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Whose Hydropower? From Conflictual Management into an Era of Reconciling Environmental Concerns; A Retake of Hydropower Governance towards Win-Win Solutions?

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Abstract: Hydropower has been core in the nation-building process of several countries. This includes Sweden in which it currently supplies around 50% of the electricity and particularly Norway where almost all electricity is generated from hydropower. In these countries, as well as many others, the provision of hydroelectricity enabled urban and rural development, industrialization and other core value-added activities. However, it was realized with significant environmental costs, particularly at the local level. Traditionally, there has been a divide in perceptions on hydropower production, in which stakeholders tend to box it either as an environmental hazard or as a socio-economic benefit. During the last century, these diverging perspectives have influenced political and regulatory approaches as well as the perceived role of hydropower at large. Different attempts to bridge this divide have been made. This is not least true in the present day, considering the role of hydropower as a low-carbon solution, and a balancing source to counter increased intermittency from new renewables into the energy system. These features of contributing to the global good of mitigating climate change need to be assessed against the potential negative environmental consequences on biological diversity, outdoor recreation and landscape perceptions at large. These concerns triggered social mobilization and even became instrumental in establishing environmental NGOs with the core focus of fighting hydropower projects. Contrasting and often conflicting opinions are still prevailing, as exemplified with the implementation of the EU Water Framework Directive (WFD). However, there are current signs and new knowledge available suggesting that we are moving into a new era of hydropower governance. A potential reconciliation of contrasting perceptions is pending, but there is strong inertia to change. We argue that the understanding of past political modes and regulatory approaches are essential to develop more sustainable hydropower governance systems fit for future societal and environmental needs. We currently have the benefit of drawing on lessons learned. This provides an opportunity to shape new governance systems that are more balanced in a way not experienced before.

Keywords: integrated water resources management; the role of hydropower and reservoirs in climate change mitigation and adaptation; governance of water resources in regulated river basins

1. Scientific Approach

A potential reconciliation of how to perceive the role of hydropower is pending, but past experiences and well established political practices make this effort demanding. A central aim of this article is to improve the understanding of the factors that have shaped regulatory approaches towards hydropower. This article explores the issue of hydropower governance and more particularly responds

to a hypothesis that hydropower is currently not sufficiently appreciated in the current, established systems for addressing sustainable solutions. This is aimed at satisfying current economic, social and environmental needs without compromising the ability of future generations to satisfy their needs [1] (pp. 28–30). More explicitly, the article therefore aims to respond to the following governance concerns:

There is a historic continuum of imbalance in assessment systems focusing on hydropower.

We need to identify the bottlenecks and associated regulatory frameworks that have shaped current hydropower assessment systems.

The world is currently moving towards a new low-carbon era where the value of hydropower again needs to be reassessed.

The article draws on qualitative analyses of hydropower governance (the concept of governance is used as a descriptive term encompassing different processes of governing hydropower resources in relation to structures of specific regulations, actions, norms and accountability schemes as enacted by a variety of stakeholders [2]) schemes and regulatory approaches with a specific reference to Sweden and Norway. Therefore, the analyses have for the most part been conducted by assessing and evaluating different literature sources. It draws on a number of written sources such as public documents and reports from regional and international institutions as they are the main providers of written evidence to specific processes that have shaped regulatory schemes and landscapes implemented at national and regional levels. Selected scientific papers have added perspectives to key environmental concepts central to the overarching research questions explored. Additional sources include historic and contemporary written documents representing both energy and environmental interests. This is done to observe how these interests have evolved in terms of perceived influence and focus over time. Web based sources have also provided complementary information, providing updates on statuses of different concepts and processes explored in the article. Sources have been selected based on their usefulness in supporting the ambition to better enable connecting perceived local environmental challenges with more systematic and broader references to relevant energy and environmental political issues. They also enable understanding and better visualization on major deviations in perceived focus between these interests over periods of time. This also better allows the overall analyses and identification of governance gaps needed to be filled to reach more sustainable solutions, balancing hydropower benefits and challenges. Such a scientific approach enables more comprehensive and mutually accepted solutions for any hydropower producing country, and the reasoning included in this article should be relevant universally beyond the references to Norway and Sweden.

2. Changing Perspectives on Hydropower Governance in Various Eras

Hydropower has been a prominent part in the development of energy systems in both Norway and Sweden, making up the lion's share of electricity generation historically until the present day. Hydropower as a source for energy has therefore always been in focus as priorities related to development and natural resources management have shifted over specific time periods. When both nations struggled to reach prosperity and economic security, hydropower's many advantages as a source for reliable energy supply was the dominated view. When economic gains were made and a deeper understanding of the value of a pristine environment and the ability to deliver eco-system services emerged, perspectives changed. Consequently, hydropower has been a very central element in discussions, mobilizations and reactions when energy production has been in line with or at odds with development phases and outlooks.

Currently, hydropower development is in many regards stagnant in both nations. This is not due to the lack of still existing potential that could possibly be exploited. This exists both in untapped river basins due to environmental concerns, but also in other parts of these countries [3]. It is also not because of a lack of technology including types of hydropower and practices for impact mitigation that could present better options for exploitation of hydropower resources in these nations [4]. Instead, the sought and preferred additions of hydropower capacity in these nations are achieved through efficiency improvements of existing facilities [5]. At the same time, new issues relating to the values

hydropower provides are emerging. The role of hydropower as both a provider of renewable energy and as enabler to increase other renewable energy sources to mitigate climate change and associated environmental and socio-economic values, is gaining more attention [6]. These emerging perspectives, however, might not be reflected sufficiently in present day governance systems as these were shaped during eras where other political priorities dominated. Lock-in effects from the systems might produce bottle necks in understanding how hydropower could possibly best be exploited in the present era taking both existing and emerging challenges as well as opportunities associated with hydropower fully in to account [7]. To fully understand exactly how current systems for hydropower guidance came in to being and how they presently influence the way hydropower development is pursued today, one needs to look back in modern history and the evolution of hydropower governance to this day. The following section will highlight the evolving environmental perspectives on hydropower, shaping the policy, legislative landscape and societal approaches related to this energy source.

3. Hydropower as Part of the Early Economic Development—An Era of Exploitation

Hydropower was instrumental for the industrialization processes both in Norway and Sweden. Though electricity was produced in lesser scale from hydropower already in the early 19th century, the major breakthrough came in late stage of the 20th century when construction of large power plants and reservoirs commenced. Early electric generation in Sweden was provided by coal fired steam plants [8]. Signs of emerging localized pollution due to coal consumption, as in many industrializing nations at the time, suggested that new sources for electricity were needed. Sweden was relatively well endowed with easily accessible, flowing water. Technical limitations in transporting electricity over long distances, however, prevented the exploitation of hydropower. The development of the three-phase alternating current electricity system for transfers over long distances changed conditions for hydropower development, allowing greater distances between generation sites and consumers [9]. This also catalyzed early development of electrified railway transport benefitting not least transport of iron ore, central to the Swedish economy. The remote hydropower production sites particularly in northern Sweden, could more easily be useful to major industrial hubs in the south. A multitude of hydropower plants were constructed during the first half of the 20th century and hydropower was the base of Swedish electricity production until the introduction of nuclear power in the 1960s [10].

Hydropower has been generating energy in Norway for many centuries enabling the functioning of local sawing mills, but around 1900 systematic efforts were made to exploit this natural resource for other industrial purposes. Still, the local ownership remained strong and the regulatory approaches were often adjusted to local concerns. Simultaneously a governance system was developed and mandatory licenses were granted by the central authorities. This was also developed to secure public and national control of these resources vis-à-vis private—often foreign—investors such as the Swedish Wallenbergs who increasingly were taking an interest in Norwegian waterfalls. Consequently, legislative work was made promptly after Norway gained its independence from Sweden in 1905 and the Industrial Licensing Act as well as the Watercourse Regulation act were both passed by the Norwegian parliament (Stortinget) in 1917 enabling the development of hydropower resources under national control. Until the World War II, however, most of the hydropower resources in Norway were not exploited, and those realized were mostly made through small hydropower plants with an installed capacity of less than 10 MW [11].

In 1918, new water legislation was adopted in Sweden. The purpose was to gather existing water laws under one umbrella, but also to enable hydropower in order to meet rapid development and need for electricity. The new legislation introduced permit duty for erecting or changing dam structures. The possibility of retrials was also introduced with the 1918 water law. This meant that the water installation could be tried against new conditions and in accordance to the at that moment existing legislation. However, the first opportunity of retrial was only allowed 55 years after a permit had been issued and then new retrial opportunities were possible every 40 years. The combination of factors including unprecedented growth in electricity demand following World War II, allowed for a massive

investment period in Swedish hydropower with rapid development of Swedish rivers leaving only four major rivers totally free from any kind of hydropower installations [12].

Certain efforts were made of suggesting protective zones in pristine areas in Norway, but until World War II the hydropower promotional schemes did not really manifest extensive development of large plants—mostly due to lack of funding. Thus, small plants being realized were not strongly challenged neither by environmental concerns nor social protest. The core concern was to exploit the natural resource and promote industrial activities in line with local conditions and priorities, and it was assessed as a less capitalist/venture approach than the situation in Sweden [13]. After World War II, however, the industrial efforts and political landscape towards hydropower exploitation significantly changed.

4. The Post-War Decade—An Era of Growing Environmental Concerns

When nuclear power was emerging as an alternative source of electricity which would eventually lead to considerable popular resistance, the first national environmental movements against hydropower were already mature.

An era of massive growth in hydropower installations in rivers with changes to natural landscapes coupled with the state dominated process and perceived abuse of power against local interests, generated a political backlash. The vast impacts of hydropower on pristine eco systems helped catalyzing an increasing public interest for environmental preservation. Growing popular concern over time was also channeling to contemporary politics and subsequent formulations of laws and regulation.

Resistance to hydropower in Sweden gained momentum through a number of controversial ventures receiving a lot of publicity. A forerunner to later cases was the exploitation of Stora Sjöfallet, when Vattenfall in 1919 sought to construct a large regulation dam in the heart of the national park hosting the fall. Nine national parks had been assigned by the government the same year Sweden established its first environmental protection law in 1909 [14]. This was also the formation year of the Swedish Environmental Protection Organization [15].

The "battle for Vindelälven" in 1970 can symbolically be noted as the event that indefinitely halted large scale hydropower development in Sweden [16]. This can also possibly be identified as the event where the environmental movement had emerged as a heavy influence in national hydropower politics capable to alter decided developments. Vindelälven was highly prioritized in terms of hydropower exploitation. Permission to exploit the river had been given from the environmental court. In addition, major environmental organizations, involved county boards, affected municipalities and local populations were in favor of hydropower development. However, there were some local protests against the project that gained momentum and spread throughout the country and came to include environmental organizations such as Sportfiskarna, tourism organizations and elements of political parties in the parliament. Despite the fact that Vindelälven was approved for exploitation as part of the "Sarek peace" (the "Sarek Peace" was a 1961 agreement between hydropower interests in Sweden and the Nature Protection Organization to protect a number of environmentally valuable river stretches from exploitation [17]) and agreed by the parliament, the government increasingly experienced popular and incidentally political motions turning against the project [18]. Consequently, the government declared in April 1970 that Vindelälven was not to be exploited. The era of big hydro in Sweden came more or less to an end by that decision. The four remaining major undeveloped rivers (as well as several other water courses) in Sweden received protection against hydropower development, something that was later strengthened in the assertion of these as "national rivers" in 1987 [19].

After the World War II, the hydropower policy of Norway become much more focused on realizing and following up ready-made plans from a number of industrial projects that had been designed and initiated by the German occupants. One example is the construction of a primary aluminum smelter in Årdal. At the same time, rebuilding Norway after the war motivated many politicians to think bigger than locally based small hydro powered development schemes and the policy of "power-socialism"

became the mantra during the 1950s. Other manufacturing plants were also realized, but they all needed abundant supply of electricity—which triggered hydropower development as the locomotive for economic growth. Most of these projects were funded and owned by the public and particularly the central government [20].

From the mid-1960s, arguments for environmental protection became much more manifest on the Norwegian political agenda and arguments were more based on verified scientific reasoning than just aesthetic feelings [21,22]. A major controversy was the Mardøla project in which the local and national protesters were more united. This was instrumental for the consolidation of the environmental movement against hydropower in Norway [23]. Revisions were made in the Watercourse regulation act in 1959, allowing environmental revisions of the licensing conditions after 50 years, but the arguments against hydropower production became stronger. Consequently, the first hydropower protection plan was approved by the Parliament in 1972 and the environmental protection of water courses became more institutionalized [24]. In 1976, a second hydropower protection plan was approved.

In connection to events unfolding in Sweden and Norway and similar environmental movements around the world, new principles for international law were evolving. These legal frameworks incorporated an overarching thinking of the value of nature protection and the responsibility to preserve the environment for coming generations in line with the reasoning of the World Commission on Environment and Development reflected in the Brundtland report (WCED 1987). In Sweden the new environmental act "Miljöbalken" (MB) from 1999 indicates a perceived shift from enabling exploitation to enabling conservation and it incorporates many international environmental principles emerging simultaneously. The terms "sustainable" and "stewardship" with regard to development becomes core values in the new legislation [25]. Other key features or tools of the new legislation signaling the break from the past, include several concepts and principles. The MB has a clearer gravitation towards assigning accountability on part of exploiting parties and it introduces the polluters pays principle and principles of halting activities considered harmful to the environment [26]. Another signature feature the "cautionary principle" also reflected in the Brundtland report (WCED 1987), is also a concept introduced in MB [27]. This principle states that, in situations where scientific evidence is lacking or if general insecurity related to potential incursions to the environment exists, there is reason to suspect impacts.

During the 1980s, a master plan for hydropower development was approved in Norway, but new protection plans were implemented—further and more extensively limiting the opportunities for hydropower development. Gas crackers came also on the political agenda and initially the environmental movement supported this alternative source of electricity production. However, with the growing concerns for greenhouse emissions, this was later withdrawn. In 2000 controversies against a proposed gas cracker even triggered a political crisis and change in government [28]. Further revisions of the Watercourse Regulation act were made in 1992 enabling environmental revisions of hydropower licenses after 30 rather than 50 years. Despite these regulatory changes, more additions to protecting watercourses were made—the last in 2009, which significantly influenced the watercourses available for further hydropower exploitation. The final supplement to the watercourse protection plan was approved by the parliament (Stortinget) the same year Norway decided to implement the EU Water Framework Directive [29].

5. International Regimes Causing Significant National Political Misfits—An Eco-Centric Era Consolidating Environmental Concerns

The development of International and regional environmental rules, guiding principles and frameworks during the last three decades, has subsequently been picked up in national legislation. Many of these involve water management and have functioned as a considerable influence to how these issues have been dealt with to the present day. This has also directly impacted on hydropower governance.

As previously illustrated, there seems to be a perceived break between an exploitation oriented outlook on the environment, catalyzed by the growth of the environmental movement, with a subsequent move towards a more protectionist attitude [30]. This is not least true with regard to the management of water resources [31]. A prevailing awareness was that of the interlinked nature of water to other societal goods and the importance of water resources in a number of sectors and social dimensions. The theory of integrated approaches to manage the many competing needs for water was emerging. There were a number of global events were the concept of Integrated Water Resource Management (IWRM) was developed and eventually merged into major key frameworks on water resources management on local, national as well as international levels with implications for hydropower governance.

What can be seen as interpretations of the present day IWRM approach, has one of its major roots in the so called Dublin Statement on Water and Sustainable Development. The statement was developed in preparation for UNCED in 1992 which followed up the recommendations of the Brundtland report (WCED 1987) and was then promoted in Chapter 18 of Agenda 21, making it a multilaterally agreed principle [32]. The Dublin Statement highlights four principles related to the management of water resources: (1) water is a finite and vulnerable resource, essential to sustain life; (2) water development and water management should be based on a participatory approach; (3) women play a central part in the provision, management and safeguarding of water; and (4) water has an economic value and should be recognized as an economic good [33]. There was no mentioning of geographical boundaries or units of measurement at this stage of IWRM evolution. The concept being shaped at the Dublin meeting in 1992 also highlighted other key features such as "environmental carrying capacity" being the base of assessments. Demand side management was introduced as a method to limit water consumption and the integration of water resources in all aspects of social and economic development, was called for [34].

In 2000, the second World Water Forum took place in The Hague. The meeting had an ambition to unite around a common vision of speeding up the implementation of the Dublin principles and finding practical means of doing so [35]. The vision document developed for the meeting in 2000, connects an integrated approach and the river basin scale referring to the "need to recognize cooperation on integrated water resource management in international river basins" subsequently making the connection between IWRM and the river basin scale among its key messages [36]. The same year, the Global Water Partnership defined IWRM as follows "IWRM is a process which promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" [37].

The main principle of IWRM is that of full integration of issues related to water resource management, which consequently poses several questions to how this can be achieved practically [38]. The inclination towards using the river basin as the unit of measure makes sense from the perspective of integration promoted through the IWRM concept. In other words, when integrating all the issues encompassing IWRM spanning ecology, hydrology, socio economic, cultural and gender issues, the river basin in many regards becomes the common manageable unit of analyses, a common policy denominator [39]. Consequently, Integrated River Basin Management (IRBM) developed as a subset to and extension of IWRM implementation, are more or less synonymous. The river basin is the typical and logical unit for facilitating integration as defined by the IWRM principles [40]. While many issues might benefit from being explored from a local basin perspective, there are other activities such as hydropower, where this local approach may be insufficient and lead to misleading and even invalid policy approaches and accompanying governance schemes.

In parallel to the acceptance of the IWRM concept as the main global methodology to manage water resources, a major water management framework was being developed and consequently enacted across the EU [41]. The WFD is considered by many as the great European IWRM implementation effort [42]. In 2000, EU states agreed on the need for new and single water

legislation applicable to the entire Union. The European Commission presented a proposal based on seven principles of which water management based on the river basin unit was a crosscutting theme. ((1) There is a long-term vision for the river basin, which is supported by the major stakeholders; (2) integration of policies, decisions and costs occurs across major sectoral interests such as industry, agriculture, urban development, poverty alleviation, navigation, fisheries management and conservation; (3) strategic decision-making occurs at the river-basin scale and is used, in turn, to guide actions at sub-basin or local levels; (4) great care is taken with the selection and timing of IRBM initiatives and actions; there is a need for readiness to seize unforeseen opportunities as they arise, providing that this will contribute clearly to realizing the strategic vision; (5) priority is given to maximizing active stakeholder participation in decision-making processes that operate transparently and are based on provision of adequate and timely information; (6) yhere is sufficient investment by governments, the private sector, and civil society organizations in building capacity to enable effective river-basin planning, including the establishment and operation of participatory processes; and (7) there is a solid foundation of knowledge about the river basin and the natural and socio-economic forces that influence it.) Principles highlight cross sectoral integration of polices and planning, but stress that the river basin is the proper level for strategic decision making and execution of political decisions. Issues of climate change and strategic usage of regional water resources was not part of the seven principles [43].

The WFD is an interregional water management framework implemented in all EU states plus Norway. The WFD is aimed at achieving good water status measured mainly expressed through different biological, chemical and hydro morphological characteristics [44]. The framework also encapsulates other values generated from achieving these targets, spanning social and economic spheres. Elements that are recognized from IWRM include a perceived rule of specific ecological quality standards being the principle factor from where other values should be assessed. Within this paradigm, other familiar elements such as the river basin or catchment areas further delineated into water bodies, constitute the unit of measure for different quality factors [45]. This includes biological, chemical and hydromorphological parameters deciding how the WFD concept of "good water status" should be determined [46]. The integration component key in IWRM, is also present in the WFD. The WFD, identical to prescriptions in IWRM, seeks to factor in other goods that utilizes or are affected by water resources into its frame of analyses. A third familiar concept from IWRM into the WFD, is the setup of river basin organizations (RBOs) to guide the IWRM development process in relation to specific delineated areas of mandate which are often corresponding to river basins in some way [47]. Consequently, river basin styled analyses is centered on values related to the natural flow of water and the status of biological, chemical and hydromorphological quality aspects as dominant measures determining current status of water resources and consequently how water resources can be utilized. Hydropower dams typically constitutes hinders to natural river flows causing fragmentation and changing hydromorphological conditions which is a key concern relating to hydropower in Scandinavia and also the rest of the world where hydropower and water storage is prevalent [48]. Other typical measurement parameters characterizing the status of water resources in Eco-centric evaluation methods are the presence of specific flora and fauna or in other words types of biological quality indicators. These can be determined for example by the presence of specific fish species and types of algae [49]. Chemical and hydromorphological quality factors are also often part of similar approaches to assess presence and amount of relevant chemical substances or artificial hinders in natural water courses. Assessments designed around the river basin approach and such parameters risks the marginalization of other key values supported by a specific activity in a watershed. This might not easily be measured within similar frameworks, boundaries and units of analyses.

Analyses based on an IWRM orientation consequently pose a series of outstanding difficulties with direct relevance for hydropower governance when moving from plan to practice. This is related to three different reasons concerning the approach, the scale and decision-making body:

- IWRM is in its core a process oriented approach with a set of pre-decided measures and principles that needs to be executed to address water related issues regardless of context. This can be contrasted to outcome oriented approaches where the desired results in addressing a specific problem may govern the way actions are taken.
- The river basin as a unit, further delineated into water bodies in the WFD, making it more difficult to assess other goods and services from water utilization beyond this unit which cannot easily be quantified. This is in contrast to associated impacts that can normally be measured within the local basin unit. The overriding weight of local parameters chosen based on the "eco-centric" characteristics active at river basin scale, may dominate other socio-economic goods generated from water resources.
- The requirement of establishing RBOs often imposes a supernatural function of influence with vague mandate. Recommendations coming from RBOs to support the implementation of IWRM/WFD requirements are often received at another level of governance, typically municipalities. They in turn traditionally operate with other systems of planning and norms of implantation, risking confusion at the implementing stage.

It is evident that the two previous eras have defined the view on hydropower through the specific lens of priorities and knowledge prevailing during these time periods. It is also evident that these eras have related to each other in the sense that mistakes made during the first era of exploitation have sought to be rectified by the ensuing one with growing environmental concerns and protective measures. However, this is further followed-up in the evolution of eco-centric approaches of the second era with regulatory efforts that actually are causing what is in this study mentioned as political misfits.

Currently, the perception of services provided by hydropower is changing. Perspectives and conditions can change fast, but unlocking and changing systems for planning and management can take longer time obstructing sustainable development as defined by new conditions emerging. This might be illustrated by the slow implementation of the WFD during which perspectives on climate change and the value of renewable energy has evolved substantially. This is not least over the course of several United Nations Climate Change Conferences that have been conducted during that time period [50]. As there are indications that views on hydropower is again moving towards a new era, along comes the opportunity to adjust how these assets are managed. Environmental concerns are still present, but governance schemes ought to be defined by the knowledge and conditions prevailing by the present day challenges and future needs.

6. Evidence of an Emerging New Era for Hydropower Governance

As analytic systems and legal frameworks evolving from the "eco-centric era" is currently being formalized and striving towards implantation in different settings with new conditions like the WFD, there are already signs that elements influencing relevant regulatory schemes in previous eras might be on the verge of being obsolete. New priorities might again be emerging on the global level putting a renewed focus on hydropower and its value, this time as a renewable energy source. A perceived shift in priorities and a possible move towards a new era of hydropower governance brings opportunities. As previous governance eras might have been characterized by being a reaction to the other possibly cementing zero-sum thinking between the two, a new era might negotiate and encompass priorities from both previous periods. If this is the case, we are moving towards something that can be described as win-win scenarios scoring high in both environmental and socio-economic values rather than one overtaking the other. On the back of knowledge generated from two previous eras, there might now be a window of opportunity to build upon existing systems of hydropower governance and move into a new system for decision making able to fulfill environmental as well as socio-economic needs while at the same time also taking emerging issues into account. Figure 1 below seeks to illustrate the relationship between the three eras of hydropower governance explored in this article.

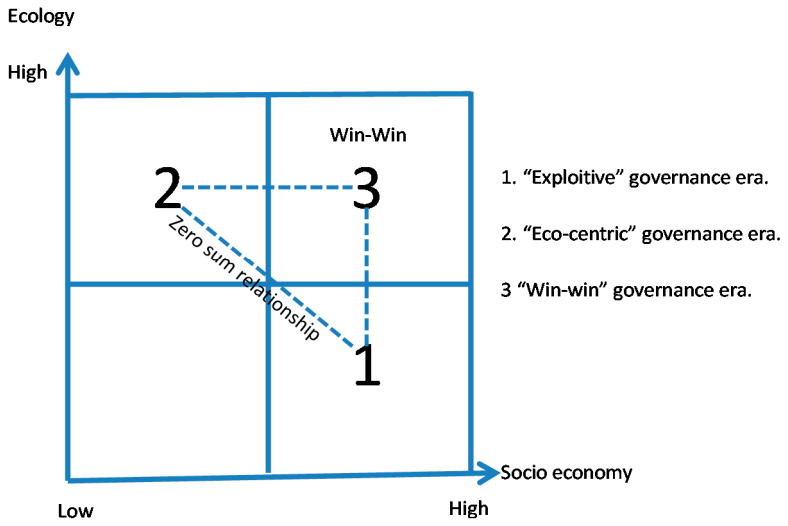

Figure 1. Defining "win-win" scenarios in a new hydropower governance era.

The world has undergone significant and rapid changes since the time of the early development and establishment of IWRM and IRBM concepts as well as the creation of the WFD. Concepts only remotely coming into the general consciousness during that time have since grown in importance and associated risks have also become more visible. Globalization and the notion of global connectedness, particularly in the shape of climate change as well as technical and scientific advances coupled with the growing need for renewable energy, is changing perspectives of aspects relating to tradeoffs between environment and socio-economic needs. It is not these two values pitted against each other per se, it is rather a theory of causality increasingly understood that local environmental and ecological goods cannot be sustained if the overarching problem of addressing global climate change and associated environmental impacts are not effectively addressed. This means that renewable energy is central in any actions to prevent what is a present trajectory of moving the world well above the limit of a 2 °C temperature increase from pre-industrial levels indicated as a threshold by the Intergovernmental Panel on Climate Change (IPCC) in 2014 [51]. It also means that any region with renewable energy potential that has the ability to reduce their carbon emissions needs to make decisive changes. Pledges from individual countries have already been made through COP 21 and the Nationally Determined Contributions to mitigating climate change. Several EU Directives and stated priorities also signal a clear focus of a shift towards renewable energy [52]. The Nordic region is no exception, where both Sweden and Norway have declared commitments towards carbon neutrality by 2050. Hydropower is at the very heart of this debate due to the many unique features it holds with regard to assist a transition towards a fossil free world.

Hydropower is a renewable energy source in itself, currently being the largest contributor of renewable electricity globally by far [53]. However, there are also other features. Along with its low emissions profile, one of hydropower's greatest appeals is its flexibility. Demand for electricity changes over the course of each day and night, over the course of the week and month, seasonally and annually. The fluctuations follow usage patterns in businesses and in households, as well as temperature changes that result in increased demand for power for heating or cooling. Peak demand can be considerably higher than the hourly average. This means that electricity suppliers, when sourcing from intermittent renewables such as wind and solar, need to deal with multiple challenges at once: providing a steady minimum supply (what is known as "baseload"), meeting peak demand, and making up the differences between demand and renewable generation at any given time [54].

Electricity suppliers and other market actors rely on demand forecasts to guide key decisions about generation levels, electricity purchase and investment needs over time. Some power sources are considered better suited for delivering baseload power, because production cannot be quickly turned

on or off (or ramped up or down) to match fluctuations in demand or types of supply disruptions. For example, nuclear, coal and biomass power plants can take hours to start up [55]. To meet peak demand, producers look for "dispatchable" sources that can be turned on or up more quickly. Natural gas turbines plants can be dispatched within minutes; hydroelectric facilities with reservoirs are even faster [56]. Natural gas and hydropower are thus commonly used as sources of dispatchable power supply to strengthen the security of electricity supply when climate mitigating measures are realized.

Consequently, it can easily be deducted that, among the currently available technology options at scale, hydropower is crucial in any transition towards low carbon energy solutions. Realizations tied to identifying the emergence of a new policy era with relation to hydropower, can possibly be formulated in the following statements:

- Addressing local environmental issues means jointly addressing global challenges particularly the overriding issue of climate change.
- Addressing climate change means system change with societies fueled and operated by renewable energy systems.
- Hydropower is not only the largest source of renewables, near fossil free electricity; it is also currently a pre requisite in order to facilitate the incorporation and expansion of other sources of renewable energy sources that are intermittent in character.

When returning to the issue of analytical systems determining both the environmental and socio-economic good of hydropower, it becomes clear that this is a multi-dimensional issue. It might also be concluded that any approach evaluating the merits and impacts of hydropower, needs a broader scale of measurement than local quality factors determined at basin scale like those required in the WFD. These factors should be part of any assessment related to hydropower, but then coupled with a set of not yet identified or determined factors able to quantify other goods measured beyond the local and possibly even beyond the national level. As electricity more and more is a commodity produced and traded between nations in shared systems, the value of hydropower is defined by atypical borders where the balancing capabilities of hydropower can also be capitalized upon by users far separated from the physical area of actual production. The Nordic power pool is an example of this, but increasingly there are opportunities through new interconnectors to central Europe and the UK.

Changing perspectives on the benefits from hydropower production might also mean that the perception of acceptable trade-offs from hydropower generation is changing. The new era suggests that there are several connected dimensions in play, spanning global to local and affecting development outcomes. Possibly the realization of how the global issues impacts on local are the most profound. Nations can no longer act as singular entities in terms of priorities regarding energy production, and consumption with ensuing CO_2 emissions, at least not if seeking a sustainable future. Climate change is an overriding threat affecting all, whether a country is contributing more or less to the common problem. This means that addressing global, common environmental threats equates addressing also very local environmental issues. There can be no separation. Producing renewable energy is a cornerstone in order to negotiate the threat of a changing climate and the environmental impacts associated with it. At the same time, while seeking better inclusion and understanding about benefits from hydropower in an emerging governance era, new evidence is also emerging on related impacts. These impacts possibly also stretch beyond the local level and need to be part of assessment systems capable of providing win-win solutions. The notion that hydropower reservoirs produce carbon emissions has been explored for some time. Still, however, it is rather inconclusive. That large reservoirs emit both carbon dioxide and methane, particularly in early stages of their life cycles, is a rather established science. This is in line with the understanding that emission levels related to hydropower plants are context and site specific [57]. This is just one of many examples of established and emerging fields of science that needs to be included in any type of sustainable governance approach related to hydropower. This is not least true as these types of impacts are likely to have effect beyond the local scale and directly related to mitigating climate change. This is the very issue where hydropower

holds among its greatest added values. Another similar issue, which is perhaps best characterized as an emerging scientific field related to hydropower, is that of hydropower as a cause of variations in local climate patterns [58]. These evolving scientific landscapes need to be reflected in decision making on hydropower. It also eludes to the important aspect of needed governance characteristics in a win-win era and that these approaches need to be flexible and adaptable so that emerging as well as established science can sufficiently be part of the overall system analyses. This is not least important since knowledge generation often moves at a quicker phase than formulation of new regulations and laws.

Hydropower is presently a key to renewable energy production from several perspectives. Thus, it is important to keep hydropower generation high in regions where no feasible options exist, but at the same time minimizing environmental impacts at the local level in the same regions through new operational designs that might be a consequence from hydropower generation. Those two pillars constitute frames for what a win-win scenario in the new policy era should look like; a new environmental design of hydropower governance addressing the double environmental challenge of reconciling local and global concerns.

The historic hydropower eras previously described with a still prevailing institutional eco-centric approach, might serve as illustrations of periods where imbalance characterized priorities related to the two pillars: from paving hydropower's way regardless of consequences to near halting further development of the energy source due to environmental concerns. It should be noted that hydropower governance of those eras where the result of: (1) the priorities of the time; and (2) the scientific understanding of the time. A similar reasoning can be related to the new policy era erupting, building on the priorities, knowledge and experiences of the present day. Main differences compared to the previous eras are current knowledge of the linkages between renewable energy provision, mitigating climate change and the preservation of functioning eco-systems for the purpose of sustainable development. We need all parts to secure prosperous conditions also for future generations. A balance between the objectives, or pillars, must be met at every level of environmental and energy related considerations. We argue that the governance approach being developed during the eco-centric era ought to be extended to encompass economic, social and environmental needs of the present as well as in line with a reasoning of sustainable development. In the next section we provide crucial references that must be in place to realize more appropriate governance approaches.

7. Outlining a Governance Approach in the New Policy Era Allowing for Win-Win Opportunities

Issues explored in above sections point to a need to find a suitable method of assessing the current role and value of hydropower. This needs to encompass both local and regional aspects through quantitative and qualitative approaches. Politics are changing, but still we need improved knowledge of how to reconcile economic, social and environmental concerns related to hydropower.

However, in order to achieve solutions that could be perceived as delivering positive outcomes for a broader set of interests and concerns, certain issues in relation to any intervention approach or governance framework must be considered. Following that, there are different tools at disposal in order to achieve political targets. Therefore, there are some characteristics that should be inherent to any management and decision-making system in what we refer to as "the new policy era" of hydropower governance as explored below.

8. Science Based and an Inter Disciplinary Orientation

As can be evident from the different hydropower eras described, perceived and documented impacts from hydropower development have the potential of stirring up emotions and subjective arguments far beyond those actually being at stake. The possible effects of this were most visible during the era encompassing the rise of the environmental movement during the 1960s and 1970s. The focus was less on identifying appropriate operational means, but rather to avoid further exploitation of hydropower through comprehensive environmental protection schemes.

The concept of fully preserved ecosystems and a pristine environment picked up momentum and spread well beyond the areas of potential and perceived impacts. This blocked development. It even happened in projects that already had been approved by relevant stakeholders, as possibly best exemplified in the case of Vindelälven in Sweden. Still, today, emotionally fuelled perspectives have a central part in the perception of hydropower development. In Sweden, many of the most active lobbyists and opponents to hydropower can be found in member based special interest organizations such as recreational fishing and river conservationists [59]. It can be assumed that lobbying groups representing special interests are part of a reasoning where more localized perspectives are promoted, thus enabling the current status quo [60]. If the focus is preserving possibilities for recreational fishing, it can be assumed that arguments of a broader regional orientation including concerns about climate change and renewable energy fall in less fertile grounds. Consequently, there is risk for cementation of perspectives dominating the "eco-centric" era, those that created new laws and directives such as the WFD even. Inertia to change may consequently be paramount, despite the clear evidence that broader perspectives need to dominate the current debate on hydropower.

While emotional engagement is good as an enabler to achieve interaction and dialogue between concerned stakeholders, it is pivotal that this engagement is based on scientific evidence relating to decisions on hydropower, and any systems designed to deal with its consequences.

Any process likely to either promote or hinder project development should be supported by scientific evidence as base for arguments in order to understand what harm will come to the environment from hydropower development as well as the assessed effectiveness of any mitigation measures presented. Scientific information utilized should also span all relevant fields of knowledge relevant to the specific situation in order to provide the best possible foundation for decision making. In addition, the benefit from a macro perspective of the addition of more renewable energy should be accounted for in a scientific manner.

Using a scientific, transparent and comprehensive departure platform ensures that all parties understand and relates to a common and verified fact base or reality when assessing pros and cons. This will also produce best possibilities to find balanced trade-offs. In a practical sense this would mean that whenever necessary, dialogue processes are initiated and continued between stakeholder groups, a commonly agreed information platform that makes up the basis of any discussions. Besides, early stages of dialogue are constituted by processes deciding on scientific data, methods and key figures and values relevant for the purpose of discussions. These procedures are normally agreed and recognized by all involved parties though interpretations of these might differ. This would minimize risks of discussions reaching dead ends because groups refer to different evidence bases when seeking to reach consensus. Dialogue processes must be sustained and conducted in an iterative manner so that new science can be scrutinized and possibly infused into decision making and project development on a continuous basis.

Subjective values and emotional reasoning should not be ignored as they have potential to trigger better participation and engagement, but this should possibly best complement a scientifically centered process encompassing both quantitative and qualitative methods.

9. Outcome Rather Than Process Orientation

In order to shape any approach with the aim of producing balanced decisions leading to win-win solutions, the desired outcomes of any taken action must be clear. This would constitute a perceived break with the approach of dominating governance frameworks of the former eco-centric era that can be said to be more process oriented in nature. This means that the sustainability of a process will not be determined by a set of pre-defined conditions such as the need for certain organizational set-ups (such as with IWRM), or pre-defined scales or units (IWRM/IRBM and WFD). The desired objective should instead serve as guide in determining what arrangements and norms/references that should be set up and more importantly what political arrangements are already in place that can be built on. It is evident in the set-up of the WFD echoing IWRM with pre-defined requirements

(such as water authorities and river basin organizations to the analytical units of river basins and water bodies) that the correlating process should be able to deliver on outcomes in any given circumstance and in any contexts. These approaches are not only time and resource consuming, but show clear evidence of generating bottleneck effects when moving from plans to implantation, which is evident from experiences with the WFD [61].

Difficulties with pre-defined analytical units such as water bodies and river basins related to the WFD, also risk limiting possibilities to find and understand reasonable tradeoffs in specific circumstances. A possible example of this can be found in the current process of implementing the WFD vis-à-vis hydropower. This is the case both in Sweden and Norway. When seeking to address the issue of what can be considerable loss to hydropower generation at national scale, the methodology outlined by the Swedish agencies has the departure point in river basin/water body analytics as imposed by the WFD. It is specified by the framework that measuring and assessing tradeoffs between different goods is confined to boundaries set within an eco-centric system [62]. The assessment concluded that 1.5 TWh annual loss of hydropower generation is to be considered a threshold for refitting hydropower plants in accordance with modern environmental requirements [63]. However, to date there has been no detailed methodology presented publically that shows how the threshold was decided. This might be especially true in relation to the issue of how that exact value is assessed specifically in relation to the resiliency of Swedish hydropower generation as part of the broader electric system. It is also unclear how the assessment has factored in future conditions and need for renewable energy as a defined societal good beyond the basin scale and also possibly part of a macro-regional development agenda. These issues might indicate that the static environment offered by process oriented methodologies, are not sufficient to determine tradeoffs between environmental and socio economic good in a new and changing era of hydropower governance [64].

It can reasonably be argued that the era of exploitation is an example of an outcome oriented approach in its singular focus on electricity generation for development and economic growth which ultimately compromised any possibility for win-win solutions. The argument against a repetition of such unsustainable outcome oriented approaches is the amount of scientific documentation generated from that period to the present providing strong scientific evidence against such intervention types. It has (not least as part of attempting to implement eco-centric approaches) been fully proven scientifically the type of harm that will come to ecosystems and many socio-economic values if sufficient mitigation measures are not deployed. There is plenty scientific evidence to support the reasonable usage of such measures. Findings and recommendations presented in the 2000 report Dams and Development: A New Framework for Decision-making, created by the World Commission on Dams is one major example, of many, related to this [1]. Consequently a repetition of similar development patterns would then go against the first condition presented above (i.e., scientifically based) of characteristics constituting a sustainable approach.

10. Open for Adaptation and Adjustments

As suggested in the section above, a sustainable management approach related to water resources management and hydropower governance should not be locked in to a pre-defined process, but rather be shaped depending on the expected outcomes that are explicitly formulated. It can therefore be assumed that several different fields of science and technology might be combined in the same management approach. Some of these components can span and gravitate more towards financial arrangements, ecological design/landscape engineering, construction techniques and built environment or stakeholder participation measures, just to mention a few. Three general but important approaches, however, should be highlighted in this regard; open-mindedness, subject to revisions and solutions oriented approach. These three approaches might be crucial enablers for efficient, but more sustainable hydropower governance. An open-minded approach: Once a desired outcome or outcomes have been identified and formulated, an approach should be able to identify and assume the relevant scale of intervention, the relevant stakeholders to be engaged and the needed components

such as financial instruments, possible infrastructural measures or dialogue formats (or the required combination) needed to reach the end goal. This would be in contrast to acting on pre-definitions of these subjects. An approach subject to revisions: The approach should be iterative in the sense that it should have the flexibility to adjust rather quickly to identified bottlenecks and problems and then re-shape certain elements of a process throughout the chain from planning to implementation. It is therefore crucial that every practitioner involved in the management approach are in a continuous dialogue process thus ensuring a unified understanding of key issues but also the ability to infuse new knowledge and make changes to an ongoing process quickly and seamlessly.

A solution-oriented approach: Special notice should also be paid to "end users", i.e., the people responsible for implementation of management systems. In a best-case scenario, a management system can be applied universally and is equally understood by concerned parties (something the new era approach outlined here seeks to support). However, this might not always be the case. Often there is a considerable distance between theory and practice when implementing any type of management framework. Consequently, there can be gaps in understanding different institutional functions depending on where they are on the spectrum between theory and practice or planning and implementing. If the application of a specific system is not universally understood, it should at least be satisfactory to the ones in charge of implementing them. Therefore, a system should be flexible enough to cater to the understanding of those that will ultimately be in charge of making sure that the desired outcomes are delivered. In other words if the practitioners are used to a specific system of planning and implementation, it is advantageous to make sure that identified outcomes can be reached within the frames of that particular system to furthest extent possible without having to construct a completely new tool box for implementing desired outcomes. For example, recommendations and required measures needed to be carried out on part of implementing the WFD often become a concern of national municipalities. These entities normally govern water and land resources as part of already well- established systems for spatial planning through master plans and zoning plans. Harmonizing recommendations in relation to water resources on part of the WFD to fit these planning systems, would not only enable more efficient implementation but can also save resources needed for re-training of professionals and capacity development. It would also reduce risks of possible institutional inertia to adapt to new methods for planning and implementation.

We argue that hydropower is core to reconciling the satisfaction of covering economic, social and environmental needs—both for current and future generations. However, hydropower has caused significant environmental damage and the effects on livelihood opportunities for those impacted have sometimes been severe. Nevertheless, new scientific evidence indicate quite clearly that hydropower is part of the solution—and through new operational and environmental designs in the way hydropower plants and reservoirs are managed, even local environmental concerns can be accommodated. However, it assumes that core stakeholders are willing to seek the best solutions in the long run.

Currently, hydropower governance is strongly impacted by the eco-centric era, but the challenges of implementing the WFD in heavily modified water bodies impacted by hydropower indicate quite clearly that new approaches must be sought. These approaches need to be able to sufficiently address hydropower from a broader development perspective than current systems, such as the WFD, allows. We argue that these must be science based, more outcome oriented and adaptable to suit core concerns and context specifics. Developers and producers feel these requirements, but new solutions are increasingly implemented through environmental design approaches of identifying better win-win solutions [65]. A major challenge, however, is the prevailing inertia in the governance framework. A path-dependency caused by past experiences is hampering regulatory agencies to adjust to current needs. This is happening despite innovative efforts promoted by some hydropower producers

11. Conclusions

It is evident when looking through a historical lens that current hydropower governance is a consequence of past time periods that had certain characteristics and priorities. An era of

un-checked exploitation for economic gain and development were steered by systems designed to enable hydropower development with little regard to consequences. A reaction to that era can then be identified. Consequently, natural resource managing systems with a gravitational center in "eco-centric" thinking and conservation shaped the period leading up to the present day.

These "eco-centric" management systems, of which the WDF is one, have proven difficult to move from theory to practice. There is an abundance of factors and activities not easily evaluated within the pre-defined boundaries and spatial units often defined as part of these types of systems which can often lead to conflicts in priorities creating a vacuum in decision making and a lack of tools to properly evaluate trade-offs. There is evidence to support that we are once again moving in to a new era of hydropower governance increasingly putting focus on the miss-matches of current systems for managing water resources vis-à-vis other societal goods. It is an era where definitions are not yet fully established and hydropower is at the very heart of this discussion. In other words we are entering an era rich in opportunity to create new well adapted governance systems able to deliver on a wide spectrum of equally important development goals.

A new understanding of how climate effects will impact both human and environmental systems on local level as well as macro-regional (global) is quickly emerging. A changing climate will impact ecosystems indiscriminately risking the functionality and preservation of these systems affecting future development opportunities if unchecked. The key to mitigate this is by replacing fossil based energy systems with renewable ones. Hydropower is one of the largest contributors to renewable energy provision as well as energy balancing capabilities worldwide. The uptake of this wider system thinking in re-shaping global priorities has evolved rapidly even during the time period of moving eco-centric management systems from planning to implementation. The latter is a process that is still not anywhere near realized. Consequently these are at the risk of being obsolete or at least partially irrelevant even before they have reached satisfactory levels of implementation globally.

There is now the opportunity to build on experiences from two preceding governance eras that generated both positive and negative lessons. In addition, the amount of scientific knowledge and general awareness has probably never been higher.

On the back of previous periods it would seem that systems based management frameworks resting on a solid base of scientific evidence to support any action taken are within reach. This ensures that decisions are robustly supported by information that everybody can understand and trace to relevant sources and doing so in an equal, non-biased manner. Hydropower is neither good nor bad per se, but services and provision enabled by hydropower should be better appreciated when impacts and outcomes are assessed.

Outcome oriented approaches also seems to hold advantage compared to process oriented ones that currently still dominates thinking on how to manage resources in relation to hydropower. The slow implementation of these systems suggests that pre-defining systems for water resources management is functional in a theoretic environment, but challenges often arise when being confronted with realities on the ground. This brings the argument to a third crucial element of a new era styled management approach; the feature of adaptability. Changes in thinking and knowledge can occur fast as proven in this article, but management systems, connected laws and implemented regulations can be more static. Governmental regulators may provide inertia to change that even can represent a commercial risk for industry.

Attention most also be paid to the end user to ensure sustainable and efficient follow through of recommendations. End user groups or implementers of management systems are often composed differently than those designing the systems. Hence, management systems would need to have built in functions enabling continuous input informing on changing realities. This also includes feedback to those in charge of coordinating the governance system, governmental bodies and the regulators. They should also have enough flexibility so that new knowledge can be incorporated when recommendations are implemented.

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