Assessment of social acceptance of 30 starts/stops in Ume River

A HydroFlex report

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HydroFlex

Increasing the value of hydropower through increased flexibility

Deliverable 5.6 Assessment of social acceptance of 30 starts/stops in Ume River

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Authors	Oddgeir Andersen, Sara Heidenreich
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Executive Summary

The objective of this report is to assess the social acceptance of increased hydropower flexibility. Using a case study approach focusing on one of the HydroFlex reference sites, Stornorrfors power plant located in the Ume River in Sweden, we investigate how different user groups of the river perceive and engage with scenarios of increased flexibility, compared to the current operating regime of the power plant. Since Umeå city is located at the riverbank of Ume River, the human use of the river and riverbanks covers a wide range of activities. Based on interviews with stakeholders at Ume River during winter and spring 2020/2021 and a supplementary literature review, we assess and map reasons for support and resistance for increased flexibility. This investigation includes scenarios with and without the mitigation technology ACUR (Air Cushion Underground Reservoir – a technology developed in the HydroFlex project), which minimizes the water fluctuations induced by flexible operation schemes.

Our study showed that most stakeholders were generally positive towards hydropower and increasingly flexible operation schemes as enabler of the deployment of intermittent renewable energy and, thus, as contribution to the mitigation of climate change. In line with previous research, environmental impacts of hydropeaking were of major concern to the users of Ume älv. In addition, informants mentioned a range of practical concerns connected to their specific uses of the river, such as safety concerns related to ice crossing as well as erosion and landslides, access to facilities for recreational purposes and difficulties for boating and kayaking activities. Finally, informants experienced a lack of information from power plant owners and demanded better dialogue and participation in decision-making.

We recommend that power producers and policy makers do the following to address public concerns and increase support for highly flexible operation of power plants:

- Recognition and inclusion of the diversity of relevant stakeholders, indigenous people and their concerns
- Early and continuous involvement of stakeholders both with regard to the operation scheme of the power plant and with regard to mitigation and compensation measures. Those not interested/relevant can drop out
- Establishment of a communication arena between NGOs/stakeholders and the power company and definition of a person from the power plant operator as responsible for public contact and outreach
- Stronger focus on information to the public (signs), active use of media about reasons for more flexible operations of the power plant, information about water level changes (for safety reasons)
- Access to sites – power plant owners should actively engage with local organizations to make riverbanks and viewpoints an attractive tourism and recreation site.
- Follow existing environmental recommendations and standards and actively compensate the local community (e.g., infrastructure with local value, not necessarily money)

Table of Contents

1 Introduction

The recent IPCC report emphasizing the urgency to limit global warming to 1,5°C and the rising climate activism of the young generation call for an acceleration of the current transition of the European energy system towards a sustainable and renewable production. In this transition, hydropower can play a key role. Hydropower is considered a climate-friendly and cost-efficient renewable energy source (Kumar et al., 2011). In the energy mix of the EU, hydropower has a major share. In 2020, when electricity generation from renewables overtook electricity generation from fossil fuels for the first time within the EU, hydropower supplied 13% of the total electricity, making it the second largest renewable right after wind power which supplied 14% (IHA 2022; Agora Energiewende and Ember 2021). Further, hydropower is the largest energy storage technology while being able to operate with high flexibility. Hence, hydropower has the potential to balance intermittent renewable sources, such as wind and solar, which will be key components in the future European energy mix. Moreover, hydropower can provide a variety of services on the local level, among others, climate adaptation through flood and drought control (Tahseen and Karney, 2017). As Lindström and Ruud (2017: 10) point out, "among the currently available technology options at scale, hydropower is crucial in any transition towards low carbon energy solutions". Particularly the Nordic countries can act as flexibility provider for Europe (Skar et al., 2018; Siemonsmeier et al., 2018).

If hydropower increasingly is used as provider of flexibility to the energy system in order to enable the deployment of more intermittent renewable energy sources, hydropower plants will have more variable operation schemes. The H2020 project HydroFlex aims to create the environmental, social, and technical basis to enable this flexible operation of hydropower plants, i.e., large ramping rates, frequent start and stops, and possibilities to provide a large range of system services such as frequency and voltage regulation, black start capability, synchronous condenser operation and spinning reserve. Flexible operation schemes, also known as hydropeaking, lead to frequent and rapid changes in discharge (Gostner et al., 2011). The term "flow ratio" describes the relationship between highest and lowest discharge during hydropeaking. Discharge will be altered several times a day – the HydroFlex project is working with scenarios with up to 30 starts and stops per day – and the rapidly fluctuating water levels downstream the outlet have negative environmental impacts (Haas et al., 2019).

Over the past years, the Nordic countries have already seen an increase of hydropeaking in their rivers (Ashraf et al., 2018). This new role of Nordic hydropower as provider of flexibility to a renewable energy system requires new forms of hydropower governance, which take into consideration both environmental and socio-economic concerns and address climate change (Lindström and Ruud, 2017). Furthermore, as Perlaviciute et al. (2018) argue, the energy transition is only viable when people support new policies and projects. Ferrario and Castiglioni (2017) emphasize that while earlier energy transitions were characterized by being governed top-down, the current transition requires bottom-up implementation with participation of every citizen. Indeed, in many parts of Europe, citizens become more engaged in questions about the future energy supply of nations and regions. The Norwegian debate about the price level of electricity during winter 2021/22, compared to the price level elsewhere in Europe is one recent example. Therefore, "well-informed public preferences are key to enabling successful and sustainable energy transitions worldwide" (Volken et al., 2017). Also the increasingly flexible operation of hydropower plants is dependent on citizen support and on an active involvement of citizens in decision-making processes concerning the operation of the plants, its environmental impacts and its consequences for other uses of the water (for example, tourism, fishing, recreation) (Tahseen and Karney, 2017). Hence, energy providers should know and understand public attitudes and concerns in order to be able to address critical issues in the planning stage when new technologies are implemented (Koch et al. 2015) and during operation.

However, compared to other energy technologies, such as wind and solar, surprisingly little research has been conducted on social aspects of hydropower (Tabi and Wüstenhagen, 2017). Existing hydropower research within the Social Sciences and Humanities has mainly focused on issues of social acceptance and participation based on case studies among which countries from the Global South are dominant (Tabi and Wüstenhagen, 2017). Considering the potential new role of hydropower as enabler of the European energy transition, more research is needed about cases in Europe. Further, previous research mostly studies the development of new power plants, while the issue of changing the operation of existing plants to a more flexible operation scheme has been studied less.

Therefore, **the objective of this report is to assess the social acceptance of increased hydropower flexibility**. Using a case study approach focusing on one of the HydroFlex reference sites, Stornorrfors power plant located in the Ume River in Sweden, we investigate how different user groups of the river perceive and engage with scenarios of increased flexibility, compared to the current operating regime of the power plant. Ume river is regulated and Stornorrfors power plant is located close to Umeå city, Sweden. Since Umeå city is located at the riverbank of Ume river, the human use of the river and riverbanks covers a wide range of activities. Based on interviews with stakeholders at Ume River during winter and spring 2020/2021 and a supplementary literature review, we assess and map reasons for support or resistance for increased flexibility. This investigation includes scenarios with and without the mitigation technology ACUR (Air Cushion Underground Reservoir – a technology developed in the HydroFlex project), which minimizes the water fluctuations induced by flexible operation schemes. Further, we describe what mitigating measures are needed to address public concerns and increase support for flexible operation schemes, and we provide recommendations for power producers and policy makers.

2 Social acceptance of renewable energy technologies

The concept of "social acceptance" is widely used in research and policy. Upham et al., (2015: 101) describe it as "one of the most policy-relevant social science concepts in the field of energy technologies". However, the concept is often used in a simplified and misleading manner and social acceptance research understood in a reduced way as a study of public resistance to new technologies with the aim of overcoming resistance, gaining acceptance, and facilitating a smooth technology implementation. By contrast, as Wolsink (2018: 291) points out, the concept of social acceptance encompasses "all dynamic positions and actions – taking initiatives, early adoption, support, resistance, opposition, apathy, tolerance, uncertainty, indifference – that are relevant for the degree of renewables' innovation". Moreover, social acceptance research increasingly calls for moving from instrumental approaches towards more critical approaches to social acceptance (e.g., Batel and Rudolph, 2021).

2.1. NIMBY and YIMBY

The NIMBY (Not in my Backyard) concept has been a common explanation for public resistance within social acceptance research (Burningham, 2000; Batel and Devine-Wright, 2021) and is still widely used to characterize opponents of renewable energy technologies by policymakers and developers and in public discourse (Heidenreich, 2015; Wolsink, 2018b). The NIMBY concept relates to the observation that publics tend to be generally supportive of increased development of renewable energy technologies (RET), while concrete projects are often met with opposition (e.g., Cowell, 2010; Pidgeon & Demski, 2012; Wüstenhagen et al., 2007; Aas et al., 2014, Knudsen et al., 2015). In many cases, local communities have to carry the 'costs' of having renewable infrastructure in their neighborhoods. Given the negative aesthetic, environmental and economic impacts that local communities must deal with, a NIMBY response is understandable (Wolsink, 2007; Cohen et al., 2014).

However, the NIMBY concept has been criticized for simplifying the complexities of local opposition and for portraying local opponents to renewable energy infrastructure as irrational, selfish and ignorant and as barriers to development (Devine-Wright, 2009; Soini et al., 2011). An increasing number of studies also shows that the assumptions underlying the NIMBY concept cannot be confirmed in empirical studies. It is not a general rule that opposition increases with proximity to the proposed renewable energy developments and that property values decrease (Wolsink, 2012; Hoen et al., 2011). In contrast, several studies indicate that citizens with renewable infrastructure in their proximity are as supportive or even more supportive – YIMBY (Yes In My BackYard) - than people living in larger distances to such developments (Haggett, 2010; Jones & Eiser, 2010; Swafford & Slattery, 2010). Following the increasing critique of the NIMBY concept, it has been dismissed as explanatory concept from most of social science research on renewable energy technologies and alternative theories have been proposed.

2.2. The social gap

Several alternative theories aim to explain the abovementioned gap between high public support for renewable energy infrastructure development in general, expressed for example in opinion surveys, and the frequent local opposition to concrete developments – also referred to as the 'social gap' (Bell et al., 2005; Bell et al., 2013).

The 'democratic deficit' explanation refers to that the outcome of the permitting processes for renewable energy infrastructures does not reflect the will of the majority because decisions are influenced by a (loud) minority of opponents, while a (silent) majority of people might be in favor of the development (Toke, 2002). The 'qualified support' explanation refers to that the majority of that most proponents of renewable infrastructure developments support the developments only with specific qualifications, e.g., regarding the impacts of development on the environment, landscape and humans. As many public surveys merely ask if respondents support developments in general, without giving them the opportunity to enter qualifications, this might account for certain shares of the social gap (Bell et al., 2005). Yet another very prolific explanation attributes local opposition to renewable energy infrastructure development to citizens' place attachment (Devine-Wright, 2009), defined as "positively experienced bonds, sometimes occurring without awareness, that are developed over time from the behavioral, affective and cognitive ties between individuals and/or groups and their socio-physical environment" (Brown & Perkins, 1992: 284). All three alternative theories mentioned here go beyond simple NIMBYism (Bell et al., 2013).

2.3. The social acceptance framework: Multiple actors, dimensions and relations

Instead of focusing only on overcoming local resistance to renewables infrastructures and explaining the social gap, the concept of social acceptance as introduced by Wüstenhagen et al. (2007) and further developed by Wolsink (2018a) focuses on multiple actors and dimensions and includes all kinds of relations the different actors can have to renewable energy infrastructure development. In the triangle of social acceptance, Wüstenhagen et al., (2007) distinguish between three dimensions: socio-political acceptance, community acceptance and market acceptance. Based on critique with regard to the framework's lack of emphasis on the interrelations between the three dimensions and on intermediate actors (e.g., Devine-Wright et al., 2017), Wolsink (2018a) presented a revised version of the social acceptance triangle (see figure 1), which also addresses institutions and the institutional framework within which the different actors operate. In this framework, socio-political acceptance focuses on policies and institutional aspects, general public opinion towards renewable energy infrastructure and actors such as policy makers, regulators and other key stakeholders. Community acceptance refers to the local level and specific renewable energy projects, and actors such as end users, local authorities and local citizens. Market acceptance focuses on investments, electricty use and market regulation and actors such as consumers, producers and investors (Wüstenhagen et al., 2007; Wolsink, 2018a).

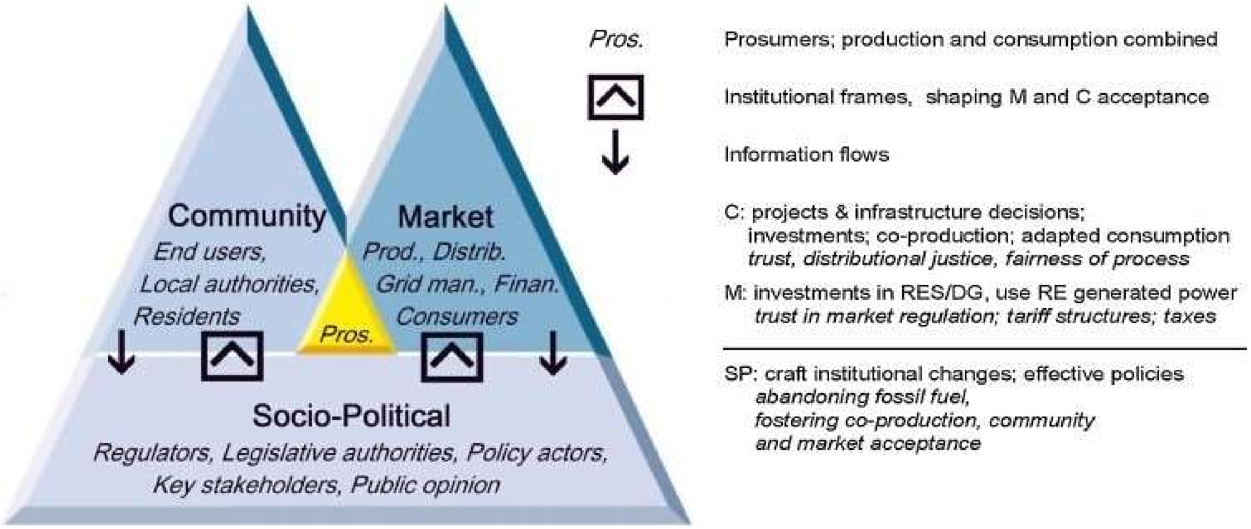

Figure 1: Wüstenhagen et al.'s three dimensions of social acceptance of renewables' innovation; advanced multi-layered conceptualization for STS based on coproduction, with characteristic actors, key objects, and major process influences (Wolsink, 2018a)

Tabi & Wüstenhagen (2017) emphasize the close interrelationship between the social acceptance of hydropower and justice issues. 'Energy justice', which is based on the concept of 'environmental justice' is a rather new concept to investigate the fairness, equity and inclusiveness of energy transition processes. It is often defined by the three tenets: (1) 'Distributional justice' refers to the question how benefits and burdens are shared among different social groups and individuals; (2) 'Recognition justice' addresses social inequalities, representation and diversity of transition processes; and (3) 'Procedural justice' focuses on the fairness of decision-making processes (Jenkins et al., 2016; Heffron et al., 2015). The tenets of energy justice provide important additional analytical lenses to the social acceptance framework.

To summarize, despite encompassing multiple dimensions, actors and relations in its conceptualization (Wüstenhagen et al., 2007; Wolsink, 2018a; Devine-Wright et al., 2017), the concept of social acceptance is often used in a very simplified, reduced and instrumental manner – to understand and prevent resistance frequently characterized as NIMBY opposition, as described above. This provides only a partial understanding of social acceptance which may lead to a problematic knowledge base for policymaking, planning and citizen engagement. Hence, it is important to recognize the complex socio-technical processes involved in the development and implementation of renewable energy infrastructure. As Batel and Rudolf (2021: 253) put it, "The primary objective should no longer involve a problematization of the 'social' dimensions in order to find 'acceptable' solutions to pave the way for technological transformation, but instead embody a critical engagement with the development of RET as social and political projects".

3 Methods

This report is based on a case study approach using the HydroFlex reference site Stornorrfors power plant and Ume River as case for investigating the social acceptance of hydropower flexibility. As impacts of hydropower differ between cases, it is important to consider the local contexts, or, as Botelho and colleagues (2017: 902) state, "To achieve equity and efficiency in the decisions, it is important to understand how the different characteristics of the projects impacts citizens' welfare". Hence, in this report, we focus mainly on the community acceptance dimension of social acceptance.

3.1 Case study - Interviews

We performed interviews with different stakeholders representing the community acceptance dimension, such as representatives from non-governmental organizations (NGO's) covering landowners (Skifteslag/byamän/fiskeråd), anglers, nature and culture foundations, Swedish tourist association and upstream municipalities. We also interviewed a representative from the power plant owner. We used semi-structured interviews, with first a section on the informants' background and relation to the river. We continued with a section on how the informants relate to the current operational regime and to scenarios with increased flexibility (30 starts/stops per day) and to the HydroFlex-developed mitigation concept ACUR. This included investigating reasons for resistance or support. Finally, the informants discussed what mitigation measures that should be taken. All interviews were performed via videolink (Zoom/Teams/Skype), due to travel restrictions because of the Covid pandemic.

3.2. Literature review

In order to understand the case study in the light of previous research and due to limited access to interviewees without connections to stakeholder organizations (regular citizens) because of travel restrictions due to the COVID pandemic, we conducted a supplementary literature review. The basis was a literature review conducted in a research project related to the HydroCen research centre focusing on social acceptance of hydropower. The search was conducted in two databases; (Web of Science and Scopus) and resulted in 2583 papers. In a second round, we searched for papers specifically addressing flexibility (or hydropeaking, fluctuations, water levels) among these papers which – after removing the papers that did not have a social scientific focus - resulted in seven papers. Because of this low numbers of papers specifically addressing hydropower flexibility, we decided to also present an overview of social acceptance research on hydropower in general.

4 Social acceptance of hydropower and hydropeaking– a brief overview

As mentioned above, comparatively little research has been conducted on the social acceptance of hydropower in general and even less research addresses hydropower flexibility in particular. In this section, we will present a brief overview of some of the main insights from the existing Social Science and Humanities research on hydropower.

4.1. Hydropower in general

Before addressing the aspects of hydropower development that may lead to controversy and conflict, it is important to mention that hydropower largely is positively perceived as climate-friendly technology and often not very highly contested (Hinzmann et al., 2019; Karlstrøm and Ryghaug, 2014).

In a recent review of literature on public perceptions of hydropower, Mayeda and Boyd (2020) identify three primary factors determining how publics perceived hydropower projects: environmental and socio-economic impacts, and public participation practices. Similarly, Hinzmann et al. (2019) clustered topics relevant for public perceptions of hydropower into the following topics: economic costs and benefits, quality of life, ecological effects, public participation, energy policy and energy preferences.

Indeed, *environmental issues* are prominent in the literature and several studies emphasize the importance of environmental impact as factor for how people consider hydropower development (Tabi and Wüstenhagen, 2017; Autti and Karjalainen, 2012). Hydropower is frequently considered a threat to the river ecosystem and biodiversity, in particular to fish (Klinglmair et al., 2015; Baylan, 2017). The importance of environmental aspects for peoples' engagement with hydropower is both related to the idea of the environment and nature as having a pristine value in itself and therefore to be protected from any human intrusion and to the idea of the environment and nature as a resource to be used by humans both for economic and other activities, such as recreation. Autti and Karjalainen (2012), e.g., show how the negative impact of hydropower on migratory fish had economic consequences for local communities because they lost their income from fishing. In addition, the loss of fish had important cultural consequences because fishing culture was an important part of the identity of the local community.

The impact of hydropower on culture and identity relates to another important aspect, the importance of people's conceptions of place and landscapes and their *place attachment* (Autti and Karjalainen, 2012; Gormally et al., 2014; Cowell and Devine-Wright, 2018). As for other renewable energy technologies, such as wind power, the way people relate to hydropower is closely connected to how they relate to the places and landscapes where the power plant is developed (Cowell and Devine-Wright, 2018). People were, for instance, very supportive of hydropower development in an area which historically has been using waterpower. This demonstrates the important role of attachments to both physical, social, cultural and historical attributes of places (Gormally et al., 2014). Studies also indicate that familiarity with hydropower relates to support for new developments (Gaede et al., 2020).

The impact of hydropower on landscapes indicates the importance of *visibility*, which may cause conflicts between energy production and *tourism,* for example (Ferrario and Castiglioni, 2017). Based on a case study in Van, Turkey, Baylan (2017) illustrates how different business interests were in conflict with each other, in this case, hydropower development conflicted with tourism development. This relates to *economic aspects,* which also have an important role for the social acceptance of hydropower. This includes distributional questions, such as whether local communities will benefit economically either through direct benefits such as compensations or indirect benefits such as taxes or jobs (Klinglmair et al., 2015; Tabi and Wüstenhagen, 2017; Diaz et al., 2017). How a new or refurbished hydropower plant or a changed operation scheme will affect electricity prices does also play a role (Hinzmann et al., 2019). Another relevant factor is *ownership*, as people tend to be more supportive of locally led schemes (Gormally et al., 2014; Tabi and Wüstenhagen, 2017; Rygg et al., 2021).

In line with research on other energy technologies, several studies emphasize the importance of *energy justice* in hydropower development and implementation, and establish a link between social acceptance on the one hand and procedural justice, that is, fair, democratic and inclusive participation in decision-making, and distributional justice, that is, a fair distribution of benefits and disadvantages, on the other hand (Tabi and Wüstenhagen, 2017; Diaz et al., 2017; Nesheim et al., 2018; Pagnussatt et al., 2018). Ensuring the participation of relevant publics in decision-making enables the access to local knowledges, enhances the chances for public support and improves the quality of decisions (Nesheim et al., 2018; Flacke and de Boer, 2017). Ferriario and Castiglioni provide an example of a case where developers attempted to make a hydropower project invisible and to "distort communities' perception of reality in order to avoid conflicts" (2017: 834), thereby underestimating citizens' ability to uncover these strategies. The consequences were even greater conflicts. Hence, the authors conclude that more transparency and a focus on environmental justice is needed in decision-making processes. In addition to procedural and distributional justice, recognition justice, that is the importance of recognizing the different social groups and paying attention to social inequality and injustice, plays an important role. An example of a group whose interests often have been overlooked and who are particularly affected – also in the context of hydropower - are indigenous people. Mercer et al. (2020), e.g., demonstrate how large-scale hydropower threatened traditional food sources of indigenous groups and thereby their entire way of life. Similarly, Sami rights were at the core of the dramatic conflict about the hydropower development in Alta, Norway (Andersen and Midttun, 1985).

The need for democratic and inclusive dialogue and decision-making processes that go beyond one-way provision of information and that start early and continue over time in order to ensure hydropower development that serves societal interests is emphasized by a series of studies (e.g., Baylan, 2017; Diaz et al., 2017; Do et al., 2020; Öhman et al., 2016; Nesheim et al., 2018). Especially the aspect that the socio-materiality of hydropower projects changes over time (Armstrong and Bulkeley, 2014), shows that citizen participation needs to be continuously conducted.

4.2. Hydropower flexibility

Although the role of hydropower as enabler of the deployment of more intermittent renewable energy sources is increasingly gaining public attention (Lindström and Ruud, 2017), very few studies focus on social acceptance of increasingly flexible hydropower operation and hydropeaking. The environmental effects of hydropeaking – which play an important role for social acceptance – have been studied more. Ashraf et al. (2018, p. 2), e.g., describe a "conflict between environmental and economic objectives" in Nordic rivers and emphasize the importance of mitigating negative environmental effects of hydropeaking.

Studies have shown that the fluctuating water levels can have negative impacts on biodiversity (Haas et al., 2019; Gostner et al., 2011; Ashraf et al., 2018). Frequent variations in water velocity and levels can affect fish species' energy consumption, predation risk and hamper migration possibilities. Gostner et al. (2011), e.g., state that many fishes, macroinvertebrates and aquatic plants are not able to survive frequent fluctuations. However, results from flow modelling in the HydroFlex-project show that the steepness/gradient of the riverbanks are crucial with regard to impact when water levels are reduced due to lower discharge (Burman et al., 2019; Burman, 2020). In addition, a high flow ratio may create more negative impact than a lower flow ratio. More importantly, in large river systems, the water level fluctuations are modelled to be smaller (reduced negative impact), than in more medium sized rivers, and that the speed of change in water level will level off with increasing distance downstream the power plant outlet (Burman, 2020).

In addition to affecting the river ecosystems, hydropeaking does also have impacts on the human use of the river, which must be considered more in the management of hydropeaking (Onstad, 2011). Human use of the river can be divided into consumptive and non-consumptive use. Non-consumptive use is typically aesthetic, recreation, exercise, cultural, boating and wildlife viewing, while consumptive use is angling and use of water for irrigation or drinking water supply.

Aas and Onstad (2013) and Onstad (2011) have studied two of these user groups, anglers and kayakers, at the river Nidelva in Norway, and investigated how they cope with hydropeaking. For the anglers, fluctuating water levels meant that they had to adjust their fishing practices through several strategies, including changing fishing locations (spatial substitution), changing the time they fish (temporal substitution) and changing their fishing gear (tactical substitution) (Onstad, 2011). Kayakers coped with hydropeaking through strategies of temporal and spatial substitution. For both groups, minimum flows were least attractive and unexpected rapid reduction of discharge most annoying (Aas and Onstad, 2013). In order to mitigate the negative impacts of hydropeaking on their use of the river, both groups suggested better information from and dialogue with the power company. In addition, both groups were positive towards physical modifications of the river, such as stone blocks or channel modifications (Aas and Onstad, 2013).

While Aas and Onstad (2013) study of anglers and kayakers only addressed the dimension of community acceptance, Qvenild et al. (2015) emphasize that community acceptance can differ from socio-political acceptance at the national level. In their scenario study of fluctuating water levels due to both pumped storage and hydropeaking, the authors found that impacts on environment and biodiversity were the main concerns of the local community. Other, more practical, concerns related to unstable and unsafe ice conditions and its consequences for safety and transportations opportunities and negative impacts for recreation (Qvenild et al., 2015). The authors also stressed that the local community bears the burden of the environmental impacts, and that benefits for society on a larger scale (regional-national or global), such as increasing renewable energy production or increased flexibility, should be locally compensated in some way. Compensation could typical be that the power plant company helps local society with for example infrastructure, or other services to the benefit of local communities, not only compensation in form of money or cheap electricity fees to households. Also in this case, early participation of stakeholders in dialogue and decision-making processes and the need for information/warnings in situations of safety concern are emphasized.

While these studies focus mainly on consumptive and non-consumptive users of the respective rivers, it is important to keep in mind that also non-users may have interests in and value the rivers either because they would like to have the option of using it or because they want the river to be protected (Teigland, 1999).

5 The case study

In this section, we describe the location of the case study and the mitigation technology concept ACUR.

5.1 Stornorrfors hydropower plant and Ume älv (river)

The case we focus on in this report is one of the reference sites of the HydroFlex project, Stornorrfors hydropower plant, which is operated by Vattenfall. Stornorrfors is Sweden's second largest hydropower plant and generates the most electricity of all hydropower plants in Sweden. It is equipped with four Francis turbines with a total capacity of 599 MW. The Stornorrfors power plant is located by the Ume Älv River in Västerbotten County, Northern Sweden, around 10 km outside the city of Umeå. It is the most downstream hydropower plant of a series of 21 dams/hydropower plants in the 470 km long Ume River, which is inhabited by around 150000 people including 53 Sami reindeer herding companies (Öhman, 2016). Stornorrfors has one of Europe's longest fish ladders (300 metres long).

While hydropower plays a major role as basis of Sweden's electricity supply and enabler for increasing the production of other renewables, hydropower has significant negative effects on river ecosystems in Sweden (Renöfält et al., 2017). A report from Energiforsk states that more than half of the vegetation along the beaches of Ume River disappears and that erosion due to fast water level fluctuations is a problem (Renöfält et al., 2017). Previous research also indicates challenges related to safety and reports a high number of accidents. Öhman (2016: 9) characterizes Ume River as “major risky industrialized area where the public are left to deal with all risks on their own”.

5.2 The proposed mitigation concept ACUR

A large part of the existing hydropower plants (HPPs) in Europe have been in operation for many decades. In fact, hydropower has undergone decades without major technical innovations.

The Air Cushion Underground Reservoir (ACUR) concept is a new technology aimed to reduce negative impact on aquafauna if power plants in the future should operate with increased ramping rates. The mitigation technology is related to increased operating flexibility of hydropower plants. In short, the ACUR concept shall mitigate rapid shifts in water flow downstream power plants with technology developed to rapidly adapt to shifting demand for hydropower with up to 30 starts and stops in power production per day. 30 starts and stops per day can be translated into a change in water level downstream the power plant outlet more frequently than every hour (every 48. min). For the ACUR system, the main principle is that an air compressor/expander shall pump air into a ACUR chamber to force water from this chamber into the river downstream the turbine. The aim is to reduce the speed of the drop in water level when the hydropower production is reduced (Figure 2) (for more information see Storli and Lundström, 2019).

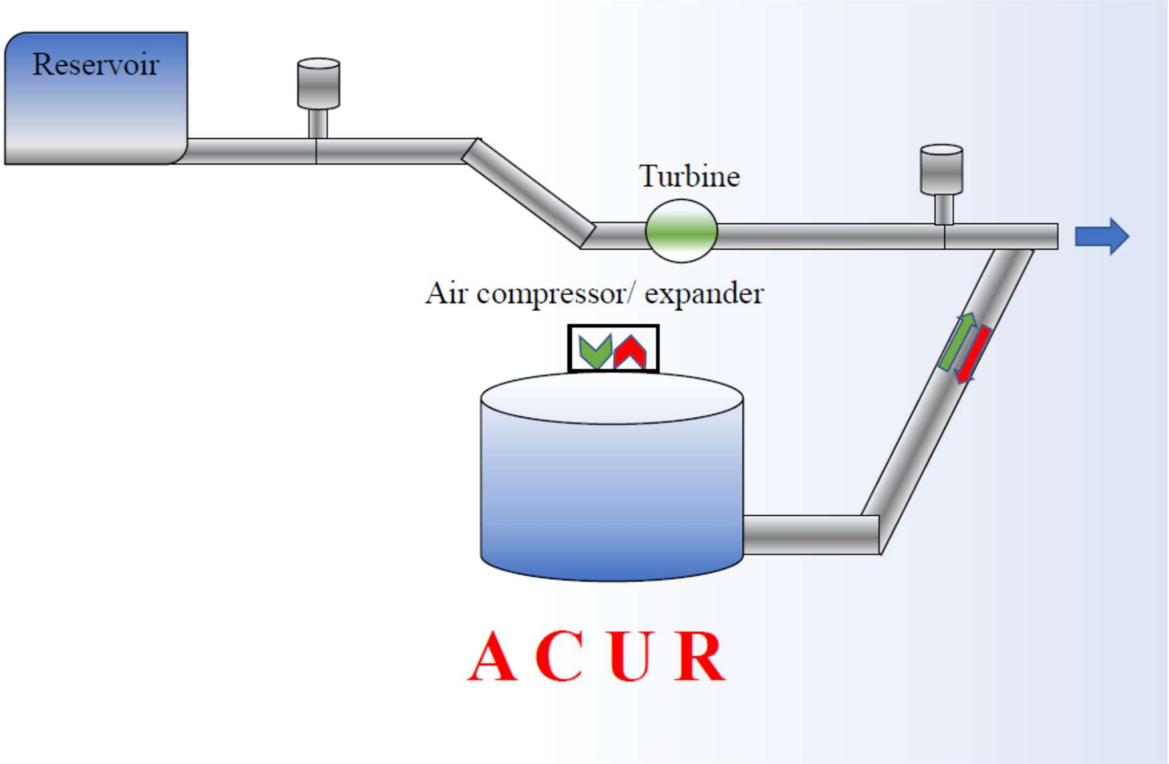

Figure 2. Schematic overview of the ACUR concept.

Task 5.1 in the HydroFlex project has shown that the ACUR system is not suitable for Ume river. Because of the rivers size and discharge volume, the reservoir volumes needed to operate the ACUR system are too large and therefore considered unrealistic (Saferi and Storli, 2021). Due to these practical limitations, other study locations like Bratsberg in Nidelva, Trondheim, might be better suited for this technology. However, since the project consortium decided that the social acceptance study (Task 5.4) was to be carried out with Stornorrfors power plant and Ume River as case, the questions we asked our informants along Ume River regarding ACUR are therefore more of a hypothetical character. However, the informants' opinions reflect their general view on mitigation technologies and what they think is most important in this setting.

6 Results of interview study

Here, we present the results from the interviews of stakeholders along Ume River. We have tried to generalize our findings, as they also will be applicable to other river systems and settings. In the end of each chapter, we have provided a recommendation, which is mainly based on our findings. When relevant, we also include results from the latest research on environmental impacts in the HydroFlex project.

6.1 Reasons for support of increased flexibility

In general, we found low resistance among stakeholders to hydropower development in Sweden, compared to Norway. High support for hydropower development and flexibility must be seen in a context where informants referred to hydropower as renewable technology (“green energy”), which benefits global environment, and reduces the need for non-renewable energy production. According to several informants, renewable energy is important in times of climate change and an important enabler of introducing other intermittent renewables, in particular wind power.

6.2. Reasons for resistance of increased flexibility

In this chapter, we describe the main reasons for resistance of increased flexibility. Both anglers and landowners were concerned that there seems to be more use of highly flexible operations now than before. The anglers’ main concern was that more frequent fluctuations in water level led to increased stress on aquatic fauna and flora. The same concern was raised by people with interest in ornithology. They expressed concern about waterfowl, both ground nesting and feeding in the nature reserve in the estuary of the river. In addition, anglers were concerned about fish migrations, and that highly flexible hydropeaking would additionally hamper (a current problem) the migration of Salmon to the river upstream Stornorrfors and to the tributary Vindelelven. However, anglers appeared to be less concerned about stranding of fish downstream Stornorrfors power plant. One reason for this was that Ume River on the section downstream the water outlet from the power plant has rather steep river banks and short distance to the sea. The level of concern for stranding of fish would probably be higher in rivers where water fluctuations will affect a longer part of the river or with a more gradual riverbank. There is also reason to remember that the speed of water level change will decrease with increasing distance from the power plant outlet.

Anglers and other users of the river (boaters and kayakers) raised also more practical concerns, like the use of jetties and boat moorings if they would expect to experience more fluctuating water levels, and especially if the flow ratio was high. A few landowners also reported that they had encountered problems with erosion and landslides, and they were concerned if more frequent fluctuations in water levels/flow ratio should enforce the problem with erosion and landslides.

In winter, the ice cover on rivers and lakes can serve as a transportation route for snowmobiles or recreational use like cross country skiing and snowshoe walking. As described in detail in chapter 6.4, the power company gave one example from Lule river in north-Sweden where there are problems related to safe crossing of an ice-covered river. The problems with unsecure ice-conditions occurred because of fluctuating water levels, due to hydropeaking.

With regard to a potential implementation of the mitigation technology concept ACUR, some of our informants argued that the ACUR technology was a waste of energy; in the sense that large amounts of electric power are needed to run the ACUR system. Others also argued that the ACUR basin/excavation residues will be area-consuming and there might be problems related to where to store the excavation residues if they were not used directly into other construction projects.

Our recommendation based on the assessment of support and resistance to more flexible operation schemes at the Stornorrfors power plant in Ume älv is that the maximum rate of change in water level, measured as centimeters per hour (cm/hr) should follow the environmental recommendations/standards provided in (Bakken, Forseth & Harby (red.), 2016; Bakken et al., 2021) and not exceed 13 cm/hr the first 2 km (or the distance flow modelling shows most affected) downstream water outlet any time of the year. This will reduce impact on aquatic fauna and also reduce issues related to secure ice conditions.

6.3. Stakeholders' perceptions of the power plant operator

Some of the informants complained that there is wrong information on information boards on facilitated areas near Stornorrfors (Lakshoppet), and that the power plant owner (Vattenfall) should correct/upgrade information to the public. The feedback we got from our informants, was that it is hard to find the right responsible person to talk to if you want to contact the power plant owner (Vattenfall) with regards to the wrong information on facilitated areas near Stornorrfors. The same is also true when these persons tried to contact Umeå municipality as co-owner of Stornorrfors. However, other stakeholders feel they have good dialogue with Vattenfall (i.e., angler organizations). How easy it is to reach the right responsible person depends probably more on established networks/contacts. To our experience, there is no formalized system/contact person between the public and the power company.

Our recommendation is that the power plant owner should clearly define a responsible person for public contact/outreach.

6.4. The power plant operator (Vattenfall)

The power plant operator faced challenges with communicating the need for, and value of changes in hydropower operations, towards a more flexible operating regime. They felt a stronger resistance among politicians, authorities and regulating bodies now than before. This was even true with regard to small modifications of hydropower operations, even if environmental aspects were accounted for. In Sweden, there is a standard environmental mitigation rule, that power plant owners can use up to 2,3% of the amount of water to mitigate environmental conditions. One possible strategy is to work with improving the understanding of the value of hydropower of politicians, authorities, regulating bodies and the public.

The power plant operator also acknowledges the need for better communication with NGOs/stakeholders and some fish management areas. They made a point out of good cooperation with several fish management areas, but there was room for improvement of cooperation with other fish management areas. The power plant operator also provided examples of cooperation with local residents and gave us a good example of cooperation with reindeer herders from Eunnacerro sameby along Lule river. A "sameby" is a financial and administrative union that is regulated by the reindeer husbandry act. When reindeer from Eunnacerro sameby migrate between autumn and winter pastures, and back from winter to spring pastures, they need to cross Lule river. On this particular section of the Lule river, the water level fluctuates as a consequence of hydropeaking in an upstream hydropower plant. The consequence is that the ice is not safe to use as a transportation route when crossing the river. The reindeer herders from Eunnacerro have therefore an agreement with the power company that they can tell the power company a few days in advance, before the reindeer herd shall cross the river, to secure ice conditions for a safe reindeer crossing and for use of snowmobiles. After the reindeer heard has crossed and moved on, the power plant is operated with hydropeaking again. Through this cooperation, the power plant operator contributes to sustain traditional use of the river as a transportation route and reduces conflict with local use traditions.

Our recommendation is in line with what the power plant operator already has recognized: the necessity of good communication with local users like the reindeer herders, and also with stakeholders with strong interest in the affected river system like anglers, kayakers and tourism industry etc. In addition, before implementation of a hydropeaking regime, it is important to map all affected stakeholders and invite them to participate in the environmental impact assessments.

6.5. Mitigation measures

In Sweden, there is a standard Environmental mitigation rule, that power plant owners can use up to 2,3% amount of water to mitigate environmental conditions. In the river system we studied, fish stocking of salmon was the only mitigation effort that was implemented. The power plant owner secures that the water level is favourable for the salmon fry when released. In addition, they used this 2,3% of water to trigger fish migrations.

The ACUR technology seems in principle positive for aquatic species, especially to avoid stranding of fry. However, highly flexible hydropeaking will continue to stress aquatic organisms all year round. On the other hand, flow modelling shows that in large river systems, the water level fluctuations are estimated to be smaller (reduced negative impact), than in small and medium sized rivers. In addition, the rate of change in water level will level off with increasing distance from the water outlet. As already mentioned in chapter 5.2, the volume of water discharge in Ume River exceeds the current capacity of ACUR technology, and ACUR was therefore classified as a not realistic mitigation technology in this particular river.

Our recommendation:

- In cases when needed, we recommend that there should be possible to surpass the 2,3% of water rule for mitigation purposes.
- Based on environmental conditions in the affected river, define a maximum change in water level per hour (13 cm/hr) on selected hotspots (f.ex spawning areas)
- Relevant stakeholders such as environmental NGOs and direct users of the river should be involved in dialogue and decision-making with regard to potential mitigation measures as well as in continuous evaluations and adjustments of existing measures.

6.6. Compensation measures

One established compensation measure is that members of “Skifteslag” (landowners with possibilities to develop hydropower on their property or sell concession rights) has an annual amount of free electric power. Another suggested measure is that the power plant owner helps to facilitate for public use of the landscape near by the river, within the frames of public safety. For example, some informants mentioned that they want to use the dam as a possibility to cross the river (by foot or bicycles), because there were few bridges near the power plant and the surrounding areas of the river are frequently used for recreational purposes.

Regarding the fish stocking, both angler related NGO’s and the power plant owner agree that there should be fish stocking to compensate for loss of natural fish production/recruitment. This is also in accordance with the European water framework directive (EU WFD), where an ideal state should be natural recruitment only, but stocking is necessary to compensate for reduced ecological state.

Our recommendation with regard to compensation measures is to cooperate (more closely) with stakeholder groups and indigenous people (samebyer) affected by regulated rivers, as described in chap 6.4. and to facilitate for better recreational and tourism use of the area around the hydropower plant.

7 Conclusion and recommendations

The objective of this report was to assess the social acceptance of increased hydropower flexibility. Based on a case study of the Stornorrfors hydropower plant in Ume River in Sweden and supplemented by a literature review, we investigated how different stakeholders and user groups of the Ume River perceived and engaged with the current operating regime of the power plant and with scenarios of increasingly flexible operation schemes. We focused our investigation mainly on the dimension of community acceptance.

Our study showed that most stakeholders were generally positive towards hydropower and increasingly flexible operation schemes as enabler of the deployment of intermittent renewable energy and, thus, as contribution to the mitigation of climate change. In line with previous research, environmental impacts of hydropeaking were of major concern to the users of Ume älv. In addition, informants mentioned a range of practical concerns connected to their specific uses of the river, such as safety concerns related to ice crossing as well as erosion and landslides, access to facilities for recreational purposes and difficulties for boating and kayaking activities. Finally, informants experienced a lack of information from power plant owners and demanded better dialogue and participation in decision-making.

Based on the outcome of the study, we recommend that power producers and policy makers do the following to address public concerns and increase support for highly flexible operation of power plants:

1. Recognition and inclusion of the diversity of relevant stakeholders, indigenous people and their concerns
2. Early and continuous involvement of stakeholders both with regard to the operation scheme of the power plant and with regard to mitigation and compensation measures. Those not interested/relevant can drop out
3. Establishment of a communication arena between NGOs/stakeholders and the power company and definition of a person from the power plant operator as responsible for public contact and outreach
4. Stronger focus on information to the public (signs), active use of media about reasons for more flexible operations of the power plant, information about water level changes (for safety reasons)
5. Access to sites – power plant owners should actively engage with local organizations to make riverbanks and viewpoints an attractive tourism and recreation site
6. Follow existing environmental recommendations and standards and actively compensate the local community (e.g., infrastructure with local value, not necessarily money)

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