to be pumped to the higher reservoir at times of low electricity demand and during high demand, the water is released to the turbine for the purposes of supplying electricity.[25] The pumping storage plant has a flexible and balancing role. Like the other reservoir using plants, it has the ability to balance the power grid both for 'demand-driven fluctuations and generation-driven fluctuations' [26]

Small-scale vs. large-scale hydropower

Hydropower plants can also be categorized based on their sizes. While there is no common definition for small-scale and large-scale hydropower installations, over the years different metrics have been used to differentiate between the two types.[27] Many countries make a general distinction depending on the installed capacity of the hydropower plant. In Europe, the limit for small-scale hydropower is set to below 10MW which is recognised by the ESHA.[28] Capacities above 10MW would be classified as large-scale hydropower. In other regions, this may differ, for example in the United States the limit is up to 25MW and in China, it is up to 50MW.[29] Capacities below 1 MW can also be classified as 'mini hydro' plants[30] For the purposes of this thesis, the European capacity guidelines will be used for differentiating between 'mini', 'small' and 'large' hydropower plants.

Large-scale hydropower can include run-of-the-river, hydropower with storage reservoir and pumped hydropower installations. However, small-scale installations are mostly run-of-the-river installations since they structurally have a smaller impact on the water source.[31] While small-scale hydropower may have a smaller environmental impact it also has relatively a

[24] Ibid.
[25] IHA, Pumped Hydro, https://www.hydropower.org/factsheets/pumped-storage
[26] Corà, E. et al. (2020).
[27] ESHA. Environmental Barometer on Small Hydropower; Sherpa Project; European Small Hydropower (https://www.yumpu.com/en/document/read/19504904/environmental-barometer-on-shp-esha)
[28] Abbasi, T.; Abbasi, S.A. Small hydro and the environmental implications of its extensive utilization. Renew. Sustain. Energy Rev. 2011, 15, 2134–2143.
[29] Kibler, K.M.; Tullos, D.D. Cumulative biophysical impact of small and large hydropower development in Nu River, China. Water Resour. Res. 2013, 49, 1–15.
[30] Corà, E. et al. (2020). Hydropower Technologies: The State of the Art p.13
[31] Refer to ESHA. Environmental Barometer on Small Hydropower; Sherpa Project; European Small Hydropower (https://www.yumpu.com/en/document/read/19504904/environmental-barometer-on-shp-esha)

minimal electricity output compared to large-scale hydro plants. Hydropower has a big presence in European rivers, but studies show that the use of small-scale hydro plants is especially prominent in Europe.[32] Further findings present the risk of small-scale plants having a large environmental impact in Europe, since they are many within a region its presence can disrupt river continuity while having a smaller electricity production contribution.[33]

2.1.2 Benefits of hydropower installations

Hydropower has been a prominent renewable energy source for centuries and the energy source continues to have a prominent role in maintaining the reliability of the European power grid. There are several characteristics of hydropower production that sets it apart from other renewable energy production methods. Hydropower technology is best known for its reliability and flexibility.

Hydropower technology utilises reservoirs, which allow for the storage of water and provides the advantage of controlling the production of energy to a time when it is needed.[34] This factor makes it flexible to use and adaptable to climate changes such as the yearly rainfall fluctuations in different regions. It can meet real-time electricity needs by supplying energy immediately or storing it for future use.

The ability to stop and start the generation of energy from water flow makes hydropower plants not only important for electricity supplies but also provides vital support for other forms of energy generation in the vicinity. Renewable energy sources such as wind and solar energy are less flexible in nature as they are more dependable on weather changes.[35] At times when these forms are not able to generate energy, the storage system of hydropower becomes useful for powering a certain region. Thus, hydropower contributes greatly to the diverse energy mix of renewable technologies. Hydropower also produces energy at a lower cost, considering the installations' long lifespan and low operating costs.[36]

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[32] Schwarz Ulrich, Hydropower pressure on European rivers: The story in numbers, 2019, FLUVIUS, WWF, RiverWatch, EuroNatur, GEOTA p.4
[33] Ibid.
[34] Siemonsmeier, M., et al (2018): Hydropower Providing Flexibility for a Renewable Energy System: Three European Energy Scenarios. A HydroFlex report.Trondheim: HydroFlex.
[35] Bremen, L.V. (2010).
[36] Killingtveit Å, (2014)

2.2 Hydropower as an environmental challenge

The effects of hydropower development can have both beneficial and negative environmental and social consequences. Hydropower is an environmental challenge due to the environmental impacts its development has shown to cause through extensive studies. Botelho highlights that the environmental impacts reported for hydropower production often refer to biodiversity limitations, impacts on fauna and flora, landscape impacts and water resource impacts.[37] An environmental impact can be defined as "the effects that the activities of people have on the environment"[38] Hydropower projects will unavoidably impact the watercourse and alter its hydrological regime where it's constructed and affect the surrounding environment.[39] The severity of the alteration will depend on the factors discussed above; the type of installation, the size of the plant, the chosen location and whether certain precautions have been taken to mitigate against the challenges presented by hydropower production. For example, run-of-the-river hydropower installations do not significantly alter the river flow compared to those installations that require building a reservoir for storage purposes. The EU Natura 2000 site is the largest network for environmentally protected areas in the world.[40] Regardless of their protected status, these areas have been and continue to be locations for hydropower development. A study from 2019 shows that 21% of hydropower plants in Europe are situated in protected areas.[41] Hydropower developments also cause changes in the surrounding ecosystems and lead to a loss in biodiversity. This is especially a concerning occurrence in the protected zones where vulnerable species and habitats exist. The environmental challenges related to hydropower production will be presented by exploring the effects on biodiversity, water quality and vulnerable populations.

[37] Botelho, A et al. (2017). Assessment of the environmental impacts associated with hydropower. In Renewable and Sustainable Energy Reviews (Vol. 70, pp. 896–904). Elsevier Ltd.
[38] Ghosh TK, Prelas M (2011) Energy Resources and Systems. Vol 2, Springer. P.114
[39] Bergengren J, Näslund I, Kling J (2013) Hydroelectric impact on aquatic ecosystems. Maritime and Water Authority, Gothenburg.
[40] European Commission, Natura 2000, https://ec.europa.eu/environment/nature/natura2000/index_en.htm
[41] Schwarz, U. (2019) p.6

2.2.1 Biodiversity

The biodiversity in water bodies is negatively impacted by hydropower installations since these constructions alter their natural habitat. Various plant and animal species within this ecosystem will have to adapt to these changes and in the worst cases, they can find the space uninhabitable. For example, hydropower development has been identified as one of the leading factors for the 83% decline in freshwater species populations in the past 50 years.[42] The hydrologic characteristics of a river can be distorted with the construction of dams by inhibiting the ecological continuity of fish movement and sediment transportation.[43]

Migratory fish species

Freshwater ecosystems including rivers accommodate about 40% of the world's fish species.[44] Fish species in European rivers have been reducing in quantities due to the effects of hydropower installations. While it is rare that these species get extinct completely, the reduction of the species populations still demonstrates a problem. In Belgium, a run-of-the-river hydro plant, on the river Lhomme was estimated to have caused a 50-59% reduction in the surrounding fish biomass, in the 4 years after the installation.[45] The most prominent effect on fish populations is migration barriers caused by hydropower dams. Hydropower dams obstruct the flow of the river and cause an issue for aquatic populations.[46] Migratory species require different habitats in different phases of their life cycle, and they travel long distances to secure food, mate and find refuge.[47]

A recent global study has revealed that only a third of the world's longest rivers remain free-flowing, due to the impact of human-made obstacles including hydropower installations.[48] The

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[42] WWF. 2018. Living Planet Report - 2018: Aiming Higher.
Grooten, M. and Almond, R.E.A.(Eds). WWF, Gland, Switzerland. P.56

[43] Bergengren J, Näslund I, Kling J (2013) Hydroelectric impact on aquatic ecosystems. Maritime and Water Authority, Gothenburg.

[44] National Geographic, "Freshwater threats and species", https://www.nationalgeographic.com/environment/habitats/freshwater-threats/

[45] Anderson, D., Moggridge, H., Warren, P. et al. (1 more author) (2015) The impacts of "run-of-river' hydropower on the physical and ecological condition of rivers. Water and Environment Journal, 29 (2). 268 - 276. ISSN 1747-6585

[46] Ghosh TK, Prelas M (2011a) Energy Resources and Systems. Vol 2, Springer, Netherlands.

[47] Bergengren J, Näslund I, Kling J (2013) Hydroelectric impact on aquatic ecosystems. Maritime and Water Authority, Gothenburg.

[48] Grill, G., Lehner, B., Thieme, M. et al. Mapping the world's free-flowing rivers. Nature 569, 215–221 (2019)

hydropower installations contribute to blocking migration routes for fish species and consequentially driving biodiversity loss. European rivers are also home to critically endangered migratory fish species like the Beluga sturgeon eel.[49] While all fish species require clean free-flowing water environments, migratory species especially rely on obstacle-free watercourses.[50] Obstacles in the water reduce the access to spawning grounds for migratory fish species. Another fish species directly affected by the effects of hydropower installation in rivers, is the Salmon, which lives and migrates between the sea and rivers. A Norwegian study has found that in addition to the disruption of river flow, the changes in water temperature caused by hydropower dams can affect the growth of young Salmon.[51]

Landscapes and forest habitats

Landscapes and nearby forest habitats are also affected by hydropower developments. Dam construction in rivers has long-term consequences of widescale landscape fragmentation and a high degree of hydrologic alteration.[52] The negative impacts of river barriers on migratory fish species contribute to the imbalance of nutrients in the upstream forests.[53] The nutrient dynamics of a river become altered with the lack of certain migratory fish, like the salmon, being able to transport valuable nutrients like nitrogen and phosphorus.[54] When these fish species are unable to migrate between different streams or certain fish populations are declining in the area, the valuable nutrients within the watercourse cannot be imported to the boreal forests affecting its nutrient balance negatively.[55] The issues involving biodiversity are interconnected and demonstrate the widespread effects of hydropower developments in the environment.

Sedimentation

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49 Baffert and Freund, (2022)

50 Bergengren J, Näslund I, Kling J (2013) Hydroelectric impact on aquatic ecosystems. Maritime and Water Authority, Gothenburg.

51 Saltveit, S. J, 1990. Effect of decreased temperature on growth and smoltification of juvenile Atlantic salmon (Salmo salar) and brown trout (Salmo trutta) in a Norwegian regulated river. 5, 295-303

52 Zhao Q, Liu S, Deng L, et al. (2012) Landscape change and hydrologic alteration associated with dam construction. Int J Appl Earth Obs 16: 17–26.

53 Bernthal, F.R., Armstrong, J.D., Nislow, K.H. & Metcalfe, N.B. (2022). Nutrient limitation in Atlantic salmon rivers and streams: Causes, consequences, and management strategies. Aquatic Conservation: Marine and Freshwater Ecosystems, 1– 19.

54 Ibid. p.5

55 Burrows, R.M., Hotchkiss, E.R., Jonsson, M., Laudon, H., McKie, B.G. and Sponseller, R.A. (2015), Nitrogen limitation of heterotrophic biofilms in boreal streams. Freshw Biol, 60: 1237-1251.

The installation of dams in addition to disrupting a river's composition of nutrients also affects its sediment load. Certain particles flow slower and settle in the reservoirs leading to sedimentation and can cause a deficit in sediments flowing to downstream areas. [56] For example, an accumulation of sediment and organic matter was caused by the installation of a run-of-the-river hydro plant in Portugal which affected the density of the river stretches.[57] The fragmentation of rivers also causes river environments to be more vulnerable to the spread of invasive species in the area. The introduction of new materials into the river from hydropower construction increases the threat of invasive species accommodating into the ecosystem.[58] Thus, migratory species that are already disrupted can also face the threat of invasive species in their habitat.

2.2.2 Water quality and flow regime

River fragmentation is defined as the interruption of natural river flow by human activity which includes the construction of dams.[59] Fragmentation caused by hydropower installations changes the composition of the natural river ecosystem. Especially hydro plants with water reservoirs can cause the flooding of an upstream area. The diversion of water within rivers can leave certain areas dry or alternate between drought and flood-like conditions.[60] The consequences of flooding can impact the biodiversity by causing loss of habitats.[61] Especially plant species will drown in these flooded areas. For example, riparian vegetation alongside reservoirs in Sweden has decreased by around 84% in degree of coverage, compared to rivers without installations.[62] The effects of flooding can also harm the people living in the area. Additionally, although hydropower is a renewable energy source its construction, operation and maintenance can involve the output of greenhouse gas emissions.[63]

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[56] International Hydropower Association. (2019).
How-to Guide: Hydropower Erosion and Sedimentation.
London: IHA.
[57] Anderson, D, et al. (2015) The impacts of "run-of-river' hydropower on the physical and ecological condition of rivers. Water and Environment Journal, 29 (2). 268 - 276. ISSN 1747-6585
[58] (Tang, 2009)
[59] UNEP/GRID-Arendal, River Fragmentation and Flow Regulation, https://www.grida.no/resources/5821
[60] Richter, Brian D., Ruth Mathews, David L. Harrison, and Robert Wigington (2003) Ecologically Sustainable Water Management: Managing River Flows for Ecological Integrity, Ecological Applications, Vol. 13, No. 1, pp. 206-207.
[61] Jansson, Roland. The effect of dams on biodiversity. Department of Ecology and Environmental Science, Umeå University. 2006.
[62] Ibid. p.79
[63] Kumar A, et al. (2012)

One of the main impacts of hydropower installations is the decline of the water quality since the technologies used in the energy production process alters the water that flows naturally.[64] Changes in the hydrological regime of the water source can be attributed to hydropower plants with reservoirs causing changes in water levels and temperature.[65] The downstream water quality can decrease as the upstream water travels through the reservoir by collecting sediment.

Specifically for hydropower with storage reservoirs and pumped hydropower, their operation can cause significant water level fluctuations, which effects are seen in the downstream rivers or riparian zones.[66] This release of 'turbined water' that alters the natural water flow and causes strong fluctuations in the water level is called hydropeaking.[67] The instability of water flow caused by hydropeaking can impact biodiversity as well as water quality.

It should also be noted that climate change is contributing to the challenges faced by the EU energy sector. The European Environment Agency (EEA) has stated that European energy production including renewable source production is vulnerable to climate change effects and extreme weather fluctuations.[68] This is likely to impact water availability as well as lead to changes in the hydrological regimes. Additionally, the report highlights that Southern Europe will face dryer climatic conditions while Northern Europe will face rainier seasons.[69] These climate change effects will have an impact on where hydropower production will be promoted more. There could be a potential ambition to generate more energy from hydropower in the Northern regions which could be concerning for the aquatic environments in the Nordic region.

3 The energy-water nexus and regulatory landscape of EU hydropower production

The EU has committed itself to ambitious goals for becoming a low carbon-emitting region using efficient renewable energy sources. The EU has set itself targets to reduce greenhouse gas emissions by at least 40% below 1990 levels and a binding target of relying on renewable

[64] Bergkamp G, Mccartney M, Dugan P, Mcneely J (2000) Dams, Ecosystem Functions and Environmental Restoration
[65] Edenhofer O et al. (2012)
[66] Greimel, F, et al (2018). Hydropeaking Impacts and Mitigation. 10.1007/978-3-319-73250-3_5.
[67] Ibid. p.91
[68] European Environment Agency (2019) p.43
[69] Nsenergybusiness.com. (2022)

energy by at least 32% by 2030.[70] The set targets are meant to incentivise a more sustainable and secure energy supply in the EU. Additionally, as a part of the European Green Deal[71], the EU has pledged to be climate neutral by 2050 in line with its climate action commitments under the Paris Agreement.[72] In order to deliver the European Green Deal the Commission also proposed increasing renewable energy targets from 32% to 40% for 2030 while 'working with nature to protect our planet and health'.[73] In order for the EU to meet its 2030 ambitions and its binding target of climate neutrality by 2050, the EU is presently working on the revision of its climate and energy targets through the 'Fit for 55 package'.[74] This revision includes a further promotion for renewable energy production from 32% to 40% by 2030 as well as a focus on integrating renewable fuel across sectors. The energy-water nexus becomes relevant in this situation since the increased promotion of renewable energy includes hydropower production which also impacts the surface waters of the EU. Hydropower becomes one of the tools for these ambitions as it represents a large share of the projected renewable energy generation growth according to the Member States' National Renewable Action Plans (NREAP).[75] For example, in Sweden 1 TWh of new hydropower is proposed to be added to its energy mix by 2025.[76] This will be in the form of increasing the capacity of large-scale hydropower plants and a very limited potential for new small-scale hydropower plants.[77] Hydropower is an electricity source and as part of the 2019, Clean Energy Package is also subject to the EU Electricity Directive.[78]

The challenges faced by the EU aiming to both pursue ambitious renewable energy goals as set out in the EU Renewable Energy Directive and the EU Water Framework Directive highlight the issue of balancing these objectives and current environmental policy integration. The following chapter will further address the fragmentation in the EU Directives that promote

[70] Directive (EU) 2018/2001 (RED II)
[71] European Commission Communication (COM(2019) 640) 'The European Green Deal'
[72] United Nations / Framework Convention on Climate Change (2015) Adoption of the Paris Agreement, 21st Conference of the Parties, Paris: United Nations
[73] European Commission (2022) Delivering the European Green Deal https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en#cleaning-our-energy-system
[74] Communication from the Commission To The European Parliament, The Council, The European Economic And Social Committee and The Committee Of The Regions 'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality COM/2021/550 final
[75] Scarlat N, et al. Snapshots of renewable energy developments in the European Union. Status in 2010 and progress in comparison with National Renewable Energy Action Plans. . EUR 26338. Ispra (Italy): Publications Office of the European Union; 2013. P.26
[76] The Ministry of Infrastructure, Sweden's Integrated National Energy and Climate Plan (2020) p.199
[77] Ibid.
[78] Directive (EU) 2019/944

opposing environmental goals and present the trade-offs in legislation and how it impacts different stakeholders.

3.1 EU Water Framework Directive

The Water Framework Directive (WFD) [79] is the most relevant EU-wide water legislation, setting out objectives for protecting water body quality, aquatic biodiversity and drinking water.[80] The main two objectives of the WFD are to prevent the further deterioration of water environments and the restoration of surface water bodies. The WFD sets a standard for implementing water resource management from the river basin level.[81] The first objective is commonly known as the 'principle of non-deterioration' for which Member States implement specific measures. Second, Member States should aim to achieve 'good status' or 'good ecological potential' of surface water by protecting and restoring the surface waters[82]

Its key requirement initially set a general target for water bodies in the EU region to reach "good ecological status" and "good chemical status" by 2015.[83] 'Good status' is the cornerstone for ensuring that water bodies are protected and do not continue to deteriorate in the present day. 'Good ecological status' concerns the protection of the biodiversity in watercourses including fish fauna, different marine algae and the hydrological characteristics of water bodies while 'good chemical status' concerns the protection of the thermal, oxygenation and acidification statuses.[84]

In connection to this, In the EU, constructing water storage for power generation has been emphasized as one of the main causes of hydromorphological pressures on waters. [85] Hydropower production is not directly regulated by the WFD, however, the

[79] Directive 2000/60/EC
[80] European Commission 2012
[81] 2000/60/EC Art. 2.9
[82] 2000/60/EC Art. 4(1)(a).
[83] 2000/60/EC Art. 4.1
[84] Annex V of 2000/60/EC (WFD)
[85] Common Implementation Strategy for WFD and Hydro-morphological pressures Policy Paper (2000/60/EC) 2006 p.6

hydromorphological pressures on surface waters are documented to be caused by altered water bodies and habitats to which hydropower plants contribute.[86]

To hold member states accountable the WFD introduced the River Basin Management Plan (RBMP) which must be updated every 6 years.[87] The RBMP reports on the present status of water bodies and sets out environmental objectives with actionable measures for each river basin in accordance with the WFD. [88] The active involvement of interested stakeholders in this process is also highlighted.[89] Especially the preamble of the WFD recognizes that the success of the legislative measure is dependent on 'close cooperation and coherent action' with the 'consultation and involvement of the public, including users'. [90] The river basin management procedure provides involved authorities the flexibility to deal with the ecological pressures and quality statuses of waters as long as these areas are identified for applying adequate protection and restoration measures. The category of 'heavily modified water bodies' (HMWB) as specified in Article 4(3) of the WFD[91] lets the Member States identify and separately address physically altered water bodies by human activity.

Human activity includes hydropower production alongside irrigation and navigation of waters which have been identified as the reasons for the significant change in natural water quality and composition.[92] The storage of water for hydropower generation purposes was identified as the third common activity for designating a water body as an HMWB.[93] It is important to highlight that 'Heavily modified' water bodies are given less strict derogation guidelines and aim for 'good ecological potential' instead.[94] The WFD also provides exemptions for the principle of non-deterioration. If the set conditions are met, under Article 4.7, allows for the new modifications to the physical characteristics of water bodies or failure to achieve good water status.[95] This new modification can include the installation of new hydropower plants.

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86 EEA Report, European Waters Assessment of Status and Pressures No 7/2018, p.72
87 2000/60/EC Art.11
88 Ibid.
89 2000/60/EC Art.14
90 Directive 2000/60/EC, Preamble Para 16, Para 14
91 2000/60/EC (WFD)
92 Euroelectric Policy Briefing Note, Heavily Modified Water Bodies: the WFD's Tool to Consider Specific Uses. D/2020/12.105/44 p.5
93 Kampa, E. & C. Laaser (2009)
94 2000/60/EC (Art. 2.16; Art. 4.3).
95 2000/60/EC Art 4.7

Furthermore, and related to hydropower issues, the Common Implementation Strategy for the EU Water Framework (CIS) [96] was developed to provide Member States guidance on the integration of the WFD with other sectoral interests. A risk assessment produced for the WFD presented findings of hydromorphological impacts being one of the most pertinent risks that needed to be addressed to achieve the goals of WFD and hydropower generation was identified as one of the main reasons for these impacts.[97] The CIS recognizes the need for balancing WFD and RED objectives and sets out recommendations for good practices and policy integration efforts. It sets out different mechanisms such as strategic planning and incentives that can be used for the balancing of the Directives. However, it does also recognize that its guidelines are recommendations that the Member States apply on a case-by-case basis [98] The lack of integration on the legislative level can present issues in how this balance can be achieved on the EU-wide level and to what degree such integration should take place.

3.2 EU Renewable Energy Directive

The recast of the Renewable Energy Directive in 2018 as a part of the 'Clean Energy for all Europeans Package' has updated the renewable energy target to at least 32% of consumption by 2030. (RED II)[99] Each EU Member State has adopted national renewable action plans to contribute to the achievement of the RED II targets.[100] This ambition has aimed to establish the EU as a region committed to the reduction of emissions and the promotion of renewable energy production. Additionally, more recently the European Commission has proposed to increase the EU's renewable energy target for 2030 from 32% to 40%.[101] This is proposed as part of the "Delivering the European Green Deal" package and advances the goal of becoming a climate-neutral region by 2050.[102] This revision of RED II depicts the EU's commitment to increasing renewable energy sources in Europe and the updated targets will likely contribute to more hydropower developments within the region. The urge to reach climate neutrality by 2050 and meet the clean energy objectives of the EU could incentivise the creation of new hydropower plants in EU waters as well as increase the production of existing hydropower plants.

[96] Kampa E, Von der Weppen J. (2011)
[97] Ibid. p. 7
[98] Ibid p.58
[99] Directive (EU) 2018/2001 (RED II) Art. 3.1
[100] Ibid.
[101] European Commission 2022 Clean Energy for All Europeans Package Available at: https://energy.ec.europa.eu/topics/energy-strategy/clean-energy-all-europeans-package_en
[102] Ibid.

Hydropower production potential in EU waters has mostly been expended already which makes it likely that new installations would be impacting the few areas that have been left unaltered.[103] This additional pressure on planning and permitting new renewable energy generation in the EU further demonstrates the need for balancing and integration between the WFD and RED.[104] The cross-sectoral issues should be first addressed to ensure the future of sustainable hydropower production. The changing environmental conditions caused by climate change in this case is a driver for both WFD and RED objectives. Climate change will unavoidably further deteriorate aquatic environments and necessitate the use of renewable energy in the future.

3.3 EU Nature Directives

The Birds Directive and Habitats Directive

To conserve Europe's vulnerable and endangered species and habitats, the Birds Directive[105] and Habitats Directive[106] have been put into force. These EU Nature Directives require its Member States to identify certain conservation areas for the protection of habitats and species. These designated nature protection areas make up an EU-wide Natura 2000 network which is currently the largest network for protected areas in the world.[107] These sites are accompanied by a species protection regime for European species detailed in the Habitats Directive.[108] These species protection objectives are especially relevant in the context of hydropower production, as its operation can impact these species, within or outside the Natura 2000 sites. Especially, migratory fish and birds are at risk when a hydropower plant is located by a river. For example, the European sea sturgeon Acipenser Sturio has been listed under the Habitats Directive as a species to be protected.[109] Article 6 of the Habitats Directive sets out the requirements for the protection and management of Natura 2000 sites requiring the Member States to 'implement positive conservation measures which correspond to the ecological requirements'[110] and take

[103] Balat, M (2006). Hydropower Systems and Hydropower Potential in the European Union Countries.
[104] Banet C, (2021) p.13
[105] Directive 2009/147/EC on the conservation of wild birds
[106] Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora
[107] Established by the 1992 Habitats Directive and the 1972 Birds Directive.
[108] 92/43/EEC Annex II, IV, V
[109] listed in Annex IV of the Habitats Directive
[110] 92/43/EEC Article 6.1

‘take appropriate measures to avoid any deterioration’.[111] Article 6.2[112] is especially relevant to new hydropower plant projects and similarly to the ‘non-deterioration principle’ of the WFD[113] to avoid activities that would detrimentally disturb the habitat or species in the area an assessment procedure has to be taken to assess the potential impacts. As directed by Article 6.3[114] an Appropriate Assessment (AA) must be undertaken for any project that would affect a Natura 2000 site to assess the effects, considering the site’s conservation aims.

The EIA Directive

The Environmental Impact Assessment (EIA) Directive[115] was implemented in 1985 and revised in 2014[116] with the objective of assessing and taking environmental impacts into account for ‘proposed activities which are likely to have a significant adverse impact on the environment.’[117] An EIA is mandatory for projects listed under Annex I which are determined to have a significant impact on the environment while projects listed under Annex II are left to the discretion of Member States on a case-by-case basis depending on factors such as location or size.[118] This assessment essentially provides procedural requirements for national authorities to receive environmental risk information for consideration before deciding on the progression of the proposed project.[119] However, while this facilitates informed decision-making it does not definitively halt a project based on significant environmental impact risk. National authorities will still have the opportunity to consider the results from the EIA and balance them with other considerations like public interest and economic development.[120] Additionally, the EIA Directive recognizes the need for a ’coordinated and/or joint procedure’ with the Appropriate Assessment if this is required under both the EIA provisions and the EU Nature Directives.[121] This points to an integration between the two Directives and requires the assessment of environmental impacts from different aspects.

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[111] 92/43/EEC Article 6.2
[112] 92/43/EEC
[113] 2000/60/EC
[114] 92/43/EEC
[115] 2014/52/EU
[116] 2014/52/EU
[117] Principle 17 of the Rio Declaration
[118] 2014/52/EU
[119] COM/2009/0378 final p.5
[120] 2014/52/EU Art 6.
[121] 2014/52/EU Art 2 (3)

4 The national implementation of Hydropower regulation in the Nordic region: Case Studies of Finland and Sweden

4.1 Background

Out of the five sovereign Nordic states, this paper will focus on Finland and Sweden to assess the national implementation of hydropower regulation. At the EU member state level, there is uncertainty and a lack of a collective approach for policy integration and balancing between the RED and the WFD.[122] This chapter will consider the successes and conflicts in implementing both ambitious renewable energy targets and environmental protection efforts in the Nordic region. Both Finland and Sweden have committed to carbon neutrality and as member states of the EU, the ambitious climate targets set for the region apply to them. The case studies from these countries present issues in loss of fish populations, dam safety, and impacts on indigenous populations. The stakeholder conflicts between the hydropower industry, environmental protection groups and local populations further highlight the conflict in applying the WFD and RED from the top down.

The International Hydropower Association identifies that hydropower generation has increased by around 4% in Europe from 2020 to 2021, primarily due to the increased production in the Nordics and Iberia.[123] Sweden was the 7th highest producer with a hydropower installed capacity of 16,478 MW while Finland had an installed capacity of 3,263 MW in 2021.[124] The Nordic region's electricity generation has been getting closer to decarbonization with it being recorded as 87% carbon-free in 2019.[125] Hydropower-generated electricity has contributed to the Nordic electricity system significantly and become a staple to the renewable energy mix both regionally and nationally. Both Finland and Sweden are sparsely populated states and share a cold climate. The cold climate characteristic especially contributes to energy consumption and the subsequent dedication to investing in increased renewable production for

122 ARCADIS (2011)
123 International Hydropower Association (2021) p.30
124 Ibid.
125 Nordic Energy Research (2019) p.12

energy security.[126] They are also cooperative states in electricity transmission and are currently in the works of constructing a new transmission connector to be put into use in 2025.[127]

The Nordic countries are noted to be forerunners in electrification through green energy production and energy decarbonization in the European region to which hydropower production contributes.[128] The Nordic countries have met their 2020 renewable energy production targets as set under the EU Renewable Energy Directive two years ahead of schedule[129] making it prospective that the region will be continuing to progress toward meeting their decarbonization agendas.

4.2 Finland

Finland has the aim of achieving carbon-neutrality by 2035 and becoming the first fossil-free welfare society in the world.[130] Finland's energy combination is primarily domestic biofuel and nuclear and the import of oil.[131] Its renewable energy production has been growing yearly and hydropower has been a significant part of renewable energy generation.[132] However, the potential for new hydropower developments is unlikely since most of the country's capacities have already been exploited or development is restricted due to environmental protection.[133] Currently, other renewable sources such as wind-generated energy are explored more than hydropower in the country. This is due to the geographical and environmental limitations on mainly large-scale hydropower plants.[134] Instead small-scale hydropower production is seen as

[126] Aslani A, Naaranoja M, Helo P, Antila E & Hiltunen E (2013) p.506
[127] Fingrid. (2022).
[128] Herrera Anchustegui, I. Glapiak, A. (2021)
[129] Nordic Energy Research (2021)
[130] Ministry of the Environment (2022)
[131] IEA (2018) p.13
[132] Ibid. p.24
[133] Aslani, Naaranoja, Helo, Antila, & Hiltunen, (2013), p. 509
[134] Ibid.

more prospective which is also supported by the Finnish government through financial incentives.[135]

The WFD has been implemented in Finland through the Act on the Organisation of River Basin Management and the Marine Strategy (1299/2004), Government Decree on Water Resources Management (1040/2006) and Government Decree on Water Resources Management Regions (1303/2004).[136] Finland reports on its RBMPs for eight river basin districts including Vuoksi, Kymijoki-Gulf of Finland, Kokemäenjoki Archipelago Sea-Bothnian Sea, Oulujoki-Iijoki, Kemijoki, and the Finnish part of Tornionjoki.[137] Out of the eight river basin districts two are shared with Norway and Finland as seen in Figure 1. The Ministry of the Environment and Ministry of Agriculture and Forestry are the authorities responsible for leading water resources management work in Finland.[138] The two authorities are tasked with the implementation of the Water Management Act and as well as reporting to the EU on the matters. The Finnish Environment Institute (SYKE) also acts as the national body for implementing WFD principles as well as executing environmental monitoring and research of the nation's water bodies.[139] Currently SYKE has an ongoing project regarding *Assessing and valuing ecosystem services for managing hydropower constructed rivers systems* (ECORIVER) which is due to finish in 2023.[140] This project recognizes the need for sustainable river management and implements a new impact assessment method to provide a cost-benefit analysis of hydropower production on regulated rivers.[141]

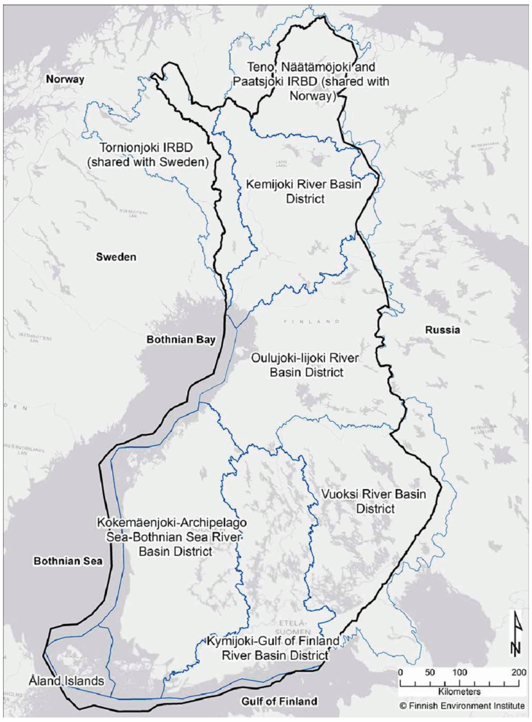

Figure 1 Map of the 8 River Basin Districts of Finland. Source: Alahuhta, J et al. (2013)

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135 Ibid.
136 Ministry of the Environment (2022) Management of water resources and marine environments in Finland Water resources management
137 SWD (2012) 379 Final
138 Ministry of the Environment (2022) Management of water resources and marine environments in Finland Water resources management
139 Finnish Environment Institute, State of the sea and monitoring (2022)
140 Finnish Environment Institute, Assessing and valuing ecosystem services for managing hydropower constructed rivers systems - (ECORIVER) (2022)
141 Ibid.

4.2.1 Case one: Kemijoki River, Finland

The Kemijoki River, which is located in Northern Finland, is the longest river in Finland and currently has 16 hydropower plants located in its watercourse that are owned by Kemijoki Oy and Pohjolan Voima Oy.[142] After World War II Finland experienced a rapid expansion in hydropower plant projects, especially in the Kemijoki basin district. However, due to the old nature of the hydropower plants, their construction lacked environmental considerations and adequate fish pass measures which would be ensured in the present day.[143] This has impacted the Finnish biodiversity severely and led to the significant loss of the local salmon population.[144] The downstream and upstream hydropower plants have consequentially permanently closed the migratory routes for salmon, sea trout and anadromous whitefish pushing these migratory fish close to extinction.[145] Furthermore, hydrological alterations caused by the multiple hydropower installations have caused Kemijoki's lakes to deteriorate and lead to raised water levels impacting the water quality.[146] Finnish rivers with hydropower dams have mostly been classified as HMWB but regardless of their mitigated ecological quality criteria, 66% of these heavily modified water bodies were reported as not meeting the 'good ecological potential' standard between the 2004 and 2009 planning period.[147] The Kemijoki River constitutes an HMBW due to the disruption caused by hydropower dam installations in its aquatic environment. It has been noted that in Finnish waters specifically, the challenges for restoring migratory fish stock and balancing their existence with hydropower production, stems from the fact that Finnish water policy has in the 20th century prioritized the allocation of available water resources to electricity production.[148]

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142 Kemijoki.fi. 2022. Power plants and production. [online] Available at: <https://www.kemijoki.fi/en/power-plants-and-production-2.html>
143 Milknaric M, Bauer S, (2018) Harnessing Europe's Rivers for Power – is it worth it? Revolve. P.54
144 Soininen, N. Belinskij, A. Vainikka A & Huuskonen H (2019)
145 Marttunen, M; Hellsten, S. (2003) Heavily modified waters in Europe – A case study of Lake Kemijärvi, Finland Finnish Environment Institute p. 18
146 Ibid.
147 Finnish Environment Institute (2013)
148 Soininen, N. Belinskij, A. Vainikka A & Huuskonen H (2019)

Figure 2 Kemijoki near the Vanttauskoski power plant Source: Samuli Lintula / Wikipedia Commons

Most recently, the proposed construction of the Sierilä hydropower plant with a dam reservoir (44 MW) in the last free-flowing part of Kemijoki River caused controversy nationally. In 2017, Nature conservation organizations like the WWF and the Finnish Association for Nature Conservation called on Kemijoki Oy to abandon the new project plan.[149] Additionally, the local population has petitioned against the project for the conservation of natural environmental values, impact on livelihoods and the effects on reindeer husbandry.[150] The Rovaniemi City Environmental Board had issued a building permit for the Sierilä hydro plant; however, this decision was revoked by the Supreme Administrative Court (KHO) on the basis that the project plan lacked detailed plans for a coastal zone project.[151] Regardless in 2020, Kemijoki Oy has received a new building permit from the Rovaniemi Environmental Board for the planned Sierilä hydro plant. As the project falls under Annex I of the EIA Directive 2011/92/EU, an EIA has been completed and the permit has been granted to Kemijoki Oy.

The project continues to be contentious between stakeholders. The Lapland District of the Finnish Association for Nature Conservation has appealed to the Rovaniemi City Environmental Board for the consideration of migratory fish.[152] Despite the conflicting nature of the progress for the Sierilä hydro plant, much focus has not been given to the underlying

[149] Yle (2017) Extensive appeal to Kemijoki Limited Liability Company: no new power plant in Rovaniemi (translated) https://yle.fi/uutiset/3-9955269
[150] Ibid.
[151] Yle (2020) KHO: The Sierilä power plant must not be built without a town plan (translated) https://yle.fi/uutiset/3-11300273
[152] Yle (2020) The Lapland District of the Finnish Association for Nature Conservation appeals for migratory fish: Sierilä hydropower plant to be divested https://yle.fi/uutiset/3-11558529

issue of Finland's ambitious renewable targets conflicting with aquatic and biodiversity protection measures. The sensitive debate between the RED and WFD objectives presents a hostile environment for hydropower production at the national level. However, it is worth noting that in April 2019 a hydropower project proposal for the Kemihaara Dam was rejected on the grounds that the river was protected under the Natura 2000.[153] The project was rejected due to the criteria for "no alternative solutions" under Article 6.4 of the Habitats Directive not being fulfilled.[154]

4.3 Sweden

Sweden's energy combination is mainly hydropower, bioenergy and nuclear power.[155] Sweden has the benefit of favourable geographic and aquatic conditions for hydropower production, especially in the northern part of the country.[156] These conditions include its mountainous region, high rainfall and low evaporation environment.[157] Sweden has one of the highest hydropower production potentials in Europe with the capability of around 176 TWh per year.[158] It has over 2000 hydropower plants which bring the country an energy output of around 64 TWh annually, constituting around half of Sweden's electricity consumption.[159] Similarly to Finland, Sweden has committed to having zero net greenhouse gas emissions by 2045.[160]

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[153] Schäfer, T. (2019)
[154] Kemihaara case (Valtioneuvoston päätöstä Natura-poikkeuksesta koskeva valitus (Rovaniemen ja Itä-Lapin maakuntakaava, Kemihaaran suot) 1453/2019
[155] Sweden.se. (2022) Energy use in Sweden. [online] Available at: <https://sweden.se/climate/sustainability/energy-use-in-sweden>
[156] Sweden facing climate change (2007) – threats and opportunities SOU 2007:60 Final report from the Swedish Commission on Climate and Vulnerability Stockholm. p.15 p.304
[157] Ibid.
[158] Balat, M (2006). Hydropower Systems and Hydropower Potential in the European Union Countries. (p. 965-978) Energy Source, Part A: Recovery, Utilization and Environmental Effects Volume 28, Issue 10
[159] Lindström, A and Ruud, A. (2017) Swedish hydropower and the EU Water Framework Directive. Stockholm Environment Institute, CEDREN
[160] Climate Act SFS (2017:720)

The Swedish national Environmental Code (Miljöbalken; Statute 1998:811) and water specific Water Management Ordinance regulation "Förordningen om förvaltning av kvaliteten på vattenmiljön "(SFS 2004:660)" have implemented the WFD. Sweden has five river basin districts which are the Bothnian Bay, the Bothnian Sea, the North Baltic, the South Baltic and Skagerrak and Kattegat.[161] Out of the five, three are shared with its neighbouring countries Norway and Finland as seen in Figure 3. Sweden adopted the Environmental Code in 1999 which initiated the use of environmental quality standards for pollution control and environmental protection.[162]

Figure 3 Map of the 5 River Basin Districts in Sweden. Source: Lindegarth, M et al. (2016).

Under the Environmental Code, 26 rivers are explicitly protected from hydropower operation including four major national rivers that have permanent legal protection: Torne River, Vindel River, Kalix River and Pite River.[163] The term national river (Nationalälvarna) was introduced in 1992 and does not constitute a legal definition but rather of symbolic value.[164] The purpose of this river protection scheme is to ensure that water in these rivers is not diverted for hydropower development purposes: "Hydroelectric power stations must not be built and water regulation and diversion for the purposes of power generation must not be undertaken".[165] Regardless, many of the protected rivers under the Swedish Environmental Code have already become affected by hydropower operations. It is reported that almost 90% of hydropower projects which are operating today in Sweden, were granted operation before the implementation of environmental legislation regarding hydropower use.[166]

For example, the large-scale hydropower plant called Sikfors was built in the Pite River in 1911 and was relicensed in 1990.[167] Different water districts in Sweden face different environmental

161 Utslappisiffror.naturvardsverket.se. 2022. River basin district characteristics.
162 Swedish Environmental Code, Ch. 5
163 Swedish Environmental Code, Ch.4 Section 6
164 Schäfer, T. (2021) p.11
165 Swedish Environmental Code, Miljöbalk 1998:808. (1998) Ch.4 Section 6
166 Rudberg P. (2013) Sweden's Evolving Hydropower Sector: Renovation, Restoration and Concession Change CEDREN
167 Pitea.se. 2022. Pite River - Sights. Available at: <https://www.pitea.se/en/Visitors/Sights/product/?lang=en&TLp=742131>

pressures. Notably, the northern parts of Sweden face the issue of long-standing hydromorphological challenges due to alterations caused by hydropower production and log-driving.[168] The most northern river basin district is the Bothnian Bay which is an essential fish population area and key seal reproduction area of the region.[169] The Scandinavian Mountain range embodies the northern parts of Sweden which explains the prevalence of hydropower installations in this region. The northern part of Sweden and the electricity generated from hydropower in this area largely supply energy needs in the southern parts of Sweden.[170] As depicted in the Bothnian Bay RBMP which is the district in the northernmost part of Sweden, the extensive hydropower activity in the area has caused significant morphological changes in the major rivers of the area. [171]

The two authorities responsible for the regulation and management of Swedish RBMPs and WFD implementation are the Swedish Agency for Marine and Water Management (SwAM) and the Water Authorities (Vattenmyndigheterna).[172] The authorities are involved in ensuring environmental quality standards of Swedish river basin districts are upheld in accordance with WFD standards. [173] Today, about 80% of Sweden's river systems have hydropower installations.[174] This has contributed to the classification of Sweden's rivers as HMWB where there are no reasonable ways a water body can reach 'good status'. In addition to the issue of conserving the water bodies the most discussed biodiversity impact in Swedish water bodies with hydropower installations is the issue of migrating fish. [175] Sweden's River Savers Association (Älvräddarna Samorganisation) is a river protection-focused environmental organization that was founded in 1974.[176] The organization especially advocates for dam removals in Natura 2000 areas and financially supports dam removal expenses.[177]

[168] Fehér J, et al. (2012)
[169] Pekcan-Hekim, Z et al. (2016)

[170] Löwgren, S. (2021). p.103
[171] Swedish Water Authority of the Bothnian Bay Water District (2016) p.17
[172] About the Water Authorities, https://www.vattenmyndigheterna.se/other-languages/english.html
[173] https://www.vattenmyndigheterna.se/vattendistrikt/bottenviken/om-bottenviken.html or IBID CHECK
[174] WWF (2022) http://www.wwf.se/wwfs-arbete/wwfs-arbete/1582825-projektkarta-strommande-vatten-och-vattenkraft.
[175] Älvräddarna Samorganisation. Om Vattenkraft. Available online: https://alvraddarna.se/fakta/om-vattenkraft
[176] Ibid.
[177] Borg C, Dam Removal Europe (2020) We can expect more dam removals in Sweden in the next decade.

Presently, several restoration plans for rivers and their biodiversity have been put in place by the Swedish government. The Swedish "national hydropower relicensing plan" (Nationel Prövningsplan) according to Sweden's Environmental Code has commenced a review process for all hydropower plants that do not have modern operating permits.[178] This relicensing plan puts around 2000 Swedish hydropower plants in scope for review and they will need to apply for a new license between 2022 and 2036.[179] This initiative will likely significantly support the restoration of water bodies in Sweden since hydropower plant owners will either have to modify and upgrade their installations to apply for a new license or choose to be decommissioned. Sweden has also set up a Hydropower Environmental Fund, which was set up in collaboration with eight of the country's hydropower companies, to help owners with costs associated with hydropower plant removals.[180] However, Sweden has alongside other EU countries recently faced criticism for overusing the Article 4 exemptions of the WFD.[181] The Swedish government has been accused of overusing the WFD exemptions to avoid implementing strong environmental measures in the case of revising the licenses for hydropower plants that have new environmental conditions in the present day.[182] Rather than applying the exemptions such as the "Overriding public interest" principle on a case-by-case basis the Swedish government has allowed for the exemptions to be used in a more general manner.

The exploitation of exemptions in this manner goes against the non-deterioration principle set out in Article 4 of the WFD. A case-by-case application of the exemptions is commended by the WFD to ensure that adequate consideration is given before a water source is derogated further from its current status. A legal study conducted on behalf of the WWF found that the flexible legal landscape on this matter has allowed involved stakeholders to misuse exemptions in practice at the expense of the water bodies' health.[183] The benefits from the 'national hydropower relicensing plan' is constrained by the political decision set by the government in its national plan which establishes a cap of 1.5 TWh total generation capacity loss yearly on hydropower production due to environmental measures.[184] This planning decision prioritizes

178 Swedish Agency Marine and Water Management (2019), Towards sustainable hydropower in Sweden.
179 Rewilding Europe (2020), New agreement brings large-scale dam removal a step closer in Sweden.
180 WWF (2021) Dam Removal Benefits for Nature and People Seminar Report
181 WWF (2022) Sweden widely flouting EU freshwater health rules. https://www.wwf.eu/?uNewsID=6832391
182 Ibid.
183 WWF (2022) EU Countries are Failing Freshwater Ecosystems. Factsheet EU Water Law
184 Lindström, A and Ruud, A. (2017) p.13

the interests of renewable energy production by limiting environmental measures and using this limitation as a general rule allows for the misuse of WFD exemption in the relicensing process. While Sweden has proposed that all hydropower plants need to apply for new environmental permits, these permits will be limited in practice when a political limitation of 2-3% in production loss is in place.[185]

4.3.1 Case two: Dalälven River, Sweden

The Dalälven River is located in central Sweden, and it has a big catchment area of 33,480 km^2 with 39 hydropower plants in its watercourse owned by Fortum. [186] The river is formed by the convergence of two rivers originating in the Scandinavian Mountain range. The Trängslet dam, which is the highest earth-filled dam in Sweden, is also situated in the Dalälven River and has an output of 651 GWh.[187] The use of hydropower on an industrial scale expanded during the 20th century. Similarly, to Finland, the rapid expansion of the hydropower sector, and in Sweden on an even larger scale, caused degradation of the watercourse. A river-specific study on the Dalälven highlighted the negative environmental impacts on fish fauna caused by hydropower and the regulation for fish.[188] Protection efforts, in this case, highlight the need to consider the ecological limits of the water body. For example, the release of Salmonid fish for compensation purposes should only be considered if the water body is large enough to sustainable maintain the fish population.[189]

The Dalälven is one of the 'national rivers' under the protection scheme of the Swedish Environmental Code. Interestingly, the river protection schemes of the Swedish Environmental Code were implemented after the dispute on hydropower production on the Dalälven River but this did not prevent it from becoming an HMBW.[190] The Habitats Directive sets out specific requirements for the protection and conservation of fish populations that are vulnerable.[191]

[185] WWF (2022) Sweden widely flouting EU freshwater health rules.
[186] Voitto Kokko, Peter Hjerthén, Hans Ingfält, Karl-Erik Löwen & Arne Sjögren (2015) Development of Dalälven hydro power scheme in Sweden, La Houille Blanche, 101:4, 5-14
[187] Ibid.
[188] Kampa E, Hansen W. (2004)
[189] Ibid.
[190] Schäfer, T. (2019)
[191] 92/43/EEC

Species within the Salmonid category which includes salmon, trout, and freshwater whitefishes are listed in Annex II of the Directive to ensure their conservation.[192]

Figure 4 Forshuvud hydropower plant in Dalälven River. Source: Fortum

Fish species will have a minimum viable population (MVP) size which is an "estimate of the number of individuals required for a high probability of survival of a population over a given period of time." [193] For example, the brown trout's MVP is around 1200 beings where 500 are at reproductive age.[194] The active pursuit for sustainable fish habitats must thus consider the effects of population density. Fish farming is one of the mitigation measures used in the Dalälven River to comply with WFD objectives and restore fish populations in the water course.[195] However, the mitigation measure has raised potential conflicts for the sustainability and safety of fish.[196] Potential detriments include imbalances in population sizes and the spread of diseases.[197] In this context certain mitigation measures can impact natural fish production and worsen the impacts of HMBW. It has been recommended that the integration of HMWB requirements into other policy fields would be necessary to achieve WFD objectives, especially in an aquatic environment that has considerable hydropower production.[198] While this

[192] Ibid.
[193] Honnay, O. Genetic Drift, Encyclopedia of Ecology (Second Edition), Elsevier, 2008, P. 114-117
[194] Kampa E, Hansen W. (2004)
[195] Ibid. p.168
[196] Ibid.
[197] European Parliament (2009), Regulatory and Legal Constraints for European Aquaculture
[198] Ibid.

integration would be necessary within member states an initiative from the EU level would present a good standard for all member states to follow regarding conserving biodiversity within HMBW.

The NCC has also been commissioned by Fortum to take an initiative for increasing hydropower dam safety in the Dalälven river.[199] In December 2022, the NCC and Fortum signed a framework agreement to repair and ensure maintenance of all Fortum hydropower plants in Sweden which is expected to be completed in 2024.[200] For example, Dalälven River's Forshuvud hydropower plant has been operating since 1990 and its repair will likely enhance its power generation. Focusing on repairing existing hydropower technologies which are currently going against WFD goals is an important initiative to take at a member state levels. Especially, before new hydropower production is promoted in water bodies already affected by degradation. In my opinion, measures for improving the efficiency and safety of existing hydropower plants rather than investing in new hydropower plants would be a prospective solution for balancing both WFD and RED objectives. If EU regulators took a cohesive stance for all member states to repair old inefficient hydropower installations before advocating for new hydropower construction, it would provide a balancing feature between the opposing directives.

4.3.2 Case three: Lule River, Sweden

The 460km long Lule River (Julevädno)[201] is a large river flowing from the northern mountainous area of Sweden to the southeast. Its watercourse accounts for around 25% of Sweden's hydropower with 15 plants located in the river.[202] The Lule River is partly located in Luleå which inhabits about 78,000 people.[203] It is an essential source of hydropower for the country and includes one of the largest hydropower plants in Sweden: The Harsprånget (977

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[199] NCC (2021) NCC and Fortum increase dam safety in Dalälven https://www.ncc.com/media/pressrelease/a39b2733cf172750/

[200] Ibid.

[201] In Sami language the river is called Julevädno.

[202] Drugge, L. (2003) Geochemistry of the Lule River, northern Sweden, before and after regulation. 2003:63. Institutionen för Samhällbyggnadsteknik. Luleå, Luleå University of Technology

[203] LULEÅ http://citypopulation.de/en/sweden/norrbotten/2580__lule%C3%A5/

MW) plant which was commissioned in 1952.[204] The Harsprånget plant is notable for being situated close to Jokkmokk which is a Sami town inhabiting the indigenous Sámi community.[205]

Figure 5 Harsprånget in Jokkmokk Source: Jokkmokk.se

The Sámi communities inhabit the northern parts of Sweden, Finland and Norway. The historical Sápmi lands have extensive natural resources and rich wildlife biodiversity, allowing the Sámi people to fish, fur trap and reindeer herd for a livelihood.[206] However, climate change and industrial activity have threated the existence of Sámi communities on their historical lands.

Currently, about 80% of large-scale hydropower generating plants in Sweden, Finland and Norway are in Sápmi lands.[207] The expansion of hydropower production in Sweden has led to an impact on the Sámi indigenous communities in addition to environmental biodiversity. The Treaty on the European Union states that the "Union is founded on the value of respect for human dignity (…), equality and respect for human rights, including the rights of persons belonging to minorities."[208] The environmental impacts of hydropower production in these areas have resulted in a degradation of fishing areas and reindeer pastures which

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[204] Mellgren, E. "Third time counted for Harsprånget", Ny Teknik 28 July 2012.
[205] A Pearl of Power, https://evolution.skf.com/en/a-pearl-of-power-2/
[206] Chatterjee, P. (2021) Human Rights Pulse. Sweden's Troubled Relationship with The Indigenous Sámi Community
[207] Larsen and Inga, (2020) Sámi lands and hydroelectric power in Sweden – what's the potential to redress harm and injustice?
[208] Article 2, Consolidated Version of the Treaty on European Union (2012) C 326/13

consequentially has impacted the minority community's cultural traditions and livelihood.[209] This causal effect goes against the Treaty of the European Union which commits to upholding fundamental human rights by combatting discrimination and respecting cultural diversity. Hydropower production has a negative impact on its surrounding environment and in addition to biodiversity and water quality degradation, it also has lasting effects on local populations. Since the Sámi population has been recognized as a minority indigenous community, the environmental issues caused by hydropower production are linked to human rights issues. Studies have also presented how the impacts on the Sámi people in the Lule River constitute a form of industrial settler colonialism.[210]

Considering the effects of hydropower installation on local populations which in this case affect a minority group illustrates how human rights issues are connected to environmental protection issues. The geographic divide of where Swedish hydropower is produced and used especially highlights a disparity. While the majority of the Swedish population lives in the southern areas of the country, most of the hydroelectric plants are situated in the northern areas of the country.[211] Furthermore, even though Chapter 17 of the Swedish Environmental Code regulates the minimum flow in dammed rivers, a lot of the old dams located on the Lule River lack environmental adaptation measures for the protection and restoration of aquatic species.[212] Studies have shown that the dam activity on the Lule River has altered the flow regime of the river and created the longest dry channel in Europe.[213] However, there are companies within the hydropower industry like Vattenfall. They argue that complying with the WFD regulations hinders hydropower production in the present day and underestimates the environmental benefits of fossil-free energy production.[214] A successful transition and ambition towards

[209] Jaakkola, J.J.K., Juntunen, S. & Näkkäläjärvi, K. The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union. Curr Envir Health Rpt 5, 401–417 (2018).
[210] Össbo, Å (2022) Hydropower company sites: a study of Swedish settler colonialism, Settler Colonial Studies,
[211] Löwgren, S. (2021). p.103
[212] Renöfält, B. M., Jansson, R., & Nilsson, C. (2010). Effects of hydropower generation and opportunities for environmental flow management in Swedish riverine ecosystems. Freshwater Biology, 55(1), 49–67
[213] Siergieiev, D., Widerlund, A., Lundberg, A., Almqvist, L., Collomp, M., Ingri, J., & Öhlander, B. (2014). Impact of hydropower regulation on river water composition in Northern Sweden. Aquatic Geochemistry, 20(1), 59–80.
[214] Bostorp, C., Hedenström, C., Nilsson, O., & Sparrevik, E. (2014). Konsekvensanalys: Förbättringsåtgärder som kan bli aktuella för att uppnå God Ekologisk Potential (GEP) i Kraftigt Modifierade Vattendrag (KMV) [Impact assessment: Improvement measures that may be needed to achieve Good Ecological Potential (GEP) in Heavily Modified Water Bodies (HMWB)]. Vattenfall.

renewable energy production should also recognize the rights of indigenous people. Only then can a sustainable future involving all communities within a state be ensured.

Mitigation for populations within the Jokkmokk area has mostly involved monetary compensation. Jokkmokk residents have expressed dissatisfaction with the compensation amount offered to them considering the impacts they endure from hydropower plants in the area and the overall revenue generated from Lule River's hydropower generation.[215] The deterioration of the Lule River's natural landscape has both environmental and cultural impacts on the Sami population.[216] These circumstances mainly caused by hydropower plant expansion have threatened the cultural continuation and lifestyle of the Sami population in Northern Sweden. The implementation of the 2019 Swedish national hydropower relicensing plan, gives the authorities an opportunity to take into account the long-term social impacts on indigenous groups from hydropower installations in Northern Sweden and is likely to increase dam removal proposals in the region.

5 The Legal Issues in the current regulatory landscape for EU hydropower generation

Hydropower generation has become a solution and problem in climate change mitigation efforts.[217] While it is a popular renewable energy source it has also proven to contribute to water degradation and biodiversity loss, as the three case studies illustrate for Finland and Sweden. EU leaders have legislated and delivered detailed environmental protection mechanisms for their Member States. These include directives on the aquatic environment, natural habitats and species in the environment. Similarly, they have also advanced the reduction of GHG emissions within the region by promoting renewable energy production and setting binding targets for reducing emissions. However, in my opinion, these policies and regulations lack integration and clear balancing efforts between their objectives. It has resulted in trade-offs between climate change mitigation by way of renewable energy production and mitigation against environmental degradation of water bodies.

[215] Löwgren, S. (2021) p.114
[216] Ibid. p.115
[217] UNFCC (2018) How Hydropower Can Help Climate Action

5.1 Policy fragmentation

In the present-day water and energy needs have become a cross-sectoral issue. Although the water sector and energy sector are interconnected in the case of hydropower generation, at the EU level the policies governing water protection and renewable energy production have been developed separately from each other. While the EU has set strong policies for EU energy through the European Green Deal,[218] and continues to propose increasing renewable energy targets for climate change mitigation, these initiatives have not explicitly involved consideration of renewable energy technologies on the environment and specifically their impacts on freshwater resources. Notably, the recent 'Fit for 55 package'[219] proposes a further promotion of renewable energy production from 32% to 40% by 2030. Rather a separate Water Framework Directive[220] focuses on regulating water-related developments within the EU, requiring all EU waters to reach "good" ecological status by 2015, and the latest by 2027. Energy-related policies have not effectively taken into account their use of water as a resource and thus water sources continue to become scarce and derogated.[221] Despite global water scarcity and many EU member states dealing with HMWB, the promotion of renewable energy production as a climate mitigation measure seems to have been given priority before recognizing and managing conflicts of water degradation.

This regulatory landscape has caused a policy fragmentation making it difficult to balance hydropower production in light of environmental protection measures.[222] This fragmentation in the environmental law field has overarching consequences in the adequate implementation and maintenance of the WFD principles. This conflict presents itself in several aspects including increased biodiversity degradation, disagreements between stakeholders, and human rights violations against indigenous people.

The goal of reducing the EU region's GHG emissions through the implementation of the RED has increased the use of financial incentives for supporting renewable energy production on the

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[218] European Commission Communication (COM(2019) 640) 'The European Green Deal'
[219] Communication from the Commission To The European Parliament, The Council, The European Economic And Social Committee and The Committee Of The Regions 'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality COM/2021/550 final
[220] Directive 2000/60/EC
[221] Vanham, D, et al. (2019). The consumptive water footprint of the European Union energy sector & "Science for Environment Policy": European Commission DG Environment News Alert Service, edited by SCU, The University of the West of England, Bristol.
[222] Pittock, J. (2011)

national level.[223] This in turn has caused an increased motivation for hydropower production in the EU and revived the hydropower industry globally in the 21st century.[224] Additionally, the recent global energy shortage crisis caused by the Russian military invasion in Ukraine and following political tension and implemented sanctions has threatened Europe's energy supply from Russia.[225] For example, Finland, a neighbouring country to Russia, has faced halted gas supply imports from Russia.[226] This development also contributes to the urgency for European countries to diversify their energy sources.

The increased development of hydropower in EU water bodies has also not spared protected Natura 2000 sites.[227] First, as identified in chapter 2, existing hydropower installations cause hydromorhological pressures on European waters. Both large-scale and small-scale hydropower installations present environmental challenges in different ways and have energy and environmental policy implications. The preference for small-scale hydropower installations in European rivers has led to the operation of multiple small-scale plants in a single water body region presenting risks of cumulative impacts.[228] Additionally, due to the smaller structure of these plants they have the ability to avoid many regulations that large-scale installations face, further highlighting gaps in policy coherence and implementation.[229]

The prominence of hydropower developments in EU waters is mainly due to the majority of small-scale hydropower installations.[230] These hydropower plants have the benefit of operating without the environmental impact caused by reservoirs. Furthermore, the European Environment Agency (EAA) highlights that their installation location being small tributaries not only has an adverse impact on fish populations, but its low electricity production renders the plants inefficient, especially when compared to the environmental impacts it causes.[231] Large-scale hydro plants on the other hand mostly operate with a water storage reservoir which

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223 European Commission (2022) EU renewable energy financing mechanism https://energy.ec.europa.eu/topics/renewable-energy/financing/eu-renewable-energy-financing-mechanism_en
224 Zarfl C, Lumsdon AE, Tockner K. A global boom in hydropower dam construction. Aquat Sci 2015:161–70
225 Deutsche Welle (2022) "Business EU moves to speed up energy investments amid Ukraine war, rising gas prices"
226 BBC (2022) "Russia halts gas supplies to Finland"
227 Schwarz, U. (2019) p.6
228 Ma, M. (2022)
229 Ibid.
230 Schwarz, U (2019) p.4
231 EAA Hydropower Position Paper (2020)

has been reported to be the main cause of hydromorphological pressures on water bodies.[232] Since the balancing of hydropower production on the policy level has not been clearly addressed the cross-sectoral nature becomes concealed. As seen in the Dalälven River case in Sweden, old hydropower dams were built before advanced environmental legislation was set out to protect rivers from human activity. Thus, developments such as the 'national river' protection scheme of the Swedish Environmental Code are unable to address the environmental damage caused by old hydropower installations and some still in operation will continue to cause.

The policy fragmentation involved in hydropower development further highlights the lack of integration of hydropower matters into the WFD. The implementation of the WFD has influenced views on hydropower development through the designation of HMWB by member states and the identification of hydromorphological pressures. The advantage of the WFD is that it has transformed the way new hydropower developments are assessed in terms of environmental impacts before construction goes ahead.[233] The WFD has influenced member states to better manage their river basin districts and take a more cautious approach to hydropower production by implementing environmental assessments such as the EIA Directive on proposed new projects.[234] However, the detrimental effects of existing hydropower installations, which were installed before the introduction of the WFD, do not face similar environmental impact scrutiny. In order to set a standard similar to new hydropower projects, existing older hydropower installations should go through 'upgrading plans' to assess improvement possibilities regarding environmental impacts.

Furthermore, the application and effectiveness of the EIA differ in quality depending on states' application and concerns regarding their relationship with other EU directives and policies have been raised.[235] There is also a need for stronger measures to avoid implementing hydropower plants in protected areas such as Natura 2000 sites and mitigating those that already exist in the Natura 2000 sites.[236]

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[232] Common Implementation Strategy for WFD and Hydro-morphological pressures Policy Paper (2000/60/EC) 2006 p.6
[233] The EIA and SIA have facilitated a system for impact assessment concerning environmental and social concerns.
[234] 2014/52/EU
[235] COM/2009/0378 final p. 7-10
[236] Bertzky, M., B. Dickson, et al. (2010).

Strategic planning between the EU Nature Directives and WFD in the context of hydropower production is facilitated through the AA and EIA. The Birds and Habitats Directives implement conservation measures for endangered species which also protects vulnerable species in freshwater ecosystems such as Salmonids. The environmental impact assessments introduced through the EU Nature Directives supplement the objectives of the WFD by aiding in evaluating the extent of damage caused by proposed hydropower projects. However, there is a lack of similar coherence between the objectives of the RED and WFD.

Thus, the additional pressure from the RED and its objectives for promoting new hydropower developments only exacerbates the existing legal and policy conflicts. The ambitions for climate neutrality stress the need for WFD to be resilient in addressing the issues of hydropower development. In order to ensure the future resilience of the overarching benefits of water management objectives, the present conflicts must be addressed at the policy level. Such conflicts include the WFD's lack of focus on improving existing hydropower plants which continue to have a detrimental environmental impact. Especially hydro plants that have been situated on Natura 2000 sites.

One can argue that these challenges have the potential to be addressed through innovative policymaking which incorporates different stakeholder views to produce a common integrated policy on hydropower development in the EU. Furthermore, Principle 3 of the OECD Principles on Water Governance would support this as it 'encourages policy coherence through effective cross-sectoral co-ordination' highlighting 'especially between policies for water and the environment, health, energy…'[237]

While the European Commission has agreed not to revise the WFD for the purpose of weakening WFD objectives[238] a revision for including matters of hydropower development considering the changing climate and renewable energy targets would further strengthen the regulation.

[237] OECD Principles on Water Governance (2015)
[238] WWF, EU Water Law Will NOT be Changed, Confirms European Commission. (2020)

5.2 Non-deterioration principle

The European Court of Justice (ECJ) defined what constitutes deterioration in the *Weser* case.[239] The ECJ defined a deterioration to be the degradation of the environmental quality of a water body to a lower quality status by 'at least one quality element'.[240] One of the main principles established by the WFD is the non-deterioration principle which aims to maintain the present quality status of water bodies.[241] However, this principle is supplemented by certain exemptions. The nature of these exemptions provides member states with flexible application of the WFD, however, there is also a risk of undermining the original principle of non-deterioration during application.

The relevant exemptions for the analysis of hydropower development can be broadly divided into three sets. Firstly, the exemption for achieving the 'good ecological status' of water bodies can be applied by member states by designating water bodies as HMWB or artificial, where achievement would cause significant adverse effects on the environment.[242] This exemption allows for applying the lower environmental target of achieving 'good ecological potential' instead of good ecological status.[243] However, this designation has to be declared in the respective RBMPs and reviewed during each management cycle.[244]

Secondly, member states can be exempt from achieving set quality targets in given time frames and be granted an extension, given that 'no further deterioration occurs in the status of the affected body of water.[245] Additionally, this extension would only be applied in the case that meeting the original time frames would be disproportionately costly, or natural conditions of the water body obstructs this aim. Thirdly, the exemption that has been contentious in this field,[246] is the notion that failure of achieving 'good ecological status' or 'potential' will not be constituted as a breach of the WFD when this is the due to new modifications to the physical characteristics of the water body or as a consequence of 'activities for sustainable human development'.[247] For this exemption to apply certain criteria must be met such as 'all

[239] C-461/13 para. 52-70
[240] Ibid. para 69
[241] 2000/60/EC Art. 4
[242] Ibid. 4 (3)
[243] Ibid. Art. 3 (21)
[244] Ibid. 4
[245] Ibid. 4 (4)
[246] Söderasp, J. Pettersson, M. (2019)
[247] 2000/60/EC Art. 4 (7)

practicable steps being taken' to mitigate the adverse impact on the water body status. [248] More notably, there must be an 'overriding public interest' for the exemption to apply, which is clarified as the environmental objectives set in Art. 4 (1) by the WFD being 'outweighed by the benefits' of such modification or activity causing deterioration. [249]

The exemptions to the non-deterioration principle constitute a contentious area since their application undermines the WFD environmental goals and is an obstacle for member states achieving WFD objectives. [250] The justifications for and implementation of WFD exemptions further present an imbalance between water protection objectives and the objectives of human activities with "overriding public interest". The 'Schwarze Sulm' judgement[251] led to justifying the "overriding interest" of renewable energy production for the reduction of fossil fuel dependence over the non-deterioration of the water body. – which further implies that hydropower production can defy the environmental protection objectives of the WFD. This demonstrates that the lack of clear balancing between the RED and WFD in the current regulatory landscape can be more favourable for the RED objectives. The ECJ accepted that energy transition constitutes an art. 4 (7) 'overriding public interest' justifying the deterioration of the Austrian hydropower plant. [252] While the case provided clarity to the notion of 'sustainable human development activities' and how it can justify water deterioration, the inclusion of renewable energy production in these activities can be a slippery slope for future exemption cases. [253] Water deterioration can become a widely accepted necessity for the promotion of renewable energy production if similar cases to the 'Schwarze Sulm' arise in the future. The application of renewable energy production as overriding public interest lacks a wider stakeholder involvement which would undermine the varied interests of stakeholders on the matter.

Furthermore, the level of discretion Member States are given when exploring exemptions to the 'non-deterioration' principle highlights that the balancing of interests responsibility is often left to the national authorities to decide.[254] The level of protection applied to EU water bodies relies on the interpretation of Member States demonstrating varying levels of environmental

[248] Ibid. Art. 4 (7) (a) – (d)
[249] Ibid. Art 4 (7) (c)
[250] Boeuf, B.; Fritsch, O.; Martin-Ortega, J. (2016) p.2-10
[251] C-346/14 (2016)
[252] Ibid. para 69
[253] Ibid. para 56
[254] Ibid. para 70

protection commitment over the interests of hydropower production. This is a problem as it is difficult to ensure a cohesive stance on environmental protection standards when member states have significant discretion on applying exemptions to a fundamental principle of the WFD. The EU has already identified points of concern for Article 4 exemptions of the WFD being overused by the Member States.[255]

Climate change projections present an additional burden in the balancing efforts between the RED and WFD objectives. The aquatic effects of climate change hinder the achievement of 'good water status' and the 'non-deterioration' principle. In 2018, the European Environment Agency (EEA) identified that only around 40% of the EU surface waters have 'good ecological status' or 'potential' which the WFD obliges to be reached by 2027. [256] It is possible for involved parties to Essentially, the initial ambitious and transformative 'non-deterioration' principle has in practice with the application of its exemptions presented certain risks of prioritizing renewable energy production. The future resilience of the WFD can be questioned if the WFD is not revised or a clearer balancing effort between renewable energy production and water protection is not explored through legislation.

5.3 The tradeoff between stakeholder interests and water management objectives

Hydropower production engages various stakeholders both from the side of promoting the renewable energy source and the side of protecting aquatic environments. Hydropower projects involve various stakeholders who operate with different levels of authority and are involved in different stages of hydropower production. These stakeholders include people from the hydropower industry, regulatory field, environmental organisations and local populations. It is essential for all involved parties to be aware and consulted on potential hydropower projects. Often these stakeholders present conflicting views and further demonstrate the tension involved with hydropower production. Major concerns involve the financial interests of the hydropower industry especially when it goes against the fundamental human rights of local populations. As well as regulatory concerns between regional guidelines and national applications such as in

[255] WWF (2022) Sweden widely flouting EU freshwater health rules. https://www.wwf.eu/?uNewsID=6832391
[256] EEA (2018)

the case of EU legislation and national implementation. The tension in practice further demonstrates the lack of integration of the WFD and RED objectives on the EU legislative level.

The relationship between these stakeholders can be conflicting and further demonstrates the need for coherence in the regulatory landscape for hydropower production. The stakeholder perspectives also raise trade-offs between long-term and short-term benefits of hydropower production and environmental protection. Hydropower production is a leading cause for EU water bodies not being able to reach 'good statuses.[257] While the benefits of hydropower generation for climate change mitigation will be realized in the long-term, the environmental effects on aquatic environments and nearby biodiversity are realized in the short-term and very locally.

Hydropower industry

Hydropower industry is a broad term and can involve stakeholders dealing with the construction, funding and representation of the hydropower sector. This industry can be divided into profit-based businesses and non-profit organisations. Energy producer companies such as Swedish state-owned Vattenfall, a prominent hydroelectric power generator in Sweden and Finland, act as electricity suppliers within the industry.[258] While the companies in the hydropower industry consider the views and recommendations of environmental bodies, they primarily operate for profit purposes.[259]

Eurelectic is a sector association representing the interests of the European electricity industry.[260] They have expressed their concern for the WFD not taking into account the needs of economic development during times of climate change.[261] While they suggest that the interests of hydropower promotion should be considered it is important to note that this sentiment highlights the desire for integrating renewable energy provisions into the WFD. Euroelectic has stated that "As it is the purpose of the WFD to strike a balance between environmental, climate and socio-economic goals, it should not unduly hamper the operation

[257] Water Framework Directive (EEA Report No.7, 2018).
[258] Vattenfall, About Us, https://group.vattenfall.com/who-we-are/about-us
[259] Ibid. Year End Report 2021
[260] Eurelectric (2022)
[261] International Water Power & Dam Construction (2019)

of existing hydropower plants or create obstacles to upgrading or developing new hydropower."[262]

On the business side, many energy producers have a stake in hydropower production. This also highlights their economic interest in hydropower production as it is an investment requiring a workforce and long-term planning. Non-profit organisations within the hydropower industry balance the playing field by advocating for sustainable hydropower. The International Hydropower Association (IHA) is a non-profit organisation with members from over 100 countries, with at least a third being from the European region.[263] It advocates producing sustainable hydropower globally by influencing companies and organisations through research, training and recognition.[264] Similar organisations exist on the European level, including the European Association for Storage of Energy (EASE)[265] and Association of European Renewable Energy Research Centres (EUREC)[266].

Banks and investors supporting hydropower companies are also crucial actors within the hydropower industry. The European Investment Bank (EIB) was involved in the funding of the Marsyangdi Corridor transmission line project, which would transfer electricity for use generated by hydropower projects in Nepal.[267] While the EIB and the project aim to meet climate change mitigation needs by improving access to renewable energy, the overall effects of the project and the inadequate consideration of local populations give rise to conflict. EIB as a financier is also just as involved as the project initiators within Nepal, and in 2021 the Complaints Mechanism uncovered within a report that the EIB provided funding to the state-owned Nepal Electricity Authority (NEA), without environmental and resettlement plans being completed for the project.[268] The involvement of local communities is thus crucial during any stage of a potential project to avoid conflicts and understand the wider impacts of proposed projects. As sustainable finance is becoming an important contributor to climate change mitigation in the financial world, banks such as the EIB have the responsibility to ensure that

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[262] Ibid.
[263] IHA, Our members https://www.hydropower.org/who-we-are/our-members
[264] IHA Advancing sustainable hydropower, Annual Report 2022. hydropower.org
[265] European Association for Storage of Energy (2022) European Energy Security Needs Storage
[266] EUREC https://eurec.be
[267] Accountability Counsel (2022) https://www.accountabilitycounsel.org/client-case/nepal-220-kv-marsyangdi-corridor-transmission-line/#overview
[268] Nagar, A. (2021) EU Energy Project in Nepal Sets Landmark Precedent on Indigenous Consent https://thediplomat.com/2021/06/eu-energy-project-in-nepal-sets-landmark-precedent-on-indigenous-consent/

the projects they financially support, respect environmental standards, indigenous communities and livelihoods.[269]

Non-governmental organisations (NGOs)

Environmental NGOs can operate from a national regional or global level. These organisations advocate for the conservation of the environment and its biodiversity. International NGOs like the WWF work on wilderness preservation and often produce findings and sustainable recommendations on the negative environmental impacts of certain human activities such as hydropower production.[270] The WWF is currently calling on EU bodies to stop supporting new hydropower installations in Europe.[271] However, it is important to note that not all NGOs take such a firm stance on the matter and some recognise the need for renewable energy in the present day which hydropower contributes to. While some organisations advocate for removing detrimental hydropower plants and ending the funding for new hydropower projects, there are organisations like Greenpeace that advocate for the sustainable and mitigated forms of hydropower production.[272]

Local populations

Locally, hydropower production impacts the population in the vicinity of the hydropower plant. Local populations often organise and express their views through organisations such as housing associations or outdoors societies (e.g. rowing, swimming). Public consultation plays an important role throughout the initiation and construction of hydropower plants. While hydropower production can in the long-term benefit local populations by generating electricity it does have negative consequences too. A Social Impact Assessment (SIA) aims to assess social consequences and plan for the social changes caused by a project or development impacting populations.[273] From the perspective of social impacts, hydropower can affect the health and safety of neighbourhoods and lead to the relocation of local populations.[274] In the case of dam construction, it has been recognised that negative downstream social impacts of rivers get

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[269] Ibid.
[270] Schwarz Ulrich, Hydropower pressure on European rivers: The story in numbers, 2019, FLUVIUS, WWF, RiverWatch, EuroNatur, GEOTA
[271] NGOs call on the EU to end support for new hydropower, https://www.wwf.eu/?1007466/NGOs-call-on-the-EU-to-end-support-for-new-hydropower, WWF 2020
[272] IHA to COP26: Sustainable hydropower is essential for net zero emissions, https://www.hydropower.org/news/press-release-iha-to-cop26-sustainable-hydropower-is-essential-for-net-zero-emissions, IHA 2021
[273] Vanclay F. (2003) p.6
[274] Cernea, M. (2004) p.7

overlooked or not adequately studied during project environmental assessments by failing to take a basin-wide assessment approach.[275]

Indigenous people are especially at risk when new developments are proposed in their living areas. In the Nordic region, the case of the indigenous Sámi people inhabiting in Sápmi, located in the northern parts of Sweden, Finland and Norway have been negatively impacted by hydropower developments negatively raising issues of discrimination.[276] In Sweden, 80% of large-scale hydroelectric power production is located in the Sápmi area.[277] The Luleälv river is located in an ecologically rich and diverse part of Northern Sweden which was impacted by the construction of the Messaure hydropower dam.[278] Not only are the Sámi people directly impacted by construction but their livelihood of hunting and fishing for food is significantly disturbed by the habitat destruction, deforestation and species loss in the construction area.[279] In this instance measures for sustainability have not been well balanced with the interests of local populations and further stress the need for public consultation and involvement of local stakeholders.

Regulators

Concerning EU waters, the EU has a regional authority regulating the conditions for hydropower production. It does so by legislating to its Member States' directives such as the WFD. However, on the national level, these countries apply the directive through their respective environmental protection agencies (EPAs) who have regulatory oversight and application responsibilities. The EPAs act as a linkage between the nation and the EU. While the national EPAs have to make sure the implementation of environmental directives is coherent within their country, often countries have different capabilities and approaches for adopting such directives. River basin management is also dealt with through the involvement of various experts within the nation who have the responsibility of producing RBMPs for their water bodies.[280]

The trade-off between the interests of all involved stakeholders especially when the actions of one group negatively impact another group. The conflict between non-governmental

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275 Cernea, M. (2004) p.6
276 AP News. (2020)
277 Stockholm Environment Institute (2020).
278 Vattenfall (2022)
279 AP News. (2020)
280 WFD source (art)

organisations and the hydropower industry highlights the industry's financial and energy production for climate change mitigation motivations. While the conflict between local populations and regulatory groups highlights the reality experienced by groups in the vicinity of hydropower plants.

6 Conclusion

Hydropower generation for electricity is an important contributor to the renewable energy sector within the EU. The benefits of hydropower use highlight its assistance in replacing the use of fossil fuels and reducing GHG emissions within the EU to meet climate change mitigation commitments of the region. Climate change mitigation efforts highlight the reasons for the EU being committed to promoting renewable energy sources as a reliable source of energy. This push for renewable energy can be seen by the proposals of the 'Fit for 55 package' as well as financial incentives set for the promotion of renewable energy in the Member States.

The Water Framework Directive intends to combat the negative environmental impacts of human activity on water bodies in the EU which includes the production of hydropower. The WFD provides a common policy for water governance requiring the 'good status' of all EU waters by 2015 which can be extended up to 2027. Its 'non-deterioration' principle sets a standard to avoid further deterioration of EU waters and aims to block unsustainable hydropower activity in the Member States. This provides a resilient framework for the Member States to follow and implement water conservation measures. However, the Renewable Energy Directive and its ambitions for a climate-neutral EU region present a conflict with the objectives of the WFD. The increasing renewable energy production targets promote hydropower production at the expense of water body quality. Additionally, the resilience of the WFD is weakened by the exemptions set for the 'non-deterioration' principle. The widespread use of the "overriding public interest" exemption against the 'non-deterioration' principle further highlights the imbalance between water protection and renewable energy promotion. While these exemptions should be used on a limited case-by-case basis, national implementation has shown that the use of exemptions continues to be a contentious matter.

In Preamble 16 the WFD calls for continued negotiation and strategy for the 'integration of protection and sustainable water management into other policy areas such as energy'. However, currently, this policy goal has not been implemented or maintained adequately.

This research has learned that there is an inherent contradiction between RED objectives, which promote increased renewable energy technologies and subsequently foster the building of new hydropower plants within the EU, and the WFD objectives which aim to halt further deterioration of EU water bodies. While the replacement of fossil fuel use is important to combat the changing climate, this transition should avoid creating additional environmental issues. The negative trade-offs from hydropower production have not been adequately mitigated as the deterioration of EU water bodies continues to impact water quality, landscapes, vulnerable biodiversity, local communities and fauna and flora.

The legal challenges present in the balancing of hydropower production and water protection highlight possible solutions and points for improvement. Policy fragmentation between the RED and WFD highlights that climate change mitigation efforts have increased motivation for new hydropower production. However, climate change concerns should also recognize the impacts of water degradation and incorporate the mitigation of existing hydropower and its impacts. Furthermore, the largest network for environmentally protected areas in the world, the EU Natura 2000 sites, have regardless of their protected status been impacted by hydropower development. To abide by the non-deterioration principle of the WFD, the Member States and regional supervision should focus on either refurbishing or removing such hydropower activity before promoting new hydropower installations.

The Nordic case studies demonstrate current environmental protection measures for hydropower production and water protection do not adequately address existing hydropower technologies and their impacts. For example, under the Swedish Environmental Code 26 rivers are explicitly protected from hydropower operation including four major national rivers that have permanent legal protection. The protection scheme of Sweden according to the WFD 'non-deterioration' principle is not effective due to hydropower already being constructed and causing deterioration in the protected areas such as the major national rivers as seen in the case of the Dalälven River.

Since around 90% of hydropower projects which are in operation today in Sweden, were granted operation before the implementation of environmental legislation regarding hydropower use the challenge becomes mitigating against existing hydropower plants. Thus, measures for improving the efficiency and safety of existing hydropower plants rather than pursuing new hydropower plants would be a prospective solution for balancing both WFD and RED objectives. This challenge can be better addressed with innovative policymaking which incorporates different stakeholder views to produce a common integrated policy on hydropower development and refurbishment in the EU.

Since hydropower production has direct effects on the objectives of the WFD, for example through its deterioration and HMBW – the WFD could be revised to include regulation in regard to hydropower development and measures for ensuring sustainable hydropower development. Whether this is by reconstructing existing plants and removing the most detrimental dams. This would provide member states with clear guidelines and promote a balanced approach to sustainable hydropower development and a region-wide understanding of the matter.

An outlook for a balanced approach to hydropower production and protecting the environment from degradation will have to involve policy level changes, scrutiny over exemption use and strategies for involving all stakeholders in hydropower matters.

While hydropower production has its drawbacks, this thesis presents the argument for ensuring sustainable hydropower production through policy coherence, restoring EU water bodies and sustainable promotion of renewable energy for the future. The EU should recognize its responsibility in reviewing existing energy policies to better balance the objectives of the RED and WFD. The Nordic case studies present the reality of conflicting objectives causing both environmental and social concerns. Strengthening policy coherence between the RED and WFD will provide a better regulatory strategy for national implementation. As Finland and Sweden also have ambitious climate change mitigation goals, the improvement of regional legislation will ensure they meet their climate goals while ensuring the protection of their water bodies from further degradation.

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